RHODE ISLAND
FRESHWATER WETLAND MONITORING AND ASSESSMENT

Expanded Pilot Demonstration Project Work Plan for EPA QAPP Review – Year 3 Continuation

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1.0 PROJECT MANAGEMENT

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1.3 Distribution List (EPA QA/R-5 A3)

- Signateurs (Title Page)
- EPA-New England, Region 1 Wetland Monitoring Coordinator and RI State Wetland Coordinator
- RINHS Wetlands Scientist

1.4 Project Organization (EPA QA/R-5 A4)

DEM Office of Water Resources is the lead agency implementing this project. DEM has contracted with the RI Natural History Survey (RINHS) and the RINHS has recruited and hired a professional wetland scientist. Where selected wetlands to be assessed are freshwater wetlands under the jurisdiction of the CRMC, DEM will coordinate with the CRMC Deputy Director. Qualified and experienced personnel are available to execute the work. Additionally, DEM will keep abreast of the EPA-AED work to develop a rapid assessment tool for isolated wetlands. The following persons will implement or participate in this project:

- Susan Kiernan, DEM – contract and grant management and project oversight.
- Carol Murphy, DEM – technical project oversight and quality assurance
- David Gregg – Exec. Dir. – RINHS –contract management & supervision of staff
- Tom Kutcher, Wetland Scientist, RINHS – office and field data collection, analysis and report writing, supervision of field assistant.
- Matt Schweisberg, EPA-New England, Region 1 – wetland program manager, EPA project contact.
- Jeanne Voorhees, EPA-New England, Region 1 – NE wetland monitoring coordinator.
- Peter Holmes, EPA-New England, Region 1– RI state wetland coordinator.
- Steve DiMattei, EPA-New England, Region 1– RI quality assurance coordinator.

1.5 Problem Definition/Background (EPA QA/R-5 A5)

As part of a comprehensive approach to wetland monitoring, DEM is demonstrating and developing a wetland rapid assessment method (RAM) for the State of RI to enhance its program in accordance with the *Rhode Island Freshwater Wetland Monitoring and Assessment Plan* (the Plan; App. A). The Year-3 effort that is the subject of this *Quality Assurance Project Plan* (QAPP) builds on and continues earlier work supported by Clean Water Act 104(b)(3) grants to develop a comprehensive plan for Rhode Island and to begin implementation. The Plan recognizes the usefulness of landscape scale analyses, rapid assessment methods and targeted monitoring and reflects the tiered approach encouraged by EPA. Data generated from monitoring and assessment will contribute to an improved understanding of wetland condition in Rhode Island and foster changes in management programs to enhance wetland protection. The Plan recognizes that data will be useful for a variety of purposes but places a priority on several specific wetland management concerns.

As the Plan is implemented it will generate information on wetland trends and condition that will be used by DEM managers seeking to evaluate and improve existing programs or develop new strategies for wetland protection. Wetland profiles, updated, as new information becomes available, will be a vehicle for sharing the data with municipalities, land trusts, conservation commissions, and non-profit groups to enhance protection, management, and education at the local level.

The overall goal of the Plan is to improve management and protection of freshwater wetlands in Rhode Island. Over the long term, the Plan aims to describe reference wetland conditions, create a baseline of information on wetland extent and condition, and evaluate cumulative impacts to wetlands. Shorter term objectives are to: a) Prioritize wetlands to inform open space acquisition, b) Develop and implement best methods for baseline monitoring of impacts to wetlands due to groundwater withdrawals, c) Monitor and assess impacts to wetlands due to loss and degradation of buffer zones, and d) Monitor location and extent to which invasive species are present and affecting wetland condition.

During the development of the Plan, DEM and NEIWPCC identified several rapid protocols employed in other states that were of interest. The aim of the review process was to select a RAM(s) that was directly applicable to State monitoring objectives, which require the characterization of wetland *condition*, specifically. The aim was *not* to characterize specific wetland functions and values, categorize wetlands for various levels of protection, or prioritize potential wetland restoration sites. Thus, the test-RAMs were selected on elements of conditional assessment, rather than functional assessment.

In the first year of Plan implementation (2006), with the assistance of the New England Interstate Water Pollution Control Commission (NEIWPCC), effort was directed to monitoring and assessment applications that involve a statewide GIS analysis and a rapid assessment method (Tier 2 RAM). The 2006 work to define a specific RAM for Rhode Island laid the groundwork for demonstrating rapid assessment on a watershed basis in Year 2 (2007) and again in the current Year 3 (2008 field season) that is subject of this QAPP.

In 2006, DEM tested two methods; the Ohio Rapid Assessment Method (Mack, 2001; App. B) and Delaware's Rapid Assessment Procedure (modified) (Jacobs, 2006) to determine how they work in RI. The methods were piloted in the first year at 27 wetlands on 18 properties. DEM worked with NEIWPCC to complete the fieldwork, data analysis and a draft report. DEM continued to pilot the Ohio (ORAM) and modified Delaware (DERAP) methods in year 2 (2007), through a contract with the Rhode Island Natural History Survey (RINHS). A preliminary RAM was developed and tested during 2007 on a sample of over 50 wetlands in the Pawcatuck River watershed, resulting in the State-specific developmental RAM, RIRAM v.1. The methods were critically reviewed with respect to objectives outlined in the Plan after this second field season. The results of Year 2 work are detailed in the report *Rapid Assessment of Freshwater Wetland Condition: Development of a Rapid Assessment Method for Freshwater Wetlands in Rhode Island* (RINHS and DEM 2008).

DEM will continue its contract with RINHS during Year 3 building on the significant progress in demonstrating field methods on a rotating watershed basis according to the two test-RAMs, and tailoring those RAMs in the development of a single relevant and effective RAM for the State of RI. Specifically, the existing models were adapted for relevance to local circumstances such as community types and local stressors, and for efficacy in addressing the State's monitoring objectives. To meet the State's objectives in the most efficient manner possible the developmental RAM was formatted to score stressor and condition metrics separate from wetland functional characteristics (value added metrics), thus provides the following benefits:

- It can be used with any wetland type.
- It does not require reference data; the hypothetical reference wetland contains no stressors, or evidence of stressors, and thus receives a perfect condition score.
- It can be used to identify reference sites for development of Tier 1 and 3 monitoring efforts.
- It is efficient; a single trained investigator can assess two wetlands in a single day and the generation of an index is limited to simple arithmetic.
- It causes minimal disturbance to the wetland, as data are collected passively by observation.
- It provides a wide array of metric data that can be used for a range of descriptive and semi-quantitative purposes.

At the commencement of project year 3, the next steps are: (1) to demonstrate the validity of the RIRAM for generating objective and meaningful results by continuing to solicit input from wetland workgroup members and by comparing RIRAM results with other relevant measures (Tier 1 and Tier 3 data), and (2) to demonstrate and enhance RIRAM's effectiveness in directly addressing State objectives. Being suitable for providing both direct analysis and a reference baseline, the RIRAM will position the State and its partners with an effective wetland-conditional- monitoring tool.

Consistent with the statewide water-monitoring plan, DEM is phasing in implementation of *the Rhode Island Freshwater Wetland Monitoring and Assessment Plan* over several years. This Year 3 will involve the demonstration and further development of the RIRAM to address State monitoring objectives according to the Plan (App. A). Specifically, Year-3 objectives are to: (1) further refine RIRAM metrics based on continued input from technical experts and through analysis to enhance its utility and user objectivity for conditional assessment, (2) demonstrate RIRAM validity for generating a regionally-effective index of overall wetland condition, and (3) demonstrate the ability of the RIRAM to directly address State freshwater monitoring and assessment objectives.

1.6 Project/Task Description and Schedule (EPA QA/R-5 A6)

To meet the Year-3 project scope of work, RINHS will conduct two distinct sampling efforts during 2008 by applying the RIRAM using field datasheets designed for data collection, analysis, and development (App. C). The first will target a set of 36 isolated wetlands distributed across the State's mainland. This effort will take advantage of an opportunity to utilize more intensive and quantitative data being collected by Dr. Peter Paton and MS candidate Annie Curtis of the College of the Environment and Life Sciences (CELS) at URI, who are working on developing an IBI for isolated wetlands under the QAPP entitled *Assessing the effects of human disturbance on New England isolated wetlands using a 3-tiered rapid assessment protocol* (Paton 2007). The quantitative data they are collecting (e.g. vegetation richness, amphibian use) will be shared with RINHS / DEM to validate and possibly refine the RIRAM, and facilitate an inter-user variability analysis. In return, RAM data collected by RINHS / DEM at the sites will be shared with them to help in the development of their IBI. This data sharing and inter-validation will enhance both projects considerably.

The second sampling effort will follow the 2007 sampling approach (as outlined in App. B), assessing 50 wetland sites in a targeted set of sub-basins identified by DEM as part of a rotating basin approach. Here, sites will be selected by a modified stratified-random process along a gradient of land use intensity. Data from this effort will be used to further refine metrics and run demonstration analyses and exercises as detailed in section 3.

The intended outcome is the establishment of an efficient monitoring tool that will:

- Supply wetland condition data necessary to directly address State freshwater wetland monitoring objectives,
- Supply the State with a high-resolution Tier 2 baseline standard from which to further develop a comprehensive wetland monitoring program,
- Clarify stressor-response relationships for key stressors, and
- Supply State policy personnel with useful descriptive/semi-quantitative data.

Project tasks and products will be conducted and developed by RINHS and DEM for Year 3 as follows:

1. The RINHS will apply the RIRAM to 36 targeted isolated wetlands (Paton 2007) across RI in summer of 2008, and will train A. Curtis (URI CELS MS Graduate student) in the application of the same RIRAM to the same wetlands.
    a. Remote (in office) data collection and field preparation
    b. Field assessments and data collection at each wetland, and field training.
2. The RINHS will apply the RIRAM to a minimum of 50 targeted wetlands within DEM-prioritized wetland basins in late summer/fall 2008. These will include the Hunt River and three Pawtuxet River sub-basins (H-P basins) in central RI.

   a. Selection of 50 conserved/public sites along a gradient of human disturbance
   b. Solicit permission to access 50 H-P sites
   c. Remote (in office) data collection and field preparation
   d. Field assessments and data collection at each of 50 selected wetlands
3. The RINHS to produce demonstration products and RAM refinement in consultation with DEM after completion of field work such as:
   a. Analysis and calibration of enhanced *Condition* metrics
   b. Inter-validation analyses between RIRAM and various functional metrics (faunal and floral indicators—IBIs) collected by Paton and Curtis
   c. An analysis investigating inter-user variability among two assessors separately conducting the RIRAM on the same wetlands
   d. An analysis demonstrating the response of wetland condition to various indices of buffer degradation at various buffer widths (addresses Plan Short-term Objective 2, App. A)
   e. A map depicting wetland invasion intensity across sites and an analysis demonstrating correlations between wetland invasion and surrounding land use intensity (addresses Plan Short-term Objective 3, App. A)
   f. A demonstration analysis identifying stressors most strongly associated with the degradation of wetland condition (addresses Plan Long-term Objective 2, App. A)

The Year 3 project and tasks enumerated above will take approximately one year to complete. Refer below for the estimated schedule of work.

2008

- August through October:
  - Field investigations and data collection at 36 isolated wetland sites
  - Field training of A. Curtis, URI CELS Graduate student (July 2008)
  - Field investigations and data collection at 50 H-P basin sites
- November:
  - Data entry
  - Meeting with DEM and coordination with expert workgroup members
- December:
  - Preliminary analysis and planning, agreed to by DEM
  - Data and data analysis review

2009

- January:
  - Analyses assessing RAM refinements
  - Analyses demonstrating the RIRAM's ability to address State monitoring objectives
  - Analyses demonstrating RIRAM validation and support of Tier 1 and 3 development
- February to May:
  - Report writing, review, and revision

- June and July:
  - Develop RIRAM guidance memorandum
  - Develop recommendations supporting the State's wetlands monitoring program
  - Deliver final report for Year 3 work

1.7 Quality Objectives and Criteria for Measurement Data (EPA QA/R-5 A7)

Wetland assessment units will be identified and assessed according to modified and adjusted rules defined in the ORAM guidance (Mack 2001; App. B) as applied to the RIRAM V.1 F08 field form (App. C). Modifications and adjustments to the ORAM and the RAM implementation will be employed as detailed in the Year-2 Final Report (RINHS and DEM 2008). RINHS and DEM will develop a guidance memorandum as the RIRAM Year 3 nears completion.

RIRAM protocols have been developed through a feedback pilot process over the past two years. The data collected are observational and ordinal. Tier 2 assessment data are generated from metrics which are generally estimated; direct measurements are not made (see Year-3 field form, App. C). Finally, the index the RAM generates is relative, not absolute, thus measures of data accuracy are not applicable.

1.7.1 Objectives and Project Decisions:

The objective of RIRAM development is to generate metrics and an index that can be applied rapidly across freshwater wetland types to describe wetland condition in RI and inform objectives identified in the Plan. The ORAM has been calibrated and assessed through correlative analyses prior to this effort, but modifications to the ORAM to meet State needs make necessary additional analysis to validate the utility of the RIRAM in generating indices of relative condition. The RIRAM will be validated or calibrated with Tier 1 and 3 data and input from members of a technical workgroup.

1.7.2 Action Limits/Levels

RAM data are generally ordinal and collected by observation and estimation, so data collection limits do not apply. Correlations between RIRAM indices and landscape (Tier 1) and Tier 3 data are expected to be stronger than those generated by applying the original ORAM metrics. In Year 2, several adjustments were made to ORAM metrics that improved their correlations with quantitative (Tier 1 and 3) data and reduced inter-user variability (RINHS and DEM 2008). In Year 3, two developmental metrics will be assessed against original metrics to determine if objectivity and utility can be improved. The predictive capacity of the RAM metrics will be assessed, and their utility revealed through analysis and interpretation.

1.7.3 Measurement Performance Criteria/Acceptance Criteria

Since RAM data are observational / estimated and ordinal, their utility is highly subject to interpretation. Acceptance or rejection of the RAM metrics and indices will ultimately be determined by the DEM, guided by input from the RINHS and members of the technical workgroup.

1.8 Special Training Requirements/Certification (EPA QA/R-5 A8)

Carol Murphy (DEM Principal Environmental Scientist) and Chuck Horbert (DEM Supervisory Environmental Scientist) are State representatives on the New England Biological Assessment Wetland Working Group (NEBAWWG). Murphy, Annie Curtis (URI/CELS MS candidate), and Tom Kutcher (RINHS Wetlands Scientist) were all formally trained in ORAM methodology by John Mack (ORAM author) in a two-day session in May, 2008 sponsored by NEBAWWG. Kutcher (RIRAM V1 Field 2008 author) trained Curtis in RIRAM implementation in July 2008. Curtis and Kutcher will apply RIRAM and ORAM to the 36 assessment units separately for inter-user variability analysis and RIRAM validations. Kutcher will apply the RIRAM to the 50 H-P sites for all other analyses.

1.9 Documents and Records (EPA QA/R-5 A9)

The format for all data reporting packages will be consistent with the requirements and procedures used for data validation and data assessment described in this QAPP.

1.9.1 QA Project Plan Distribution

This QAPP will be distributed to all appropriate staff within DEM Office of Water Resources, EPA Region 1, and the RI Natural History Survey. It will also be posted on the DEM web page: http://www.dem.ri.gov.

1.9.2 Field Documentation and Records

Field data will be hand recorded by filling out field forms (App. C) with indelible ink, and changes to such data records will be made by drawing a single line through the error with an initial by the responsible person. Field data will be housed at the RINHS CIK office until analysis and reporting are complete (see timeline above). The field data records will then be transferred to DEM to be held as detailed below.

1.9.3 Laboratory Documentation and Records

Field data will be entered into electronic spreadsheet format data at the RINHS where they will be housed on no less than two separate hard drives until analysis and reporting are complete (see timeline), upon which time they will be transferred to DEM along with any secondary and derived data. The project will implement proper document control procedures consistent with DEM's Quality Management Plan. The Project Quality Assurance Officer will have ultimate responsibility for any and all changes to records and documents after submittal to DEM.

The DEM Quality Assurance Manager and the Project Quality Assurance Officer shall retain the approved QAPP and all updated versions and be responsible for distribution of the approved version of the QAPP. The Project Contract Manager shall retain copies of all contract and grant management documents, and the Project Quality Assurance Officer shall retain all reports, memoranda, and technical correspondence between the DEM and all project personnel identified in section 1.4.

Records and documents that will be produced or adapted by the RINHS in conjunction with this project include:

- RIRAM field assessment forms (V1, Field 2008)
- Spreadsheet data files for RIRAM data storage and analysis
- GIS shapefiles of wetland assessment units and buffers, and property boundaries as available via RIGIS
- This QAPP
- Draft project report and appendices
- Final project report and appendices
- RIRAM guidance memorandum
- Invasive wetland plant species of RI guidance as time allows.

Storage of project information.

Files, paper and electronic records, and other media such as photographs will be maintained in the DEM Office of Water Resources for a minimum of three (3) years after the completion of Year-3 work and delivery of RINHS products to DEM (July 30, 2009). After 2012, some records may be moved to the DEM Records Archives for storage. As it is anticipated that wetland rapid assessment will continue after Year-3 work is completed, the time frames stated are the minimum and probably will be exceeded as the information will be needed for the ongoing program.

Backup of electronic files.

Electronic files will be maintained on the DEM network server, as well as periodically backed up locally by the Project Quality Assurance Officer on CD's or zip disks. Also, as a normal procedure, files on the network server are backed up by the DEM MIS staff at the server location.

1.9.4 Quarterly and/or Final Reports

The draft and revised Final Reports to be completed by the RINHS will include

- a summary and back ground of the project
- a detailed outline of methods employed
- data analyses and demonstrations as listed in section 1.6 number 3 and detailed below
- site maps depicting assessment boundaries and buffers
- tables and figures as necessary to illustrate the work, analyses, and results
- interpretations of results
- recommendations for next steps.

The DEM will provide written comments on the draft report and the Final Report to be completed by the RINHS will incorporate responses to or revisions based on the DEM comments.

2.0 DATA GENERATION AND ACQUISITION

2.1 Sampling Design (Experimental Design) (EPA QA/R-5 B1)

RINHS will conduct two distinct sampling efforts by applying the RIRAM using field datasheets designed for data collection, analysis, and development (App. C). The first effort will target a set of 36 isolated wetlands distributed across the State's mainland. RAM assessments will be conducted at each site for RAM validation via regression analyses against physical and biological measurement data being collected by Paton and Curtis according to the QAPP entitled *Assessing the effects of human disturbance on New England isolated wetlands using a 3-tiered rapid assessment protocol* (Paton 2007). This effort will also facilitate inter-user variability analysis, which will entail correlation investigations between user RAM scores. The sites were pre-selected by Paton and Curtis through a stratified random approach as documented by Paton (2007), to represent a wide range of human impacts.

The second sampling effort will follow the Year-2 sampling approach as outlined by RINHS and DEM (2008), utilizing 50 wetland sites in the target basins as part of a rotating basin approach. Here, sample sites were selected by a modified stratified-random process along a gradient of land use intensity to represent the full range of wetland conditions in the basins. This approach was chosen to demonstrate the RAM's utility in characterizing the condition of wetlands across a complete gradient of human disturbance. The gradient also facilitates the use of regression analysis in the development, validation, and calibration of the individual and combined RAM metrics. Sites were selected as follows:

- Utilizing GIS and RIGIS (2008) data, the RIGIS local and state-conserved *lands* shapefiles were clipped to the boundary of the target basins.
- The resulting shapefile represented conserved lands within the target basins. These properties were filtered to those containing wetlands using the *intercept* command with the RIGIS *wetlands* dataset.
- The resulting shapefile of conserved lands containing wetlands were buffered by 100m and the resulting buffer polygons were used to clip the RIGIS *2003-2004 LU/LC* shapefile to produce a land cover representation for each property and its surrounding 100 meters.
- Area for each land use within each polygon was generated and the attribute table was exported to Excel format for analysis.
- Property polygons were sorted by the % developed land (by area) represented in each from low to high.
- A random starting point between 0 and *n*/50 was selected along sorted list to represent the first assessment site, and 49 subsequent sites were selected at an interval of *n*/50 along the list to identify 50 sites.
- One wetland assessment unit from each site was selected according to rules documented by Mack (2001; App. B). If the property contained more than one unit, the center-most wetland unit completely contained within the property was selected, or the wetland unit *most* contained within the property. If >50% of the wetland unit fell outside the boundary or the wetland could not be accessed, the next closest conserved wetland meeting the criteria was substituted.

See Figures 2-1 and 2-2. Site Maps with Sampling Locations

2.2 Sampling Methods (EPA QA/R-5 B2)

Field assessments will be conducted by completely filling out one RIRAM F08 field form (App. C) for each wetland assessment unit according to methods outlined by Mack (2001; App. B) and modified by RINHS and DEM (2008). Developmental metrics 8 and 9 from the field form will be assessed in the field according to instructions written on the form and addressed in training sessions (Sec. 1.8);

guidance regarding all of the metrics and sampling methods will be developed as the RIRAM approaches the final version.

2.3 Sample Handling and Custody (EPA QA/R-5 B3)

Not applicable; no samples will be collected during this study.

2.4 Analytical Methods (EPA QA/R-5 B4)

Analyses will be restricted to field observation / estimation and statistical analysis described in Sec. 2.4.3; no physical samples will be collected.

2.4.1 Field Measurements Methods

No direct field measurements or analysis will be made during this study. Application of the RIRAM V1 Field 2008 will be conducted by a trained professional who, based on observation, training, and prior knowledge, will apply considerable interpretation and estimation of wetland processes and interactions to determine classes for the metrics comprising the RAM, which are each scored on an ordinal scale. Metric data will be recorded in this manner by hand onto RIRAM field forms (App. 3). Wetland assessment units will be accessed primarily on foot, but by canoe when more convenient or necessary. The Wetland Scientist and field assistant will walk the wetland assessment unit perimeter when possible and walk as many transects into the interior as necessary to complete the field forms with full confidence. 8” X 11” field maps containing high-resolution color digital aerial photographic images, assessment unit delineations, and 50-m and 100-m buffer delineations, will be used in the field to help the scientist in determining various RAM metrics and for positioning. Expected time spent per wetland assessment unit is one to six hours depending on the size of the unit.

2.4.2 Field Analyses Methods

Refer to 2.4.1.

2.4.3 Laboratory Analyses Methods (Off-Site)

The specific progression of analysis will be determined after the fieldwork in conjunction with DEM and with input from technical workgroup members. As a guideline, statistical analysis may be applied in this study as follows:

- Regression analysis may be applied to assess the utility of and calibrate developmental metrics 8 and 9 (App. C) of the RIRAM against stressor metrics, indices of surrounding land use intensity (from RIRAM metric 5 and derived from RIGIS 2008 data using GIS), and faunal and floral data collected by Paton (2007).
- Regression analysis may be utilized in the inter-validation between RIRAM and various developmental metrics (faunal and floral indicators) collected by Paton (2007) at 36 isolated wetland assessment units.
- Pearson’s correlation analysis and *paired t-test* analysis may be used to determine inter-user variability among two assessors separately conducting the RAM on 36 isolated wetlands.

- Regression analysis may be used in demonstrating the response of wetland condition (utilizing various RIRAM indices) to various indices of buffer degradation at various buffer widths (from RIRAM and derived from RIGIS 2008 data using GIS).
- Regression analysis may be applied in determining correlations between wetland invasion intensity (RIRAM Metric 10a in App. C) and measures of surrounding land use intensity, including RIRAM Metric 5 in App. C and metrics derived from RIGIS (2008).
- Regression analysis may be applied in a demonstration analysis identifying stressors (Metrics 6 and 7 in App, C) most strongly associated with the degradation of wetland condition (RIRAM Total in App. C).

2.5 Quality Control Requirements (EPA QA/R-5 B5)

Not applicable. Samples will not be collected.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance (EPA QA/R-5 B6)

Not applicable. No field measuring equipment will be used.

2.7 Instrument/Equipment Calibration and Frequency (EPA QA/R-5 B7)

Not applicable. No field measuring equipment will be used.

2.8 Inspection/Acceptance Requirements for Supplies and Consumables (EPA QA/R-5 B8)

Not applicable. No critical consumables will be utilized.

2.9 Data Acquisition Requirements (Non-Direct Measurements) (EPA QA/R-5 B9)

Geospatial data from RIGIS (2008) will be used in certain landscape-level (Tier 1) and validation analyses, and for site selection, as detailed in the above sections of this document. RIGIS data represent the best landscape data currently available for RI, meet FGDC mapping standards, and are widely utilized by State, Federal, and local scientists conducting geospatial analysis in the State of RI.

The ORAM (Mack, 2001) has been used as the primary basis for the development of RIRAM. ORAM has been critically analyzed (e.g. Mack and Micacchion 2007, Fennessy et al. 2004) and validated against floral and faunal measured data (e.g. Andreas et al. 2004, Stepanian et al. 2004). ORAM was determined by NEIWPCC and DEM (2006) to be one of two best available Tier-2 methods for piloting in RI.

2.10 Data Management (EPA QA/R-5 B10)

Field data will be collected and stored in a metal file cabinet in the locked office if the RINHS. RAM data will be transposed to electronic format in the form of an Excel spreadsheet file. The Excel file will be coded by date and revisions and corrections to the file will be coded by the revision or correction date followed by the suffix *revision* or *correction*. Separate versions of the dataset will be duplicated, coded specifically for analysis, and kept in a separate folder. Analysis versions will also be coded by date with each use. Baseline and analysis data files will be stored in the RINHS laboratory at CIK, URI on no less than two separate drives. GIS data will be stored in file folders as shapefiles, which will be housed on two separate hard drives within the RINHS.

Field and electronic RAM data will be quality checked for errors by the RINHS Wetlands Scientist and by a qualified research assistant following data collection and following data upload into Excel. Any corrections will be handled as noted above. The Wetlands Scientist will be responsible for data management until the data are transferred to DEM at the end of the analysis and reporting period (see timeline), at which time the DEM Project Quality Assurance Officer will be responsible for the data.

3.0 ASSESSMENT AND OVERSIGHT

3.1 Assessments/Oversight and Response Actions (EPA QA/R-5 C1)

Technical project oversight will be provided through regular correspondence between the DEM Project Quality Assurance Officer and RINHS no less than once per month. Correspondence will be in the forms of email and telephone correspondence, review meetings, memorandum, and the exchange of key data and documents according to the schedule herein. Assessment/oversight will involve review of all aspects of the project and its progress. This will also include review of the project development and data analysis prior to reporting. The technical workgroup including academic experts, DEM wetland scientists, EPA scientists, and other expert stakeholders will be consulted. According to the schedule herein, DEM and RINHS will respond to input as necessary to ensure the efficient use of project resources in developing the most effective rapid wetland-conditional assessment tool possible to meet State reporting requirements and the Plan objectives. .

3.2 Reports to Management (EPA QA/R-5 C2)

Brief memoranda and final reports will be submitted by the RINHS Wetland Scientist to the DEM Project Quality Assurance Officer at the following project milestones: (1) the completion of field work and prior to the initiation of data analysis, (2) the completion of data analysis; (3) the draft Final Report, (4) the Final Report. Memoranda may be appended to or incorporated into the final reports.

4.0 DATA REVIEW AND USABILITY

4.1 Data Review, Verification, and Validation Requirements (EPA QA/R-5 D1)

The validity and utility of the data collected by rapid assessment methods is dependent upon (1) the qualifications of the field assessors, (2) the validity of the RAM content, and (3) the analysis and interpretation of the data. The validity of RAM data is highly subject to interpretation; this is because (1) rapid assessment is based on observation and often the interpretation and estimation of processes and interactions; and (2) because the state of ecological condition is a *quality* that can not be fully characterized by the measurement of any one indicator and thus cannot be absolutely quantified (characterization of wetland ecological condition is the objective of the RIRAM). The assessors are qualified and have been formally trained in RAM application (Sec. 1.8).

In the validation exercises planned for this project, regression and other correlation analyses outlined in section 2.4.3 will reveal the power the RAM and specific RAM metrics to predict directly measurable data that may indicate wetland condition, such as amphibian, macroinvertebrate, or plant presence or richness (L3), and landscape stressors (L1). The values of the correlation coefficients from these analyses will inform interpretations of utility and soundness of the methods. While validation of RIRAM utility lies partly in results of validation analysis, review (Sec. 3.1) of the metrics, analysis methods, outcomes, and interpretations will be the ultimate verification of the developmental RAM and the data it generates.

4.2 Verification and Validation Methods (EPA QA/R-5 D2)

Data will be validated through its application to the validation analyses listed in Sec. 2.4.3. Further validation will be gained through the review process outlined in Sections 3.1 and 4.1 as follows:

1. Internal data QA/QC by RINHS and DEM
2. Internal and workgroup review of draft Final Report (including RAM protocol adjustments)
3. Internal review of Final Report

Protocols for data analysis, RAM development, and implementation methodologies may be adjusted for future applications based on comments from the technical workgroup and the project participants. The DEM holds ultimate authority in the adjustment of the protocols according to review feedback. Adjustments to the RIRAM based on validation analysis outcomes and based on internal and workgroup feedback will be documented in the Final Report.

4.3 Reconciliation with User Requirements (EPA QA/R-5 D3)

The objectives of Year-3 include further refining RIRAM metrics and protocols to enhance utility and user objectivity, demonstrating RIRAM validity and utility in support of the State wetland monitoring program, and the demonstrating the ability of RIRAM in directly addressing State freshwater monitoring and assessment objectives.

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FIGURES

Figure 2-1. Site Map of 36 isolated wetlands with Sampling Locations

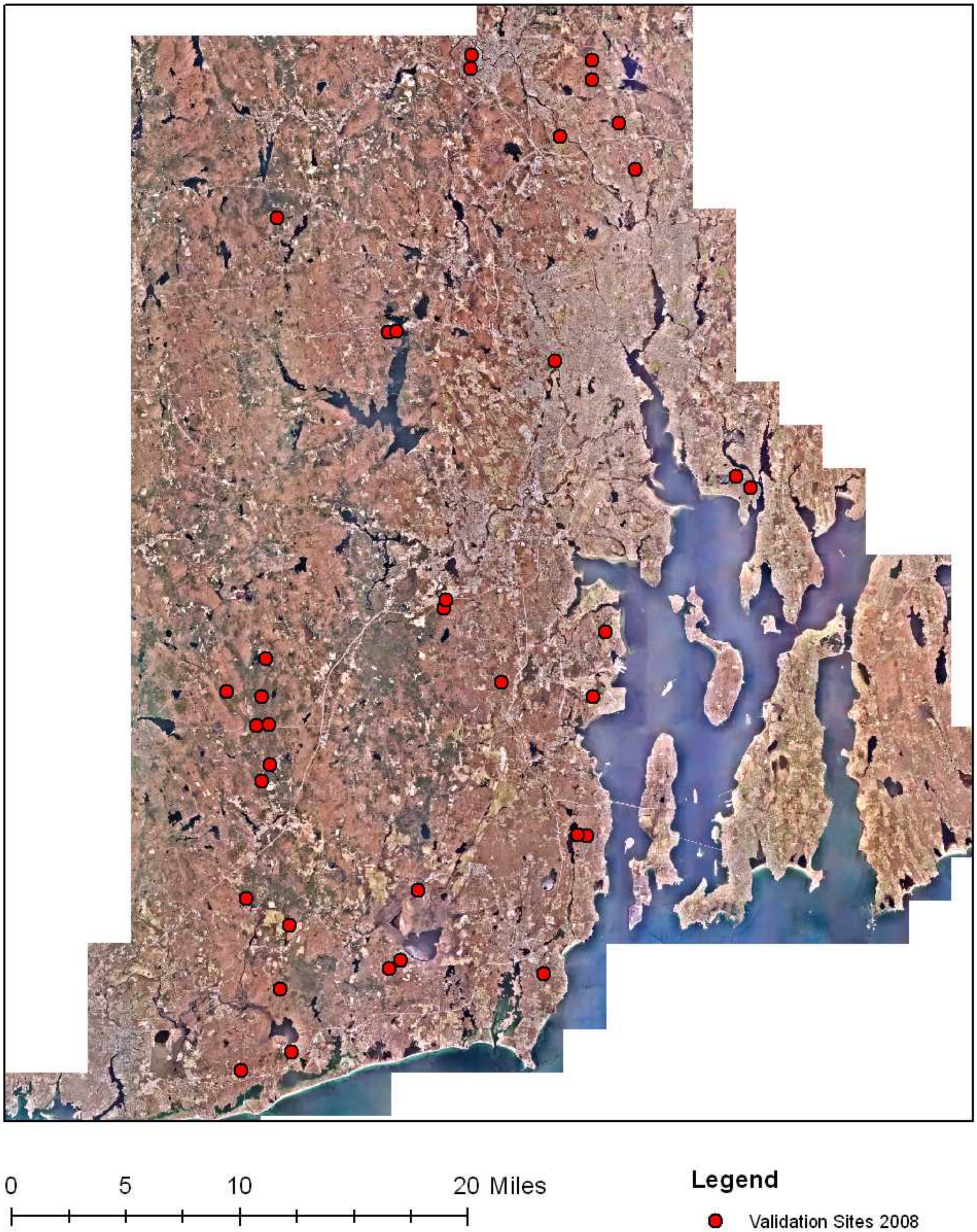

Figure 2-2. Site Map with H-P Basin Sampling Locations

APPENDICES

APPENDIX A

RI Wetland Plan (Plan NEWWPCC and DEM 2006)

Rhode Island Freshwater Wetland Monitoring and Assessment Plan

Prepared by

NEW ENGLAND INTERSTATE WATER POLLUTION CONTROL COMMISSION
www.neiwpcc.org

and

RHODE ISLAND DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
Office of Water Resources
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Executive Summary

At present, although many states are tracking losses and gains in wetland acreage, there is little or no information on the condition of the nation's wetlands. Under the Clean Water Act, states are required to monitor and report on the condition of all waters of the United states, which includes wetlands. To fulfill this requirement and to enhance its already comprehensive wetland program, the Rhode Island Department of Environmental Management (RIDEM), with grant support from the Environmental Protection Agency (EPA) and working with partners in the state, has developed a plan for systematic monitoring of freshwater wetlands in Rhode Island.

The goal of wetland monitoring and assessment in Rhode Island is to improve protection and management of wetlands by understanding the cumulative impacts of human activities on the condition or health of wetlands. A three-tiered approach to monitoring, advocated by EPA, will be used to address the following long and short-term objectives, identified by DEM and partners:

Long-term objectives

- Develop a database of information necessary to evaluate trends in wetland condition.
- Identify causes and sources of wetland degradation including cumulative impacts to wetlands.
- Identify program and policy changes needed to improve overall wetland condition statewide.
- Evaluate the effectiveness of wetland management and protection programs with respect to wetland condition.

Short-term objectives

- Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms.
- Develop and implement methods for monitoring impacts to wetlands due to water withdrawals.
- Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones).
- Monitor location and extent to which invasive species are present and affecting wetland condition.

To develop objectives, DEM staff and partners were asked what they thought the data needs were for wetland monitoring in Rhode Island and what information about wetland ecological condition might help them do their jobs better and help us all improve wetland protection and management. Through discussions with partners, objectives were identified and prioritized with an emphasis on how information generated from monitoring efforts could be applied to important wetland management issues.

The three-tiered approach

The three-tiered approach to wetland monitoring includes a landscape assessment (Level 1), which offers a preliminary view of wetland condition using GIS; a rapid field assessment (Level 2), which involves relatively simple methods to gather field data in a half-day's time; and a more intensive site assessment approach (Level 3), in which one or more biological assemblages, as well as physical and chemical parameters, are studied to better describe the existing condition of the wetland. Higher levels of effort require more resources to implement, but produce more detailed information about wetland condition on the ground. All levels of effort are intended to work together and work can begin at different levels simultaneously.

Table 9 (pg. 26-27) summarizes the short-term objectives of this plan, the rationale for choosing those objectives, and an overview of how Levels 1, 2, and 3 can be used to address the objectives.

Utilize existing methods and information

Several states have been developing and testing wetland monitoring and assessment methods at all levels of effort. By using and adapting existing methods, Rhode Island can maximize limited resources and make progress toward goals more quickly. Additionally, Rhode Island is fortunate to have many experienced wetland professionals in the state. In developing this plan, existing information about freshwater wetlands in the state was gathered and will be used wherever feasible.

Updates to RIGIS wetlands data essential

Accurate landscape assessment methods demand the most current data in GIS. In addition to being out of date, there are significant positional errors in the RIGIS wetlands data set. Prior to developing a comprehensive landscape assessment tool for Rhode Island, it is essential to update the required GIS data layers. DEM is participating in discussions about this need with other partners in the state and has committed funds to support RIGIS updates. Until those updates are complete, existing RIGIS data will be used, in part, to address plan objectives.

Implementation

Wetland monitoring and assessment activities will be phased in over the next five years (Table 10, pg. 29). Rhode Island will focus early efforts on testing and adaptation of existing Level 1 and 2 methods and incorporate Level 3 efforts where required and feasible.

In year 1, existing RIGIS data will be used to develop a landscape profile of wetlands statewide and to characterize wetlands near water withdrawal sites. Concurrently, DEM will review and test existing rapid assessment methods in the field beginning at wetlands that may be influenced by well withdrawals.

In years 2 and 3, rapid field methods will be adapted if necessary, based on lessons learned as they are first tested, and will continue to be used to address short-term objectives. Depending on the status of RIGIS updates, a landscape level assessment tool will be developed and used to prioritize wetlands for open space protection.

In years 3–5, rapid assessment methods will continue to be applied and refined on a rotating basin schedule in cooperation with surface water monitoring. Intensive site level assessment needs, including application of existing data in Rhode Island, will be considered and implemented where feasible.

QAPP's will be developed for each level of effort. In addition, ongoing discussions will take place to better understand and make decisions about reference conditions, core indicators, data management, and revisions and additions to methods and objectives as the program matures over time.

Products of wetland monitoring and assessment efforts

This plan, and results from wetland monitoring and assessment efforts, can benefit RIDEM, as well as non-profit organizations, local communities, watershed groups, and organizations involved in freshwater wetland protection and management in the state. Products of this work will include a database of information about wetland condition, maps and profiles of wetlands by watershed, and detailed information pertaining to each plan objective with initial focus on water withdrawal, buffer zone condition, invasive species, and priority wetlands for acquisition. With this information, RIDEM will recommend management actions to improve wetland condition statewide. Data will also be included in water quality and status and trend reports published biannually by the state.

Plan review and updates

This plan will be reviewed periodically by DEM, wetland partners, and the Rhode Island Environmental Monitoring Collaborative (RIEMC).

Acknowledgments

Throughout this project, I have had the privilege of working closely with Carol Murphy who co-authored this plan. Her comprehensive knowledge of wetland science and policy, her commitment to wetland protection, and her interest in collaborating with others has helped make this a better plan. I'd like to extend a special thanks to Carol, and to the many individuals in Rhode Island who bring tremendous scientific expertise and passion to environmental protection in this state. Deborah K. Pelton, NEIWPCC

Development of this freshwater wetland monitoring and assessment plan was made possible with funding from the Environmental Protection Agency, through 104(b)(3) wetland program development grants, and the Rhode Island Department of Environmental Management's Office of Water Resources. The New England Interstate Water Pollution Control Commission (NEIWPCC) administered the grant and provided technical support for this initiative.

Rhode Island is fortunate to have an abundance of talented wetland professionals in state government, at its universities, and in the private and non-profit sectors. With the goal of developing a comprehensive plan with input from cooperating agencies and individuals, we invited several 'wetland partners' within and outside of DEM to provide input to the plan. We are grateful to the many knowledgeable, motivated individuals, all of whom are tremendously busy people, who volunteered their time to contribute to this effort. People from the following agencies and organizations contributed to this plan in a variety of ways:

Within RI DEM: Sue Kiernan, Deputy Chief of OWR, for holding the vision of how wetland monitoring and assessment can enhance water quality protection in RI, for securing EPA funding, for shaping the monitoring objectives, and moving the effort forward in a meaningful way. Also within RI DEM, Connie Carey, Joe Casey, Russ Chateauneuf, Howard Cook, Hank Ellis, Rick Enser, Alicia Good, Chuck Horbert, Paul Jordan, Jane Kelly, Dan Kowal, Kathleen McPherson, Mickie Musselman, Jay Osenkowski, Nick Pisani, Lisa Primiano, Chris Raithell, Cathy Sparks, Jennifer Stout, Claire Swift, Brian Tefft, Steve Tyrrell, Marty Wencek, and former DEM staff Mike Dahlquist, Fred Presley, and Jessica Smith.

Outside RI DEM**:** Dr. Frank Golet for giving freely of his time, for sharing his vast knowledge of wetland science, and for thoughtful comments on the plan. Also outside RI DEM Eugenia Marks (Audubon Society of Rhode Island), David Reis (Coastal Resources Management Council), Sherry Brant-Williams, Suzanne Lussier, Rick McKinney, and Cathy Wigand (EPA Atlantic Ecology Division), Peter Lockwood (Mason & Associates, Inc.), Helen Cottrell, deceased, (formerly of Narragansett Bay Estuary Program), Andy Lipski (Natural Resource Conservation Service), Dori Boardman (RI Association of Wetland Scientists), David Gregg and former staff Ginger Brown (RI Natural History Survey), Wenley Ferguson (Save the Bay), Julie Lundgren (formerly of The Nature Conservancy of RI), Drs. Peter August, Art Gold, and Peter Paton (URI College of Environment and Life Sciences), Greg Mannesto (US Fish and Wildlife Service), and Denise Poyer (Wood Pawcatuck Watershed Association).

In addition to the wetland partners in Rhode Island who contributed substantially to the plan, we are appreciative of the wetland monitoring and assessment expertise of colleagues at EPA Region 1 and EPA Corvallis, WA: Peter Holmes, Mary Kentula, Matt Schweisberg, Rich Sumner, and Jeanne Voorhees. Finally, Rhode Island has also benefited greatly from the ideas and suggestions from state colleagues that were shared freely and with encouragement: Randy Apfelbeck (MT DEQ), Tom Bernthal (WI DNR), Bruce Carlisle (MA CZM), David Davis (VA DEQ), Jeanne DiFranco (ME DEP), Kelly Heffner (PA DEP), Amy Jacobs (DE DNR), Marjorie Kaplan (NJ DEP), John Mack (OH EPA), Ralph Tiner (USFWS MA), and Denice Wardrop (CWRC, PA).

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A) MONITORING PROGRAM STRATEGY

The goal of wetland monitoring and assessment in Rhode Island is to improve protection and management of wetlands by understanding the cumulative impacts of human activities on the condition or health of wetlands. This understanding, grounded in scientific evidence, can help guide future management and protection actions by the state, municipalities, local organizations, non-profit groups, and citizens. Wetland monitoring and assessment is an essential element of the comprehensive water monitoring strategy for the state, developed by the DEM Office of Water Resources. This plan outlines a multi-level approach to wetland monitoring, as well as long and short-term objectives identified by a group of wetland partners in the state. This plan is intended to be revised and updated periodically to reflect lessons learned and evolving needs of the state. An initial 5-year implementation plan is proposed. Review of this wetland monitoring plan will be conducted by wetland partners, identified in the early stages of the planning process, as well as the Rhode Island Environmental Monitoring Collaborative.

INTRODUCTION & BACKGROUND

The importance of freshwater wetlands

Wetlands are among the most productive and valuable ecosystems in the world (Mitsch & Gosselink 2000). In addition to supporting richly diverse communities of organisms, wetlands provide ecological functions with significant value to society. It is essential to preserve and protect functions such as the provision of fish and wildlife habitat, natural water quality improvement, flood storage, protection from shoreline erosion, natural resource products in the marketplace, and opportunities for recreation, education, and aesthetic appreciation (USEPA 1995).

Freshwater wetlands in Rhode Island

Freshwater wetlands cover approximately 16% of Rhode Island's surface area (Miller & Golet 2001). Palustrine wetlands, which include marshes, wet meadows, swamps, bogs, fens, and shallow ponds are the most abundant type (83%) in Rhode Island. Forested wetlands (swamps), account for approximately 78% of palustrine wetlands in the state (Table 1). The majority of Rhode Island swamps are dominated by broad-leaved deciduous trees; red maple is the most abundant species at most of these sites. Needle-leaved evergreens (coniferous) swamps, dominated by species such as white pine, Eastern hemlock, or Atlantic white cedar are less common. Bogs and fens (2%) are the least abundant wetlands. Marshes and ponds each account for approximately 5% of palustrine wetlands.

Table 1. Area of palustrine freshwater wetlands in RI by wetland type (Miller & Golet 2001). This table does not include non-persistent wetlands in open water habitats.

Type	Description	Palustrine (Acres)	% of total Palustrine
POW	Palustrine Open Water	4,460	5%
EMA	Emergent Wetland: Marsh/Wet Meadow	4,340	5%
EMB	Emergent Wetland: Emergent Fen or Bog	229	<1%
SSA	Scrub-Shrub Wetland: Shrub Swamp	9,602	10%
SSB	Scrub-Shrub Wetland: Shrub Fen or Bog	2,060	2%
FOA	Forested Wetland: Coniferous	10,900	12%
FOB	Forested Wetland: Deciduous	60,684	66%
FOD	Forested Wetland: Dead	225	<1%
	TOTAL	92,500	

Sensitive wetland types were identified in the Woonasquatucket Restoration planning process (Golet, et al. 2002), and freshwater wetland habitats of greatest concern for conservation have been identified in Rhode Island's Comprehensive Wildlife Conservation Strategy by RIDEM Division of Fish and Wildlife with other partners (2005)(Table 2).

Table 2. Sensitive wetland types.

Sensitive Wetlands (Golet, et al. 2002; Table 11)	Habitats of Conservation Concern (DEM Division of Fish and Wildlife 2005)
• Marsh or wet meadow • Stream • Pond • River • Cedar swamp • Shrub bog or fen • Emergent bog or fen	• Atlantic White Cedar Swamps • Bogs and fens (including sea level fens) • Freshwater marshes • Freshwater tidal marshes • Vernal ponds • Floodplain forests

Freshwater wetland protection in RI

Approximately 16% of freshwater wetlands in Rhode Island are protected (i.e., under conservation ownership) either by the state (60%), a municipality (25%), or a non-governmental organization (15%) such as a private land trust, the Audubon Society of Rhode Island, and The Nature Conservancy; the other 84% of wetlands in the state are privately owned (Miller & Golet 2001).

Wetlands in Rhode Island are under the jurisdiction of Federal and state governments through the authority of several statutes (DEM OWR 1999). Federal authority is primarily encumbered within the National Environmental Policy Act (NEPA) and the Clean Water Act (CWA) (Federal Water Pollution Control Act (33 U.S.C. 1251 et seq.). In 1971, Rhode Island was one of the first states in the nation to pass legislation to protect freshwater wetlands. According to the Rhode Island Freshwater Wetlands Act (RIGL 2-1-18 et seq.), administered by DEM, it is the policy of the state "to preserve the purity and integrity of the state's freshwater wetlands in order to protect the health, welfare, and general well-being of the public." More recently, freshwater wetlands in the vicinity of the coast are regulated by the Coastal Resources Management Council (CRMC) by the Coastal Resources Management Act (RIGL 46-23-6). In general, land use is regulated in or near the main body of a wetland such that approval is required for any activity that may alter the character of any freshwater wetland. Applicants are required to avoid and minimize impacts to wetlands and no random, unnecessary, or undesirable alteration to wetlands is permitted (DEM OWR 1999).

Consistent with wetland losses nationwide, historic freshwater wetland losses in Rhode Island have occurred, although no study has been conducted to accurately estimate loss of original wetlands in the state. While conversion of wetlands for agriculture was once the greatest cause of wetland loss nationwide, today residential development accounts for the greatest percentage, both nationally and in Rhode Island (Mitsch & Gosselink 2000; DEM OWR 1999, 2004). Nationwide, in addition to losses in acreage, degradation of wetlands has resulted in increases in flood damage, drought damage, degradation of water quality, and habitat fragmentation and depletion (USEPA 1995, Sheldon, et al. 2005).

Permitted loss of actual freshwater wetland in Rhode Island is approximately 2 to 3 acres per year. Alterations to the area within 50 feet of the edge of bogs, marshes, swamps, or ponds, referred to as perimeter wetland, and riverbank wetland are permitted more routinely and currently, no data exists on the extent of these permitted alterations or the overall impact on wetland condition and function.

The DEM Office of Compliance and Inspection investigates unauthorized alterations in wetlands or the adjacent upland. On average 25% of investigations during 2001-2003 led to formal actions by OCI requiring administrative fines and restoration of wetlands. Restoration of wetlands takes time and does not necessarily replace the original habitat or functions of the wetland. Invasive species are also frequently a problem in sites that have been restored (Cavallaro & Golet 2002).

In addition to the regulatory authorities, wetland protection is enhanced through nonregulatory protection, restoration, research and education efforts conducted by a variety of agencies, organizations and teams including by DEM programs, by non-governmental conservation organizations, the Rhode Island Habitat Restoration team, universities, colleges, the Rhode Island professional wetland association (RIAWS), and by community centered groups organizations (DEM OWR 1999, 2004; Murphy & Ely 2002).

Despite existing regulatory and non-regulatory programs, degradation of wetland condition is of concern in Rhode Island. Systematic monitoring of wetlands will provide essential information about wetland condition statewide, allowing for the improvement of existing, and development of new, wetland management and protection efforts.

Why monitor wetlands?

Under the CWA, states are required to monitor and report on the condition of all waters of the United States, including wetlands. Specifically, Section 101(a) directs states to “restore and maintain the chemical, physical, and biological integrity of the Nation’s waters” and the interim goal (Section 101(b)(2)) directs states “to provide for protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. A great deal of effort to date has focused on the development and use of methods to assess lake, river, and stream condition, resulting in greater awareness of issues causing impaired water quality. Such information has led to the creation of new programs and changes to existing management strategies to improve and protect water quality.

At present, there is little information on the condition of the nation’s wetlands. A policy of “no net loss” and of “net gain” of wetlands, first established in the 1988 has become a cornerstone of wetlands protection (National Wetlands Policy Forum 1988). To satisfy water quality (305(b)) reporting requirements under the CWA, states, including Rhode Island, have largely been reporting on trends in wetland acreage. Monitoring losses and gains in wetland acreage is a valuable component of management and protection programs, however, to best protect wetland functions and values, it is essential to also know the condition of existing wetlands.

Systematic monitoring and assessment of wetlands serves many purposes: to document the location and extent of wetlands, analyze their condition, and document trends (USEPA 2002a). Knowledge gained from wetland monitoring and assessment allows managers to more effectively protect wetland and aquatic resources, prioritize restoration projects, better manage impacts on a watershed scale, and determine whether proposed projects will create water quality problems or wetland degradation.

In Rhode Island, the goal of wetland monitoring is to provide information to help better protect and manage freshwater wetlands and their upland adjacent area (protective buffer zone). In addition to being a requirement of the CWA, wetland monitoring is an EPA wetland program development priority, and an element of the Rhode Island comprehensive wetland program.

Knowledge about wetland condition can also benefit other programs including the surface water monitoring program, non-point source program, stormwater, safe drinking water, permitting programs, and non-regulatory programs.

Wetland condition

For decades scientists have recognized valuable wetland functions and have developed methods to assess how well wetlands perform those functions. While this information continues to be useful for wetland protection and management strategies, it is critical to go beyond assessment of individual wetland functions to fully comprehend the ecological condition of a wetland. Fennessey, et al. (2004) explain this well:

> *"From an ecological standpoint, wetlands perform a wide variety of functions at a hierarchy of scales ranging from the specific (e.g., nitrogen retention) to the more encompassing (e.g., biogeochemical cycling) as a result of their physical, chemical and biological attributes. At the highest level of this hierarchy is the maintenance of ecological integrity, the function that encompasses all ecosystem structure and processes. The link between function and condition lies in the assumption that ecological integrity is an integrating "super" function of wetlands. If condition is excellent, then the ecological integrity of the wetland is intact and the functions typical of that wetland type will also occur at reference levels."*

A functional assessment method can identify which functions a wetland is capable of performing and how well the wetland is actually performing those functions. However, certain functional assessments may not adequately describe overall condition of the wetland (Fennessey, et al. 2004). For example, a wetland that is rated high for flood storage capacity using a functional assessment method could have a dominance of non-native plant species (bioinvasives), and therefore be less able to provide wildlife habitat expected of that type of wetland (compared to an undisturbed reference site). An assessment method that addresses function and condition, i.e., a conditional assessment, acknowledges the value of the wetland for flood storage and also indicates a level of ecological degradation for that wetland. The comprehensive nature of such a conditional assessment provides decision-makers with more information on which to base their decisions.

B) MONITORING OBJECTIVES

Identifying plan objectives

This Rhode Island plan for wetland monitoring and assessment was developed with an emphasis on how information might be utilized and applied at the state and local levels to improve protection and management of freshwater wetlands. To identify objectives for the plan, meetings were held with wetland partners within and outside of the DEM. We asked partners the following questions:

1. What do you think are the data needs for freshwater wetland monitoring in Rhode Island?
2. What information about wetland ecological condition might help you do your job better and help us all improve wetland protection and management?

Our goal was to create a comprehensive list of issues, needs, and applications to use as a guide, and to update periodically, as the program develops. We organized the initial list into categories that reflected potential threats to wetland condition, data needs, and management applications of wetland monitoring and assessment data (Table 3).

Table 3. Potential threats to wetland condition, data needs, and management applications of wetland monitoring and assessment data.

Potential threats to wetland condition
Human-caused disturbance – direct and indirect - to wetlands: • Loss and degradation of protective adjacent upland (buffers) • Water withdrawal - from community wells, agriculture, golf courses • Increased development – road density, residential 'sprawl', landuse changes • Invasive species • Loss of groundwater recharge • Upland forest removal, fragmentation • Storm water runoff to wetlands • Road salt/sand application on roads near wetlands • Sedimentation • Recreation projects • Loss/degradation of wetland types, and therefore, biodiversity – e.g. forested wetlands, wet meadows, vernal pools •
Data & database needs
• Current and regular future updates to RIGIS landcover and wetland coverages • Inventory of wetland abundance, type, and condition • Database for storage of wetland conditional information • Continued scientific research to better understand wetland function and condition and response of biological communities to human-caused disturbance • Data on extent of permitted alterations to adjacent upland ('perimeter wetland'), riverbank wetlands, floodplains • Estimates of historic freshwater wetland loss in the state •
Management applications for wetland monitoring and assessment
• Identify causes and degree of degradation of wetland condition • Analyze short and long-term trends in wetland condition for decision-making • Identify reference wetlands along gradient of disturbance • Prioritize wetlands for open space protection/acquisition • Identify policy and program changes required to improve wetland condition • Monitor compliance & success for mitigation, creation, and restoration at proactive and enforcement sites • Eventual development and support of water quality standards for wetlands • Use data to help with "predictability" of permit applications • Monitor the application and effectiveness of BMP's • Relate wetland condition to size and condition of upland adjacent area (buffer) • Determine requirements for effective monitoring of wetlands near water withdrawal sites • Monitor biodiversity of species in wetlands • Develop education and outreach materials & programs for wetland monitoring & assessment •

To develop specific objectives for the plan, wetland partners suggested priority needs. Long-term objectives are understood to take longer than 10 years to meet. Short-term objectives are intended to be met in a 1-5 year timeframe.

Rhode Island wetland monitoring and assessment plan objectives

Long-term objectives

The long-term objectives of wetland monitoring and assessment in Rhode Island are to:

- Develop a database of information necessary to evaluate trends in wetland condition.
- Identify causes and sources of wetland degradation including cumulative impacts to wetlands.
- Identify program and policy changes needed to improve overall wetland condition statewide.
- Evaluate the effectiveness of wetland management and protection programs with respect to wetland condition.

Systematic monitoring and assessment of wetland condition will, over time, produce necessary data to help evaluate management decisions for wetland protection. In the longer term, it is essential to understand cumulative impacts to wetlands, which result from land-use changes, water withdrawals, loss of protective buffers, invasive species, sedimentation, fragmentation, and a number of other factors.

Short-term objectives

The initial objectives of the Rhode Island wetland monitoring and assessment plan are to:

- Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms.
- Develop and implement methods for monitoring impacts to wetlands due to water withdrawals.
- Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones).
- Monitor location and extent to which invasive species are present and affecting wetland condition.

Rationale for focusing on short-term objectives

Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms.

An effective way to protect wetlands is through acquisition of wetlands and their surrounding upland habitat. Although there is no targeted wetlands acquisition program at the state level, state and local open space programs prioritize and acquire lands that may contain wetlands. In addition, the Division of Planning and Development at DEM has received federal funds under the North American Wetland Conservation Act (NAWCA) to acquire easements or titles to wetlands for the protection of waterfowl habitat. Information about wetland condition can indicate which wetlands might be best prioritized for protection and this information can be considered with other factors to prioritize lands for acquisition. Wetlands that are already protected can be monitored periodically to ensure that their integrity is maintained.

Develop and implement methods for monitoring impacts to wetlands due to water withdrawals.

"*Hydrology is probably the single most important determinant for the establishment and maintenance of specific types of wetlands and wetland processes*," (Mitsch & Gosselink 2000). Changes to wetland hydrology, then, can result in impacts to species composition and richness, and wetland functions such as water quality improvement, primary productivity, and nutrient cycling, which can ultimately impact surface water quality downstream. Recreational opportunities can also be impacted by changes in wetland hydrology (e.g., less water, impaired water quality).

Competition for finite supplies of freshwater in Rhode Island has intensified with increases in population, residential development and associated commercial development (http://envstudies.brown.edu/projects/watershed/Partnerships/WUSG_Action_Strategy.htm). It is clear that extraction of too much groundwater or at too fast a rate can significantly impact surface water quality and supply. To date, specific impacts to wetlands due to water withdrawals have not been well-examined. With the growing population and demand for water, it is imperative wetlands are monitored for hydrologic changes due to water withdrawals and that associated impacts are assessed.

Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones).

Existing rules and regulations aim to protect various wetland types, as well as a 50' perimeter around certain wetlands as a buffer. Regulation of the 50' perimeter applies to all bogs, but only to marshes, swamps and ponds of a certain minimum size criteria. There is little permitted loss of wetland each year, yet historic encroachment as well as current unpermitted alterations and losses to wetlands and upland adjacent areas may threaten wetland integrity resulting in loss of habitat, degraded water quality, increased presence and abundance of invasive species, and diminished capacity for wetlands to function at their highest levels. There is a growing pool of science that documents the importance of maintaining upland buffer zones around wetlands, not only to provide wildlife habitat, but also to protect water quality. In Rhode Island, we currently do not know the condition of upland areas around our wetlands, nor the actual impacts of insufficient buffers on wetland condition. There is a need to assess the effectiveness of existing buffer protection strategies in the state as they relate to wetland condition.

Monitor location and extent to which invasive species are present and affecting wetland condition.

Non-native invasive species threaten the ecological character and function of Rhode Island ecosystems and can result in reduced social and economic value of those ecosystems, as well as potential human health threats (Gould & Endrulat 2005). In addition to habitat loss, wetland biodiversity and function are degraded in wetlands that contain invasive species such as purple loosestrife and Phragmites (Flack & Benton 1998). Some of Rhode Island's disturbed wetlands already contain these, and other, invasive species. RIDEM considers the effective management strategy of early detection and prevention (Flack & Benton 1998) a necessity for dealing with invasive species and is prioritizing this effort in the wetland monitoring and assessment plan.

Additional objectives for wetland monitoring and assessment will be added as the program is developed and implemented.

C) CORE INDICATORS OF WETLAND CONDITION

In Rhode Island, in 2001, a workshop was conducted by key science, management, and planning professionals through the Partnership for Narragansett Bay to determine ecological indicators for Narragansett Bay and its watersheds. The resulting report, prepared by Kleinschmidt Associates (2003), identifies indicators and metrics for landscape composition, habitat condition, water and sediment condition, and fish and wildlife populations and biodiversity in the state. Freshwater wetlands, specifically the number of acres by type and function, and the length of wetland shoreline, were recognized as important indicators of habitat quantity and quality for the Bay and its watersheds. As in the Kleinschmidt report, this plan recognizes the role of freshwater wetlands as indicators of habitat quantity and quality, but further recognizes the essential role wetlands play in landscape composition (overall watershed health) and surface water quality.

Beyond assessing quantity of wetlands, this plan is concerned with indicators of wetland condition. Monitoring and assessment methods are still in the early phases of development compared to surface water quality assessment; therefore, identification of core and supplemental indicators of wetland condition is ongoing. Based on existing research in other states and best professional judgment of likely indicators of wetland condition, Rhode Island will begin to examine the following as broad indicators of wetland condition (Table 4). These indicators will be refined during implementation of wetland monitoring and assessment at multiple levels of effort over time.

Table 4. Working list of indicators of wetland condition (to be revised and expanded as more is learned during implementation of wetland monitoring and assessment in RI). Indicators are categorized into tiers based on a multi-level approach to monitoring advocated by EPA.

Level of Effort	Potential Indicators of Wetland Condition
Landscape Assessment (Level 1)	• wetland continuity/fragmentation • adjacent upland buffer width and composition • % natural cover and composition in watershed Supplemental parameters to measure: • % impervious surface in watershed • density of roads & distance from wetland • density of residential development
Rapid Field Assessment (Level 2)	• # and type of physical, chemical, biological stressors to the wetland – in wetland and in surrounding buffer • % cover of invasive species in wetland and in buffer
Intensive Assessment (Level 3) Assemblages to consider: algae, macroinvertebrates, vegetation, amphibians, birds, fish	• species composition, diversity, richness • abundance of selected species • invasive species presence and abundance • rare species presence and abundance

D) MONITORING DESIGN

GENERAL APPROACH TO MEETING OBJECTIVES

Multi-level approach to monitoring and assessment of wetland condition

A comprehensive wetland monitoring and assessment program is implemented through three levels of effort. Work can begin at any level, or at different levels simultaneously. Each level builds upon the others (USEPA 2002a).

Level 1 – Landscape Assessment – Offers a preliminary view of wetland condition on a large scale using GIS to display and analyze wetland and land use coverages. Wetland condition is predicted from a set of landscape-based indicators.

Level 2 – Rapid Field Assessment – Requires a half-day to one day in the field. Methods are relatively simple and involve a checklist to evaluate condition and identify stressors to a wetland. Used to validate results of Level 1 assessments.

Level 3 – Intensive Site Assessment – Intensive efforts in the field, in which one or more biological assemblages - vegetation, invertebrates, amphibians, birds, algae - are collected and analyzed to generate indices of biological integrity – a numerical and descriptive value that indicates ecological health as a function of human disturbance. Physical and chemical parameters are also measured and correlated with results of the biological assessment. These assessments are labor and cost intensive, but provide more accurate, higher resolution information than the landscape or rapid assessment methods. Used to validate Level 2 and Level 1 assessments.

Rhode Island will focus early efforts on testing and adaptation of existing Level 1 and 2 methods, and incorporate Level 3 efforts where required and feasible.

Example tools from other states

Several states have been developing and testing methods for wetland monitoring and assessment at all three levels of effort. Using examples from other states, Rhode Island can more efficiently apply limited resources to methods that others have already tested. We have reviewed several existing methods and approaches to wetland monitoring and assessment, and present a brief summary, by level of effort, in Appendices A (Level 1), C (Level 2), and D (Level 3). The methods highlighted in Appendix A were selected from many possibilities, as they seem well-suited for testing in Rhode Island. A more thorough review of these methods, as well as field-testing and adaptation of methods to meet Rhode Island's needs will occur in the early states of implementation.

Pertinent tools and research from Rhode Island

Rhode Island is fortunate to have many experienced wetland professionals in state government, non-profit organizations, the private sector, and at several universities in the state. In developing this plan, we attempted to gather existing information about freshwater wetlands in Rhode Island to determine what information might be applicable for wetland monitoring and assessment. In the plan, we highlight existing landscape level (GIS) tools (Level 1; Appendix B) that might be adapted for use, and we briefly summarize field research projects (Level 3; Appendix E). that may offer methods or results that can be applied to wetland monitoring and assessment needs. Wherever feasible, we will apply existing information in Rhode Island to help meet our objectives.

Watershed approach

The watershed approach looks at the interaction between habitats and the collective functioning and health of those habitats, recognizing the interconnectedness of water, upland, and wetlands (USEPA 2002a). Following a watershed-planning model, organizations working together can more efficiently and effectively solve problems and utilize limited resources. Rhode Island is using a watershed approach as a key strategy for integrating more proactive wetland protection and restoration initiatives (DEM OWR 1999). Implementation of wetland monitoring and assessment efforts will be organized on a watershed basis (rotating basin approach), in cooperation with surface water monitoring and other environmental protection initiatives.

Site selection considerations

In addition to utilizing the rotating basin approach, there are several opportunities to sample wetlands in cooperation with other programs:

- SWG - Wetland habitats of greatest concern are identified in the Rhode Island's Comprehensive Wildlife Conservation Strategy developed for the state Wildlife Grant (SWG) program (DEM Division of Fish and Wildlife 2005). Monitoring of those habitats is required in their plan; therefore, we would like to collaborate on monitoring efforts and locations.
- Compliance sites - Monitoring at enforcement sites is another need identified by wetland partners at DEM. With limited staff resources, the Office of Compliance and Inspection is not able to continue monitoring restoration sites after a minimum required period of time (1 to 3 years). We plan to monitor wetland condition for longer periods of time at selected compliance sites where possible.
- Impaired waters/TMDL - Because wetlands provide a valuable water quality improvement function, we are interested in monitoring wetland condition in watersheds that contain impaired waters (from the 303(d) report), and therefore require a TMDL. Monitoring and assessment of wetlands near impaired surface waters will require coordination with the Surface Water and TMDL programs at DEM.
- Vernal pools – A great deal of research on vernal pools (seasonal ponds) in Rhode Island has been conducted by scientists at URI, NRCS, TNC, EPA AED, and DEM. These organizations discuss opportunities to collaborate on research efforts and identify protection and management strategies for seasonal ponds. We anticipate some level of monitoring and assessment of vernal pools during implementation of this plan.

Participation in national and regional wetland monitoring workgroups

In 1996, a workgroup of wetland professionals from national and state government, tribes, and universities, under the direction of the EPA was formed to focus on the topic of wetland monitoring and assessment. The mission of the National Wetland Monitoring and Assessment Work Group is "to help states and tribes build their capacity to implement and sustain wetland monitoring and assessment programs that support wetlands restoration and protection, through policy and guidance development, and technical and programmatic study." The goal of the workgroup is "to ensure that wetland monitoring and assessment is integrated in the state monitoring strategy along with rivers, streams, and lakes in a watershed approach." (http://www.epa.gov/owow/wetlands/bawwg/). Regional monitoring work groups have also been formed, including the New England Biological Assessment of Wetlands Workgroup. These groups meet regularly to discuss issues and share methods pertaining to wetland assessment. Rhode Island has participated in both the national and regional work groups since 1997 and has gained a great deal of support and information that will help to efficiently implement its own wetland monitoring and assessment program.

Formation of RI workgroups

The first step in project implementation will be the formation of workgroups comprised of professionals in Rhode Island versed in each plan objective as it is being implemented. Workgroups may consist of members from state and local government, non-profit organizations, universities, and other pertinent organizations.

A discussion of the 3-tiered approach to wetland monitoring follows.

LEVEL 1 - LANDSCAPE LEVEL ASSESSMENT OF WETLAND CONDITION

Rationale for using a Level 1 landscape tool

The condition of a wetland is largely determined by the land use surrounding the wetland. In order to better protect and manage wetlands throughout the state, it is essential to know the location and ecological condition of existing wetlands, and what the potential threats are from surrounding land use. At the landscape level, wetland distribution and abundance, and surrounding land uses are displayed and analyzed in a GIS. Such a tool enables managers to view wetlands by watershed statewide and infer condition of those wetlands based on certain indicators in the landscape such as the density of roads, residential, or commercial development. Landscape analysis, though coarse in scale, is an efficient, cost-effective way to preliminarily assess wetland condition. Information gained from this level of effort, such as a wetland inventory, trends analysis of wetland loss, causes of loss, and cumulative impacts or future threats to wetlands from surrounding land uses can be used to guide wetland management decisions. Priority sites for field verification, protection, and restoration can be selected based on landscape analysis, directing limited resources to the most immediate needs.

Current limitations of RIGIS and the need to update the RIGIS wetlands dataset

To ensure accuracy and reliability of a landscape level tool to assess wetland condition, it is essential to update the RIGIS wetlands dataset. In their report, "Options for Mapping Rhode Island's Wetlands," Miller, et al. (2001) provide a thorough review of the limitations of the RIGIS wetlands data and offer suggestions for improving wetland mapping in the state. Although RIGIS wetland maps are more detailed that maps in many other states, there are significant positional errors created when wetland delineations were digitized from 1988 aerial photographs and entered into RIGIS. Users of RIGIS maps have also noted errors in wetland classification (Miller, et al. 2001). Furthermore, the land use/land cover dataset is 10 years old. Prior to developing a landscape assessment tool for wetlands assessment in Rhode Island, it is essential to update the required GIS data layers.

Needs for updated RIGIS datasets are being discussed with other partners in the state. An implementation schedule and technical details of how the data layers will be acquired will depend, in part, on additional sources of funding. The cost of the effort is directly related to the type and scale of the source imagery. A subgroup of mapping professionals in RI, convened by the RIEMC, support color infrared large-scale imagery. Until RIGIS updates are complete, we plan to delay development of a full-scale landscape assessment tool. In the short-term, to help address the proposed objectives at the landscape level, we will use available RIGIS data.

Most states rely on NWI wetland maps for their Tier 1 work. Updates to NWI maps, created from newer imagery and techniques, have been completed for coastal Rhode Island through a partnership between the Narragansett Bay Estuary Program (NBEP) and the USFWS. Partnering with USFWS to update NWI maps for the rest of the state is another option worth considering at this time.

Wetland classification

One challenging aspect of conducting a wetland assessment, is determining which changes are attributable to natural variation versus those caused by anthropogenic factors. The goal of classification, or grouping different kinds of wetlands into unique classes for comparison, is to reduce variability within classes caused by differences in natural factors such as geology, hydrology, topography, and climate (USEPA 2002c).

Several wetland classification schemes have been developed over the last thirty years with virtually all using some aspect of hydrology as a defining characteristic (Mitsch & Gosselink 2000). Geology, climate, and vegetation are also recognized in classification methods.

Cowardin classification (Cowardin et al. 1979), historically used primarily for wetland inventory purposes, relies heavily on vegetation life forms, as well as geomorphology, chemistry, and hydrology to describe different wetland classes (Mitsch & Gosselink 2000). In the current RIGIS database, wetlands are classified using a modified version of the Cowardin system.

The hydrogeomorphic classification system (HGM; Brinson 1993). was designed to be used to evaluate the physical, chemical, and biological functions of wetlands (Mitsch & Gosselink 2000). The method is based on geomorphic setting, dominant water source, and dominant hydrodynamics, with the understanding that a certain suite of ecological functions is attributable to a certain HGM class because of its landscape position, primary water source, and water regime (EPA 2002, Voorhees 2004). The method was designed to be independent of plant communities, since it depends on the geomorphic and hydrologic properties of the wetlands; however, vegetation often indicates the HGM forces at work (Mitsch & Gosselink 2000).

In the early phases of monitoring and assessment in the state, the current modified Cowardin classification system will be used, however, we also recommend that Rhode Island explore the possibility of further enhancing the wetland classification with hydrogeomorphic (HGM)-type modifiers as developed by Tiner (2003). This enhanced classification identifies a wetland's landscape position, landform, waterflow path, and waterbody type (R. Tiner, pers. comm. 2005).

With this additional classification, an enhanced 'landscape profile' of wetlands, which describes the spatial distribution and relative abundance of different classes of wetlands in a geographic area, can be completed for the state. Utilizing this wetland profile, landscape level assessments of wetland function and ecological health can be made and evaluated over time (Tiner 2003). Future changes to wetland types and amounts, and ecological condition can be compared to an initial baseline of information, which will aid the state in determining whether program activities are meeting goals and standards of protection programs (J. Voorhees, pers. comm. 2004).

Examples of existing landscape level assessment tools from other states

Utilizing example tools already developed in other states, Rhode Island could make rapid progress in developing an appropriate landscape level analysis method to assess wetland condition. Examples of some existing tools are described in Appendix A. A more in-depth review of these examples is expected during implementation of the Rhode Island Wetland Monitoring and Assessment Plan to determine which tools are most appropriate for testing in the state. Full development of a landscape level assessment tool will require updates of wetland data in RIGIS and will not be pursued fully until those updates are complete. Utilizing existing RIGIS data in the meantime, landscape level methods will be utilized to begin addressing RI's short-term objectives.

Existing landscape assessment tools in RI

Rhode Island is fortunate to have extensive wetland knowledge to draw upon for the development of a wetland monitoring and assessment plan. It is a goal of this plan to build upon existing research in the state where possible. At the landscape level, we recommend consideration of several existing tools already developed in Rhode Island: A summary of each of those tools, developed by researchers at URI, TNC, EPA's Atlantic Ecology Lab, and through URI's Cooperative Extension Service, can be found in Appendix B.

How Level 1 landscape methods can help RI address the short-term objectives

A landscape level assessment tool can be used to address several questions about wetland location and condition statewide. Application of a landscape tool to RI's short-term objectives is briefly described below. To help meet these objectives, development of landscape profiles of wetlands by watershed is a valuable first step. Wetland profiles are required to provide a baseline foundation for use in site selection and future trends analysis and will be an important vehicle for sharing data with municipalities, land trusts, conservation commissions, and non-profit groups to enhance protection, management, and education at the local level.

Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms.

A landscape level assessment tool can be used to indicate which wetlands should be prioritized for acquisition. Certain criteria and aspects of a wetland such as size, position in the landscape, and extent of natural land cover surrounding the wetland can be evaluated in GIS. Other factors, such as wetland location relative to already protected open space, presence of endangered species, and identification of ecologically sensitive areas are additional factors that may be considered when prioritizing wetlands for acquisition. Results of the GIS analyses can help state and local managers and planners prioritize open space acquisition projects by providing information on the location and extent of wetlands worthy of immediate and permanent protection in Rhode Island.

Develop and implement methods for monitoring impacts to wetlands due to water withdrawals.

As an initial step toward assessing impacts to wetlands due to water withdrawals, a landscape tool is an efficient way to display proximity of existing community wells and agricultural lands to wetlands. This information is already available in RIGIS. Additional information such as soil type, surficial geology, and wetland class can be analyzed to determine which wetlands are most sensitive to water withdrawals. This type of characterization will help direct limited resources to the most sensitive areas.

Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones).

Understanding the condition of adjacent upland (buffers) around water bodies is an essential aspect of protecting water quality and habitat. Buffer condition is being discussed and analyzed in Rhode Island using GIS (RI Rivers Council 2005; Mulé, et al. 2005), though systematic monitoring of abundance and condition of buffer zones around wetlands is not yet occurring. Using GIS, land use in buffer zones of various widths around wetlands can be displayed, described, and quantified. Wetland condition can then be inferred from the results, and correlations to particular land use patterns can be examined. As with all results of a landscape analysis tool, field work is essential in validating the tool to predict wetland condition as a function of buffer zone condition.

Monitor location and extent to which invasive species are present and affecting wetland condition.

A landscape level analysis tool may not be particularly useful for monitoring and assessment of invasive species in Rhode Island. Such a tool would not only require up-to-date aerial photographs, but invasive species specific to wetlands in Rhode Island would need to be detectable remotely. Unlike the unique spectral signal of reed canary grass in the wetlands of Wisconsin, many wetland invasive species in Rhode Island may not be able to be detected remotely. Detection depends on scale and the type of film used to produce aerial photos. It would be possible in GIS to keep track of locations in the state where invasive wetland plants exist (presence/absence), and to monitor that information over time. This information on the presence of invasives might eventually be correlated with indicators of wetland condition such as land use or a particular type of stressor to a wetland. It is valuable to begin building a baseline of information now to examine causes of wetland degradation and keep track of problems as they develop.

General steps toward development and utilization of landscape assessment methods are outlined in Table 5.

Table 5. General steps for developing and applying a Level 1 landscape assessment methods to RI wetland monitoring and assessment objectives.

General steps for developing and applying a Level 1 landscape assessment methods in RI
• Update RIGIS wetland and land use coverages – partner with other GIS users. Consider regional or RI partnership to update the rest of RI NWI quads with HGM enhanced classification (Tiner). • Form workgroup dedicated to development and application of Level 1 methods to RI wetland monitoring and assessment objectives. • Create a landscape profile of wetlands by watershed statewide (use existing RIGIS data initially). • Review how Level 1 will be used to address short-term objectives for RI: Open Space – After RIGIS data layers are updated, identify and prioritize wetlands for protection. Criteria for prioritization to be determined by workgroup based on factors such as vulnerability, position in the landscape, habitat value, rarity, and other indicators. Water Withdrawal – Plot water withdrawal sites and characterize potential threats to adjacent wetlands. Buffer Zones – After RIGIS data layers are updated, describe size and composition of buffer zones around wetlands. Identify sites for field assessment. Invasive Species – The ability to remotely detect invasive species depends on the scale at which any new imagery is captured. GIS can be used to store and plot the location of invasive species identified in the field. • Review tools from other states and in RI and decide which tools are most appropriate for use in RI to meet objectives. • ID data products, data storage requirements, reporting needs. • Evaluate Level 1 results based on results of Level 2 (RAM).efforts. • Review how landscape tool can be applied to meet additional monitoring and assessment objectives as they are identified

Level 1 summary

Landscape level assessments will generate valuable information for improved understanding, protection, planning, and management of wetlands in Rhode Island. Details and decisions about the development and testing of landscape assessment methods will be made by a workgroup formed during the initial phase of wetland monitoring and assessment. In the first year of work, wetland profiles will be developed using GIS, and wetlands in proximity to water withdrawal sites will be identified and characterized. After RIGIS updates are complete, landscape assessments will be used to address additional objectives, including prioritization of wetlands for protection and buffer zone assessments.

LEVEL 2 - RAPID FIELD ASSESSMENT OF WETLAND CONDITION

Rationale for using a Level 2 rapid assessment tool

Rapid assessments are field-based monitoring tools that provide a wealth of information about wetland function and condition in a relatively short period of time. Over the last several years, many states have developed rapid assessment methods for a variety of purposes including regulatory requirements, the evaluation of best management practices, assessment of ambient wetland condition on a watershed basis, and determination of mitigation project success. These methods have been shown to be sensitive tools to assess anthropogenic impacts to wetland ecosystems, and are important components of monitoring programs (Fennessey, et al. 2004). Data collected in the field using rapid assessment methods are used to validate results of landscape level analyses.

Rapid assessment methods are based on indicators of wetland condition that are derived from an understanding of the processes that create, maintain and degrade wetlands in the landscape (Fennessey, et al. 2004). The universal features of wetlands - hydrology, hydric soils, and the resulting biotic communities, particularly hydrophytic vegetation - are the foundation of any assessment method. One of the assumptions underlying assessments of condition is that wetlands respond predictably to stressors. Indicators of wetland condition can be based on the response of the wetland to stressors (e.g., the percent cover of invasive species), or on the stressors themselves (e.g., hydrologic modification), or both (Fennessey, et al. 2004).

In their report, “Review of rapid methods for assessing wetland condition,” Fennessy, et al. (2004) evaluated several existing methods. The criteria they used to evaluate the methods included the following:

a. The method can be used to measure wetland condition;
b. The method should be rapid;
c. The method should involve an on-site assessment; and
d. Results of the method can be verified.

Several methods reviewed in Fennessey, et al. (2004), were noted for meeting the above criteria. Given that these methods have proven effective in other states, and that resources are limited in Rhode Island, it is recommended that RIDEM test a few existing methods in the early phases of their state wetland monitoring program. Using and adapting existing research, Rhode Island can immediately begin gathering valuable information about wetland condition.

Examples of existing rapid field assessment methods from other states

During the past several years many states have been developing wetland assessment tools or modifying existing methods as they develop statewide wetland monitoring and assessment programs. Of the many examples of rapid assessment methods that Rhode Island could test in the early phases of a monitoring program, tools from Massachusetts/Rhode Island, Ohio, and Pennsylvania stand out as some of the best examples.

Each of the methods, summarized briefly in Appendix C, is designed to describe wetland condition as it occurs along a gradient of human disturbance. Although the methods vary in approach, they demonstrate the underlying concept that wetlands respond predictably to anthropogenic stresses.

Rhode Island rapid assessment methods

Although no RI-specific rapid assessment method for freshwater wetland condition exists at present, rapid assessment methods have recently been developed in RI to predict wetland function at potential restoration sites (Miller & Golet 2001), and to assess wetland function at restored sites (Cavallaro & Golet 2002). In addition, EPA's Atlantic Ecology Laboratory, in partnership with MA Coastal Zone Management, is developing a rapid conditional assessment method for coastal salt marshes in Rhode Island. This method, along with others described in Appendix C, will be reviewed for possible adaptation to assess condition of freshwater wetlands in the state.

How a Level 2 rapid assessment tool can help RI address short-term objectives

Rapid assessment methods consider several categories of information that are useful in developing information about wetland condition in Rhode Island. From this more comprehensive database, information pertaining to specific objectives can be extracted and assessed as needed. The following are ideas on how the rapid assessments above can contribute valuable information about each of Rhode Island's short-term objectives in the early phases of wetland monitoring and assessment.

Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms.

Rapid assessment efforts on the ground can be used to gather information about the ecological integrity of a wetland. Many wetlands that are prioritized for acquisition are presumed to be the least disturbed, and as such, could be considered reference wetlands for the state. Other wetlands worthy of protection through acquisition may be those that are vulnerable to rapid urbanization or those already in urban areas that provide habitat and heritage functions, as well as flood abatement and water quality improvements. These wetland characteristics and functions can be evaluated on the ground using rapid assessment methods. For example, in methods developed by MA, OH, and PA, factors such as landuse in and around wetlands, position of the wetland in the landscape, stressors to the wetlands, habitat description, cultural values, and special features such as the presence of critical habitat for endangered species are among those useful for determining which wetlands are most in need of permanent protection.

Results of these methods can be correlated with a landscape level analysis to validate the predictions of the landscape tool and identify which indicators on the ground are most predictive of wetland quality. Because wetlands are complex ecosystems, it is beneficial to monitor and assess as many features of the wetland as possible when developing indicators of ecological integrity and build a baseline of information on wetland condition along a gradient of human disturbance.

Develop and implement methods for monitoring impacts to wetlands due to water withdrawals.

Using rapid assessment methods in the field, a substantial amount of information about wetland hydrology and ecological condition can be obtained, which will help build a baseline of information and indicate when stresses to a wetland might be caused by water withdrawal. In the rapid assessment methods we've reviewed, several measures are pertinent to assessing impacts from water withdrawals. For example, factors such as wetland hydroperiod, hydrologic connectivity, changes to hydrologic conditions or stressors such as ditching, draining, filling, and the description of plant communities including the relative presence of natural and invasive species, are assessed using rapid assessment methods.

In combination with information about the location of groundwater wells and vulnerable wetland types from a landscape level analysis, rapid assessment methods can provide important baseline information about wetland condition as a function of wetland hydrology and existing vegetation cover. Changes in vegetation, as well as hydrology, can be observed over time and assessed to determine the impact of water withdrawals on wetlands. Additional information from Level 3 efforts will contribute to a more thorough understanding of these impacts.

Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones).

It is well-established that wetlands with vegetated buffer zones between the wetland and human land uses are less disturbed than wetlands without such buffers. Also, where human land use is more intensive, wetlands are subject to greater degrees of disturbance (Mack 2001). To better understand the qualities of buffers around wetlands in Rhode Island, it is helpful to begin by assessing buffer characteristics at the landscape level, then gather more detailed information on the ground. The methods developed by MA/RI, OH, and PA all have components that focus on buffer zone characteristics.

In all three methods, land use around the wetland is described. In the PA method, a buffer score is assigned to each wetland based on the width and vegetation type of the buffer. Points are subtracted if the buffer is penetrated by some type of anthropogenic stressor such as a culvert through the buffer to the wetland edge. The buffer score can be considered on its own and/or the number and type of stressors noted in the Stressor Checklist can be correlated with buffer characteristics. Results from other data collected in the field, such as the percent cover of invasive species, can also be correlated with buffer characteristics.

In ORAM (Mack 2001), they define buffer as, “non-anthropogenic landscape features which have the capability of protecting the biological, physical, and/or chemical integrity of the wetland from effects of human activity.” Buffer width is estimated in the field and more points are given for wider average buffer width. The intensity of the surrounding land use is then described and more points are assigned for the least intensive level of land use. The overall results of ORAM can be correlated with buffer size and land use to determine relationships between the two with the expectation that wetlands are more degraded with small buffer zones and high intensity human land use surrounding them.

The value in testing each of these methods in Rhode Island is that each has useful features that might be valuable in RI for determining the impacts to wetlands due to loss of protective buffers.

Monitor location and extent to which invasive species are present and affecting wetland condition.

Rapid assessment methods can be an effective means of documenting the presence and extent of invasive species in wetlands. They can also provide additional information about surrounding stressors, and the resulting condition of wetlands, to help managers and planners better understand and deal with the problem of invasive species.

In all three methods discussed, as well as many other existing methods, the presence and extent of non-native invasive species is recorded. Utilizing rapid assessment methods in RI to monitor and assess invasive species is an important step toward better protection and restoration of wetlands, in general. It is also important for prevention and early detection of invasive species problems in the state.

Table 6 describes steps involved in the development of a Level 2 rapid field assessment method for RI.

Table 6. General steps for developing and applying a Level 2 rapid field assessment tool to RI wetland monitoring and assessment objectives.

General steps for developing and applying a Level 2 rapid field assessment tool in RI
• Form workgroup dedicated to development and application of Level 2 tool to RI wetland monitoring and assessment objectives • Review how RAM's can help address short-term objectives for RI: Open Space – rapid assessments in the field are useful for describing conditions at sites prioritized for protection through acquisition or other conservation measures. Water Withdrawal – rapid assessments of wetlands near water withdrawal sites can help characterize condition at those sites. Buffer Zones - in the field, rapid assessments can help describe wetland condition along a gradient of disturbance, which may be correlated with buffer zone size and quality. Invasive Species – rapid assessment methods under consideration for use include some assessment of the presence and abundance of invasive species on-site. • Review tools from other states and in RI and decide which tools are most appropriate for use in RI to meet objectives • ID data products, data storage requirements, reporting needs • Correlate results of Level 2 methods with Level 1 landscape assessment • Evaluate RAM results based on results of Level 3 efforts • Review how a rapid assessment tool can be applied to meet additional monitoring and assessment objectives as they are identified

Level 2 summary

The amount of information gathered about wetland condition using rapid assessment methods will provide Rhode Island with a comprehensive database of information that can be assessed over time to address short and long-term objectives. Additionally, the information gathered will be available for local organizations and citizens to better understand and protect their surrounding wetlands. In the first year of implementation, we will for a workgroup to review existing RAM's and begin testing methods in the field at selected locations. During year 2 of implementation, a RAM will be applied on a larger scale, likely in one watershed in RI. Rapid assessment methods will then be applied on a rotating basin schedule to address monitoring and assessment objectives.

LEVEL 3 - INTENSIVE SITE ASSESSMENT OF WETLAND CONDITION

Rationale for using Level 3 intensive site assessments

Objectives of a wetland monitoring and assessment program can largely be met using landscape (Level 1) and rapid assessment methods (Level 2); however, there may be a need for more intensive site assessment work (Level 3) to answer certain questions, refine the baseline of information about wetland condition, validate results from Level 1 and 2 methods, and establish direct relationships between the response of biological communities and the stressors of human activities to wetlands in Rhode Island.

In all aquatic systems, degradation of habitat leads to measurable responses by resident biological communities, which reflect the cumulative impacts of chemical, physical, and biological stressors over time (USEPA 2002b). Combined with physical and chemical data, measurements of particular characteristics of wetland macroinvertebrate, vegetation, amphibian, bird, and algal communities can provide detailed information about wetland condition across a gradient of human disturbance. Ecological parameters such as species or taxa richness, abundance, and diversity, among others, respond predictably to disturbance (USEPA 2002a, 2002b). Certain taxa are more 'tolerant' of pollution than others. Therefore, in a disturbed environment there is a measurable shift in community structure from the more sensitive or 'intolerant' species of a healthy ecosystem to more tolerant species. Similarly, success in restoration efforts can be confirmed by measured changes in communities toward 'reference' conditions along a gradient of disturbance. At this level of effort, the focus is shifted from describing stressors to a wetland to measuring the response of biotic communities to those stressors.

Monitoring and assessment of wetland condition at the intensive site level requires significant input of time, money, and scientific expertise. In return for this level of effort, meaningful, high-resolution information is obtained that can be essential for managers and planners to better protect wetlands. In addition, Level 3 data help validate results of Level 2 and Level 1 methods. Refined, reliable tools at Level 1 and 2 provide managers with a more cost-effective means of monitoring wetland condition; therefore, Level 3 efforts should be considered where feasible.

Approaches to conducting Level 3 assessments

Wetland biologists are challenged with the task of providing information about wetland condition to resource managers who are seeking to protect wetlands through regulatory and non-regulatory decision-making (USEPA 2002a). With a focus on determining impacts to wetlands from human activities, biologists must identify and measure those attributes of wetland biological communities that respond predictably to physical, chemical, or biological disturbance (USEPA 2002a). To do this, scientists can conduct bioassessments, which may include the development of indexes of biological integrity (IBI), or they may conduct research-based studies of particular aspects of a wetland such as a biotic community or wetland hydrology.

<u>Bioassessments or development of an IBI</u>

Bioassessments are based on the premise that the community of plants and animals reflect the underlying health of the environment in which they live (USEPA 2002a, 2002b). Over the past 30 years, in particular, key research on bioassessments has been conducted for surface waters (streams and lakes), and has, in recent years, been applied and adapted to wetlands. A wealth of information on the topic is available. For the purposes of this plan, we refer often to the publications and websites from the EPA, which has gathered, summarized, and made readily available valuable scientific research about the concept, value and methods of bioassessments used to monitor the ecological integrity of aquatic systems (see list of USEPA websites in references). Through EPA's 104(b)(3) wetland program development grants, many states have been able to conduct and disseminate research to establish wetland monitoring and assessment programs for their states and others.

A healthy, undisturbed ecosystem will support a certain composition and character of biological communities to which disturbed ecosystems can be compared. Resulting differences, when normalized for natural variation, can be attributed to human-caused disturbances. Biological integrity is one of the best indicators of ecosystem health because it accounts for physical, chemical, and biological stressors to the system (Karr & Dudley 1981).

To develop an IBI, researchers sample attributes of a taxonomic assemblage in wetlands ranging from good condition to poor condition. Metrics or attributes of the assemblage that show a predictable and empirical response to increasing human disturbance are identified (Karr & Chu 1999). The IBI provides a summary score that is translated into a narrative description of habitat quality or wetland condition that is easily communicated to managers and the public. Because it is impossible to measure every aspect of a biological community, a multimetric index allows for a reliable, cost-effect way to measure biological response to human disturbance at the site-level (USEPA 2002b).

A well-constructed IBI can allow scientists to measure condition of a wetland, diagnose the type of stressor damaging a wetland's biota, define management approaches to protect and restore biological condition, and evaluate performance of protection and restoration activities (USEPA 2002b). The process of IBI development is expensive and labor intensive, but provides the most detailed, reliable information about actual wetland condition along a human disturbance gradient. This relationship between wetland condition and disturbance is depicted graphically, similar to a dose-response curve. With sufficient information, an IBI can be used to determine thresholds or points along the condition vs disturbance curve where management decisions can be made to prevent further degradation of the habitat and/or take action to restore a site.

Building on substantial information about IBI's from stream research, states have been developing and testing biological monitoring methods for wetlands to determine which attributes are most useful to measure. Different assemblages respond differently to stressors. For example, algal communities are more sensitive to nutrient pollution, while vascular plants may be impacted more directly by hydrologic changes (USEPA 2002a). Monitoring more than one assemblage increases the power of the method to describe wetland condition. The following table (Table 7) summarizes the strengths and limitations of monitoring certain communities in a wetland.

Table 7. Strengths and limitations of assemblages for use in wetland bioassessments (adapted from USEPA 2002a).

Assemblage	Strengths	Limitations
Algae	✓ easy to sample ✓ respond quickly to stressors ✓ present in many wetland types ✓ reflects individual wetland condition ✓ sensitive to nutrient enrichment	✓ requires expertise to identify ✓ does not integrate effects over a broad landscape ✓ not socially recognized as important ✓ less sensitive to habitat alteration
Amphibians	✓ socially recognized as important ✓ easy to identify ✓ integrates effects to wetlands over time ✓ integrates effects over a broad landscape ✓ sensitive to hydroperiod alteration	✓ difficult sampling protocols ✓ not taxonomically rich in many wetlands ✓ not present in all wetland types ✓ not sensitive to nutrient enrichment
Birds	✓ present in many wetland types ✓ socially recognized as important ✓ integrates effects to wetlands over time ✓ integrates effects over a broad landscape	✓ difficult sampling protocols ✓ take longer time to respond to stressors ✓ do not reflect individual wetland condition ✓ less sensitive to chemical stressors
Fish	✓ socially recognized as important ✓ integrates effects to wetlands over time	✓ not present in all wetland types ✓ not taxonomically rich in many wetlands
Macroinvertebrates	✓ present in many wetland types ✓ taxonomically rich ✓ respond quickly to stressors ✓ integrate effects to wetlands over time ✓ reflect individual wetland condition ✓ sensitive to nutrient enrichment ✓ IBI has been developed in other states ✓ prior research in wetland bioassessments	✓ not socially recognized as important ✓ requires expertise to identify ✓ requires a lot of time to process samples in lab
Plants	✓ present in many wetland types ✓ taxonomically rich ✓ integrate effects to wetlands over time ✓ sensitive to nutrient enrichment ✓ sensitive to hydroperiod alteration ✓ sensitive to habitat alteration ✓ IBI has been developed in other states ✓ prior research in wetland bioassessments	✓ take longer time to respond to stressors ✓ moderately recognized as socially important ✓ moderately reflective of individual wetland condition

Attributes and metrics such as species richness and composition, tolerance and intolerance to human disturbance, trophic composition, and populations characteristics of assemblages all present reliable options for describing wetland condition (USEPA 2002b). Though costly in its application, once an IBI has been developed and tested, it can be a powerful tool for determining wetland condition.

<u>Research-based studies</u>

To help answer specific questions about wetland condition, it can be valuable to monitor and assess particular aspects of a wetland through a Level 3 research-based study design. This can include studies of a specific assemblage, such as amphibians, plants, birds, or invertebrates, that are not used in the development of an IBI per se, but which provide required information about life history and resource requirements. Another example of Level 3 research would be regular monitoring of groundwater levels and hydrologic inputs and outputs, as well as the resident biotic communities to build a baseline of information required to understand the impacts of groundwater withdrawal on wetlands. To better understand causes and impacts to ecological condition of a wetland, it is valuable to monitor physical and chemical parameters of wetlands, as well as the biological communities.

Several studies on wetland communities and hydrology have already been conducted in RI (see Pertinent research in RI). These studies alone may not provide enough information to describe overall wetland ecological condition, but can provide essential supporting information about condition or the response of biota to disturbance.

Decisions about when and how to conduct intensive Level 3 studies should be made by managers and scientists based on needs and available resources. Level 3 efforts are labor and cost intensive and therefore can only be conducted as resources allow.

Examples of existing Level 3 methods from other states

While Rhode Island plans to apply most of their resources to landscape and rapid field methods, the decision about when and how to apply intensive site assessments to RI objectives will be made easier by the work already conducted by other states. Examples of existing methods and metrics are described briefly in Appendix D.

Pertinent research in RI

Rhode Island is fortunate to have a strong wetland research community. Scientists at the University of Rhode Island, the Rhode Island Natural History Survey, the Natural Heritage Program, and The Nature Conservancy, to name some, have conducted studies to better understand wetland ecology, hydrology, and wetland-dependent wildlife. Appendix E describes highlights of research findings that have advanced Rhode Island's base of knowledge about wetlands and their biological communities. How these studies inform and support Level 3 wetland monitoring and assessment efforts will be considered as the state evaluates best methods for meeting long and short-term program objectives.

How Level 3 intensive site assessment tools can help RI address short-term objectives

The substance of biological monitoring lies in the ability to measure the response of biological communities to human caused disturbances in a wetland. These responses can then describe where a community is along a disturbance gradient and inform management decisions. Although Rhode Island plans to rely mainly on Level 1 and Level 2 analyses to meet short-term objectives for wetland monitoring and assessment, Level 3 efforts are recognized as important and will be considered when possible and necessary. How Level 3 efforts can help meet short-term objectives is described below.

Prioritize wetlands (and adjacent upland habitat) for protection through open space acquisition and other land protection mechanisms.

Wetlands that are identified as priorities for permanent protection may represent a range of ecological condition, depending on where they are located. For example, wetlands protected in urban areas may be degraded compared to those in rural areas that will likely be considered pristine. Level 3 assessments of biological communities in these wetlands can be conducted to develop baseline data for wetland health along a gradient of human disturbance. This level of assessment will be useful for recognizing thresholds of degradation, allowing managers to target restoration and protection efforts.

Develop and implement methods for monitoring impacts to wetlands due to water withdrawals.

To answer questions about the impacts of water withdrawals on wetlands, Level 3 studies will be necessary. Information about hydrology, groundwater levels, and vegetation will be particularly valuable for understanding baseline conditions prior to withdrawal, and to understand impacts to wetlands from water withdrawal over time.

Monitor and assess impacts to wetlands due to loss and degradation of adjacent upland habitats (buffer zones).

Impacts to wetlands due to loss of protective buffers may be best understood by comparing the response of biotic assemblages in wetlands with buffers and without. Theoretically, composition and diversity of macroinvertebrates, algae, or vascular plants will reflect changes in buffer quantity and quality. Such information would help managers understand how decisions to alter the landscape are impacting wetland-dependent biological communities and can help them make sound decisions for wetland management and protection.

Monitor location and extent to which invasive species are present and affecting wetland condition.

A great deal can be learned about the impacts of invasive species on wetlands by conducting Level 3 assessments. Certainly attributes such as vegetation species diversity will be impacted by invasives. Birds, amphibians, and macroinvertebrates will also be impacted by the degradation of habitat and changes in nutrient availability and food web dynamics.

Table 8 outlines steps RI plans to take to develop and implement Level 3 efforts.

Table 8. General steps for developing and applying a Level 3 intensive site assessment tool to RI wetland monitoring and assessment objectives.

General steps for developing and applying Level 3 intensive site assessment methods in RI
• Form workgroup dedicated to development and application of Level 3 assessment methods to RI wetland monitoring and assessment objectives • Review how Level 3 efforts can help address short-term objectives for RI: Open Space – biological assessments of wetlands prioritized for open space protection will provide detailed information about wetland condition and response to disturbance along a gradient. Water Withdrawal – intensive site assessments, particularly of hydrology and vegetation, will be required to fully describe condition of wetlands near water withdrawal sites. Buffer Zones – biological communities, as well as physical and chemical characteristics of wetlands, should be examined more intensively to describe the condition of wetlands as a function of the amount, composition, and condition of upland adjacent areas. Invasive Species – intensive field investigations of invasive species can inform managers of the impacts invasive species are having on wetland condition. • Review methods, metrics, and data from other states and in RI and decide how existing studies can contribute to the understanding of wetland condition. • ID data products, data storage requirements, reporting needs. • Review additional monitoring and assessment objectives as they are identified and determine whether intensive site assessments are required to meet objectives.

Level 3 summary

Though site-level wetland conditional analyses are resource intensive, the high-resolution of information can prove extremely valuable to wetland managers. Certain questions about wetland condition may not be adequately answered without Level 3 efforts on the ground. Furthermore, Level 3 efforts can help validate Level 2 and Level 1 analysis tools, which are cost-effective for states to use to systematically monitor and assess the condition of wetlands. Existing tools by other states and extensive wetland knowledge in Rhode Island provide an advantage to the state when the time comes to develop and test Level 3 methods. Certain objectives, such as understanding the impacts of water withdrawal on wetlands, will be best met by incorporating Level 3 methods in the assessment approach.

A summary of the short term objectives, the rationale for choosing those objectives, and how landscape, rapid, and intensive assessment methods can help address those objectives is described in Table 9.

Table 9. Summary of short-term objectives, rationale for choosing them, and how Level 1, 2, and 3 methods can help address the objectives.

Short Term Objectives	Rationale for choosing short-term objectives	Level 1 Landscape Assessment	Level 2 Rapid Assessment	Level 3 Intensive Assessment
Open Space Acqusition	✓ An effective way to permanently protect wetlands. ✓ Wetlands that are already protected can be monitored periodically to ensure that their integrity is maintained.	✓ Criteria and aspects of a wetland such as size, position in the landscape, and extent of natural land cover surrounding the wetland can be evaluated in GIS. ✓ Other factors, such as wetland location relative to already protected open space, presence of endangered species, and identification of ecologically sensitive areas are additional factors that may be considered when prioritizing wetlands for acquisition. ✓ Results of the GIS analyses can help state and local managers and planners by providing information on the location and extent of wetlands worthy of immediate and permanent protection in Rhode Island.	✓ Gather information about the ecological integrity of the wetland. ✓ Wetland characteristics and functions can be evaluated on the ground using rapid assessment methods. ✓ Land use in the buffer of the wetland is described. Plant communities in the wetland are identified and invasive species are monitored in the field. Stressors to the wetland are described, and cultural values assessed. ✓ Results of these methods can be correlated with a landscape level analysis to validate the predictions of the landscape tool and identify which indicators on the ground are most predictive of wetland quality. Because wetlands are complex ecosystems, it is beneficial to monitor and assess as many features of the wetland as possible when developing indicators of ecological integrity and build a baseline of information on wetland condition along a gradient of human disturbance.	✓ Wetlands that are identified as priorities for permanent protection may represent a range of ecological condition, depending on where they are located. ✓ Level 3 assessments of biological communities in these wetlands can be conducted to develop baseline data for wetland health along a gradient of human disturbance. ✓ This level of assessment will be useful for recognizing thresholds of degradation, allowing managers to target restoration and protection efforts.
Water Withdrawal	✓ Changes to wetland hydrology can result in impacts to species composition and richness, and wetland functions such as water quality improvement, primary productivity, and nutrient cycling, which can ultimately impact surface water quality downstream. Recreational opportunities can also be impacted by changes in wetland hydrology (e.g., less water, impaired water quality). ✓ Extraction of too much groundwater or at too fast a rate can significantly impact surface water quality and supply. With the growing population and demand for water, it is imperative wetlands are monitored for hydrologic changes due to water withdrawals and that associated impacts are assessed.	✓ A landscape tool is an efficient way to display proximity of existing community wells to wetlands. This information is already available in RIGIS. Additional information such as soil type, surficial geology, and wetland class can be analyzed to determine which wetlands are most sensitive to water withdrawals. This type of characterization will help direct limited resources to the most sensitive areas.	✓ Using rapid assessment methods in the field, a substantial amount of information about wetland hydrology and ecological condition can be obtained, which will help build a baseline of information and indicate when stresses to a wetland might be caused by water withdrawal. ✓ Natural and invasive plant communities are identified and monitored. Soil parameters, such as soil moisture content can also be measured from samples collected in the field. ✓ The wetland hydrology and the degree to which it has been altered by human disturbance are evaluated. Specifically, questions pertaining to maximum water depth of the wetland and duration of standing water/saturation are of value when establishing a baseline of information about wetland hydrology. ✓ Changes in vegetation, as well as hydrology, can be observed over time and assessed to determine the impact of water withdrawals on wetlands.	✓ Information about surface and groundwater levels, and vegetation will be particularly valuable for understanding baseline conditions prior to withdrawal, and to understand impacts to wetlands from water withdrawal over time.

Short Term Objective	Rationale for choosing short-term objectives	Level 1 Landscape Assessment	Level 2 Rapid Assessment	Level 3 Intensive Assessment
Buffer Zones	✓ Existing rules and regulations aim to protect various wetland types, as well as a 50' perimeter around certain wetlands as a buffer. Regulation of the 50' perimeter applies to all bogs, but only to marshes, swamps and ponds of a certain minimum size criteria. ✓ There is little permitted loss of wetland each year, yet historic encroachment as well as current unpermitted alterations to wetlands and upland adjacent areas may threaten wetland integrity resulting in loss of habitat, degraded water quality, increased presence and abundance of invasive species, and diminished capacity for wetlands to function at their highest levels. ✓ In RI, we currently do not know the condition of upland areas around our wetlands, nor the actual impacts of insufficient buffers on wetland condition. There is a need to assess the effectiveness of existing buffer protection strategies in the state as they relate to wetland condition.	✓ River and stream buffer condition is being discussed and analyzed in Rhode Island using GIS (RI Rivers Council 2005; Mulé, et al. 2005), though systematic monitoring of abundance and condition of buffer zones around wetlands is not yet occurring. Using GIS, land use in buffer zones of various widths around wetlands can be displayed, described, and quantified. Wetland condition can then be inferred from the results, and correlations to particular land use patterns can be examined.	✓ Wetlands with vegetated buffer zones between the wetland and human land uses are often less disturbed than wetlands without such buffers. ✓ Buffer size is estimated. Land use around the wetland is described and categorized by intensity. Stressors in the buffer area around wetlands are identified. ✓ Results from other data collected in the field, such as the percent cover of invasive species, may also be correlated with buffer characteristics.	✓ Impacts to wetlands due to loss of protective buffers are best understood by comparing the response of biotic assemblages in wetlands with buffers and without. Theoretically, composition and diversity of macroinvertebrates, algae, or vascular plants will reflect changes in buffer quantity and quality. Such information would help managers understand how decisions to alter the landscape are impacting wetland-dependent biological communities and can help them make sound decisions for wetland management and protection.
Invasive Species	✓ Non-native invasive species threaten the ecological character and function of Rhode Island ecosystems and can result in reduced social and economic value of those ecosystems, as well as potential human health threats (Gould & Endrulat 2005). In addition to habitat loss, wetland biodiversity and function are degraded in wetlands that contain invasive species such as purple loosestrife and Phragmites (Flack & Benton 1998). Some of RI's disturbed wetlands already contain these, and other, invasive species. RIDEM considers the effective management strategy of early detection and prevention (Flack & Benton 1998) a necessity for dealing with invasive species and is prioritizing this effort in the wetland monitoring and assessment plan.	✓ Using a landscape assessment tool to detect invasive species would require up-to-date aerial photographs and invasive species specific to wetlands in Rhode Island would need to be detectable remotely. Detection depends on scale and the type of film used to produce aerial photos. It would be possible in GIS to keep track of locations in the state where invasive wetland plants exist (presence/absence), and to monitor that information over time. This information on the presence of invasives might eventually be correlated with indicators of wetland condition such as land use or a particular type of stressor to a wetland. It is valuable to begin building a baseline of information now to examine causes of wetland degradation and keep track of problems as they develop.	✓ Rapid assessment methods can be an effective means of documenting the presence and extent of invasive species in wetlands. They can also provide additional information about surrounding stressors, and the resulting condition of wetlands, to help managers and planners better understand and deal with the problem of invasive species.	✓ A great deal can be learned about the impacts of invasive species on wetlands by conducting Level 3 assessments. Certainly attributes such as vegetation species diversity will be impacted by invasives. Birds, amphibians, and macroinvertebrates will also be impacted by the degradation of habitat and changes in nutrient availability and food web dynamics.

PROPOSED TIMELINE FOR IMPLEMENTATION

Wetland monitoring and assessment activities will be phased in over the next five years, as resources allow (Table 10). In the first year, a landscape profile of wetlands statewide will be developed using existing RIGIS data while DEM works with others to plan for essential RIGIS updates to wetland and land use/land cover data layers. Existing RIGIS data will also be used in Year 1 to characterize wetlands near water withdrawal sites. Concurrently, DEM, with input from a workgroup, will review and test existing rapid assessment methods in the field beginning at water withdrawal sites, as yet to be identified.

In years 2 and 3, rapid field methods will be adapted if necessary based on lessons learned as they are first tested, and will continue to be used to address short-term objectives. Depending on the status of RIGIS updates, a landscape level assessment tool may be developed and used to prioritize wetlands for open space protection.

In years 3–5, rapid assessment methods will continue to be applied and refined on a rotating basin schedule in cooperation with surface water monitoring. Intensive site level assessment needs, including application of existing data in RI, will be considered and implemented where feasible.

QAPP's will be developed for each level of effort. In addition, ongoing discussions will take place to better understand and make decisions about reference conditions, core indicators, data management, and revisions to methods and objectives as the program matures over time.

Table 10. Proposed 5-yr timeline for wetland monitoring and assessment activities in Rhode Island.

Wetland Monitoring and Assessment Tasks	Year 1	Year 2	Year 3	Year 4	Year 5
Work with other GIS partners in RI to accomplish updates to wetland data in RIGIS	✗	✗	✗		
Develop/Test/Apply Landscape Assessment Methods & Data (Level 1)	✗			✗	✗
Develop landscape profile for wetlands in RI using existing RIGIS data; examine trends compared to historic records; repeat profile every 5 years for future trends analyses.	●				
Open space (depends on updated RIGIS data)				●	●
Water withdrawal (1st characterize issue using existing RIGIS data)	●				
Buffer zone assessment (depends on updated RIGIS data)				●	●
Invasive species (ability to detect remotely depends on scale of photography acquired; can record location of invasive species in GIS)					
Develop/Test Rapid Assessment Method (Level 2)	✗	✗	✗	✗	✗
Open Space (use RAM to describe conditions of various wetlands prioritized for protection)				●	●
Water withdrawal (use RAM at selected sites to describe condition of wetlands near/vulnerable to water withdrawal)	●	●	●	●	●
Buffer zone assessment (use RAM to describe wetland and buffer condition; recommend restoration sites/needs)		●	●	●	●
Invasive species (part of RAM, create long-term data record)		●	●	●	●
Apply Site Level Assessment where needed (Level 3)		✗	✗	✗	✗
Review & Summarize existing Level 3 RI research		●	●		
Apply existing Level 3 RI research			●	●	●
Program Development					
Quality Assessment Project Plans – develop for each level of effort and revise as needed	✗	✗		✗	
Develop information management structure – decide how to best manage data, ID partners, products	✗	✗		✗	
Continuous review of data storage and management needs		✗	✗	✗	✗
Develop reference criteria and identify reference sites (ongoing)		✗	✗	✗	✗
Baseline monitoring of wetland condition statewide – begin compiling results and determine best methods for continued assessment statewide				✗	✗
Review and revise core indicators of wetland condition			✗	✗	✗
Evaluate program – are short-term objectives being met, are long-term objectives being addressed, what method revisions are required, what new objectives should be added, report on lessons learned (approx. every 3 yrs)			✗		
Recommend strategies to reduce impacts identified through monitoring and to enhance wetland management statewide			✗	✗	✗
Wetland monitoring information & program reporting (Integrated Water Monitoring and Assessment Report (305(b)/303(d)), RI Wetland Status and Trends Report, RIEMC, etc.)	✗	✗	✗	✗	✗
Develop education and outreach materials to enhance public education about monitoring and assessment of wetland condition – consider volunteer monitoring program				✗	✗

E) QUALITY ASSURANCE

To ensure scientific validity of sampling, data analyses, and reporting activities, Quality Assurance Project Plans (QAPPs) for wetland monitoring and assessment will be developed, in compliance with EPA requirements, by DEM with input from a workgroup during implementation of each phase of the plan.

F) DATA MANAGEMENT

Individual data management and analysis systems are in place for different programs within the DEM Office of Water Resources, including the surface water monitoring and wetland permitting programs, among others. Historically, these management systems were developed according to specific program needs and have not yet been well integrated across programs. Data are shared among programs for reporting and management planning when needed; however, a long-term goal of the Department is a data management system that meets the needs of state water programs while supporting integrated data analysis and facilitating access to data and assessment information (DEM OWR 2005).

Surface water quality data are managed in a system of Access databases that work with RIGIS to summarize chemical and biological water quality data by watershed. In addition, the EPA assessment database (ADB) is used to calculate the percentages of state waters that support their designated uses and explain how impairments were identified.

The wetlands permitting and compliance programs utilize a Visual Foxpro management system to track wetland losses and gains through permitting and restoration activities. With the assistance of an EPA technical contractor, DEM is currently in the process of examining the feasibility of uploading data to STORET from its existing data systems (DEM OWR 2005). Integration of STORET into DEM's data management systems remains a goal of the Department and will be considered with the development of management systems for wetland monitoring and assessment data.

RIGIS is used extensively by RIDEM to display geographic data about natural resources in the state. Data about statewide wetland coverage and condition will be available in RIGIS to allow easy access for research and analysis. Landscape-level data gathered during wetland monitoring and assessment activities will be managed in a GIS format.

The RI Natural Heritage Program database is currently managed by the RI Natural History Survey. It may be possible to store and manage wetland monitoring data through this database. Data storage and analysis requirements, as well as staff and funding requirements need to be reviewed by the Department in coordination with the RI Environmental Monitoring Collaborative, which discussing environmental monitoring data management issues statewide.

From the existing systems, and with guidance from EPA and examples from other states, an appropriate management and analysis system will be designed for wetland monitoring and assessment data in RI.

G) DATA ANALYSIS/ASSESSMENT

Appropriate data analyses will be determined during implementation of the wetland monitoring plan according to the objectives being addressed and the level of effort used to gather data. To achieve the long-term objective of understanding wetland condition statewide, data will be gathered and assessed by watershed on a rotating basin schedule, in cooperation with the surface water monitoring program where feasible. At the landscape-level, GIS will be used to manage and analyze data. During implementation of Level 2 and Level 3 efforts, appropriate sample design and analyses will need to be established by a workgroup of professionals, possibly with the assistance of the EMAP program. Data will be analyzed to identify characteristics of reference wetlands across a gradient of human disturbance, trends in wetland quantity and quality over time, specific indicators of wetland condition at each level of effort, and thresholds of conditional changes along a gradient of disturbance. Appropriate data analysis and assessment will require the assistance of personnel trained in statistics and data management and analysis.

H) REPORTING

At minimum, wetland monitoring and assessment results will be reported in Rhode Island's biennial Integrated Water Quality Monitoring and Assessment Report and the Wetland Status and Trend reports published by the DEM Office of Water. In addition to being included in these required reports, information on the condition of wetlands in RI is intended to be shared (available via the web) with state and local groups and non-profit organizations responsible for or interested in the protection and management of wetlands.

Products of wetland assessment will include maps, tables, and reports of results pertaining to short- and long-term objectives, including priority wetlands for open space acquisition, characterization of wetlands near water withdrawal sites, description and assessment of buffer zone condition around wetlands, location of invasive species, and overall wetland condition as a function of cumulative impacts to wetlands. Indicators of wetland condition will be identified and a profile of condition over time will be developed and made available to decision makers. Over time, the plan will be revised and new objectives will be added and reported.

Communicating results of a wetland assessment: Narrative and quantitative ratings

To understand and communicate the results of a wetland monitoring and assessment method, some frame of reference or standard is used. Relying on empirical evidence and best professional judgment, wetland condition along a gradient of human disturbance can be described using narrative statements and/or numeric values. At one end of the continuum are wetlands that can be described as pristine, exceptional, undisturbed, excellent, exceptionally significant, or a similarly appropriate statement. At the other end are wetlands that might be described as significant, impaired, degraded, or disturbed, with moderately degraded or substantially significant wetlands somewhere in between (Fennessey, et al. 2004, Mack 2001). Some methods arrive at narrative statements through a process of assigning scores, from a range of possibilities, for characteristics of a wetland. Scores can be assessed for individual wetland qualities and/or summed to provide an overall "score", which is then assigned an appropriate narrative descriptor for wetland condition (Fennessey, et al. 2004).

How a state chooses to convey results of their wetland assessments is up to the state. The goal is to provide meaningful information about wetland condition to improve protection, restoration, and management decisions for all wetlands. Rhode Island is dedicated to this goal and intends to use narrative descriptors to convey results of wetland conditional assessments to the managers, planners, and citizens of the state.

I) PROGRAMMATIC EVALUATION

The Comprehensive Watershed and Marine Monitoring Act of 2004 (RIGL 46-23.2) requires all monitoring initiatives to be reviewed by the RI Environmental Monitoring Collaborative for inclusion in a systems level monitoring plan being developed by the RI Bays, Rivers, and Watersheds Coordination Team (RIGL 46-31). To develop timely adaptive management strategies, annual updates of each monitoring program are required, and 3-year reviews of the statewide monitoring strategy will be conducted, resulting in revisions and updates to the strategy.

In addition to program evaluations required by state law, the DEM Office of Water regularly updates its Comprehensive Surface Water Monitoring Strategy. The wetland monitoring and assessment plan will be reviewed and evaluated as part of these updates. Through the RI Performance Partnership Agreement with EPA, annual targets will be set for wetland monitoring program activity.

Wetland monitoring and assessment activities, as well as the overall plan, will be evaluated by the monitoring workgroup and other appropriate reviewers to determine how well objectives are being met, and whether the information being shared with decision makers is contributing to improved protection and management of wetlands. The proposed timeline and required resources will also be evaluated and necessary revisions will be made.

J) GENERAL SUPPORT AND INFRASTRUCTURE PLANNING

There is widespread interest in wetland monitoring and assessment in RI, both within DEM and among partners outside DEM. Currently, DEM does not have the internal capacity to implement this new monitoring initiative without additional staff and resources. DEM is working with technical support staff from NEIWPCC, supported by EPA grant funds, to plan for wetland monitoring and assessment. The next step is to begin implementation of year 1 activities (Table 6) with funding support from EPA. Wetland monitoring will be administered by the Office of Water as part of the comprehensive wetland management program, in collaboration with wetland partners outside DEM.

Initial development and testing of a landscape level analysis tool can be achieved in-house (at DEM) by GIS staff, with existing supervisory and management support for wetland monitoring and assessment. DEM is also seeking to cooperate with outside partners to make efficient use of resources and achieve common goals for wetland protection and management.

To fully implement an effective wetland monitoring and assessment program, QAPP’s and a data management system will need to be developed. These activities, as well as the specific sample designs will require time, appropriate staff, and resources. Once Level 2 and Level 3 activities begin, there will also be a need for field equipment, laboratory space, and trained professionals to do the work. DEM will explore partnerships with universities, non-profits, and possible volunteer efforts to accomplish the goals of wetland monitoring and assessment for the state.

Budget & resources required

Budget estimates and required resources are being developed.

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EPA Wetland Fact Sheets
http://www.epa.gov/owow/wetlands/facts/contents.html

EPA Wetland Bioassessment Fact Sheets
http://www.epa.gov/OWOW/wetlands/wqual/bio_fact/

EPA Monitoring and Assessment
http://www.epa.gov/owow/wetlands/monitor/

EPA Modules: Methods for Evaluating Wetland Condition
http://www.epa.gov/waterscience/criteria/wetlands/

EPA Wetlands and Watersheds
http://www.epa.gov/owow/wetlands/watersheds/

EPA Biological Assessment of Wetlands Workgroup
http://www.epa.gov/owow/wetlands/bawwg/

EPA New England Biological Assessment of Wetlands Workgroup (NEBAWWG)
http://www.epa.gov/region01/eco/wetland/

EPA Wetland Status and Trends
http://www.epa.gov/OWOW/wetlands/vital/status.html

RIDEM home page
http://www.dem.ri.gov/

RIDEM Fish and Wildlife – State Wildlife Grant Program
http://www.state.ri.us/dem/programs/bnatres/fishwild/swgindex.htm

Rhode Island Natural Heritage Program
http://www.state.ri.us/dem/programs/bpoladm/plandev/heritage/index.htm

Rhode Island Habitat Restoration Team
http://www.edc.uri.edu/restoration/html/backgrnd.htm

Rhode Island Vernal Pool Website
http://www.uri.edu/cels/nrs/paton/

State of Rhode Island, Local Wetland Protection Projects
http://www.state.ri.us/dem/programs/benviron/water/wetlands/ongoing.htm

Audubon Society of Rhode Island, Refuges
http://www.asri.org/refuges.htm

The Nature Conservancy of Rhode Island, Nature Preserves
http://nature.org/wherewework/northamerica/states/rhodeisland/preserves/

Rhode Island Rivers Council
http://www.planning.state.ri.us/rivers/default.htm

Rhode Island Natural History Survey, Ecological Inventory, Monitoring, Stewardship Program
http://www.uri.edu/ce/rinhs/eims1.htm

Land Trust Alliance
http://www.lta.org/

List of Rhode Island Members of the Land Trust Alliance
http://www.lta.org/findlandtrust/RI.htm

URI Cooperative Extension MANAGE Model
http://www.uri.edu/ce/wq/mtp/html/manage.html
http://www.uri.edu/ce/wq/mtp/html/man_fs.html

Rhode Island Local Comprehensive Plans - Handbook
http://www.planning.ri.gov/comp/handbook16.pdf

RIDEM Education and Outreach Materials
http://www.dem.ri.gov/programs/benviron/water/permits/fresh/index.htm
http://www.dem.ri.gov/programs/benviron/water/wetlands/index.htm

Appendix A

Examples of Level 1 landscape assessment methods from other states

Existing Level 1 landscape assessment tools

Utilizing example tools already developed, Rhode Island could make rapid progress in developing an appropriate landscape level analysis method to assess wetland condition. While objectives and data layers for existing tools vary somewhat, each was developed to provide information to help improve wetland management and protection, a common goal for all states, including Rhode Island. Several states have developed landscape level assessment methods that could prove useful in Rhode Island. Examples from some of those states are described below. Attention should be paid to their general approach, as well as to specific data layers and analyses performed to meet their objectives. A more in-depth review of these examples is expected during implementation of Rhode Island's wetland monitoring and assessment plan to determine which tools are most appropriate for testing in RI.

Massachusetts / Rhode Island

Through a cooperative effort, the Massachusetts Costal Zone Management (MA CZM) office and the Atlantic Ecology Research Laboratory of the USEPA (EPA AED) are developing a combined landscape/rapid assessment method for characterization of salt marsh condition in New England (Carlisle & Wigand 2004). Eleven indicators are examined using GIS, including landscape position, wetland size, and shape, exposure, aquatic edge, connectivity and associated habitat, land use in marsh study unit buffer (150 m), ditching/draining of the marsh, fill and fragmentation, tidal flushing, and diking/restriction in the marsh. Rapid field assessments are then conducted and an overall assessment is made of salt marsh condition. The goals of this approach are to link condition with disturbance and determine the most important criteria required to answer questions about wetland condition (B. Carlisle, pers. comm. 2004). Several aspects of this method may prove useful for assessment of freshwater wetlands in Rhode Island.

Virginia

The Commonwealth of Virginia is in the final stages of developing their wetland monitoring and assessment plan, which includes a multi-level approach to monitoring to achieve an overall goal of no net loss of wetland acreage and function, and objectives designed to support regulatory decision-making (Davis 2004). Their landscape level method was developed by researchers at the Virginia Institute of Marine Science, and adopted for use by the Commonwealth. The method assesses wetland condition for all mapped NWI wetlands by hydrologic unit using GIS (Havens, et.al. 2004). The GIS protocol analyzes wetland type, hydroperiod, size, proximity to other wetlands, percent landcover types within the wetland drainage area, proximity to roads, road type, and road alignment. Information about wetland condition and functional capacity by hydrologic unit is then used in local and state planning for priorities pertaining to wetland and aquatic ecosystem health (Havens et al. 2004).

Wisconsin

In the Milwaukee River Basin of Wisconsin, a landscape level assessment tool is being developed to perform an updated inventory of wetlands and prioritize for restoration projects. This GIS tool aims to produce a big picture view of the varying roles wetlands play in maintaining water quality, preventing flooding, and providing habitat (Kline & Bernthal 2002). To achieve this goal, GIS is being used to analyze wetlands and soils data layers, as well as roads, lakes, streams, land cover, and drainage patterns in the basin. Additional information such as the location of flood-prone areas, water quality problems, and loss or degradation of fish and wildlife habitat are also examined to produce information about the overall condition of wetlands in the watershed.

Collectively, this information is used to prioritize areas in the basin that require restoration, as well as improve management strategies to maximize and protect wetland functions.

Another landscape assessment tool has been developed in WI to assess plant community integrity using remote sensing data to map the extent and cover of reed canary grass, *Phalaris arundinacea*, an invasive species in wetlands (Bernthal & Willis 2004). Unlike many invasive species, reed canary grass has a unique spectral signature that can be seen in Landsat satellite imagery. This has allowed Wisconsin to map areas of wetland as small as 0.5 acres that are heavily dominated by reed canary grass. The information has resulted in the documentation of the dramatic impact of this invasive in Wisconsin's wetlands and allowed the state to determine the specific land cover type (agricultural cropland) that is most strongly correlated with its dominance. Field efforts then further describe the relationship between stressors to the local landscape and resulting invasion of invasive species. Restoration, management, and protection goals are then established using the information generated by a combination of landscape and field assessment methods.

<u>Delaware</u>

Since 1999, Delaware's Nanticoke Watershed has been the focus of wetland conditional and functional assessment methods development. The state of Delaware is using a multilevel approach (levels 1, 2, and 3) to assess wetland condition, beginning in the Nanticoke watershed, to describe the health of wetlands and identify the dominant stressors to wetlands (A. Jacobs, pers. comm. 2004). This information is then used to prioritize restoration efforts through non-regulatory programs.

A landscape-level wetland assessment method, developed by Ralph Tiner of the US Fish and Wildlife Service and tested in the Nanticoke watershed, evaluates indices that characterize and assess trends in the integrity of natural habitat in watersheds (Tiner 2004). Six indices that address natural habitat extent and four that deal with human-caused disturbance focus largely on the extent of natural cover throughout a watershed, with an emphasis on locations important to fish, wildlife, and water quality. The six "habitat extant indices" are natural cover, river-stream corridor integrity, vegetated wetland buffer integrity, pond and lake buffer integrity, wetland extent, and standing waterbody extent. The four "habitat disturbance indices" involve dammed stream flowage, channelized stream flowage, wetland disturbance, and habitat fragmentation by roads (Tiner 2004). Results of the analyses include maps that highlight features of the watershed such as wetland type; extent of natural habitat vs. developed and agricultural lands; the nature of buffers around wetlands, ponds, rivers, and streams; altered wetlands; potential wetland and stream buffer restoration sites, and the extent of stream channelization and damming. Further, correlations can be made between road density and habitat fragmentation and degradation using this tool (Tiner 2004).

Tiner (2004) notes in his paper that a landscape tool is useful for a first-cut look at conditional assessment of ecological systems, but that landscape indices do not account for direct discharges, the effects of groundwater withdrawals, or other factors that cannot be measured using remote sensing techniques. Like other states, Rhode Island is addressing the limitations of a landscape tool by incorporating field level efforts for wetland monitoring and assessment to more completely understand wetland condition in the state.

Appendix B

Examples of Level 1 landscape assessment methods in Rhode Island

Existing landscape assessment methods in RI

Rhode Island is fortunate to have extensive wetland knowledge to draw upon for the development of a wetland monitoring and assessment plan. It is a goal of this plan to build upon existing research in the state where possible. At the landscape level, we recommend consideration of the following tools in initiating a wetland assessment program:

GIS-Based Assessment of Freshwater Wetland Wildlife Habitats in Rhode Island

Researchers from the University of Rhode Island developed a GIS-based assessment tool to determine the capacity of freshwater wetlands to support wildlife habitat based on certain characteristics of wetland evaluation units (also called ‘wetunits’) in the landscape (Golet, et al. 1994). Wetland faunal diversity and abundance were assessed from attributes of the wetland units including size, hydrologic setting, surrounding upland habitat, wetland juxtaposition, and contribution to local wetland diversity and abundance, among other attributes. Selected wetland attributes were based on a wetland habitat evaluation system published by Golet in 1976 and used by RIDEM for nearly 20 years.

Key considerations for using this information, as reported in Golet. et al. (1994), include the following: (1) the standard for assessment that was used, i.e., the capacity of a wetunit to support wetland faunal diversity and abundance; (2) the limitations of the RIGIS wetlands database; (3) the artificial nature of wetunits; and (4) the need to view each wetunit’s characteristics in ecological, geographic, and social contexts. The project was recommended as a tool to develop management schemes for wetunits, and only secondarily for comparison among wetunits.

With those considerations in mind, results from this analysis tool could provide an effective assessment of wetland condition based on several attributes analyzed for habitat quality: wetunit size, wetland class rarity, surrounding upland habitat, specifically the upland habitat quality index, which assigns a value category of low, moderate, or high to a wetunit, and wetland juxtaposition.

Details of how best to apply and adapt this tool would be determined in the implementation phase of the wetland assessment plan once a dedicated workgroup is formed.

The Nature Conservancy (TNC)

Ecoregional Planning Projects

The Nature Conservancy has extensive GIS expertise and works closely with state and local GIS professionals on a variety of projects. TNC has been instrumental in maintaining and updating the open space data layers in the state. TNC RI office and Eastern Regional Office assembles numerous GIS data layers at both the state and watershed levels (including coverage across state boundaries) and at a regional level (J. Lundgren, pers. comm. May 2005). As part of their ecoregional planning, TNC has compiled GIS data layers and analyses on landscape condition, impervious surfaces, river classification and condition assessment, river buffers, roadless blocks, forest types, and other watershed and forest attributes. Additional work on ecosystem modeling and mapping are underway and TNC RI is involved in joint efforts concerning assessment and protection of vernal pools and other wetlands. Many of the TNC assembled data layers and analyses will be available for public use (some have already been distributed) and may be useful in statewide work in assessing and monitoring wetlands.

Cooperation with RIDEM Div. of Fish and Wildlife on the state Wildlife Grant (SWG) program

TNC is working closely with the Division of Fish and Wildlife (DFW) to map critical habitats in RI as part of the state Wildlife Grant (SWG) program. The goal of this program is to develop a long-term strategy to protect wildlife species and the habitats upon which they depend. One aspect of achieving this goal is to identify and map critical habitats for conservation of species. This mapping effort, being done by TNC, is pertinent to the state wetlands monitoring plan as well. We have participated in several meetings for the SWG planning process, including the habitat mapping portion, and look forward to future cooperation with TNC and DFW. The state wetland monitoring plan will ideally be useful to DFW to satisfy, in part, their requirements for a monitoring plan for each of the critical habitats they have prioritized for protection.

Landscape Development Intensity Index (LDI)

Researchers at EPA's Atlantic Ecology Lab (AED) in Narragansett, RI have been developing a landscape tool called the Landscape Development Intensity Index (LDI), which quantifies the stressors acting upon a wetland and provides a coarse assessment of wetland condition along a gradient of disturbance (S. Brant-Williams pers. comm. 2004). GIS data and imagery are used to identify wetland points, around which a coefficient, or land use index, is assigned to each different land use. With this method, stressors to wetlands are described and degradation to the wetland predicted. Furthermore, this analysis can be used to run 'what-if' scenarios to predict impacts of different land uses on wetlands. This tool is currently in a test phase of development in several states where it is being tested against wetland condition (S. Brant-Williams pers. comm. 2005). Once verification of the model-based predictions of wetland condition is complete, the tool can be used more widely. Because it is based on GIS data, the most up-to-date data and imagery will produce the most reliable, accurate tool for use assessing wetland condition statewide.

MANAGE Watershed Assessment Model

MANAGE, the Method for Assessment, Nutrient-loading, and Geographic Evaluation of watersheds and groundwater recharge areas, is a watershed assessment tool using computer-generated maps to evaluate pollution risks of land use and landscape features (Bellet, et al. 2003). MANAGE evaluates the cumulative effect of current land use, future development, and pollution management practices on water resources. Although the model is intended to predict threats to drinking water supplies in the state, several features of this tool may be applicable to assessing wetland condition. For example, the comprehensive assessment feature of the model calculates percent impervious area, percent forest and wetland cover, and landuse characteristics in the upland area adjacent to wetlands. This landscape approach, as well as data generated from this tool, may help wetland managers better describe and understand threats to wetlands in RI's watersheds.

Appendix C

Examples of Level 2 rapid field assessment methods from other states

Existing Level 2 rapid field assessment methods

During the past several years many states have been developing wetland assessment tools or modifying existing methods as they develop statewide wetland monitoring and assessment programs. Of the many examples of rapid assessment methods that Rhode Island could test in the early phases of a monitoring program, tools from Massachusetts/Rhode Island, Ohio, and Pennsylvania stand out as some of the best examples.

Each of the methods summarized below is designed to describe wetland condition as it occurs along a gradient of human disturbance. Although the methods vary in approach, they demonstrate the underlying concept that wetlands respond predictably to anthropogenic stresses.

Massachusetts/Rhode Island – Rapid Assessment Method for Characterizing the Condition of New England Salt Marshes

This method, currently being developed jointly by Massachusetts Coastal Zone Management (MA CZM) and EPA's Atlantic Ecology Research Division (AED) in Narragansett, RI, is intended to provide quantitative and qualitative information on the condition of coastal salt marshes with a relatively small investment of time and effort. Condition in this case is defined as the relative state and integrity of selected components that collectively comprise the salt marsh (Carlisle & Wigand 2004). Although this method was originally intended for salt marsh assessment, it could be adapted for freshwater wetlands in RI.

Prior to collecting field data, several aspects of the wetland are described in the office using GIS and maps. In the field, plant community and species, wetland slope, soil characteristics, stressors to the wetland and recreational or educational value of the wetland, among other factors, are examined. A database of results for each indicator is analyzed to determine not only where each wetland falls along a gradient of human disturbance, but also which indicators best predict or correlate with overall wetland condition.

Ohio – Ohio Rapid Assessment Method for Wetlands (ORAM)

Ohio's rapid assessment method was developed starting in 1996 and is currently used primarily to support their wetland permitting regulations. Ohio learned that once a baseline of results about wetland condition was established, strong scientific evidence about wetland quality was more useful in their permitting program than relying solely on best professional judgment when determining impacts to wetlands (J. Mack, pers. comm. 2005).

Eventually, it became a requirement of Ohio's wetland permitting program that, "an appropriate wetland evaluation methodology… be used to determine the category of the wetland which is the subject of the application" (Mack 2001). Though the use of ORAM, specifically, was not mandated, it became (and is currently) the standard tool for wetland assessment. In addition to daily use for the regulatory program, ORAM is used regularly as an assessment tool in non-regulatory programs (J. Mack, pers. comm. 2005).

ORAM evaluates several metrics, either qualitatively or quantitatively, to come up with an overall score of wetland condition (Fennessey, et al. 2004). Indicators include those related to wetland size, buffer size and quality, surrounding land use, hydrology, substrate, habitat, plant communities, stressors to the wetland, and special characteristics that need to be considered, such as rare plant communities. Using this method, the Ohio regulatory and non-regulatory communities can best decide how to protect and restore wetlands in the state.

Pennsylvania – Penn state Stressor Checklist

The Penn state Stressor Checklist combines landscape (Level 1) and rapid field methods (Level 2) to tabulate the number of stressors present at a site while considering the effects to the wetland of the surrounding buffer (Fennessey, et al. 2004).

The landscape portion of the Stressor Checklist categorizes land use within a 1-km radius of the site. Once wetlands are classified by the dominant surrounding land use, e.g. forest, agriculture, etc…, they are sampled in the field following a worksheet that lists stresses to the environment in the following categories: hydrologic modification, sedimentation, dissolved oxygen, contaminant toxicity, vegetation alteration, eutrophication, acidification, turbidity, thermal alteration, and salinity. The assumption of this approach is that a site is in good condition unless there is evidence of disturbance present. If the surrounding land use affects wetland condition by 'penetrating' the buffer (by culverts that connect upland directly to wetland through the buffer, for example), the value of the surrounding buffer is decreased in calculating the score (Fennessey, et al. 2004).

This approach differs somewhat from the tools of Ohio and other states. Although a score is calculated for wetland condition, the primary purpose is to create a profile of stressors to a wetland so that management decisions can be made to fix the problems (D. Wardrop, pers. comm. 2005). At the Cooperative Wetlands Research Center (CRWC) of Penn state, they have been developing a database of reference wetlands in different land use categories, with the understanding that wetlands surrounded by agriculture, for example, will not be described by the same ecological conditions as a forested or a more developed landscape (D. Wardrop, pers. comm. 2005). By establishing reference wetlands across a gradient of human disturbance, they have established a means of identifying and describing degraded wetlands in each category. As such, they are able to set realistic restoration and protection goals.

While certain questions in the Stress Checklist may be not be appropriate to Rhode Island wetlands, certain modifications could be made to the tool to make it useful. The appeal of this approach is that it provides a comprehensive description of stressors to a wetland in a short period of time. Understanding the composition of different stressors on a watershed scale could help direct future management decisions regarding wetland and water quality in those watersheds. Additionally, by establishing a baseline of where certain stressors are now provides an efficient way to monitor and correct stressors that might occur in the future.

RI rapid functional assessment methods

Rhode Island has a long history of utilizing wetland functional assessment methods. Recently, Miller and Golet (2001) developed a rapid functional assessment method to predict wetland functions that would be provided should a degraded wetland or buffer be restored. This method consists of both GIS and field-based questions that pertain to the wetland site and surrounding area. Another rapid functional assessment method was developed by Cavallaro and Golet (2002) to assess the outcome of restored wetlands at enforcement sites in Rhode Island. These methods will be reviewed further to determine whether they can be applied to assess ambient condition of wetlands in the state.

Appendix D

Examples of Level 3 intensive site assessment methods from other states

Existing Level 3 intensive site assessment methods

The decision of when and how best to conduct Level 3 efforts for wetland monitoring and assessment is made easier with existing research by other states. Largely with the support of EPA funding, several methods have been developed and tested in other states, though much remains to be learned about wetland conditional assessment. Here we describe just a few of the Level 3 efforts other states are conducting and highlight examples of metrics they have found to be predictive of wetland condition.

Maine – Since 1998, the Maine Department of Environmental Protection has been developing a biological monitoring and assessment program for wetlands, focusing on macroinvertebrates and algae in freshwater marshes. With well-tested sampling methods in place and a strong program plan, Maine has developed a baseline of information that is recognized and more frequently being referenced by regulatory and non-regulatory programs in the state (J. DiFranco, pers. comm. 2004, USEPA 2003).

Ohio – The Ohio Environmental Protection Agency (OH EPA) has developed numerous methods for wetlands monitoring and assessment at all levels of effort (J. Mack, pers. comm. 2004). In addition to developing metrics for macroinvertebrates and amphibians, a very strong tool for wetlands assessment is the floristic quality assessment index (FQAI) for vascular plants and mosses for the state of Ohio (Andreas, et al. 2004). In very basic terms, the FQAI is a weighted average of plant species richness with a weighting factor called a coefficient of conservatism (C of C), a value assigned by professionals familiar with the narrowness or breadth of a plant's ecological tolerances (Andreas, et al. 2004). The FQAI method consists of obtaining a plant species list for a site, assigning a C of C value, and calculating values that indicate relative abundance of native species, or the floristic quality of the site, which can be compared to other wetland sites. This tool has been found to be very good at detecting disturbance in wetlands in Ohio as well as several other states (USEPA 2003).

Minnesota – A great deal of research on vegetation and macroinvertebrate IBI's comes from the MN Pollution Control Agency (Helgen & Gernes in Rader et al., eds 2001, USEPA 2003). Their work began in 1992 and has, through several projects, produced reliable IBI methods for determining wetland condition. Each IBI is composed of 10 attributes of wetland vegetation or invertebrates. The IBI's and individual metrics show graded responses to a range of human disturbance and to specific stressors (Helgen & Gernes in Radar, et al. 2001). The most sensitive invertebrate metrics were intolerant taxa, Odonata, ETSD (mayflies, caddisflies, fingernail clams, caddisflies), and total taxa. The strongest vegetation taxa were the sensitive species, percent tolerant taxa, persistent litter, vascular genera, and non-vascular taxa (Helgen & Gernes in Radar, et al. 2001).

Montana – Montana also began developing wetland biological criteria in 1992 at the MT Department of Environmental Quality (MT DEQ) (R. Apfelbeck, pers. comm. 2004). Research in MT has focused on several assemblages including algae, macroinvertebrates, vegetation, and amphibians (USEPA 2003). Useful macroinvertebrate metrics for wetland assessment include number of taxa, percent dominant taxa, POET taxa (count of stoneflies, dragonflies, mayflies, and caddisflies), number of individuals, number and percent of chironomid taxa and numbers of mollusks and leeches (USEPA 2003).

Wisconsin – Another state that has produced a wealth of information on wetland assemblages, particularly macroinvertebrates and vegetation, is Wisconsin. The Wisconsin Department of Natural

Resources has led studies in Wisconsin that have produced three multimetric indices for wetland assessment: The Wisconsin Wetland Macroinvertebrate Index (WWMI) and the 100-count macroinvertebrate biotic index (100-count MBI) for macroinvertebrates, and the Wisconsin Wetland Plant Biotic Index (WWPBI) for vegetation (USEPA 2003). The WWMI is composed of 12 abundance metrics (ex. mollusks, damselflies, caddisflies, midges, mosquitoes, total invertebrates, among others), 2 richness metrics (noninsects and total taxa), and one percentage metric (percentage caddisflies). The 100-count MBI includes 9 percentage metrics (ex. total bugs, total caddisflies, chironomids, sum of EOT taxa (mayflies, dragonflies, stoneflies), among others) and 1 richness metric (noninsect taxa). The WWPBI is based on eight plant metrics derived from transect data including one richness metric (total taxa), one percent metric (floating-leafed plants) and seven importance value-based metrics (ex. Carex, reed canary grass, cattail, duckweed, and others) (USEPA 2003).

In addition to the methods and metrics that can be tested and adapted for Rhode Island, other states offer a great deal of experience and “lessons learned” to benefit states, such as RI, in the early phases of implementation of a monitoring and assessment program. When the time comes for RI to implement a Level 3 approach to wetland assessment, we will have the advantage of being able to build on the existing research from others.

Pertinent Level 3 research in RI

Pertinent research in RI

Rhode Island is fortunate to have a strong wetland research community. Scientists at the University of Rhode Island, the Rhode Island Natural History Survey, the Natural Heritage Program, and The Nature Conservancy, to name some, have conducted studies to better understand wetland ecology, hydrology, and wetland-dependent wildlife. Below are highlights of research findings that have advanced Rhode Island's base of knowledge about wetlands and their biological communities. How these studies inform and support Level 3 wetland monitoring and assessment efforts will be considered as the state evaluates best methods for meeting long and short-term program objectives.

Amphibians

In search of cost-effective amphibian monitoring methods, Crouch and Paton (2000) found that using egg-mass counts, particularly for wood frogs and salamanders, is a viable way to monitor populations, though access to ponds is not always possible and high water can make it impossible to get into them. Not all amphibians lay egg masses, however, so other monitoring methods such as call surveys or drift fence arrays may be necessary to accurately monitor amphibian populations (Crouch & Paton 2002).

In their studies to understand how the characteristics of breeding ponds and the adjacent landscape are related to amphibian presence and abundance, Egan and Paton (Egan 2001; Egan & Paton 2004) determined that hydroperiod and vegetation complexity are important for breeding amphibians in seasonal ponds. Landscape characteristics such as road density (e.g. <12m/ha for wood frogs) and low density development were found to negatively influence the occurrence of amphibians. More wood frogs and spotted salamanders were located in ponds with greater amounts of shrub cover and wood frog egg-mass counts were higher in landscapes with more forested uplands and forested wetlands (Egan 2001). To protect amphibian habitat quantity and quality, it is essential to protect both the breeding ponds and the surrounding upland habitat.

Mitchell (2005) documented the influence of seasonal pond hydroperiod on egg-mass production by wood frogs and salamanders by measuring surface water levels in 65 seasonal ponds in the Pawcatuck watershed for a 3-year period and counting egg-masses each spring. Egg-mass numbers were greater in ponds that were flooded for longer periods of time, with greatest number contained in ponds that were flooded for 28-36 weeks.

Birds

The Atlas of Breeding Birds in Rhode Island (Enser 1992) is a valuable resource for landuse planners, biologists, and decision makers to examine the impacts of development on the landscape. For the Atlas, Enser developed bird survey techniques and developed baseline data for the location of breeding birds in RI. He described high avian diversity in marshes and river floodplains near large trees, as well as red maple swamps.

In forested swamps in RI, extensive research has been conducted on the relative influence of forest habitat characteristics and landscape context on the presence, abundance, and diversity of birds (Merrow 1990, Deegan 1995, Miller 1999, Golet et al. 2001). Overall bird species richness was found to be strongly related to swamp area, but that even small swamps supported wetland-dependent breeding bird species. The Northern Waterthrush, for example, was found in small swamps as long as other swamps were nearby. The presence of the Canada Warbler was influenced by swamp size (>6 ha), the distance from roads (>300 m), and forest cover (>50%) within 2 km, indicating that Canada Warblers are unlikely to be found near urban or agricultural land uses.

The impact of landuse characteristics on birds in riparian zones was examined by Lussier et al. (2005), who found that bird species diversity was negatively impacted by increases in residential land use. The number of intolerant species decreased and the number of tolerant species increased at 20% development with 5% impervious cover.

The importance of forested buffer zones around wetlands was emphasized by Millard (1994), who found a decline in bird populations due to low nesting success near upland areas lacking forest cover.

Swamp and seasonal pond (vernal pool) hydrology

A 7-year study on water levels in forested wetlands was reported by Lowry (1984), Golet and Lowry (1987), and Golet et al. (1993). They were able to quantitatively describe water regimes in 6 red maple swamps and 6 Atlantic white cedar swamps and describe the relationship between environmental factors and vegetation in the wetlands.

Studies by Davis (1988) and Allen (1989) found agreement among hydric soil classification, vegetation identification, and wetland hydrology as criteria for identification of wetland boundaries in red maple swamps.

Recently, in an extensive study on 65 seasonal ponds in RI, Skidds (2003), and Skidds and Golet (2005) developed a multivariate model for estimating pond hydroperiod from site characteristics such as pond morphology, geology, chemistry, and vegetation, negating the need for long-term hydrologic monitoring. Their results suggested that estimates of pond hydroperiod can then be used to assess the suitability of individual ponds as breeding sites for wood frogs and spotted salamanders.

Macroinvertebrates

Stream biomonitoring has been conducted over the last several years in Rhode Island as part of the 305(b) water quality monitoring requirements of the Clean Water Act. Studies on stream macroinvertebrates in RI are few; however, results from research by da Silva (2003) and Lussier, et al. (2004) have provided some important information for the state. They found that the abundance of macroinvertebrates decreased with an increase in residential land use and that declining stream health occurred at thresholds as low as 5% impervious cover in the watershed.

A substantial amount of research and field work went into the production of The Rhode Island Odonata Atlas (Brown & Briggs 2004). This comprehensive resource on dragonflies in the state provides not only a comprehensive list of species by township, including a few species of conservation interest, but also describes essential habitat conditions required for protection of rare species. Species diversity was found to be high where large areas of protected and/or undeveloped landscape exist. Examination of the pollution sensitive species in the state will likely be useful in assessing watershed health (Brown & Briggs 2004).

Vegetation

The relationships among watershed land use, vegetated riparian condition, and invasive plants were explored in one study (Lussier, et al. 2004). Results showed that adverse effects in riparian zones corresponded with degradation of tributary streams and increased urbanization.

Skidds (2003) and Mitchell (2005) conducted detailed studies of vegetation in seasonal ponds of the Pawcatuck River watershed. Using correlations between plants identified along transects in 65 different ponds and hydroperiods at the same locations, these researchers were able to develop an approach for estimating pond hydroperiod from the vegetation in the deepest zone. Such a tool is useful for further predicting success of pond breeding amphibians and for establishing management strategies for protection of these valuable wetland habitats.

In their studies on wetland water levels, Lowry (1984), Golet and Lowry (1987), and Golet, et al. (1993) related vegetation data to water regime. Detailed information was gathered on tree growth rates, as well as species composition and abundance of trees, shrubs and herbs. Similarly, bird studies by Merrow (1990), Deegan (1995), and Miller (1999) involved detailed vegetation analyses as they attempted to relate bird community characteristics to habitat.

Studies on wetland plant physiology have shown that certain plants exhibit reproductive strategies to deal with fluctuating water levels (Hogeland 1984) and nutrient enrichment of a water body (Sinden-Hempstead 1994). Such information may help scientists and managers better understand the condition of a wetland ecosystem by examining types and characteristics of the resident vegetation.

Appendix F

Database of wetland-related research in RI

During the early phases of plan development, we gathered information about what is already known about freshwater wetlands in Rhode Island. Below are brief summaries of the research and projects we learned about during our search for information. We are aware this is not an exhaustive list of projects related to wetlands work in RI. This database of information can be updated with other projects and information, and is a good source for others interested in learning about wetland-related research in Rhode Island.

Level of Assessment: landowner research, biol. inventory
Project Title: A conservation plan for wetlands and associated natural resource areas in Little Compton and Tiverton, RI
Author: Jane Jackson
Additional Contact(s): Julie Lundgren, Kevin Ruddock
Organization: The Nature Conservancy
Publication Information: funded in part by RIDEM, 104(b)3 grant; copy of file in DEM OWR files
Date: December 2001
Environment Assessed: wetlands and associated uplands in 2 towns in RI
Assemblages Studied: vegetation, animals, birds, odonates
Project Goal: to work with conservation partners to identify priority conservation areas of wetlands and associated uplands in Tiverton and Little Compton, RI.

Level of Assessment: landscape
Project Title: Development of a statewide freshwater wetland restoration strategy
Author: Nicholas Miller
Additional Contact(s): Francis Golet
Organization: URI, Dept. of Nat. Res. Sci; RI DEM, Office of Water Resources, US EPA, Region 1
Publication Information: Funded by a 104(b)(3) grant; bound copy, Carol Murphy's
Date: August 2001
Environment Assessed: wetlands for restoration in RI
Assemblages Studied: none: restoration strategy
Project Goal: GIS used to identify RI wetlands for restoration using aerial photos, soil data, land cover. Looked for differences between 1939 and 1988 photos - wetland loss, land cover surrounding wetland. Look at impacts: filling, draining, removal of upland veg., impedence of surface flow, removal of wetland veg., trash dumping, stream channelization, invasive spp., sedimentation. Looked at potential for improvement in wetland function to prioritize sites.

Level of Assessment: landscape
Project Title: Freshwater wetland dynamics and related impacts on wildlife in South Kingston, RI, 1939 - 1972
Author: James Parkhurst
Additional Contact(s): Frank Golet
Organization: URI
Publication Information: MS thesis (have abstract and full bound copy)
Date: 1977
Environment Assessed: freshwater wetlands one acre and larger in S. Kingston, RI
Assemblages Studied: birds, wildlife, vegetation
Project Goal: to determine changes wetland acreage and type by interpretation of aerial photos taken in 1939 and 1972, and by extensive field inspection.

Level of Assessment: landscape
Project Title: MANAGE Watershed Assessment Model
Author: Lorraine Joubert
Additional Contact(s): Dorothy Kellogg, Art Gold, James Lucht, Pete August
Organization: URI Cooperative Extension
Publication Information: www.uri.edu/ce/wq/mtp/html/man_fs.html - see full reports and fact sheets for SWAP examples
Date: current
Environment Assessed: wetlands are part of model - # acres, location in watershed
Assemblages Studied: none: landscape assessment

Project Goal: MANAGE is the Method for Assessment, Nutrient-loading, and Geographic Evaluation of watersheds and groundwater recharge areas. It is a watershed assessment tool using computer-generated maps to evaluate pollution risks of land use and landscape features. MANAGE evaluates the cumulative effect of current land use, future development, and pollution management practices on valuable water resources. The focus is on identifying land use and natural features where pollutants are most likely to be generated and move to drinking water supplies. Relationship between watershed characteristics and water quality is grounded on basic, widely accepted concepts about movement water and pollutants applicable to both surface stormwater flow and leaching to GW. One of the principles is that forest, wetlands and naturally vegetated shoreline buffers have documented ability to retain, transform, or treat pollutants.

Level of Assessment: landscape
Project Title: Wetlands strategic action plan; Town of North Kingston, RI.
Author: Brian Lesinski
Additional Contact(s):
Organization: EA Engineering, Science, and Technology, Inc.
Publication Information: prepared by EA Engineering, Science, and Technology, Inc. in conjunction w/Mason & Assoc., Komar Consult., Applied Bio-Systems, Inc.
Date: March 2002
Environment Assessed: all wetlands in N. Kingston, RI
Assemblages Studied: none: conservation plan
Project Goal: wetlands were mapped and classified resulting in updated GIS tool for long-term wetland management and planning.

Level of Assessment: landscape
Project Title: Landscape change in Rhode Island: Assessing development patterns, formative factors, and ecological consequences
Author: Alyssa Novak
Additional Contact(s): Y.Q. Wang
Organization: URI
Publication Information: MS Thesis
Date: 2003
Environment Assessed: forested environment
Assemblages Studied: none: landscape analysis
Project Goal: More attention is being given to urbanization processes because residential and commercial areas are expanding rapidly, and growth rates show no sign of slowing as populations grow in size, affluence, and technological capacity. The incursion of residential and commercial developments into terrestrial habitats is resulting in measurable changes to the composition and pattern of habitats and to the fauna and flora assiciated with them. To better understand landscape change processes, land-use and land-cover changes resulting from urbanization in the state of RI was documented, socioeconomic factors influencing landscape changes were identified, and it was determined how the conversion of land affected the state's forest ecosystems.

Level of Assessment: landscape
Project Title: GIS-Based assessment of freshwater wetland wildlife habitats in the Pawcatuck River watershed of Rhode Island
Author: Francis Golet
Additional Contact(s): Peter August, Jeffrey Barrette, Carol Baker
Organization: URI, Dept. of Natural Resources
Publication Information: Project conceived by Brian Tefft. Help from DEM, EPA Reg. 1.
Date: December 1994
Environment Assessed: FW wetlands in Pawcatuck River watershed, RI
Assemblages Studied: none: landscape assessment
Project Goal: to create a GIS-based wetland habitat assessment method. Technique assesses the relative capacity of a discrete area of Palustrine wetland (known as a "wetunit") to support wetland faunal diversity and abundance.

Level of Assessment: landscape - mapped from aerial photos, field check
Project Title: Inventory and habitat evaluation of the wetlands of Richmond, RI
Author: Francis Golet
Additional Contact(s): Anthony Davis
Organization: URI

Publication Information: Occasional papers in Env. Science, RI Agricultural Experiment Station Contribution No. 2098; Bound… small, lt. green cover, belongs to Carol
Date: September 1982
Environment Assessed: Wetlands of Richmond, RI
Assemblages Studied: none: mapping and inventory
Project Goal: The wetlands of Richmond were classified and mapped from 1975 photos, and each was rated numerically according to its ability to support large, diverse wildlife communities…. The major threats to wetlands were determined to be residential development and road construction.

Level of Assessment: landscape, rapid, site
Project Title: Complementary approaches to watershed assessment
Author: Suzanne Lussier
Additional Contact(s): Sara daSilva
Organization: USEPA, AED Narragansett
Publication Information: poster
Date: 2004 [work done 2002, 2003]
Environment Assessed: streams and riparian wetlands
Assemblages Studied: macroinvertebrates, vegetation, birds
Project Goal: Objective to compare indicators of stream and riparian condition with the composition of breeding bird populations in 6 RI subwatersheds along a range of residential land use.

Level of Assessment: landscape, rapid, site
Project Title: A multiple scale approach to assessing the biological integriy of Rhode Island streams
Author: Sara da Silva
Additional Contact(s): Art Gold
Organization: URI
Publication Information: MS Thesis (have abstract and pdf version of full thesis)
Date: 2003
Environment Assessed: streams
Assemblages Studied: macroinvertebrates
Project Goal: This study assessed how well indices of biological integrity relate to landscape variables and explored which spatial scales are most useful for assessment of RI's streams and rivers.

Level of Assessment: landscape, rapid, site
Project Title: Indicators of anthropogenic disturbance in streams and receiving salt marshes
Author: Sara da Silva
Additional Contact(s): Suzanne Lussier
Organization: URI; USEPA, AED Narragansett
Publication Information: poster
Date: 2004 [work done 2002, 2003]
Environment Assessed: stream, riparian zone, salt marsh
Assemblages Studied: macroinvertebrates, vegetation
Project Goal: Objective was to compare indicators of stream and riparian condition with analagous indicators of the coastal salt marshes into which they discharge.

Level of Assessment: landscape, site
Project Title: Within-pond and landscape-level factors influencing the breeding effort of Rana sylvatica and Amby stoma maculatum
Author: Robert Egan
Additional Contact(s): Peter Paton
Organization: URI
Publication Information: MS Thesis
Date: 2001
Environment Assessed: seasonal ponds in RI
Assemblages Studied: amphibians
Project Goal: To develop management guidelines for pond-breeding amphibians, it is important to understand how the characteristics of both the breeding pond and the adjacent landscape are related to amphibian presence and abundance.

Level of Assessment: landscape, site
Project Title: Hydric soil patterns in riparian corridors of the glaciated northeast: Groundtruthing the soil survey geographic data base (SSURGO)
Author: Adam Rosenblatt
Additional Contact(s): Art Gold
Organization: URI
Publication Information: MS Thesis
Date: 2000
Environment Assessed: riparian zone soil
Assemblages Studied: none: hydric soils
Project Goal: Past research has found that riparian sites with hydric soils possess high groundwater nitrate removal potential, while non-hydric soils appear to have minimal removal rates. The presence of hydric riparian corridors often occur as narrow bands that are challenging to map. The objectives of this study were 1. to characterize the landscape attributes and occurrence of hydric soils along riparian corridors of lower order streams and 2. investigate the accuracy of SSURGO digital soil maps to depict the patters of soil drianage classes and occurrence of hydric soils along riparian corridors of lower order streams.

Level of Assessment: rapid
Project Title: Landscape and habitat predictors of Canada Warbler (Wilsonia canadensis) and Northern Waterthrush (Seiurus noveboracensis) occurrence in RI swamps
Author: Nicholas Miller
Additional Contact(s): Frank Golet
Organization: URI
Publication Information: MS thesis
Date: 1999
Environment Assessed: forested wetlands
Assemblages Studied: birds
Project Goal: examined the relative influence of forest habitat characteristics and landscape context on the presence of both bird species in 80 survey plots located in 44 RI forested swamps during 1997 and 1998.

Level of Assessment: rapid
Project Title: The Rhode Island Odonata Atlas
Author: Virginia Brown
Additional Contact(s): Nina Briggs
Organization: Rhode Island Natural History Survey
Publication Information: abstract from RINHS conference proceedings 2004
Date: 2004
Environment Assessed: streams, rivers, wetlands
Assemblages Studied: macroinvertebrates
Project Goal: To inventory Odonates in Rhode Island

Level of Assessment: rapid
Project Title: Outcome of freshwater wetland restorations ordered by the RIDEM Office of Compliance and Inspection
Author: Lisa Cavallaro
Additional Contact(s): Frank Golet
Organization: URI
Publication Information: Final report prepared for RIDEM OWR, for an EPA 104 (b) (3) grant
Date: April 2002
Environment Assessed: marshes and wet meadows - mitigation projects
Assemblages Studied: none: wetland restoration sites
Project Goal: To evaluate wetland sites where restoration of biological wetlands had been attempted. Specifically interested in determining 1. whether wetland was created during mandatory restoration projects, 2. if the restored wetland was performing functions and values typical of natural wetlands, and 3. whether invasive plant species were a specific management issue in restored wetlands.

Level of Assessment: site
Project Title: Avian community-habitat relationships in red maple swamps and adjacent upland forests in southern RI
Author: Bob Deegan

Additional Contact(s): Frank Golet
Organization: URI
Publication Information: MS Thesis
Date: 1995
Environment Assessed: red maple swamps, upland forest, Washington Co. RI
Assemblages Studied: birds
Project Goal: The relationship between the avian community and its habitat was investigated along a soil-moisture gradient in 3 mature red maple swamps and adjacent upland forests.

Level of Assessment: site
Project Title: Relationships among hydrology, vegetation, and soils in transition zones of Rhode Island red maple swamps
Author: Sarah Allen
Additional Contact(s): Frank Golet
Organization: URI
Publication Information: MS Thesis
Date: 1989
Environment Assessed: red maple swamps
Assemblages Studied: hydrology, vegetation
Project Goal: To examine the relationships among hydrology, vegetation, and soils, and to develop field criteria for locating wetland boundaries using these parameters.

Level of Assessment: site
Project Title: Use of invertebrates by birds in red maple forested wetlands and contiguous forested uplands in southern RI
Author: Linda Arnold
Additional Contact(s): William Eddleman
Organization: URI
Publication Information: MS Thesis
Date: 1993
Environment Assessed: red maple swamps
Assemblages Studied: birds, invertebrates
Project Goal: Successful management of wetland wildlife populations requires a basic understanding of invertebrate ecology and their availability as food. Community structure, abundance, and seasonal dynamics of litter invertebrates in red maple forested wetlands are unknown. This study looked at invertebrate use by ground-foraging birds along moisture gradients from uplant forests to red maple forested wetlands.

Level of Assessment: site
Project Title: Hydrologic and vegetation gradients in the transition zone of Rhode Island red maple swamps
Author: Anthony Davis
Additional Contact(s): Frank Golet
Organization: URI
Publication Information: MS Thesis
Date: 1988
Environment Assessed: red maple swamps
Assemblages Studied: vegetation
Project Goal: Objectives: 1) to describe hydrologic relationships among soil drainage classes along a gradient from wetland to upland at three forested sites in RI. 2) to determine which vegetation layers are the most helpful for wetland boundry location along the gradient. 3) to develop a methodology for wetland boundary determination using vegetation data.

Level of Assessment: site
Project Title: Two forms of adventitious grown on fertile shoots of the emergent macrophyte, Juncus Militaris Bigel.
Author: Amy Hogeland
Additional Contact(s): Keith Killingbeck
Organization: URI
Publication Information: Aquatic Botany, 20 (1984) 339-342
Date: 1984
Environment Assessed: freshwater wetlands, lakes
Assemblages Studied: vegetation

Project Goal: To observe and quantify the development of adventitious growth on J. militaris during a time of abnormally hight water levels.

Level of Assessment: site
Project Title: Using plants as indicators of hydroperiod class and amphibian habitat suitability in Rhode Island seasonal ponds
Author: Jonathan Mitchell
Additional Contact(s): Frank Golet
Organization: URI
Publication Information: MS Thesis
Date: 2--5
Environment Assessed: Seasonal ponds
Assemblages Studied: amphibians, vegetation
Project Goal: To develop a hydroperiod classification for seasonal ponds and investigate the merits of using plants as indicators of pond hydroperiod class.

Level of Assessment: site
Project Title: Assessing the use of call surveys to monitor breeding anurans in RI
Author: William Crouch
Additional Contact(s): Peter Paton
Organization: URI
Publication Information: Journal of Herpetology, Vol. 36, No. 2, pp. 185-192.
Date: 2002
Environment Assessed: Vernal pools
Assemblages Studied: amphibians
Project Goal: To develop a long-term monitoring program that quantified anuran population trends in RI. To assess the efficacy of using call surveys to monitor the impact of anthropogenic change of anuran populations in the state.

Level of Assessment: site
Project Title: Water regimes and vegetation of Rhode Island forested wetlands
Author: Dennis Lowry
Additional Contact(s): Frank Golet
Organization: URI
Publication Information: MS Thesis
Date: 1984
Environment Assessed: forested wetlands in RI - red maple and Atlantic white cedar
Assemblages Studied: hydrology, vegetation
Project Goal: despite increasing awareness of the importance of hydrology to wetland ecology and functions, few data existed which adequately described long-term water regimes for any of the wetland types in this country. Goal of this thesis was to quantitatively describe water levels in wetlands over a long period of time (7 years: 1976-1982).

Level of Assessment: site
Project Title: The influence of area and habitat on the avian community in red maple swamps of southern Rhode Island
Author: Jed Merrow
Additional Contact(s): Frank Golet
Organization: URI
Publication Information: MS Thesis
Date: 1990
Environment Assessed: red maple swamps in RI
Assemblages Studied: birds
Project Goal: Few descriptions of red maple swamp wildlife communities, and little research on how the wildlife are influenced by habitat features. The influence of area on wetland wildlife communities is largely unknown. Avian community composition was described and the influence of area and habitat on the avian community were examined.

Level of Assessment: site

Project Title: Biogeography of the Bog Copper butterfly (Lycaena epixanthe) in southern Rhode Island peatlands: A metapopulation perspective
Author: Joanne Michaud
Additional Contact(s): Pete August
Organization: URI
Publication Information: MS Thesis
Date: 1995
Environment Assessed: peatlands
Assemblages Studied: invertebrates
Project Goal: To examine the relationship between habitat patch geometry and occupancy by the bog copper butterfly in southern RI, which inhabits patchily distributed open peatlands throughout the northeastern US and southeastern Canada.

Level of Assessment: site
Project Title: The effect of adjacent upland habitat on predation of artificial ground nests in red maple swamps
Author: Carol Millard
Additional Contact(s): William Eddleman
Organization: URI
Publication Information: MS Thesis
Date: 1994
Environment Assessed: forested wetlands
Assemblages Studied: birds
Project Goal: Wetlands are commonly regulated by federal and state laws, but the bordering habitat often is not. Red maple swamps important habitat for breeding migratory birds. Many migratory birds are experiencing declines that have been attributed to low nesting success near a habitat edge. If adjacent upland habitat does have an effect on birds breeding in the wetland, it is important to know at what distance nesting success is improved. The effect of the type of adjacent upland habitat and distance from the habitat edge on predation of artificial ground nests in red maple swamps was examined during the breeding seasons in 1993 and 1994.

Level of Assessment: site
Project Title: Potential predictors of hyrdoperiod in southern Rhode Island seasonal ponds
Author: Dennis Skidds
Additional Contact(s): Frank Golet
Organization: URI
Publication Information: MS Thesis
Date: 2003
Environment Assessed: seasonal ponds
Assemblages Studied: hydrology, amphibians
Project Goal: The objective of this research was to develop methods for estimating pond hydroperiod from site characteristics such as pond morphology, geology, chemistry, and vegetation.

Level of Assessment: site
Project Title: Using egg-mass counts to monitor wood frog populations
Author: William Crouch
Additional Contact(s): Peter Paton
Organization: URI
Publication Information: Wildlife Society Bulletin, Vol. 28, No. 4
Date: 2000
Environment Assessed: Vernal pools, ponds
Assemblages Studied: amphibians
Project Goal: We assessed the efficacy of using egg-mass counts to monitor wood frog populations in southern RI from 1997 - 1999.

Level of Assessment: site
Project Title: Influences of water depth and substrate nitrogen on leaf surface area and maximum bed extension in Nymphaea odorata
Author: M. Sinden-Hempstead
Additional Contact(s): Keith Killingbeck

Organization: URI
Publication Information: Aquatic Botany 53 (1996) 151-162
Date: 1996
Environment Assessed: vegetated fresh water ponds
Assemblages Studied: vegetation
Project Goal: To determine the relationships among water depth, substrate nitrogen, and leaf surface area in the floating-leaved macrophyte Nymphaea odorata.

Level of Assessment: site - field surveys
Project Title: The atlas of breeding birds in Rhode Island (1982-1987)
Author: Richard Enser
Additional Contact(s):
Organization: RI DEM, Natural Heritage Program
Publication Information: RIDEM. ISBN 0-9633459-0-1. Funding in part by Fed. Aid to Wildlife Restoration Projects
Date: September 1992
Environment Assessed: all bird habitats in RI
Assemblages Studied: birds
Project Goal: "… lack of appropriate baseline data has allowed the successful promotion of projects with only cursory review of the natural elements that would be negatively impacted. It is essential to consider all species in the environmental assessment process." The Atlas provides an important first step in natural areas conservation by identifying the "what and where" of one faunal group. Goals of the atlas project were: to accurately determine the distributions of all breeding birds within RI during 1982-1987, to provide a documented baseline data source for biologists and researchers against which future change to the state's avifauna can be measured, to develop survey techniques that can be duplicated in the future, to provide one element of an ecological database to be used in land use planning, to clarify status of spp which are endangered, threatened, or otherwise uncommon in the state, and document the need for protection of unique and fragile habitats vital to the continued viability of these spp.

Level of Assessment: site, rapid
Project Title: Within-pond parameters affecting oviposition by wood frogs and spotted salamanders
Author: Robert Egan
Additional Contact(s): Peter Paton
Organization: ENSR, URI
Publication Information: Wetlands, Vol. 24, No. 1, March 2004, pp. 1-13
Date: March 2004
Environment Assessed: vernal pools, ponds
Assemblages Studied: amphibians
Project Goal: Wood frogs and spotted salamanders oviposit egg masses that can be surveyed rapidly; thus, we were able to quantify the influence of within-pond parameters on their annual breeding effort.

APPENDIX B

Ohio Rapid Assessment Method (ORAM, Mack 2001)

State of Ohio
Environmental Protection Agency

401/Wetland Ecology Unit
Division of Surface Water

Ohio Rapid Assessment Method for Wetlands v. 5.0

User's Manual and Scoring Forms

February 1, 2001

Please go to the following WebPages for the manual and forms:

http://www.epa.state.oh.us/dsw/401/oram50um_s.pdf

(Last accessed on September 17, 2008)

APPENDIX C

RIRAM F08 Field Form

Background Information

Investigator(s):	
Date:	
Affiliation:	
Address:	
Phone Number:	
Email:	
Name of Wetland:	
Site Code:	
Town:	
Property/Easement Owner:	
Access Directions:	
HGM Class(es):	
NWI Class(es):	Dominance Type(s):
RINHP Community Type(s):	
Lat/Long:	
HUC 12 Name:	
HUC 10 Name:	
HUC 8 Name:	
Assessment Unit Size (acres):	
Photos Taken:	

Site Number: **Raters:** **Date:**

I. WETLAND CHARACTERISTICS RIRAM V. F08

Stressor Total _ _ _ _ _ +

Condition Total _ _ _ _ _ =

RIRAM Total [ ]

1. Assessment Area

Select one

- [ ] >50 acres
- [ ] 25 to 50 acres
- [ ] 10 to <25 acres
- [ ] 3.0 to <10 acres
- [ ] 0.3 to <3.0 acres
- [ ] 0.1 to <0.3 acres
- [ ] <0.1 acres

2. Hydrologic Characteristics

2a. Sources of groundwater. Select all that apply.

- [ ] Groundwater
- [ ] Precipitation
- [ ] Seasonal/intermittent surface water
- [ ] Perennial surface water

2b. Connectivity. Select all that apply.

- [ ] 100 year flood plain
- [ ] Between stream/lake and human use
- [ ] Part of a wetland or upland complex
- [ ] Part of a riparian or upland corridor

2c. Maximum water depth. Select one.

- [ ] > 0.7m
- [ ] 0.4 to 0.7m
- [ ] <0.4m

2d. Duration of water. Select one or double check.

- [ ] Semi- to permanently flooded
- [ ] Semi- to permanently saturated
- [ ] Seasonally flooded
- [ ] Temporarily flooded
- [ ] Seasonally saturated
- [ ] Regularly flooded (tidal)
- [ ] Irregularly flooded (tidal)

3. Habitat Characteristics

3a. Vegetation structural diversity

Rate all present using 0 to 3 scales at right.

- [ ] Aquatic bed
- [ ] Emergent
- [ ] Shrub
- [ ] Forest
- [ ] Mudflats
- [ ] Open water
- [ ] Sphagnum

3b. Horizontal interspersion

Select one.

- [ ] High
- [ ] Moderately high
- [ ] Moderate
- [ ] Moderately Low
- [ ] Low
- [ ] None

3c. Microtopography

Rate all present using 0 to 3 scale at right.

- [ ] Vegetated hummucks/tussucks
- [ ] Coarse woody debris >15cm
- [ ] Standing dead >25cm dbh
- [ ] Amphibian breeding pools

Vegetation Community Cover Scale Apply to metric 3a

0	Absent, or comprises <0.1ha **and** <30% contiguous aerial cover
1	Present and either comprises a small part of the wetland's vegetation and is of moderate quality, or comprises a significant part but is of low quality
2	Present and either comprises a significant part of the wetland's vegetation and is of moderate quality, or comprises a small part and is of high quality
3	Present and comprises a significant part or more of the wetland's vegetation and is of high quality

Mudflat and Open Water Cover Scale Apply to metric 3a

0	Absent, or comprises <0.1ha **and** <30% continuous aerial cover
1	Low 0.1 to 1ha, or <0.1ha **and** comprises >30% continuous aerial cover
2	Moderate 1 to 4ha
3	High 4ha

Microtopography Cover Scale Apply to metric 3c

0	Absent
1	Present in very small amounts or in moderate amounts of marginal quality
2	Present in moderate amounts, but not of the highest quality, or in smaller amounts of the highest quality
3	Present in moderate or greater amounts and of the highest quality

4. Special Wetlands

Check all that apply.

- [ ] Bog
- [ ] Fen
- [ ] Old growth forest
- [ ] Atlantic white cedar swamp
- [ ] Coastal plain pondshore
- [ ] Interdunal swale
- [ ] Mature forested wetland
- [ ] Vernal pool present
- [ ] Known occurrence of state/federal threatened or endangered species
- [ ] Significant migratory songbird or waterfowl habitat or use
- [ ] Other________________________

Site Number: **Raters:** **Date:**

II. STRESSOR METRICS

Stressor Total [ ]

5. Upland buffers and surrounding land use

max 14 pts.

5a. Estimate % cultural cover within 50m buffer. Select one.

- [ ] <5% (7)
- [ ] 5 to 25% (5)
- [ ] 25-50% (3)
- [ ] 50-75% (1)
- [ ] >75% (0)

5b. Land Use Intensity weighted average within 100m buffer.
Estimate proportion of each class to the nearest tenth and multiply.

[ ] Very Low (7)	× 7 =	[ ]
[ ] Low (5)	× 5 =	[ ]
[ ] Moderately High (3)	× 3 =	[ ]
[ ] High (1)	× 1 =	[ ]

Sum weighted values for 5b score: ________

5c. Check all significant 100m buffer stressors that apply. Do not score.

- [ ] Commercial or industrial development or construction
- [ ] Sewered residential development or construction
- [ ] Unsewered residential development or construction
- [ ] Land fill or waste disposal
- [ ] Channelized streams or ditches
- [ ] Raised road beds or trails
- [ ] Row crops, turf, or nursery plants
- [ ] Poultry or livestock operations
- [ ] Orchards, hay fields or pasture
- [ ] Piers or docks
- [ ] Golf course
- [ ] Sand and gravel operation

Very Low:	Natural areas
Low:	Recovering natural lands, passive recreation, low trails/dirt roads
Mod High:	Residential, pasture/hay, mowed areas, raised roads to 2-lane
High:	Urban, impervious cover, new construction, row crops, turf crops, paved roads > 2-lane

6. Hydrologic Stressors (within or abbutting wetland)

max 7 pts.
min 0 pts.

Rate the effects of all stressors observed on 0 to 3 scale at right and sum. **Subtract total from 7.**

- [ ] road bed
- [ ] railroad track
- [ ] weir / dam
- [ ] dike
- [ ] trails
- [ ] other filling / grading
- [ ] drainage ditch
- [ ] tile drain
- [ ] groundwater or surface water pumps
- [ ] stream channelization
- [ ] dredging
- [ ] stormwater inputs
- [ ] sheet runoff inputs
- [ ] other point source
- [ ] nutrient enrichment
- [ ] toxic pollutants
- [ ] other ____________________

_ _ _ _ _ **Total**

________ **7 minus total**

Rating Scale for metric 6
0 - Noted, but no evident effect on hydrology
1 - Minor effect on hydrology evident
2 - Moderate effect on hydrology evident
3 - Severe effect on hydrology evident

Evidence of hydrologic effects and stress. Check all that apply. Do not score.
Apply these to Metric 8.

Increase in water level or hydroperiod
- [ ] Widening of wetland upstream of impoundment
- [ ] Deepening of wetland upstream of impoundment
- [ ] Abrupt wetland edge along impoundment or fill
- [ ] Dead or dying woody vegetation due to flooding
- [ ] Pioneer vegetation community present (saplings)

Decrease in water level or hydroperiod
- [ ] Flowing drainage ditch or tile
- [ ] Perched culvert or dam upstream of wetland
- [ ] Unnatural water level fluctuations obvious
- [ ] Severe root exposure (>20cm)
- [ ] Moderate root exposure (5-20cm)
- [ ] Soil fissures
- [ ] Uncharacteristic ground cover

Change in velocity or flashiness
- [ ] Excessive bank erosion or undercutting
- [ ] Root exposure due to scouring
- [ ] Floodplain erosion
- [ ] Perched culvert or dam downstream of wetland
- [ ] Perched culvert or dam upstream of wetland

Degredation of water quality
- [ ] Excessive algae or floating vascular vegetation
- [ ] Excessive submergent rooted vascular vegetation
- [ ] Rotten egg smell from sediments
- [ ] Excessively clear or strangely tinted water
- [ ] Obvious discharges, plumes, or spills
- [ ] Chemical smell
- [ ] Dead fish or larval amphibians

7. Direct Habitat Stressors (within wetland)

max 7 pts.
min 0 pts.

Rate the effects of all direct stressors observed on 0 to 3 scale at right and sum.. **Subtract total from 7.**
Also apply this metric to metric 9.

- [ ] mowing
- [ ] grazing / browsing
- [ ] clear cutting
- [ ] selective cutting
- [ ] woody debris removal
- [ ] substrate disturbance
- [ ] trails
- [ ] roads / railroad
- [ ] other filling
- [ ] shrub / sapling removal
- [ ] emergent or aquatic bed removal
- [ ] sedimentation
- [ ] dredging / ditching
- [ ] farming
- [ ] dumping trash
- [ ] dumping organic waste
- [ ] other_________________

_ _ _ _ _ **Total**

________ **7 minus total**

Rating Scale for metric 6
0 - Noted, but no effect on habitats evident
1 - Minor effect on habitats evident
2 - Moderate effect on habitats evident
3 - Severe effect on habitats evident

Site Number: **Raters:** **Date:**

III. CONDITION METRICS

Condition Total

8. Wetland Response to Hydrologic Alteration

max 12 pts.
min 0 pts.

8a. Check one only; refer to metric 6
- ☐ No hydrologic stressor effects evident (12). Skip to metric 9.
- ☐ Hydrologic stressor effects evident. Score 8b to 8d below and sum.

8b. Hydrologic response to hydrologic stressors
Check and sum all evident effects of stressors; refer to metric 6.
- ☐ Increase in water level or hydroperiod (1)
- ☐ Decrease in water level or hydroperiod (-1)
- ☐ Change in velocity or flashiness (0)
- ☐ Degredation of water quality (-1)

8x. Original hydrologic modification metric.
Refer to Metric 6
Select one or double check and average.
- ☐ None or none apparent (12)
- ☐ Recovered (7)
- ☐ Recovering (3)
- ☐ Recent or no recovery (1)

8x ☐

8c. Persistence of effective stressor(s). Check one and score.
- ☐ Discrete (3)
- ☐ Historic (>100 ya) but ongoing (1)
- ☐ Ongoing (0)

8d. Current wetland response to hydrologic stressors.
Circle a score for each and average.

	Unaffected		Degraded		Destroyed
Vegetation structure	8	6	4	2	0
Vegetation composition	8	6	4	2	0
Soil condition	8	6	4	2	0
Microtopography	8	6	4	2	0
Hydrologic Connectivity	8	6	4	2	0
		Affected			

Average 8d ☐

9. Wetland Response to Habitat Alteration

max 9 pts.
min 0 pts.

9a. Check one only; refer to metric 7
- ☐ No direct habitat stressor effects evident (9). Skip to metric 10.
- ☐ Direct habitat stressor effects evident.
  Score 9b and 9c below and sum.

9x. Original habitat alteration metric.
Refer to metric 7
Select one or double check and average.
- ☐ None or none apparent (9)
- ☐ Recovered (6)
- ☐ Recovering (3)
- ☐ Recent or no recovery (1)

9x ☐

9b. Persistence of effective stressor(s). Check one and score.
- ☐ Discrete (3)
- ☐ Ongoing (1)

9c. Current wetland response to direct habitat stressors.
Circle a score for each and average.

	Unaffected		Degraded		Destroyed
Vegetation structure	6	5	3	1	0
Vegetation composition	6	5	3	1	0
Soil condition	6	5	3	1	0
Microtopography	6	5	3	1	0
Habitat Connectivity	6	5	3	1	0
		Affected			

Average 9c ☐

10. Wetland State

max 13 pts.

10a. Total coverage of invasive plants. Refer to Appendix 1.
Estimate and select one class.
- ☐ Extensive >75% cover (0) ………………… Class 5
- ☐ High 50-75% cover (2) ………………… Class 4
- ☐ Moderate 25-50% cover (3)………………… Class 3
- ☐ Low 5-25% cover (4) ………………… Class 2
- ☐ Nearly absent <5% cover (5)………………… Class 1
- ☐ None noted (6)

Estimate cover class of each invasive species observed and list. Do not score.

Cover Class	**Species**

10b. Overall habitat development, considering **current** wetland type. Select one and assign score.
- ☐ Excellent (7)
- ☐ Very good (6)
- ☐ Good (5)
- ☐ Moderately good (4)
- ☐ Fair (3)
- ☐ Poor to fair (2)
- ☐ Poor (1)