Delaware Wetland Monitoring Strategy

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Introduction

The State of Delaware is committed to assessing its wetland resources to understand the current condition of the resource and how this condition is changing over time. Understanding the condition of wetlands will allow the State and other conservation partners to better direct resources aimed at restoration and protection efforts to avoid impacts that will further lower the condition of wetland and promote restoration of impacted wetlands. As wetlands are waters of the State, this wetland monitoring strategy is part of the State's overall Water Monitoring Strategy that directs the State's efforts to assess the condition of all waters.

Wetlands comprise approximately 30% of the State's land surface (Tiner 2001) and perform valuable functions including nutrient transformation, stormwater retention, carbon sequestration, sediment deposition, provide habitat for wildlife and maintain the State's biodiversity. These wetland functions in turn provide valuable ecosystem services such as improving water quality, reducing flooding, providing recreational opportunities and enhancing aesthetics and viewscapes. Additionally, because of their prominence in the State they are an important cultural resource to the citizens of Delaware that have supported traditions and customs for centuries. Direct and indirect impacts to wetlands can reduce the condition and subsequently function and ecosystems services that wetlands provide.

The goal of the Wetland Monitoring and Assessment Program (WMAP) of the Delaware Department of Natural Resources and Environmental Control (DNREC) is to assess the condition or health of wetlands and the functions and ecosystem services that wetlands provide. This information will then be used to inform the citizens of Delaware and to improve existing education, restoration, protection, and land use planning efforts (Figure 1.). This monitoring strategy will guide future efforts of the WMAP in the areas of protocol development, and wetland monitoring and assessment activities, research, and application of information.

Program Objectives

The objectives of the WMAP are designed to support wetland protection, management, restoration, and education programs. Specifically, WMAP objectives are:

- Develop scientifically valid assessment methods for wetlands that evaluate the condition of the resource relative to reference condition
- Assess the ambient condition of wetlands by watershed in Delaware and identify major stressors that are impacting wetlands
- Perform research to improve our understanding of wetland functions, the impact of stressors, and ecosystem services
- Evaluate the performance of wetland restoration and other compensatory wetland mitigation in replacing wetland acreage and function
- Use wetland monitoring data to educate State programs, conservation partners, and the general public to improve efforts to protect and restore wetlands
- Integrate monitoring and assessment data into watershed restoration plans and other conservation strategies
- Report on the condition of wetlands in compliance with the Clean Water Act

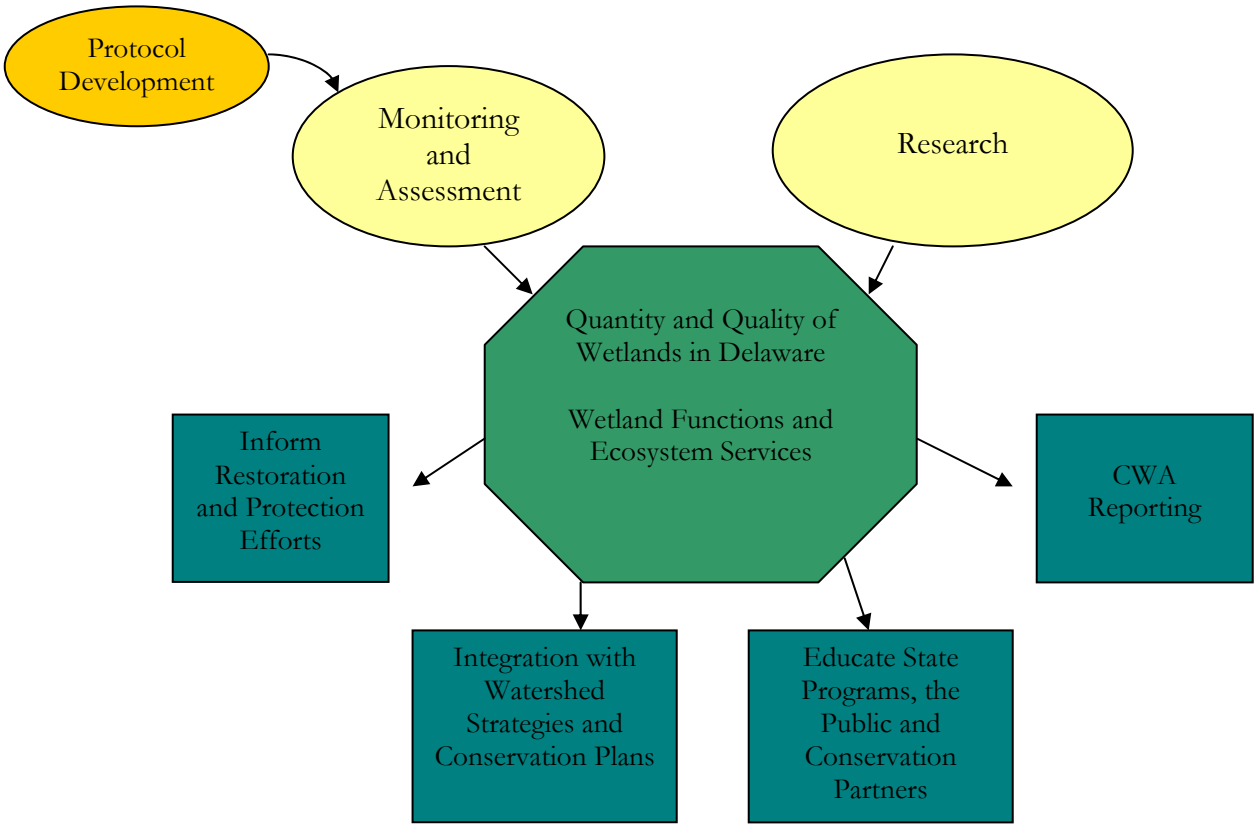

Figure 1. Components of the Delaware Wetland Monitoring and Assessment Program (yellow and orange ovals) needed to achieve the goal of assessing the condition of wetlands (green octagon) and the uses of this information to improve wetland condition (blue rectangles).

PROTOCOL DEVELOPMENT

The assessment of wetland condition requires the appropriate methods for the diversity of wetland types in Delaware. The WMAP has been developing methods using a 4-tiered approach that includes levels of assessment methods: intensive assessment, comprehensive field assessment, rapid assessment, and landscape assessment. The four tiers of assessment vary in the detail of data that are collected and the resources that are needed to perform an assessment. The multi-tiered approach provides options depending on the specific goals and resources available for a project.

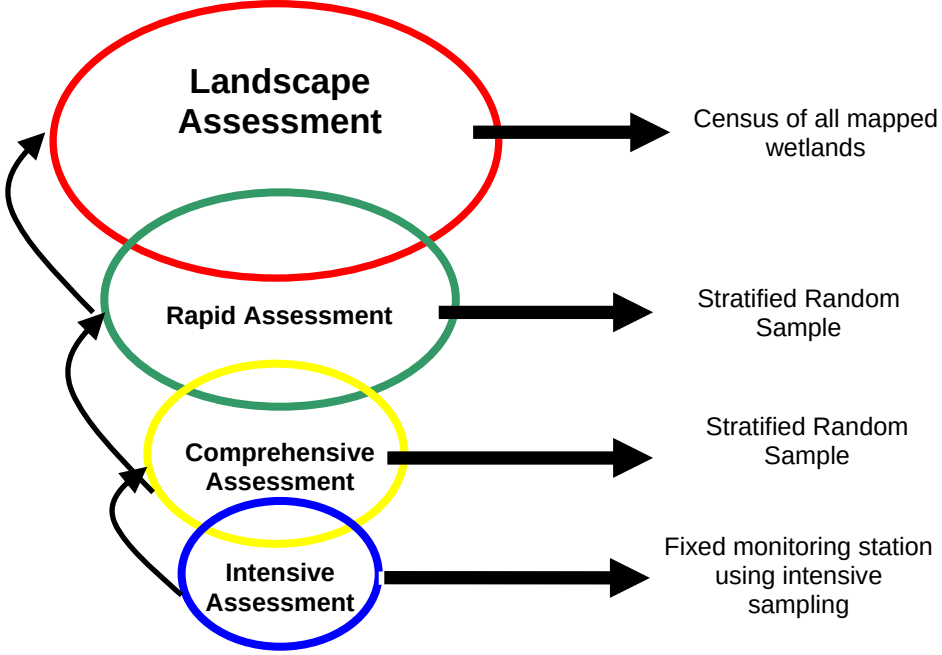

Figure 2. Four tiered approach to wetland assessment. The level of information and amount of effort increases from landscape assessment to intensive assessment.

Landscape Assessment

Landscape assessment involves the prediction of wetland condition based on surrounding land use features that can be remotely detected. For example, if a wetland is surrounded by suburban development, certain predictions can be made about how the wetland functions have been impacted based on studies that have documented the effects of various features associated with development such as increasing impervious surface, increased feral animals, increased noise, etc. The benefits of landscape level analysis are that access to private lands is not limiting, a complete census of all wetlands can be performed, and time and effort is greatly reduced because no field visits are required. The disadvantages to landscape level assessment are that predictions of wetland condition and function are based on documented relationships and may not always apply to specific wetlands, the detail of information is limited based on the type of indicators that can be assessed using remote information, staffing with GIS capabilities are required.

Weller et al. (2007) developed a landscape level assessment method in the Nanticoke watershed to predict the condition of flat and riverine wetlands based on surrounding landscape attributes. This method is a validated assessment because the predictive models were developed based on comprehensive assessment data collected on the same sites. This method can be used to predict the condition of a group of wetlands in the same HGM subclass, but is not able to predict the condition of individual wetlands with a high level of confidence. This method could be useful for prioritizing watersheds based on their level of condition. However, this method will need to be tested in additional watersheds outside of the Nanticoke to determine its applicability to the rest of the State.

Rapid Field Assessment

The Delaware Rapid Assessment Procedure (DERAP) is a rapid assessment method for determining the condition of a wetland based on a short site visit. The DERAP was developed to meet the needs of users that require a rapid assessment of the general condition of a wetland that is based on current site conditions. The DERAP uses a 2-page checklist of stressors and other site features to produce an overall score of wetland condition.

The DERAP is calibrated to the DECAP Index of Wetland Condition (IWC) using step-wise multiple regression analysis to select the stressors that best define differences in sites, and then multiple linear regression (MLR) to assign weights to the stressors. Each wetland class is calibrated separately to produce weights for each wetland type. An overall score for a site is calculated by subtracting the sum of the weights for all the stressors that are present from the possible score if no stressors are present.

The advantages of the DERAP are that it requires less time and field staff to perform, produces an overall assessment of condition that is calibrated to the DECAP, and provides an assessment of the stressors that are impacting the site. The disadvantages to the DERAP are that it does not provide the detail of information to calculate functions and services, and may not provide the level of information needed to make some management decisions.

Comprehensive Field Assessment

The Delaware Comprehensive Assessment Procedure (DECAP) is a comprehensive assessment method for determining the condition of a wetland site relative to reference condition. The DECAP and associated assessment models have been developed and refined by both regional and national wetland scientists following standard HGM development guidelines. Protocols for the DECAP can be obtained by contacting DNREC Watershed Assessment Section.

The DECAP is used to collect data on each reference site and encompasses a variety of parameters including vegetation, hydrology, soils, topography, structure, and surrounding landuses. The goal is to collect data on a wide variety of parameters to determine which ones distinguish sites based on disturbance. These data are then used to scale variables and functions for each wetland subclass. Variables (for example the density of trees per hectare) are scaled based on the reference sites with the highest score of 1.0 indicating that the variable is equivalent to a Reference Standard site (or minimally impacted) down to a score of 0.1 for a highly degraded sites where restoration is possible or 0.0 for a site where restoration is no longer possible for that variable. Variables are then combined into mathematical equations that were developed by a group of wetland scientists to depict functions including maintenance of characteristic hydrology, wildlife habitat integrity, plant community integrity, biogeochemical cycling, and buffer integrity. The final function score is not an absolute value of performance of a function but rather an index of how much that function is departing from a reference standard or minimally altered site.

Field protocols and models are in different stages of development for the various wetland types in Delaware (Table 1). Once a method has been developed for a group of wetlands they can be implemented for monitoring purposes.

Intensive Assessment

Intensive assessment involves the direct measure of specific wetland functions, processes and ecosystem services. Intensive assessments are performed to validate landscape, rapid, and comprehensive assessments and to determine long term changes in wetlands. Currently, the DWMP is working to establish permanent monitoring stations in wetlands throughout the State to collect baseline data on healthy and impacted wetlands and to determine how they are responding to different stressors and changing overtime.

HYDROGEOMORPHIC CLASS[1] Subclass	Dominant water sources of class and flow dynamics	Major source of variation within subclass	NWI vegetation classes[2]	Regional example	Protocol Development
FLAT	Precipitation; Vertical fluctuation				
Mineral soil		Hydroperiod and fire frequency	FO, SS, EM	Wet flatwoods/ Broad areas with poor drainage on mineral soils	Completed combined protocol for organic and mineral flats in the Coastal Plain
Organic soil		Peat depths (from histic epipedons to histosols)	FO, SS, EM	Great Cypress Swamp/ Broad areas with poor drainage that accrete organic matter	
SLOPE	Groundwater discharge and interflow; Unidirectional & horizontal				
Mineral soil		None available	FO, SS, EM	Spring seep	In development by UDE
Organic soil		None available	FO, SS, EM	Forested fen	
Sea-level fen	Groundwater seepage, oligotrophic, acidic freshwater		EM	Sea-level fens	Low priority because there are only a few in the State and Heritage monitors them
DEPRESSION	Precipitation or groundwater; vertical fluctuation				
Inland	With our without inlet and outlets	Hydrology	FO, SS, EM,	Coastal plain ponds, forested depressions	Completed for Coastal Plain
Interdunal Swale	Groundwater driven	Groundwater withdrawal causing intrusion of salt water, ditching, dune crossings, OMWM, invasive species	PEM	Along Atlantic coastal strand and barrier islands, shallow depressions behind primary dune ridges	Not developed
Human impounded or excavated		Size of catchment	SS, EM, AB	Borrow pits; some farm ponds;	Not developed

[1]Upper case in bold are HGM classes; lower case in bold are regional subclasses, except for deepwater environments.

[2] NWI vegetation classes: forested (FO), scrub-shrub (SS), emergent (EM), aquatic bed (AB), unconsolidated shore (US), unconsolidated bottom (UB), riverine (R), Lacustrine (L), estuarine (E), marine (M).

RIVERINE – non-tidal	Overbank flow from channel and groundwater discharge; Unidirectional				
Intermittent-Upper perennial	Non-tidal	Range of hydroperiods within riparian zone (usually < third order), gradient high, water velocities fast.	FO, SS, EM, AB	Riparian forest	Completed combined model for Riverine wetlands on Coastal Plain
Lower Perennial	Non-tidal	Range of hydroperiods within 100-y floodplain, including in-stream terraces and bars (usually > third order) Gradient is typically low; water velocities slow.	FO, SS, EM, AB	Bottomland or floodplain forest	
Beaver-impounded		Dam more temporary than human-impounded; usually < third order	FO, SS, EM, AB	Beaver pond	In development
Human-impounded[4]		Range of water residence times based on impoundment volume and discharge	FO, SS, EM, AB	Mill ponds; large farm ponds created in stream	Not developed
ESTUARINE TIDAL FRINGE	Mixture of sea and fresh water; bi-directional and horizontal				
Estuarine lunar intertidal					
	Freshwater tidal **(ETF)**		FO, EM, AB	Freshwater tidal swamps	Not Developed
	Brackish tidal **(ETB)**	Meso-polyhaline (>5 ppt)	EM, AB	*Spartina alterniflora*-dominated zone	Meso-polyhaline model in development
		Oligohaline (.5 – 5ppt)		*Nuphar advena, Zizania aquatica dominated*	Not developed

Estuarine subtidal		Low energy regime allows SAV establishment (Salinity ranges - 0 to >30ppt)	FO	Mud and sand flats; SAV beds; Oyster reefs	Not developed
Estuarine impounded		Flow is blocked by dike, gate, or dam; water source precipitation except for controlled delivery of estuarine water of varying salinity	FO, EM, AB	Waterfowl impoundments?	Not developed
MARINE TIDAL FRINGE	Marine source; bi-directional and horizontal				
Marine intertidal		N/A	US	High energy beach	Not developed
Marine subtidal		N/A	UB	Shallow littoral	Not developed

MONITORING AND ASSESSMENT

The DWMP uses the 4-tiered assessment protocols to determine the quality of Delaware's wetlands and assess the functions and ecological services that they are providing. However, to develop a comprehensive strategy from site selection to data analysis, various other factors must be considered. The following is an overview of the components of a wetland monitoring and assessment program as outlined in the EPA document, "Application of Elements of a State Water and Monitoring and Assessment Program for Wetlands".

Wetland Mapping

The most recent wetland maps for the State are based on 1992 aerial photography. These maps updated prior NWI maps from 1981/2 using existing Soil Surveys, land use data, statewide natural heritage data, and color-infrared photointerpretation. These maps are on a "quarterquad" basis with a scale of 1:12,000. The Cowardin classification system was used to label each wetland polygon in addition to special state modifiers including exceptional ecological community types, prior-converted wetlands, palustrine farmed wetlands, and riparian wetlands.

The USFWS/NWI method (Tiner 2006) is being used in Delaware as an improved wetland mapping resource for the State. This method uses photo-interpretation to update the location of existing wetlands in the watershed and includes more descriptive labels for each wetland including landscape position, landform, and hydrology modifiers for each polygon. To date the Nanticoke has been completed and the Inland Bays, and Delaware Bay watersheds are currently being updated.

Wetland Classification

We are using an HGM-based system for classifying wetlands in Delaware that was developed for the mid-Atlantic by Brooks et al. (in press). Table 1 provides a description of the subclasses including example communities, hydrology, NWI classification, and major sources of variation. The different wetland types can be differentiated using the wetland maps that have been improved with the HGM modifiers.

Survey Design

The wetland monitoring strategy for the State of Delaware involves two levels of survey design. The first is to prioritize the order in which watersheds in the State will be monitored and the second is to define how we will select sampling locations within a watershed.

> Prioritization of watersheds. Prioritization of watershed monitoring efforts will be based largely on the TMDL implementation schedule. By following this schedule, comprehensive information about the surface waters and wetlands can be combined to develop the best restoration strategy for each watershed. Figure 3 depicts a tentative schedule for future wetland monitoring efforts. The actual dates that these watersheds will be sampled and how many rounds will be sampled in a year will depend on the availability of resources at the State level and

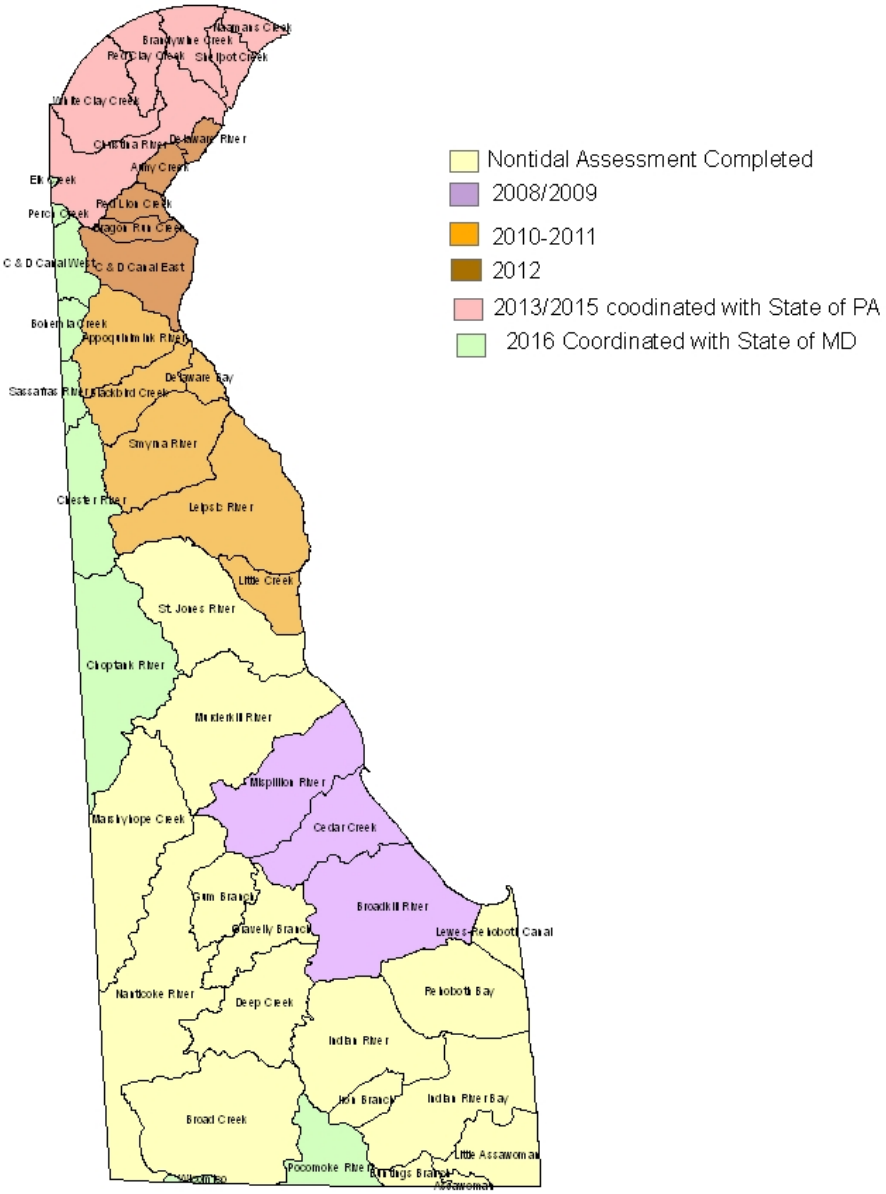

Figure 2. State of Delaware
Tentative Wetland Monitoring Schedule

development of appropriate methods. The intent of the State is to monitor these watersheds using a rotating basin approach once an initial assessment of the wetlands within each watershed has been performed.

Watershed sampling design. The approach used to select sampling locations within a watershed will be a probabilistic sampling design. We currently rely on technical support from EPA's Ecological Monitoring and Assessment Program (EMAP) to randomly select sampling sites within mapped wetlands in a watershed. DE DNREC supplies the base map and any additional criteria such as excluding man-made ponds or only including tidal or non-tidal wetlands. Currently EPA is working on developing a program that would allow States to perform this operation independently. The base map that will be used for all watersheds will be the most up-to-date wetland layer available.

Assessment Indicators and Methods

The State of Delaware is developing multiple levels of assessment methods to assess wetland condition. These levels include a landscape level assessment, Rapid Field Assessment and Comprehensive Field Assessment (Figure 2) and are described in the Protocol section above. Because the DERAP has been calibrated to the DECAP and we are achieving high correlations between the 2 methods, we use a combination of rapid and comprehensive assessments to evaluate the condition of the random sites. We determined that the most efficient use of our resources to collect the most accurate data is to perform comprehensive assessments at approximately 20% of the sites and rapid assessments at the remainder of the sites. We also continue to perform rapid assessments along with the comprehensive protocol to continue to check the correlation of the two methods. Level 1 assessment may be used to provide additional information for prioritizing which watersheds to monitor in the future.

Field Data Collection

Deployment of field crews will be based out of the DE DNREC/ Watershed Assessment Office in Dover, DE. This location will house work space for field crews and computers in which to produce maps and store data. Field crews will depart from this location daily unless we are partnering with another organization to assess the watershed and there is a more suitable location for field crews to be housed.

Based on our experience we believe that it is essential to have a full time coordinator who is responsible for implementing the monitoring in a watershed. This person should be dedicated full time to this task to be able to effectively manage the large amount of information and oversee the multitude of tasks needed to be accomplished to assess the wetlands within a watershed. This person will work directly under the Project Manager who is a DNREC employee.

Access to private property will be essential to the success of this program. We will only sample sites on private property in which we have received permission from the landowner. We have found that, in general, private landowners in Delaware are very

receptive to having field crews collect data on their property that will be used to improve the resources in their watershed. As part of every monitoring effort in a watershed, we will continue to include a public outreach component aimed at distributing information on the goals of the program as well as summaries of the data that we collect.

Quality Assurance Program and Project Plans

The DWMP collects and manages all data under an EPA approved Quality Assurance Project Plan (QAPP). These plans are updated before data are collected in each watershed. The QAPP covers project/ task organization, training, data generation and acquisition, sampling design, sampling methods, quality control, equipment testing, data management, assessment and oversight, and data review verification and validation. A copy of the QAPP can be obtained from DE DNREC/ Watershed Assessment Section.

Data Management Procedures

Training - All persons involved in the data collection process will be required to complete training to properly use the assessment protocols. One to two day training sessions will be offered by DNREC and will consist of lecture on how to properly use the protocols and high quality data collection practices and field training to demonstrate the techniques. Field crew leaders will be required to have additional training consisting of participating on a field crew to collect data until the program manager is confident that they are proficient with the techniques. While collecting data the current QAPP will be followed to ensure the highest quality of data.

Data Collection – All data collection will be performed using the standardized DE Comprehensive Assessment Datasheets and DE Rapid Assessment datasheets. DERAP may also be recorded using a palm computer which has the current version of the DERAP datasheets. Current versions of both methods are available from the DE DNREC/ Division of Water Resources/ Watershed Assessment Section.

Data Storage – All data will be entered into an Access computer database that has been developed to consistently store wetland assessment data. Additionally, if STORET becomes compatible with entering this type of information we will consider its use for including all or parts of the data collected.

Project Reporting Venues

A final report for documenting the condition of wetlands on the watershed scale and the wetland watershed profile will be produced. The condition of wetlands on the watershed scale will be included in Delaware's 305(b) report for the State. Other information will be produced as needed from the data collected including information to assist with prioritizing restoration and protection efforts.

Program Evaluation

A team of scientists and managers will be assembled to review our wetland monitoring strategy every 5 years. This team will consist of individuals with knowledge of sampling methods and techniques, survey design, as well as individuals that will be users of this information including planners and managers. After the team makes a review comments will be incorporated into Delaware's wetland monitoring strategy.

RESEARCH

Although past and current monitoring and assessment efforts in Delaware watersheds have improved our knowledge of wetland functions and conditions locally, a lot of questions still need to be answered.

Current research needs:

- Are healthier (higher condition) wetlands more resilient to sudden wetland dieback or other unpredicted events that affect wetlands?
- How does wetland condition affect the ecosystem services that wetlands provide?
- How is wetland condition as determined by the DERAP and DECAP related to specific wetland functions and aquatic life use?
- What is the impact of sea level rise on wetlands in Delaware and which wetlands are most at risk?
- What is the effect of various stressors such as hydrologic alterations, lack of buffers, and habitat modification on ecosystem services?
- Are there restoration techniques that can be used to reduce the invasion of cattail?

USE OF INFORMATION

Intro and description of each still needed

Inform restoration and protection efforts

Integration with watershed strategies and conservation plans

Educate State Programs, the Public and Conservation Partners

Clean Water Act (CWA) reporting

Literature Cited

Tiner 2001
Tiner 2006
Weller et al. 2007