Wetland Replacement in Massachusetts

June 2018

Scott Jackson
UMass-Amherst Center for Food, Agriculture and the Environment

UMass Amherst

Lisa Rhodes
Mike McHugh
MassDEP Wetlands Program

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

The Center *for* Agriculture, Food and the Environment

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Primary Authors:

Scott Jackson
UMass-Amherst

Lisa Rhodes
Michael McHugh
MassDEP

Major Contributors of Research, Field Investigation, and Data/Policy Analysis:

James Sprague
Alice Smith
Thomas Maguire
MassDEP

Dr. Kevin McGarigal
Kasey Rolih
UMass-Amherst

This report is the result of several years of data collection and analysis completed in 2015 and consideration of the policy and regulatory implications.

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Contents

List of Tables

List of Figures

Abbreviations

Brown and Veneman Study	*Compensatory Wetland Mitigation in Massachusetts*, 1998 by Stephen Brown and Peter Veneman of the University of Massachusetts Amherst
BVW	Bordering Vegetated Wetland
COC	Certificate of Compliance issued under the MAWPA
Created wetlands	A replacement area that meets the criteria of being a wetland (i.e. 50% or greater wetlands vegetation and hydric soils and/or other indicators of wetland hydrology).
MAWPA	Massachusetts Wetlands Protection Act
NOI	Notice of Intent (Application for MAWPA Approval) submitted to the municipal Conservation Commission
OOC	Order of Conditions (MAWPA Approval)
SOC	Superseding Order of Conditions (a decision issued by the MassDEP to resolve an appeal)
The Guidelines	Massachusetts Inland Wetlands Replication Guidelines
Wetland or Wetlands	Resource area defined in 310 CMR 10.55 of the MAWPA regulations as Bordering Vegetated Wetland (BVW)
Wetland Replacement Area	An area constructed as a result of a permit requirement whether or not it meets the criteria of being a wetland

I. Executive Summary

This study, the result of several years of data collection and analysis, is a follow up to *Compensatory Wetland Mitigation in Massachusetts*, published in December 1998 by Stephen Brown and Peter Veneman of the University of Massachusetts Amherst ("Brown and Veneman Study"). A key finding of the Brown and Veneman study was that the majority of wetland replacement projects (54.4%) were not in compliance with the Bordering Vegetated Wetlands performance standards of the Massachusetts Wetland Protection Act regulations, because they were either not built, or they were built but were too small, too dry, or did not meet the 75% indigenous wetland plant revegetation standard. In response to that study, MassDEP in 2002 issued the *Massachusetts Inland Wetlands Replication Guidelines ("the Guidelines")*. This study was initiated in 2011 to evaluate the success of wetland replacement projects since 2002 after the release of the *Guidelines*. The study was completed in 2015 and is referred to as the 2015 study in this report to distinguish it from the 1998 Brown and Veneman study. Since the completion of this study, it has undergone MassDEP internal review, peer review and consultation with other agencies and individuals knowledgeable in the subject area.

Notices of Intent filed between 2004 and 2008 were analyzed in 44 randomly-selected municipalities. Over 4,700 permit applications were reviewed, resulting in the identification of 152 projects that went forward and for which wetland replacement was proposed and/or required. Of these, 130 projects met the study criteria and were sufficiently documented to be assessed in the field. Landowner permission to conduct field assessments was obtained for 91 replacement sites. Field evaluations were conducted on these sites using methodologies similar to those used by Brown and Veneman.

Field investigations revealed that for 12 of the 91 projects replacement areas were never built, a failure rate of 13.2 percent. Of those replacement areas that were built, wetlands vegetation was established at 77 sites (97.5%); however, only 51 of 79 replacement areas succeeded in creating hydrological conditions appropriate for wetlands (64.5%). A number of the 51 replacement areas that met criteria for wetlands were either too small (< 90% the required size) or otherwise failed to meet regulatory requirements.

Mitigation success (or failure) can be represented in several ways. This study documented the following rates of mitigation success.

Replacement area built: 86%
Replacement area built and was wetland: 55.6%

Replacement area built, wetland and appropriately sized: 38.6%

Replacement area built, wetland and met all regulatory performance standards: 34.6%

Replacement area built, wetland, regulatory compliant, and appropriately sized: 26.8%

A number of factors were investigated to determine if municipal or regional characteristics, or characteristics of replacement projects themselves, could be used to explain mitigation success. These included: municipal population, number of NOIs filed, limited project status, NOI quality, OOC quality, quality of the overall permitting process, quality of monitoring, MassDEP region, wetland type, replacement area size, and permitting date. None of these factors showed any statistically significant relationship with any measure of mitigation success.

Comparisons of replacement areas with their associated reference wetlands found very little similarity in their respective plant communities. This was particularly true for forested wetlands, which typically occur on the drier end of the wetness gradient among wetland types. An evaluation of the indicator statuses of plants that occurred in replacement areas suggested a greater affinity for wetlands than for their associated reference wetlands. Again, the discrepancy was greatest for forested wetlands.

The results of this study suggest that highly effective wetland seed mixes and nursery stock can result in the establishment of vigorous wetland plant communities even in areas that lack wetland hydrology. The fact that the vegetation wetness index (weighted average) tended to suggest a greater affinity for wetlands in replacement areas than reference sites, even when many of the replacement areas lacked wetland hydrology, further supports the idea that vegetation can be a misleading criterion for judging mitigation success.

One objective of this study was to compare rates of wetland replacement success for projects permitted from 2004 through 2008, a period after MassDEP issued its guidance document on wetland replacement, with those documented by Brown and Veneman for a

period (1983-1994) that predated the guidance document. Comparisons generally show a small increase in wetland replacement success during the period 2004-2008 when compared to the period studied by Brown and Veneman (1983-1994).

Similar to the Brown and Veneman study completed over 18 years ago, this study found that wetland replacement is less successful than desired, and less successful than required by the MAWPA regulations. Observations made by field investigators and a review of permitting files suggest a number of areas that should be targeted for improvement. The follow-ing considerations are offered to improve wetland mitigation policy and regulation.

1. Strengthen Avoidance and Minimization regulations
2. Increase the required mitigation-to-impact ratios
3. Provide clarification on how to measure that at least 75% of the surface of the replacement area is reestablished with indigenous wetland plant species within two growing seasons
4. Require a Financial Assurance Mechanism (FAM)
5. Update performance standards and improve compliance to ensure that wetland replacement areas have appropriate hydrology.
6. Revise performance standards to allow more flexibility in locating replacement areas
7. Improve specifications for Forested Wetland Replacement Areas in Performance Standards and/or Guidance
8. Require an environmental monitor by regulation (see section H, pg. 54).
9. Extend the timeframe for monitoring from two to five years
10. Revise the Wetland Boundary Requirement
11. Consider allowing a small amount of temporary BVW alteration (that would not count toward the 5000 sf limit)
12. Revise the MAWPA regulations and/or forms to require greater oversight of wetland replacement area construction
13. Revise the MAWPA regulations and/or forms to require that wetland replacement areas be constructed before or coincident with wetland alteration where feasible
14. Consider revising the MAWPA regulations to allow for other strategies that do not require on-site in-kind replacement for all projects
15. Condense and revise the 2002 Wetland Replication Guidance and incorporate the relevant guidelines for BVW from the 2006 Wildlife Habitat Protection Guidelines for Inland Wetlands and make appropriate regulatory revisions

II. Introduction

A. Background

Wetland replacement is required in Massachusetts when loss of regulated bordering vegetated wetlands is proposed. In 1998, Stephen Brown and Peter Veneman of the University of Massachusetts-Amherst published *Compensatory Wetland Mitigation in Massachusetts* (Brown and Veneman, 1998). The primary purpose of the study was "to provide detailed and statistically robust information about the success of current wetlands mitigation practices in Massachusetts." The study also sought to "provide a baseline for comparing the effectiveness of traditional wetland mitigation for comparison with other approaches that may be developed in the future." The study found that "The majority of projects (54.4%) were not in compliance with the requirements of the Massachusetts Wetland Protection Act (MAWPA) regulations for a variety of reasons including no attempt to build the project, insufficient size or hydrology, or insufficient cover of wetland plants."

This (2015) study was conducted using methods similar to those used by Brown and Veneman. The purpose of this study is to determine if the success of compensatory wetland mitigation, specifically wetland replacement (i.e. creation), has improved since the Brown and Veneman Study was conducted.

It is important to note that the terms "wetland" or "wetlands" when used throughout this report refer to the resource area defined in Section 310 CMR 10.55 of the MAWPA regulations (Massachusetts Department of Environmental Protection, 2014)[1] as "Bordering Vegetated Wetland (BVW)." Thus, the terms wetland, wetlands, Bordering Vegetated Wetland or BVW are used interchangeably. Also, throughout this report a "wetland replacement area" refers to an area constructed as a result of a permit requirement whether or not it meets the criteria of being a wetland. The term "created wetlands" refers to a replacement area that meets the criteria of being a wetland (i.e., having 50% or greater wetlands vegetation (310 CMR 10.55(2)(c)) and either hydric soils and/or other indicators of wetland hydrology[2]). A replacement area meeting MAWPA regulations refers to the specific performance standards at 310 CMR 10.55(4)(b) (e.g., the surface area is equal to the lost area, there is an unrestricted hydraulic connection to the same water as the lost area, at least 75% of the surface is reestablished with indigenous wetland plants).

B. Questions Addressed by this Study

This study evaluated a random sample of wetland replacement areas across Massachusetts to provide a statistically valid estimate of whether wetlands are being successfully created, and whether MAWPA performance standards established in the regulations (310 CMR 10.55(4)(b)) are being met. This study addresses the following questions focused on important areas of wetland replacement success.

1. Construction: Were the required wetland replacement areas built?

The Brown & Veneman Study found that "the largest single cause of failure was that no replacement site had been built." The Brown and Veneman study found that 23% of wetland replacement areas were not built. This percentage of failure to construct replacement areas, while deeply troubling, is somewhat better than the results of other studies which showed that as much as 34% to 50% of mitigation areas were never built (National Research Council, 2001). This study also evaluates whether wetland replacement areas have been built, to determine whether efforts to achieve compliance with the wetland replacement requirement have improved in the years since the original study. In this analysis, "wetland replacement area" refers to an area built for the purpose of creating a wetland as a result of a permit requirement. Whether or not it meets the criteria for creating an actual wetland was a separate question (See Question 3 below).

2. Where wetland replacement areas were built, were wetlands created?

Our analysis for this question differed from the methodology of Brown and Veneman. In the Brown and Veneman study, success in creating wetlands was based solely on an evaluation of vegetation, without any effort to assess soils or other indicators of hydrology. The criteria used for this study to determine whether wetland replacement areas were wetland included: 1) Did the wetland replacement area have ≥50% wetland vegetation, and 2) Did the wetland replacement area have hydric soils and/or indicators of wetland hydrology. If the answer was "yes" to both of these questions, then the wetland replacement area was determined to be a wetland. Because the Brown and Veneman study assessment did not address whether hydric soils and/or indicators of hydrology were present, the Brown and Veneman results were adjusted based on the percentage of sites from this study that did not meet the criteria for hydric soils and/or indicators of hydrology to allow for a comparison of current study results to the previous study results.

3. Do the replacement areas meet regulatory performance standards?

The Brown and Veneman Study found that only 43% of projects for which wetland replacement was required were in compliance with MAWPA regulations for replacement areas (see 310 CMR 10.55(4)(b)1-7, included as Appendix A). Noncompliance resulted from replacement areas that were: 1) never built; 2) too small; 3) too dry; 4) too small and dry; and 5) did not meet the 75% indigenous wetland plant revegetation standard. This study evaluated whether wetland replacement areas met performance standards by assessing: 1) size (replacement area ≥ impact area)[3]; 2) groundwater and surface water hydrology; 3) horizontal configuration of the

1 The Massachusetts Wetlands Protection Act regulations for BVW have not changed since 1998 when Brown and Veneman completed their study.

2 310 CMR 10.55(2) defines Bordering Vegetated Wetlands as "areas where soils are saturated or inundated such that they support a predominance of wetland indicator plants." The performance standards for Bordering Vegetated Wetlands require that the ground water and surface elevation of the replacement area shall be approximately equal to that of the lost area (310 CMR 10.55(4)(b)2.) and that there be "an unrestricted hydraulic connection to the same water body or waterway associated with the lost area." (310 CMR 10.55(4)(b)4.)

3 Note that while most analyses in this study assess compliance with size requirements to be those established by the issuing authority in the OOC, the assessment of the seven performance standards considered compliance with size requirements to be the impact size versus the replacement area size, since that is what is required by the regulations at 310 CMR 10.55(4)(b)1.

replacement area with respect to the bordering water body or waterway; 4) location relative to the lost area within the same general area of the associated water body or waterway; 5) hydraulic connection to the neighboring water body or waterway; and 6) vegetation (met the 75% indigenous wetland plant revegetation standard). In addition, the presence (or lack) of hydric soils and/or indicators of wetland hydrology were evaluated as the seventh performance standard. [4] This approach provides a better understanding of not only whether all regulatory performance standards are met, but the success in meeting individual criteria to help assess where weaknesses may lie.

4. How does mitigation planning, design, permitting and compliance monitoring affect mitigation success?

The Brown and Veneman Study addressed whether a previous U.S. Army Corps of Engineers (USACE 1989) study conclusion that projects with higher design standards have a higher likelihood of success was applicable to the state of Massachusetts as a whole, and whether design of wetland replacement projects have improved over time. In general, the Brown and Veneman Study found that the completeness of Orders of Conditions (OOC) that were issued pursuant to the MAWPA regulations approving proposed alterations to wetlands did not improve significantly between 1983 and 1994, but that some improvement may have been occurring toward the end of the study period. They also found that the completeness of wetland replacement plans submitted by applicants improved significantly during the study period. Additionally, they found a significant relationship between the completeness of the replacement plan and/or Order of Conditions and the likelihood that wetland replacement projects would be in compliance with the MAWPA regulations.

In this study, data were collected on the quality of the wetland replacement plan in the Notice of Intent (NOI), the quality of the OOC based on whether specific information was included or required, and the amount and quality of compliance monitoring required by the permitting authority. These data were then analyzed to determine whether there were any significant relationships between these elements of the permitting process and mitigation success.

5. What is the relationship between issuance of Certificates of Compliance (COC) and mitigation success?

During the process of file review for each mitigation project, issuance of a COC (or not) was documented. From these data it was determined how often COCs were issued for projects that did not meet regulatory performance standards.

6. Are there characteristics of the replacement projects or the municipalities in which they are permitted that might help to explain mitigation success or failure?

A number of potential predictor variables, or hypotheses, for how community or regional characteristics might influence mitigation success or failure were identified.

- Municipal population: Communities with larger populations have a larger pool of potential conservation commissioners, increasing the likelihood that those commissions will have members with relevant technical expertise. Larger municipalities are also more likely to have paid staff, either professional staff or administrative assistants, and larger budgets.
- Number of Notices of Intent filed: Perhaps it is not the size of the municipality that is important, but the level of experience of its commissioners. Those communities that receive more filings for wetland permits may have developed more experience and standardized approaches to project review and permitting that might lead to higher rates of mitigation success.
- Limited Project Status: "Limited Projects" (310 CMR 10.53) are a category of project in the MAWPA regulations for which permitting authorities are given discretion to waive performance standards. Perhaps mitigation success would be expected to be lower for these projects because they are not necessarily held to the same standards as other projects in wetlands. [5]

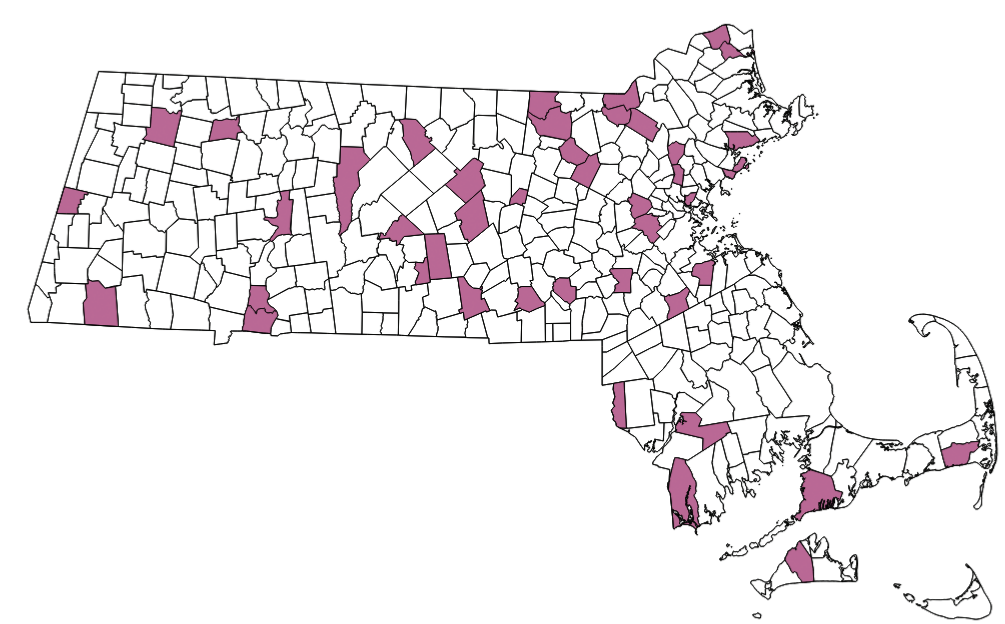
4 This seventh criterion was evaluated notwithstanding the actual Criteria 7 in the WPA regulations, which states that "the replacement area shall be provided in a manner which is consistent with all other performance standards for each resource area in Part III of 310 CMR 10.00." Evaluation of Criteria 7 was beyond the scope of this study, and would have been made more difficult because many of these projects may have met criteria in 310 CMR 10.53 for "limited projects," which allows the issuing authority to permit a project notwithstanding the performance standards.

5 The analysis of limited projects was based on a determination as to whether or not a project may have been permitted as a limited project based on the project description. In general, most project files did not indicate whether or not the project was approved as a limited project.

Table 1: List of Municipalities (n=44) (See Figure 1)

Acton	New Marlborough
Agawam	New Salem
Amesbury	Newburyport
Beverly	Newton
Braintree	Northbridge
Buckland	Oxford
Clinton	Pepperell
Dracut	Princeton
East Brookfield	Reading
Everett	Richmond
Falmouth	Savoy
Freetown	Seekonk
Groton	Spencer
Hadley	Stoneham
Harwich	Stoughton
Holden	Swampscott
Littleton	Templeton
Lowell	Tewksbury
Marblehead	Waltham
Medfield	West Springfield
Milford	West Tisbury
New Braintree	Westport

Figure 1: Map of Study Municipalities—Wetlands Mitigation Assessment



- Quality of the Notice of Intent: Higher mitigation success might be expected for projects with more complete wetland replacement plans included in their NOIs.

- Quality of the Order of Conditions: One might expect to find that mitigation success is higher when permitting authorities include special conditions in their permits (Orders of Conditions) related to wetland replacement.

- Quality of the Permitting: Some permitting authorities regularly include special conditions in their permits, while others insist that all the changes and details required during the permitting process be included in revised plans associated with Notices of Intent. Applicants are bound by the plans in the NOIs, and so this is also a valid way for commissions to influence the design, construction, and monitoring of replacement projects. Quality of the permitting is an evaluation of both the quality of the application (NOI) and the quality of the permit (OOC).

- Quality of Monitoring: When specific monitoring requirements are included in either the Notice of Intent or Order of Conditions, and if there is evidence of that monitoring actually occurring, did replacement projects show better mitigation success?

- DEP Region: Does the MassDEP region in which the project is permitted affect compliance rates?

In addition, this assessment looked at the characteristics of the wetland replacement project itself to see if they might be predictive of mitigation success.

- Wetland Type: Does the type of wetland (forested wetland, shrub swamp, marsh) being replicated influence mitigation success?

- Size: Perhaps larger wetland replacement projects are more successful than smaller ones because more planning, construction, and monitoring resources are likely to be used for larger projects.

- Date: Older replacement areas may be more successful because they have had more time to recover and mature from the initial construction activities.

7. Did issuance of *the Guidelines* in March 2002 result in any improvement in wetland mitigation success?

In 2002, MassDEP issued *the Guidelines* (Massachusetts Department of Environmental Protection, 2002). The guidance included some additional considerations that are not specifically covered in the performance standards, such as guidance on soils and monitoring. An evaluation was conducted to determine whether the guidance was being followed and whether success had increased as a result.

8. Are the plant communities in wetland replacement areas similar to those in their associated reference wetlands?

The MAWPA regulations at 310 CMR 10.55(4)(b) require that the replacement area function in a manner similar to the area that will be lost. Brown and Veneman used plant community as an indicator of similarity of function between impacted and replacement sites. However, as Brown and Veneman point out, the preface to the 1983 regulatory revisions note that "the functions served by bordering vegetated wetlands cannot be replicated in their totality by engineering means" (310 CMR, Preface, V C.). In this study the same similarity analyses were conducted as those used in the Brown and Veneman study.

C. Questions Not Addressed by this Study

Similar to the Brown and Veneman study, this study does not address projects with wetland impacts for which the conservation commission did not require wetland replacement, nor does it address unpermitted losses that occur in violation of the MAWPA. Further, this study does not address wetland restoration (as opposed to wetland creation) required as mitigation for impacts or to restore temporary impacts.

Although the MAWPA regulations require that replacement areas function in ways similar to the areas lost, there is currently a lack of widely accepted methodologies to assess and quantify wetland functions. Therefore, this study makes no effort to determine whether replacement areas are meeting the MAWPA regulatory standard that the replacement area function in a manner similar to the area that will be lost. This study is confined to evaluating mitigation success at its most basic levels: Did the project proponent attempt to build the replacement area? If so, was the replacement

Table 2: Break-Out of Municipalities by Sample Variables

DEP Region	Sample Municipalities	Sample Municipalities %	All Municipalities %
CERO	15	34.1%	21.7%
NERO	13	29.5%	23.9%
SERO	8	18.2%	23.9%
WERO	8	18.2%	30.5%

Ecoregions	Sample Municipalities	Sample Municipalities %	All Municipalities %
Boston Basin	5	11.4%	7.69%
Bristol Lowland/ Narragansett Lowland	3	6.8%	9.12%
Cape Cod/Long Island	3	6.8%	6.55%
Central Plateau	5	11.4%	11.68%
Connecticut River Valley	3	6.8%	5.70%
Northeast Highlands	4	9.1%	17.38%
Southern New England Coastal Plains and Hills	21	47.7%	41.88%

Population	Sample Municipalities	Sample Municipalities %	All Municipalities %
≤ 3000	8	18.2%	22.5%
3001 – 10,000	6	13.6%	28.2%
10,001 – 50,000	27	61.4%	42.7%
> 50,000	3	6.8%	6.6%

NOIs Filed (2004 – 2008)	Sample Municipalities	Sample Municipalities %	All Municipalities %
≤ 10	3	6.8%	9.1%
11 – 25	3	6.8%	9.1%
26 – 50	7	15.9%	14.8%
51 – 100	9	20.5%	23.1%
101 – 200	17	38.6%	29.3%
> 200	5	11.4%	14.5%

area a wetland? And did replacement areas that were built meet the specific performance standards in 310 CMR 10.55(4)(b) (not including wetland function) for wetland replacement?

D. Analysis of Previous Studies

In their report, Brown and Veneman discussed their original proposal to do a follow-up study to the 1989 Army Corps of Engineers (USACE) report (USACE, 1989) [6]to determine the longer term success of the mitigation sites studied in that report. The 1989 USACE report documented a 36% failure rate for wetland replacement projects. After evaluating the USACE study, Brown and Veneman concluded that "given the limitations of the original database design, and the lack of landowner records, the original study records were of limited value and did not provide an adequate basis for determining mitigation success statewide." Thus, they proposed and implemented a study design that differed from that of the USACE. Our study more closely follows the methodology used by Brown and Veneman.

III. Methods

A. Identification of Study Sites

The approach taken in the selection of municipalities for inclusion in the study is similar to, although not exactly the same as, that taken by Brown and Veneman. Both approaches yielded a randomized sample of Massachusetts municipalities with an appropriate geographical representation.

Using a random-numbers generator, random numbers were assigned to each of the municipalities in Massachusetts. These numbers were then arranged from lowest to highest. We chose 40 communities as our initial sample (choosing the first 40 from the list). This random sample of municipalities was then evaluated to ensure adequate representation by:

- DEP Region
- Ecoregion
- Population
- Numbers of Notices of Intent (NOIs) filed during the years 2004-2008

Bins were designated for each of these sampling variables for purposes of evaluating the random sample of municipalities (see below for details on the designation of bins).

Additional municipalities were added until at least three municipalities were included in each bin for each of the four sampling variables considered (DEP region, ecoregion, population and NOIs). The process for adding municipalities involved running down the list of randomized municipalities and choosing the first one that was from an under-represented group (bin). This was repeated until all bins had at least three municipalities.

A total of four municipalities were added to ensure adequate representation. One municipality each was added to increase to three the number of municipalities in each of the first two bins (≤ 10 and 11-25) for number of NOIs filed. Two municipalities (cities) were added to increase to three the number of municipalities in the highest bin (> 50,000) for population.

Designation of Bins for Sample Variables

MassDEP Regions

- Northeast (NERO)
- Southeast (SERO)
- Central (CERO)
- Western (WERO)

Ecoregions

- Northeastern Highlands Central Plateau
- Connecticut Valley
- Central Plateau
- Boston Basin
- Cape Cod/Long Island
- Bristol Lowland/Narragansett Lowland
- Southern New England Coastal Plains and Hills

6 In 2003, the USACE issued a new report (Minkin and Ladd, 2003) that found that 67% of mitigation projects were determined to meet permit conditions, but only 17% were considered to be adequate functional replacements for impacted wetlands.

Table 3: Ecoregions – Brown and Veneman versus Current Study

Brown & Veneman	
7 Categories	EPA Level IV Categories
Northeastern Highlands Central Plateau	-Taconic Mountains -Western New England Marble Valleys -Green Mountains/Berkshire Highlands -Lower Berkshire Hills -Berkshire Transition -Vermont Piedmont
Connecticut Valley	Connecticut Valley
Central Plateau	-Worcester/ Monadnock Plateau -Lower Worcester Plateau/Eastern Connecticut Upland
Boston Basin	Boston Basin
Cape Cod/Long Island	Cape Cod/Long Island
Northeastern Coastal Zone	-Part of Southern New England Coastal Plains and Hills
Southeastern Coastal Zone	-Part of Southern New England Coastal Plains and Hills -Bristol Lotwland/ Narragansett Lowland

Current Sampling Scheme	
7 Categories	EPA Level IV Categories
Northeastern Highlands Central Plateau	-Taconic Mountains -Western New England Marble Valleys -Green Mountains/Berkshire Highlands -Lower Berkshire Hills -Berkshire Transition -Vermont Piedmont
Connecticut Valley	Connecticut Valley
Central Plateau	-Worcester/ Monadnock Plateau -Lower Worcester Plateau/Eastern Connecticut Upland
Boston Basin	Boston Basin
Cape Cod/Long Island	Cape Cod/Long Island
Bristol Lowland/Narragansett Lowland	Bristol Lowland/Narragansett Lowland
Southern New England Coastal Plains and Hills	Southern New England Coastal Plains and Hills

Population

- ≤ 3000
- 3001 – 10,000
- 10,001 – 50,000
- > 50,000

NOIs Filed from January 1, 2004 through December 31, 2008

- ≤ 10
- 11 – 25
- 26 – 50
- 51 – 100
- 101 – 200
- > 200

Differences between our sampling approach and that used by Brown and Veneman

Here are some of the ways that our approach differed from that of Brown and Veneman.

- Brown and Veneman stratified their sample by weighting MassDEP regions by the relative number of NOIs filed. In our approach each municipality was assigned to an NOI class (see above) and we then added municipalities to the random sample to ensure adequate representation from each of the NOI class bins.

- Brown and Veneman stratified their sample by seven ecoregions. The random sample of municipalities in this study was evaluated and it was determined that each of the ecoregions was adequately represented and that no adjustments were needed. Our seven ecoregions differed somewhat from those used by Brown and Veneman (see Table 3 for details).

- The current approach adjusts the sample of municipalities to ensure adequate representation by population. Population was not considered by Brown and Veneman.

All but seven municipalities selected for this study were different from the ones that were selected for the Brown and Veneman Study. The municipalities that were in both studies include Amesbury, Braintree, Lowell, Swampscott, Oxford, Hadley, and West Springfield. There were no attempts in either study to determine compliance for individual municipalities.

B. Collection of File Data

For each of the 44 municipalities identified for study, the conservation commission was contacted and an appointment was requested to view their files for all Notices of Intent submitted between January 1, 2004 and December 31, 2008 ("the study period"). The 2004 start date of this study allowed for enough time after the 1998 Brown and Veneman Study and issuance of the 2002 *Guidelines* to be able to evaluate mitigation success and to observe any improvement. The study sample dates allowed for more than two growing seasons for the establishment of replacement areas to achieve compliance with the MAWPA regulations at 310 CMR 10.55(4)(b). As the files were reviewed, all files where wetland replacement was required were flagged for more intensive examination. A total of 5,090 NOI's were submitted in the 44 municipalities during our study timeframe, and 4,718 of those files were reviewed. Acton, Braintree, New Braintree, Savoy, Seekonk and West Tisbury pulled the files for us or reported that there were no files with wetland replacement. Projects involving coastal wetlands or other types of inland resource areas (e.g. bordering land subject to flooding, riverfront area) were not included in the study. For each file with wetland replacement, the information outlined in Appendix B was recorded: Town Data Form, including descriptions of the Notice of Intent data, the Order of Conditions data, the Project Plans, the Monitoring data if present, and the Certificate of Compliance if one had been issued. In addition to completing the Town Data Form, photos of project plans, and pertinent pages of the NOI, the OOC, or other data were taken.

Of the 4,718 files reviewed, a total of 198 proposed and/or required wetland replacement areas were identified. Note that 14 projects had multiple replacement areas. Of the original 198 wetland replacement areas, 22 were eliminated because files were poorly documented and these sites ultimately did not meet study criteria (e.g., many sites were restoration or invasive species removal and not replacement, even though the file indicated replacement). Thus, 176 wetland replacement areas were investigated.

Table 4: Town File Reviews and Field Investigations 2015 v. 1998

	2015 MassDEP/UMass Study (5-year span: 2004-2008)	1998 Brown & Veneman Study (12-year span: 1983-1994)
Files Investigated	4,718	3,519
Replacement Sites Found	198	319
Replacement Sites Eliminated (Did not meet study criteria)	22	205
Replacement Areas Investigated	176	114
Project Not Built	46	5
No Landowner Permission	38	Landowner permission not addressed in study
Total Replacement Areas Visited	92	109
Could not determine status	1 (Applicant moved, site overgrown)	n/a
Project Built/ Replacement Built	79	84
Project Built/ Replacement Not Built	12	25

Of these 176 proposed replacement areas, 46 were not built because the projects they were proposed to mitigate for never went forward. Landowner permission was not obtained for 38 sites, including 4 verbal denials and 34 for which attempts to contact landowners were unsuccessful. Limited analyses were conducted for the 34 sites (see next section). Field investigations were conducted at the remaining 92 sites. The field investigations resulted in no assessment of 13 sites because either the status could not be determined (n=1) or the project was built but the replacement area was not built (n=12). Although replacement areas that were not built were not included in the evaluation of success in constructing a replacement area that became a wetland, they were included in the overall evaluation of mitigation success. A total of 77 full field assessments and 2 partial field assessments were completed for replacement areas that had been built.[7]

7 The partial field assessments excluded the point-intercept vegetation data collected at 100 points due to landowner limitations. All other data collected for the 77 sites were collected at the two partial field assessment sites, including percent cover for vegetation.

C. Landowner Permission and Rapid Assessments

The goal of the study was to conduct site visits at as many of the projects proposing wetlands replacement as possible; however, landowner permission was necessary in order to enter onto private property to conduct an evaluation. A rigorous attempt was made to reach all landowners, including a letter, a minimum of 2 follow-up phone calls, a phone call to the municipal conservation commission (if needed), and then as a final step knocking on doors. Despite our best attempts, there were landowners that could not be reached. In some cases, the land changed hands so many times that it was difficult to find or contact the current landowner. In many cases they had unlisted phone numbers and were not present when the visit to the site was attempted. In other cases, people may have feared further regulatory involvement or enforcement and either failed to respond or denied permission to access the site. This raised concerns that not being able to get permission to access all sites could introduce bias into our study design. For example, if landowners who failed to respond or denied access did so because they believed their sites were not in compliance, then our evaluation based on sites where access was permitted could be overestimating mitigation success.

For those sites where landowner permission could not be obtained, many were situated on the property visible from either the road or a driveway to the home or commercial building. A rapid assessment protocol was developed to address both scenarios (i.e., a "Public Way Assessment" and a "Private Way Assessment") (See Appendix C). The rapid assessment methods did not allow the same level of data to be obtained as for those sites where landowner permission had been obtained. The observations from the public and private assessments provided a sense of whether the rates of non-compliance are higher (or lower) for non-permission sites relative to permission sites, based on 1) failure to build the replacement area and 2) clear indication based on a distant view that if the replacement area was built, it failed to establish a wetland.

These data have not been included in the larger study of mitigation success, but are used in the discussion of results pertaining to the percentage of sites built. This would allow us to determine a correction factor that can be used to modify results of the study based on the rapid assessment of non-permission sites. For example, if 30% of sites are non-permission sites and the rate of non-compliance is 100% higher than for permission sites, it is possible to calculate an adjustment that could yield a better (non-biased) approximation of non-compliance rates.

Example:

Non-permission sites (30% of sites): 40% rate of non-compliance

Permission sites (70% of sites): 20% rate of non-compliance

Overall rate of non-compliance = (0.3 x 40) + (0.7 x 20) = 26%

Using this correction factor, a more realistic non-compliance rate (26%) was obtained; otherwise the non-compliance rate of 20% would be biased and erode the credibility of the study results. This addresses the concern that landowners who do not give permission to access replacement sites may have refused access because they have not built the replacement areas.

Because of limitations on the type and quality of data that can be collected at non-permission sites, data could not be "corrected" for measures of mitigation success (e.g., ability to replicate plant community, evaluation of wetland hydrology, calculation of prevalence index values) other than a gross assessment of whether or not a replacement area was built.

D. Full Field Assessments (Replacement Area and Reference Wetland)

Each wetland replacement area for which access was granted was visited to collect data (see Appendix D). Wetland delineations were not performed; however, the boundary of the wetland replacement areas could almost always be readily identified through either an obvious break in slope or changes in vegetation, or the presence of erosion/siltation controls that had not been removed. Functional assessments also were not performed. At each site an adjacent or nearby reference wetland was evaluated using the same methodology as was used for the replacement area. The reference wetland was either immediately adjacent to the altered wetland, or, in most cases, immediately adjacent to the replacement area. The wetland adjacent to the filled wetland was often difficult to assess because the wetland had already been altered, was inaccessible and/or was located in a high traffic area. In most cases, when the wetland adjacent to the replacement area was used it was in the same wetland system as the altered wetland. The reference wetland sample plot was approximately the same size and shape as the replacement area that was assessed. The assessments were focused on whether the site met the performance standards at 310 CMR 10.55(4)(b), and were not intended to be functional assessments.

The following data were collected and entered into the Field Data Form for each site:

1. Was the replacement area built?

By using the project locus map and site plans obtained from the issuing authority, the site of the proposed replacement wetland was visited to see if it was actually constructed (or attempted). This involved a visual observation to determine if clearing, grading, planting, or other activities typically associated with wetlands replacement construction were undertaken. Often, erosion and sedimentation controls, stakes and/or plant tags were left in place and researchers became accustomed to looking for these clues to help locate the replacement areas.

2. Size of replacement area:

Using a measuring tape in the field, the area of the replacement wetland was determined. The measuring technique was based on the shape of the replacement area. Similar to the Brown and Veneman Study, replacement areas that were 90% of the required size were considered to have met the size requirement (thus, a conservative approach to address any possible measurement errors).

3. Estimated Percent Cover:

An ocular estimate of the total percent cover for each plant species that represented 1% or greater of the replacement area was recorded. Percent cover was estimated visually as the percent of the ground surface that would be covered if the foliage from a particular species were projected onto the ground, ignoring small gaps between the leaves and branches. See page 13 of the MassDEP manual entitled *Delineating Bordering Vegetated Wetlands under the Massachusetts Wetlands Protection Act* dated March 1995 (*http://www.mass.gov/eea/docs/dep/water/laws/a-thru-h/bvwmanua.pdf*). The wetland plant indicator status of each plant species that represents greater than 1% cover, based on the 1988 and 2012 *National List of Plant Species That Occur in Wetlands: Massachusetts* (*http://www.plants.usda.gov/wetinfo.html*), was also recorded (after the site visit).

4. Point-Intercept Percent Coverage:

Using a series of random transects, vegetation was sampled at 2-foot intervals until 100 points had been sampled. Random transects were established by starting at an upland edge and flipping a pencil in the air such that it twirls and falls to the ground. The direction the pencil pointed into the replacement area is the direction of the first transect to the opposite edge. Upon reaching the opposite edge, the procedure was repeated until a total length of 200-feet is obtained. At every 2-foot point, each plant species along a vertical line was recorded.

5. Relative Elevation:

The replacement area was reviewed using visual estimation to see if it was lower, higher, or equal to the elevation of the adjacent wetland or waterway.

6. Hydrology:

An ocular evaluation of the replacement area was conducted in the field to determine: 1) if there was evidence of dieback resulting from prolonged periods of inundation; 2) evidence of drying out of the adjacent wetland; and 3) whether the replacement area was not excavated deeply enough (to provide contact with groundwater). The degree of saturation was determined visually, by noting the presence or absence of standing water, and the presence or absence of saturated soils (note Soils Data Section below). The depth to saturation was determined by observing the presence of free water in the soil hole (also described in the Soils Data Section below). In general, saturation greater than 16 inches deep was not located. It was also noted if the replacement area received water from stormwater features (e.g. outfall pipes) and/or if it had an unrestricted hydraulic connection to a neighboring water body or waterway. Other indicators of hydrology were also recorded, including the presence of water stains, standing water, adventitious rooting, buttressing and oxidized rhizospheres (pore linings).

7. Soils Data:

At each site, the soil was sampled at one location that was representative of overall site conditions. Sampling consisted of digging a soil hole approximately 12 inches in diameter to a minimum depth of 16 inches, and typically deeper where hydric soils indicators (i.e., saturation or anaerobic conditions) or other indicators of hydrology were not encountered. A representative profile slice from the soil hole was removed and the depth, texture and color of each soil layer was recorded, as appropriate (where histosols were identified, the depth of the organic material was recorded). Also, the color and depth of any redoximorphic features such as concentrations or depletions were recorded. All soil colors were documented using a Munsell Soil Color Chart. Indicators of saturation and anaerobic conditions were documented in the uppermost horizon of soil and the subsoil down to 16" in depth. If redoximorphic indicators were found within the upper 12" of the surface or organic soil indicators documented to a sufficient depth, then the site received a "Yes" for having hydric soils.

The following hydric indicators were used in the uppermost horizon (i.e., "placed soil" in the case of wetland replacement sites):

- Soils that had a minimum of 16" of dark black organic material as measured from the soil surface. These are soils that would normally be considered histosols (organic soils);

This placed topsoil exhibits oxidized rhizospheres and redox concentrations within 12 inches of the surface, therefore it meets the criteria used in this study for documenting the presence of saturation leading to anaerobic conditions.

- Soils with a Histic Epipedon (an organic layer at the surface) when the organic layer is 8" to 16" deep;
- Hydrogen sulfide smell. A “rotten egg” smell indicates that sulfate in the soil has been converted to hydrogen sulfide gas as a result of prolonged anaerobic conditions. Any soil that had this “rotten egg” smell was considered to exhibit anaerobic conditions, regardless of depth, texture, or color of any soil layers.
- The presence of oxidized rhizospheres, pore linings, redox concentrations, nodules, or concretions in the topsoil. Because it was understood that such features may be particularly difficult to discern in a newly forming soil, for the purposes of this study these indicators did not have to meet extant coverage specifications, nor did they need to be distinct and/or prominent if in the judgment of the field scientist, the soil was on a trajectory to become hydric. [8]

When the above indicators were not found in the uppermost horizon, the extant (i.e. native) subsoil was evaluated. The following indicators were used in the extant soil when they were found within 12 inches of the surface:

- A predominantly neutral gray color (commonly referred to as “gleyed”); In the field, this meant any dominant soil color that matched the gley page from the Munsell color chart;
- A dominant soil color with a value of 4 or higher, and a chroma of 0 or 1 on any page;
- A dominant soil matrix color with a value of 4 or higher, a chroma of 2 or less, and presence of redoximorphic features such as redox concentrations (“mottles”), depletions, concretions, or nodules
- A dominant soil matrix color with a value of 4 or higher, a chroma of 3 or less, and with 10% or more low chroma mottles.[9]

8 In certain extant soils (i.e. ones that developed in place) these features would often need to be present in defined quantities and/or colors in order for the soil to meet the technical definition of a hydric soil. However, in wetland mitigation areas the topsoil, which would generally be equivalent to the A horizon in a natural soil, consists of human-transported material and may not have been in place long enough for such features to fully develop.

Soils that did not exhibit any of the above were deemed to lack hydric soil indicators.

For the purposes of this study, however, the presence of a soil exhibiting indicators of saturation or anaerobic conditions was not the only criteria for a mitigation area to be considered to have wetland hydrology. Understanding the difficulty in assessing the hydrologic regime in altered and placed fill material, investigators also documented other indicators of hydrology, including:

- Direct observation of standing surface water
- Direct observation of groundwater in the soil hole within 12" of the surface
- Direct observation of saturated soil conditions as indicated by water glistening on the face of soil hole and pedon surfaces within 12" of the surface
- Water stains on trees, boulders, retaining walls or similar features (which would indicate previous inundation of the site)
- Water-stained and matted leaves
- Soil surface cracks or algal mats in un-vegetated depressions.
- Drift lines or drift material (which would indicate that the site was subject to flooding events)
- Adventitious rooting, swollen bases, fluting, or other plant morphological adaptions to growing under saturated soil conditions

A site that exhibited any indicators of hydrology or had a soil that exhibited characteristics of saturation and anaerobic conditions was determined to have wetland hydrology. It did not have to have both. The above approach worked for the majority of the sites, but in the few cases where atypical situations occurred and the hydric soil indicators described in MassDEP, 1995, *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act, A Handbook*, were not sufficient to judge whether the soil was hydric, USACE (U.S. Army Corps of Engineers, 2012, Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region, Version 2.0) and NRCS (2010 *Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils, Version 7.0*), were used to inform best professional judgment.

8. The presence of specific invasive species listed in the replacement guidance was documented.

Those species are: Purple Loosestrife (*Lythrum salicaria*); Common Reed (*Phragmites australis*); Glossy False Buckthorn[10] (*Frangula alnus*); Honeysuckles (*Lonicera spp.*); Garlic Mustard (*Alliaria petiolata)*; Japanese Black Bindweed[11](*Fallopia japonica*); Japanese Stilt Grass[12] (*Microstegium vimineum*); Reed Canary Grass (*Phalaris arundinacea*); Oriental Bittersweet (*Celastrus orbiculatus*); Louise’s Swallow-wort[13] (*Cynanchum louiseae*) or Pale Swallow-wort (*Cynanchum rossicum*).

9. Documentation also included whether erosion and sedimentation controls had been removed and the soils and embankments properly stabilized and vegetated. Haybales left to decay did not meet the criteria.

E. Data and Statistical Analyses

The data collected for the statewide assessment sites were analyzed using similar parameters as the Brown and Veneman report to answer the questions described earlier in this report in Section II.b.

1. Was the replacement area built and was it the required size?

Using field measurement of sites that were actually built, the size of the replacement area approved by the issuing authority was compared with the area measured in the field to confirm that the sizing was as required.

9 The MassDEP 1995 *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act, A Handbook* typically requires that soils with a matrix chroma of 3 also exhibit indicators of saturation within 6 inches of the soil surface to be considered a hydric soil indicator. However, it was observed that the upper 6 inches of soil at most wetland replacement areas were recent human-placed material. To eliminate questions of whether the human-transported material had sufficient time to develop the appropriate indicators of prolonged saturation, for the purposes of this study indicators within 6 inches of the surface were not required to be present for a soil to be considered hydric.

10 Formerly known as Glossy Buckthorn (*Rhamnus frangula*)

11 Formerly known as Japanese Knotweed (*Polygonum cuspidatum*)

12 Formerly known as Nepal Microstegium (*Eulalia viminea*)

13 Formerly known as Black Swallow-wort (*Cynanchum nigrum*)

The distinct and abrupt color change in this soil profile identifies the boundary between the placed soil above and the extant (native) soil below. The shallow placed topsoil is newly forming; however, the extant subsoil is gleyed (and occurs within 12" of the surface), indicating prolonged saturation. Therefore, this soil meets the criteria used in this study for documenting the presence of saturation and anaerobic conditions needed to develop hydric soils.

The soil profile did not exhibit indicators of saturation or anaerobic condition in the topsoil or the subsoil, therefore it did not meet the study criteria for hydric soil.

Table 5: Variables with the Potential to Affect Mitigation Success

Predictor Variable	Type	Notes
Population	Categorical	Municipality population (multiple sites have the same value)
# of NOIs	Categorical	Number of filings per municipality (multiple sites have the same value)
OOC Date	Continuous	Date of issuance for the Order of Conditions (some missing values)
OOC REP_SIZE	Continuous	Size of proposed replacement area (some missing values)
Ref_type	Categorical	Reference wetland type
Quality NOI	Continuous (integer)	0-10
Quality OOC	Continuous (integer)	0-10
Quality Permitting	Continuous (integer)	0-10; Max (Quality of NOI: Quality of OOC)
Quality Monitoring	Continuous (integer)	0-10
Limited Project	Categorical-binary	1 (yes) or 0 (no)

Table 6: Measures of Success

Response Variable	Type	Notes
Success built	Categorical - binary	1 or 0; a replacement area was built
Success wetland	Categorical - binary	1 or 0; a replacement area was built and was wetland
Success wetland + size	Categorical - binary	1 or 0; a replacement area was built, was wetland, and was at least 90% of the required size
Success wetland + compliance	Categorical - binary	1 or 0; a replacement area was built, was wetland, and met all the regulatory performance standards for mitigation

2. Was a Wetland Created?

If either the ocular estimate or the point-intercept percent cover data collected in the field for wetland plants was greater than or equal to 50%, and if hydric soils or other indicators of hydrology were present, the site was determined to be a wetland.[14]

3. Did the Replacement Area Meet Performance Standards per 310 CMR 10.55 (4)(b):

To determine if the site met the 75% indigenous wetland plant revegetation standard, point-intercept transect data were used. For each of the 100 points where plant species were identified along 200-foot transects, any point that contained 50% or more plant species designated as wetland indicator plants (i.e., FAC, FAC+ FACWET, or Obligate)[15] was given a "Yes" ranking. If a point had less than 50% wetland plants, it received a "NO" ranking. If 75 or more of the points were given a "Yes," then the replacement area was considered to have met the 75% indigenous wetland plant revegetation standard. For the two sites where ocular percent cover was used, the sum of the percent covers of all wetland plants was divided by the sum of the percent covers of all plants (wetland or upland).

Appendix E describes the protocol used to evaluate the other regulatory performance standards. Sites could receive a maximum score of 7 (0 is the worst, 7 is the best).

4. Design Criteria:

The quality of the Notice of Intent, the Order of Conditions, and the monitoring that occurred (if any) was analyzed independently on a scale of zero (worst) to ten (best) for each wetland replacement area. The Appendix D Sections entitled 'Notice of Intent Quality Data,' 'Order of Conditions Quality Data' and 'Monitoring Quality Data' contain a list of questions that have a yes/no response. For each yes response a predetermined point amount is given. The points are then summed. The first three questions listed in the Appendix E Section entitled 'Analyses' explain how the scores for the individual questions were combined to get one total quality score for each (i.e., Notice of Intent, Order of Conditions, and Monitoring).

Table 7: Wetland Indicator Status Weighing Value

Indicator Status	WISi
Obligate	1
Facultative Wetland	1.67
Facultative	3
Facultative Upland	4.33
Upland	5

5. Certificate of Compliance:

What is the relationship between issuance of Certificates of Compliance (COC) and wetland replacement area success? Summary statistics for various measures of mitigation success were compared between projects that did and those that did not receive Certificates of Compliance, presumably because no request was made by the applicant.

6. Predictor Variables:

What other variables might be associated with mitigation success or failure? A number of potential predictor variables (Table 5) were tested to determine whether there were any significant relationships to mitigation success (Table 6). Logistical Regression analyses were conducted using the Generalized Linear Models function in R for the four response variables and the predictor variables in Table 5.

Summary statistics were used to describe the results by DEP region and to compare projects permitted by conservation commission with those permitted by DEP wetlands staff.

7. Similarity:

Were the wetland replacement areas similar to the reference wetlands?

14 At two sites, only ocular percent cover (and not point-intercept data) was collected to assess vegetation due to limitations imposed by the landowner.

15 The wetland indicator categories in the 1988 *National List of Plant Species That Occur in Wetlands: Massachusetts* (National List of Plant Species, 1988) was the regulatory standard from 2004-2008 and was used to calculate whether the replacement area met the regulatory standard requiring 75% indigenous wetland plant revegetation. A positive (+) or negative (-) sign was used with the Facultative Indicator categories to more specifically define the regional frequency of occurrence in wetlands. The positive sign indicates a plant that is more frequently found in wetlands, and a negative sign indicates a plant that is less frequently found in wetlands. The updated 2012 list (*National List of Plant Species*, 2012) was used for other non-regulatory analyses such as the similarity analysis. For the species Eastern Hemlock (*Tsuga canadensis*), the 1988/2012 plant lists have it listed as FACU but the Wetland Protection Act MGL C. 131 §40 lists it as a wetland plant. In this study, to determine whether a replacement area met the 75% indigenous wetland plant revegetation standard, we treated *Tsuga canadensis* as a wetland plant (FAC). Note that this plant was not found often and was not dominant on any site. For non-regulatory analyses such as the weighted average index (described below), the wetland indicator status of FACU from the 2012 plant list is used.

Table 8: Weighted Average Wetland Indicator Value: Example Calculation

Plant	Indicator Status	WISi (wetlands indicator status weighting value)	Percent Cover	IVi (importance value)	IVi x WISi
Red maple (*Acer rubrum*)	FAC	3	40	0.36	1.08
Winterberry (*Ilex verticillata*)	FACW+	1.67	30	0.27	0.45
Cinnamon fern (*Osmunda cinnamomea*)	FACW	1.67	15	0.14	0.24
Three Leaf Goldthread[16] (*Coptis trifolia*)	FACW	1.67	10	0.09	0.15
Princess pine[17] (*Lycopodium obscurum*)	FACU	4.33	10	0.09	0.39
Sheep laurel (*Kalmia angustifolia*)	FAC	3	5	0.05	0.15
Sum			110	1.00	2.46

- Wetness Index:

A Weighted Average Index was used to determine if the replacement area was drier, wetter or comparable to the reference site. The weighted average wetland indicator value for each plot was calculated based on the percent cover of each species present (at greater than 1% cover) and its wetlands indicator status.

The formula is:

$$WI = \Sigma_{i=1}^{n}(IV_i * WIS_i)$$

WI= Wetlands Indicator Value

IVi (Importance value) = the percent cover of species i in that plot divided by the total percent cover of all plants in that plot (i.e. % dominance)

WISi = the wetlands indicator status weighting value for that species.

The same weights that Brown and Veneman used were used in this study (see table 7):

A calculated Wetlands Indicator Value (WI) of 3.0 or lower indicates that the plot consists of wetlands vegetation. A value of 3.01 or higher indicates that the site is not dominated by wetlands plant species.

- Vegetation Similarity:

The vegetative communities of replacement areas were compared with those of reference wetlands using both the Jaccard and Bray-Curtis indices (Ludwig and Reynolds, 1988). The Jaccard index is based on the proportion of plant species that are common to both the replacement area and the reference wetland. The Bray-Curtis index takes into account both the proportion of species in common and the relative abundance of each species to calculate similarity.

Vegetation-based response variables (Table 9) were analyzed against the predictor variables in Table 5 using multiple linear regression and ANOVA in R.

IV. Results

Measures of success for the evaluation of mitigation projects broadly across the state were based on five levels of analysis:

1. Of those replacement areas evaluated, what percentage were actually built?

2. Of those replacement areas evaluated, what percentage successfully created wetlands?

16 Formerly known as Alaska Goldthread (*Coptis trifolia*)

17 Formerly known as Tree clubmoss (*Lycopodium obscurum*)

Table 9: Vegetative Response Variables

Response Variable	Type	Notes
Vegetation Bray-Curtis Similarity	Continuous (0-1 scale)	1-Bray-Curtis Similarity Index (reference site vs. replacement site)
Jaccard	Continuous (0-1 scale)	Jaccard similarity index
Vegetation Wetness	Continuous (values could theoretically range from -4 to +4)	Weighted index of reference site minus weighted index of the replacement site based on 2012 plant list (positive value means that the replacement site is wetter; negative value means that replacement site is drier)

3. Of those replacement areas evaluated, what percentage created a wetland that was at least 90% their required size?

4. Of those replacement areas evaluated, what percentage created a wetland and met all regulatory performance standards?

5. Of those replacement areas evaluated, what percentage created a wetland that met all regulatory performance standards and was at least 90% their required size?

A. Measure of Success: Of those Replacement Areas Sites Evaluated, What Percentage Were Actually Built?

Of this study of 91 sites, 79 (86.8%) of them included replacement areas that had been built. Since permission could not be obtained at some sites, a strategy was developed to ensure that the estimate of success was not biased. A rapid assessment of these non-permission sites from private/public access points was implemented to test and adjust the measure of success for replacement areas actually built. With the private/public access method, it was determined that replacement areas had been constructed at 25 of 30 non-permission sites (83.3%) where wetlands replacement had been required, the project was built, and status of the replacement area (i.e., built or not built) could be determined[18]

18 The rest of the non-permission sites fell into two categories: the entire project was not built or the status could not be determined.

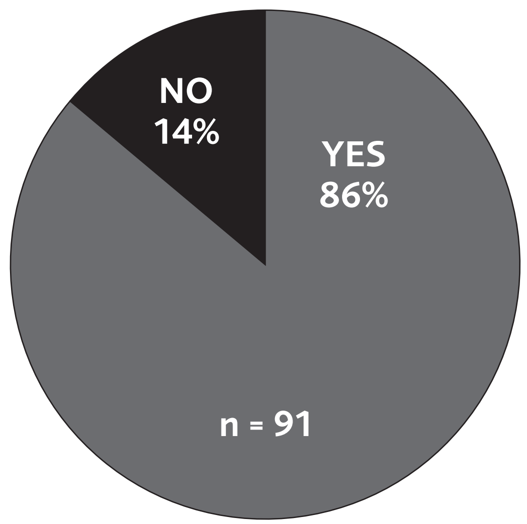


Figure 2: 14% of Required Replacement Areas Were Never Contructed

To get an adjusted percentage of sites built that would represent the full population of replacement sites (not just ones that could be accessed), these numbers were combined (i.e., 91 sites that could be accessed plus 30 sites that could not be accessed). That yielded 121 sites, 104 of which contained built replacement areas. Based on these samples it is estimated that statewide 86.0% of replacement areas were actually built. This adjusted percentage was used to determine several of the other measures of success discussed below.

Logical regression analyses of eight potential predictor variables (summarized in Table 10) yielded no significant results. None of the following were significant in explaining whether replacement areas are actually built: size of the municipality (population), the number of filings processed by conservation commissions (# of NOIs), the size of the required replacement area (OOC REP SIZE), quality of the Notice of Intent, quality of the Order of Conditions, quality of the permitting process (Max of Quality NOI and Quality OOC), quality of monitoring, or date (as indicated by the date of the Order of Conditions). Data for two other predictor variables (reference wetland type and limited project) were not collected for replacement areas that were not built and therefore, no statistical analyses were conducted for these variables.

B. Measure of Success: Of Those Replacement Areas Evaluated, Percentage that Successfully Created Wetland

To be considered to have successfully created wetlands, replacement areas had to meet the MAWPA vegetation criteria for BVW (≥50%, 310 CMR 10.55(4)(b)6)), and had to have either hydric soils or indicators of wetland hydrology (310 CMR 10.55(4)(b)2).
Of the 79 sites where replacement was attempted and assessed in the field, 51 (64.6%) contained successfully created wetlands.

Of the 25 non-permission sites where wetland replacement areas were built and could be assessed from a distance, 23 appeared to support wetlands and for two sites it was unclear whether or not they contained wetlands. On the surface it would appear that 100% (23 out of 23) of sites where the status of the replacement area could be judged were wetlands. However, these "windshield" assessments did not allow for a consistent evaluation of both wetland vegetation and soils or other indicators of wetland hydrology. Therefore, the data from the non-permission sites was used only to adjust the results for the percent of sites that were built. Examining the data from 79 field assessed sites, it was found that in 76 instances where the vegetation criterion was met, 25 of the sites failed the soils/hydrology criterion.

By taking the number of replacement sites that were built and successfully created wetlands (51) and dividing by the number of sites evaluated (91), the rate of wetland creation would be 56.0%. However, this doesn't take into account the adjusted percentage of sites actually built (86.0% rather than 86.8%, based on the adjustment from the sites assessed from public or private ways). To get a number that better describes the full population of replacement projects, the proportion of sites built (0.86) must be multiplied by the proportion of wetlands created (0.646) and converted to a percentage (55.6%).

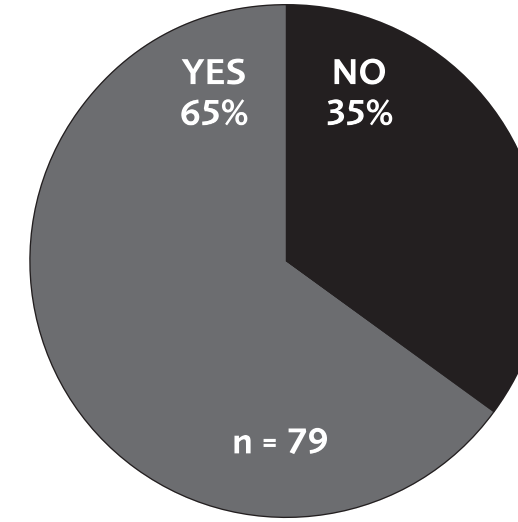


Figure 3: Of Replacement Areas Actually Built, 65% Successfully Created Wetland

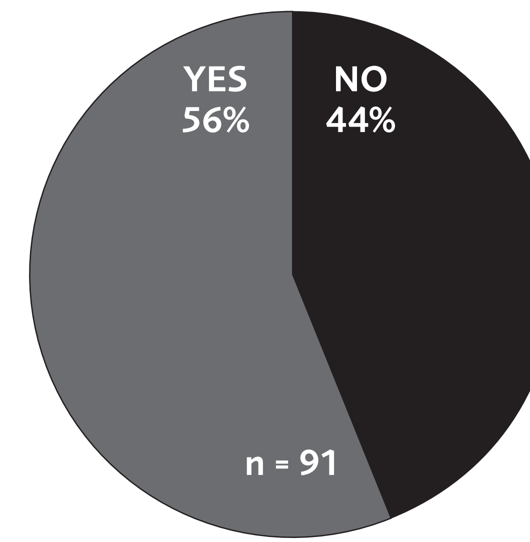


Figure 4: Replacement Areas Built and Wetland Created

44.4 percent (40 of 91) of required replacement areas failed to create wetlands, either because they were never built or they failed to support both wetland vegetation and either hydric soils or indicators of wetland hydrology

Table 10: Logistic regression analyses revealed no significant relationships between the predictor variables and success as indicated by replacement areas being built

Predictor Variable	Statisical Test	n	Probability*
Population	Generalized Linear Models – Logistic Regression	91	p=0.965
# of NOIs	Generalized Linear Models – Logistic Regression	90	p=0.471
OOC REP_SIZE	Generalized Linear Models – Logistic Regression	87	p=0.065
Quality NOI	Generalized Linear Models – Logistic Regression	91	p=0.592
Quality OOC	Generalized Linear Models – Logistic Regression	91	p=0.794
Quality Permitting	Generalized Linear Models – Logistic Regression	91	p=0.628
Quality Monitoring	Generalized Linear Models – Logistic Regression	91	p=0.105
OOC_Date	Generalized Linear Models – Logistic Regression	73	p=0.579

*These are p-values as part of the statistical analysis. They are probabilities that the the relationship between success/failure and each of these predictor variables is simply due to chance. A statistically significant relationship has a p-value < 0.05. Variables with high p-values have virtually no relationship to success/failure.

Table 11: Logistic regression analyses revealed no significant relationships between the predictor variables and success as indicated by replacement areas being built and supporting wetlands

Predictor Variable	Statisical Test	n	Probability
Population	Generalized Linear Models – Logistic Regression	79	p=0.394
# of NOIs	Generalized Linear Models – Logistic Regression	79	p=0.800
OOC REP_SIZE	Generalized Linear Models – Logistic Regression	75	p=0.565
Quality NOI	Generalized Linear Models – Logistic Regression	79	p=0.580
Quality OOC	Generalized Linear Models – Logistic Regression	79	p=0.362
Quality Permitting	Generalized Linear Models – Logistic Regression	79	p=0.509
Quality Monitoring	Generalized Linear Models – Logistic Regression	79	p=0.681
OOC_Date	Generalized Linear Models – Logistic Regression	64	p=0.466
Ref_type	Generalized Linear Models – Logistic Regression	78	p=0.125
Limited Project	Generalized Linear Models – Logistic Regression	79	p=0.304

C. Measure of Success: Of those Replacement Areas Evaluated, What Percentage Created a Wetland and was at Least 90% the Required Size

For calculating relative size of the replacement area for the analyses below, the size of the replacement area built was divided by the size of replacement area stipulated in the Order of Conditions. If the Order of Conditions lacked a required area, the size of the impact area[19] was used instead. If both of these values were missing, the record was dropped from the analysis (N=2). Table 12 presents data on the percentage of replacement areas that fell within relative size classes based on either permitted area or impact area.

% Success: Built + wetland created + >50% relative size (52.2%)

From the table an observation can be made that 93.9% of replacement areas were built and supported wetlands that were at least 50% of the size they were required to be by the Order of Conditions. By multiplying the rate at which replacement sites are built and support wetlands (55.6% from above) by this percentage (93.9%), the percentage of replacement sites that are built, are wetland, and are at least 50% of their required size was calculated to be 52.2%.

% Success: Built + wetland created + >75% relative size (44.3%)

79.6% of replacement areas that were built and supported wetlands had replacement areas making up >75% of the required size. By multiplying the rate at which replacement sites are built and support wetlands (55.6% from above) by this percentage (79.6%), the percentage of replacement sites that are built, are wetland, and are at least 75% of their required size was calculated to be 44.3%.

% Success: Built + wetland created + >90% relative size (38.6%)

Using Table 12 it is shown that 69.4% of replacement sites that were built and supported wetlands had replacement areas that were >90% of their required size. By multiplying the rate at which replacement sites are built and support wetlands (55.6% from above) by this percentage (69.4%), the percentage of replacement areas that were built, were wetland, and at least 90% of

19 The impact area specified in the Notice of Intent was used if no impact area was specified in the Order of Conditions.

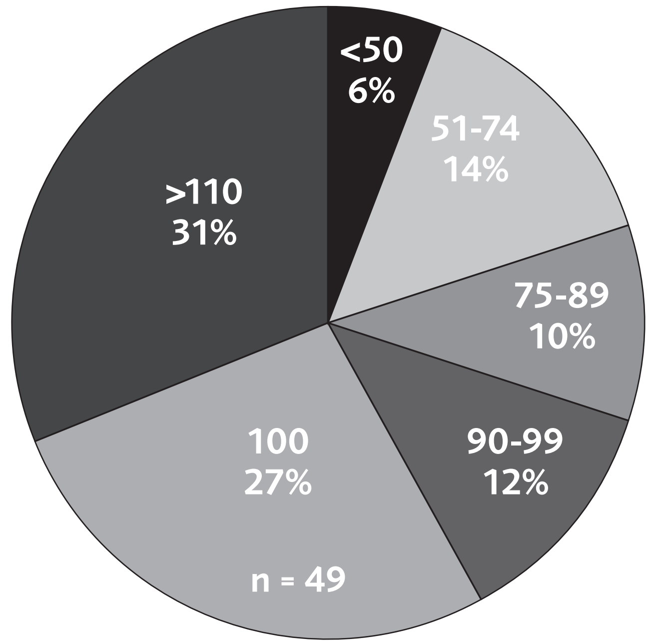


Figure 5: Relative Size of Replacement Area For Site Where Wetlands Created

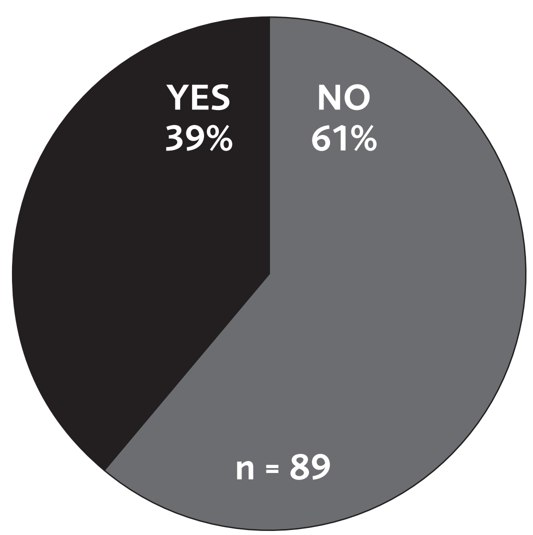


Figure 6: Replacement Areas Built, Wetland Created and Appropriately Sized

Table 12: Relative size of replacement area (for site where wetlands were created, n=49[20])

% Permitted Size	Percent of Sites	Cumulative Percentage
<50	6.1	6.1
51-75	14.3	20.4
76-90	10.2	30.6
91-99	12.2	42.9
100	26.5	69.4
>100	30.6	100.0

Table 13: Logistic regression analyses of predictor variables versus success, indicated by replacement areas built, wetland created and at least 90% of required size

Predictor Variable	Statisical Test	n	Probability
Population	Generalized Linear Models – Logistic Regression	79	p=0.036*
# of NOIs	Generalized Linear Models – Logistic Regression	79	p=0.642
OOC REP_SIZE	Generalized Linear Models – Logistic Regression	75	p=0.448
Quality NOI	Generalized Linear Models – Logistic Regression	79	p=0.343
Quality OOC	Generalized Linear Models – Logistic Regression	79	p=0.578
Quality Permitting	Generalized Linear Models – Logistic Regression	79	p=0.527
Quality Monitoring	Generalized Linear Models – Logistic Regression	79	p=0.681
OOC_Date	Generalized Linear Models – Logistic Regression	64	p=0.267
Ref_type	Generalized Linear Models – Logistic Regression	78	p=0.826
Limited Project	Generalized Linear Models – Logistic Regression	79	p=0.275

*significant at $p < 0.05$

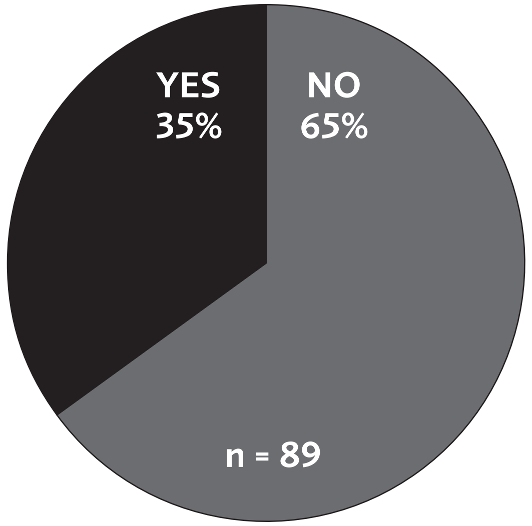


Figure 7: Wetland Replacement Areas Built and Meeting all Performance Standards

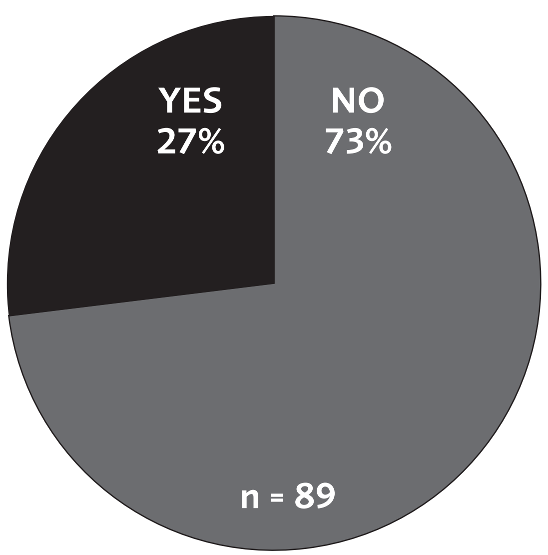


Figure 8: Wetland Replacement Areas Built, Appropriately Sized & Meeting Performance Standards

their required size was calculated to be 38.6%. This is the threshold that Brown and Veneman used for replicated wetlands that were too small. It should be noted that many issuing authorities required the size of the wetland replacement area to be greater than the impact size. This analysis uses the size that was required by the issuing authority and not the impact size.

Logistic regression analyses (see Table 13) of predictor variables versus success as indicated by replacements areas that were built, supported wetlands, and were at least 90 percent of their required size, generated only one significant result: population (p=0.036). The coefficient for this variable (the slope of the relationship) was -0.0001. While this suggests that there is a statistically significant negative relationship between the size of the municipality and success, the very small value of the coefficient means that the relationship is essentially meaningless. Further, given the large number of tests comparing predictor and response variables (68) and the alpha (α) value of 0.05 used for determining significance, one would expect three or four tests to yield significant ($p<0.05$) results simply by chance alone (68 x 0.05 = 3.4). It is entirely possible that this significant relationship is spurious.

D. Measure of Success: Of those Replacement Areas Evaluated, What Percentage Created a Wetland and Met all Regulatory Performance Standards

As noted in Table 14, titled "Regulatory Compliance (wetland created)", 63.3% of replacement areas that created wetlands were fully compliant with the MAWPA regulations. 55.6% of replacement areas were both built and supported wetlands (from above). Multiplying these two percentages together, an overall rate of regulatory compliance of 35.2% was obtained.

Logistic regression analyses of predictor variables versus success as indicated by replacement areas built, wetlands created, and all regulatory performance standards met, yielded no significant results (see Table 15)

20 Two sites were eliminated from the size evaluation because data necessary to complete the analysis were not in the files.

Table 14: Regulatory Compliance (wetland created)

Regulatory Compliance (out of 7 standards)	Percent of Sites	Cumulative Percentage
3	2.0	100.00
5	8.2	98.0
6	26.5	89.8
7	63.3	63.3

E. Measure of Success: Replacement Area Built, Created a Wetland that was at Least 90% of the Size Required in the OOC, and Met All Regulatory Performance Standards

Of the 31 replacement areas that met the seven performance standards in the MAWPA regulations and thus were considered regulatory compliant (above), all were at least 90% of the size of the impact area. However, the impact area was often smaller than the replacement area required in the OOC. Of the 31 replacement areas that were compliant based solely on the seven specific performance standards in the MAWPA regulations, only 24 were at least 90% of the size required by the OOC. Thus, the success rate when considering compliance with both the specific regulatory performance standards and the OOC was 27.0%. (Of the 89 replacement areas investigated with available size data, 24 sites were regulatory compliant and appropriately sized in accordance with the OOC

F. Measure of Success: Vegetative Similarity

The plant communities of replacement areas and their corresponding reference sites were compared using the Jaccard and Bray-Curtis Indices. The Jaccard Index only takes into account species' presence or absence, while the Bray-Curtis Index also takes into account plant abundance. For both of these indices, replacement areas where the vegetation matched reference wetlands exactly would score a 1.0. Replacement areas that had zero plant species in common with reference wetlands would score a 0.0. Figure 9 presents data on Jaccard and Bray-Curtis indices of similarity.

In general, wetland replacement areas were not similar to reference wetlands. Very few replacement areas had similarity indices greater than 0.5 and most had index scores less than 0.2. Several replacement areas had similarity indices of 0.

Multiple regression and ANOVA analyses of predictor variables versus vegetation similarity as indicated by both the Jaccard and Bray-Curtis indices yielded significant relationships for reference wetland type (p=0.007 for Jaccard and p=0.011 for Bray-Curtis).

The Adjusted R^2 indicates that roughly 9 percent of the variation in Jaccard similarity is due to reference wetland type and this is significant at $p<0.01$. The ref. typeM (marsh) which is represented by the intercept has a coefficient of 0.19; this means that the average Jaccard similarity for marshes is 0.19. The average Jaccard similarity for shrub swamps derived by adding the coefficient for Ref.typeSS (-0.07) to the intercept coefficient (0.19) is 0.12. Average Jaccard similarity for forested wetlands (WS) is 0.10. Comparisons of Jaccard similarity among the three reference wetland types using ANOVA indicate that forested wetlands have significantly lower similarity values compared to those of marshes.

The adjusted R^2 indicates that roughly 8 percent of variation in Bray-Curtis similarity is attributable to reference wetland type. This is significant at p=0.011. The reference wetland type marsh had an average Bray-Curtis similarity of 0.22. For shrub swamps the average similarity was 0.12 and for forested wetlands it was 0.11. Results for Bray-Curtis index of similarity are similar to those based on the Jaccard index. Results of ANOVA indicate that forested wetlands have Bray-Curtis similarity values that are significantly lower than those for marshes.

Table 15: Logistic regression analyses of predictor variables versus success, indicated by replacement areas built, wetland created and meeting performance standards

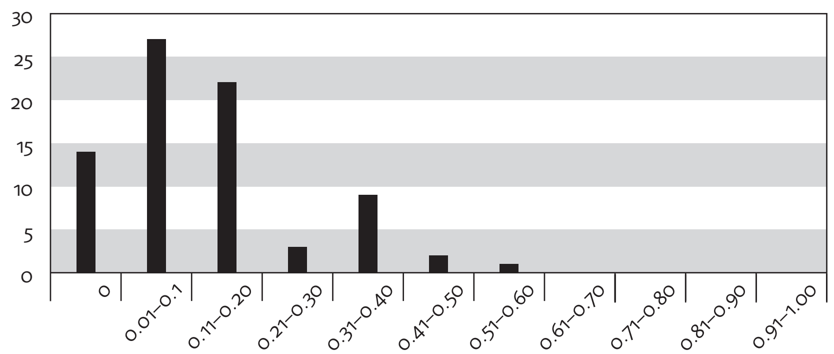
Predictor Variable	Statisical Test	n	Probability
Population	Generalized Linear Models – Logistic Regression	79	p=0.057
# of NOIs	Generalized Linear Models – Logistic Regression	79	p=0.148
OOC REP_SIZE	Generalized Linear Models – Logistic Regression	75	p=0.361
Quality NOI	Generalized Linear Models – Logistic Regression	79	p=0.825
Quality OOC	Generalized Linear Models – Logistic Regression	79	p=0.411
Quality Permitting	Generalized Linear Models – Logistic Regression	79	p=0.344
Quality Monitoring	Generalized Linear Models – Logistic Regression	79	p=0.484
OOC_Date	Generalized Linear Models – Logistic Regression	64	p=0.306
Ref_type	Generalized Linear Models – Logistic Regression	78	p=0.956
Limited Project	Generalized Linear Models – Logistic Regression	79	p=0.936

Table 16: Statistical Analyses for Jaccard Similarity

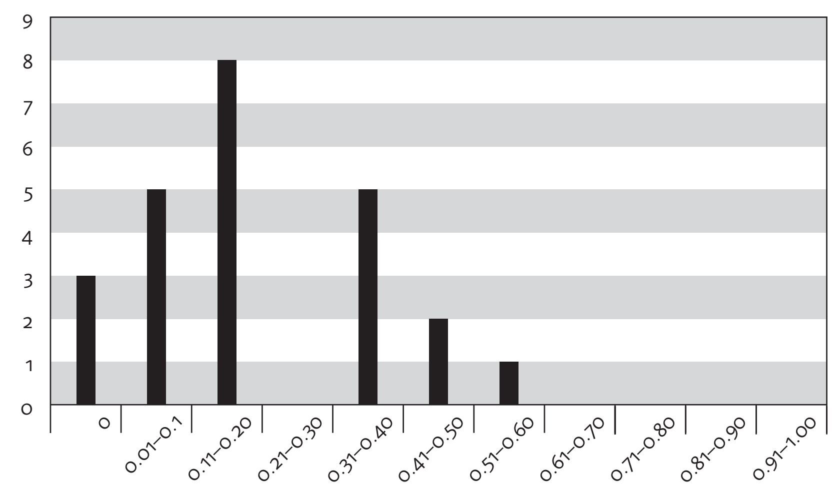
Predictor Variable	Statisical Test	n	Probability
Population	Multiple Linear Regression	79	p=0.549
# of NOIs	Multiple Linear Regression	79	p=0.259
OOC REP_SIZE	Multiple Linear Regression	75	p=0.528
Quality NOI	Multiple Linear Regression	79	p=0.671
Quality OOC	Multiple Linear Regression	79	p=0.935
Quality Permitting	Multiple Linear Regression	79	p=0.738
Quality Monitoring	Multiple Linear Regression	79	p=0.969
OOC_Date	Multiple Linear Regression, ANOVA	64	p=0.758
Ref_type	Multiple Linear Regression, ANOVA	78	p=0.007**
Limited Project	Multiple Linear Regression	79	p=0.213

**significant at $p < 0.05$

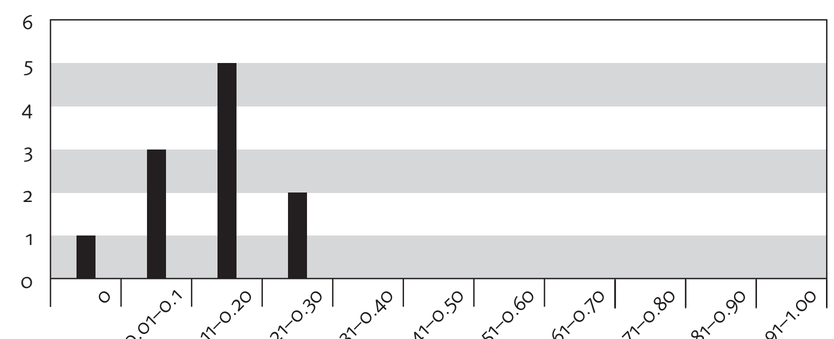
Figure 9: Jaccard and Bray-Curtis Similarity



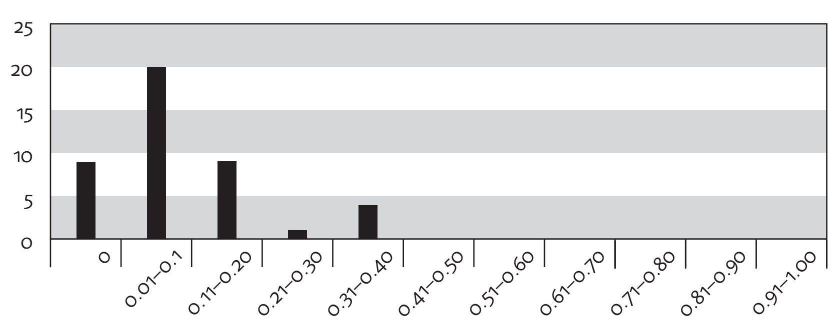
Jaccard Similarity:
All Wetlands



Jaccard Similarity:
Marsh



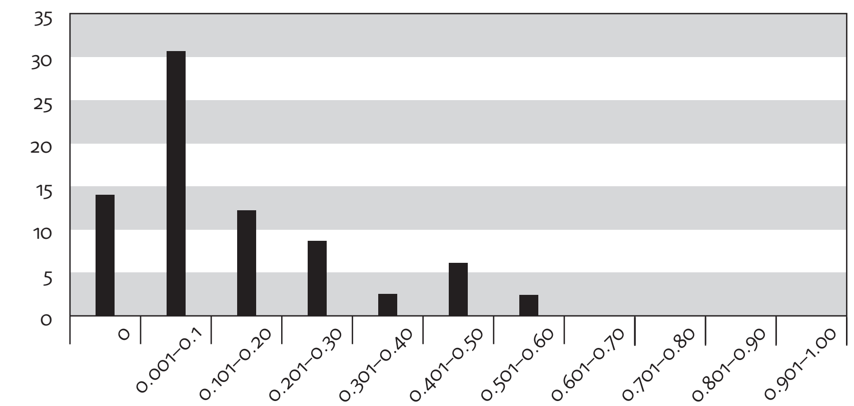
Jaccard Similarity:
Shrub Swamp



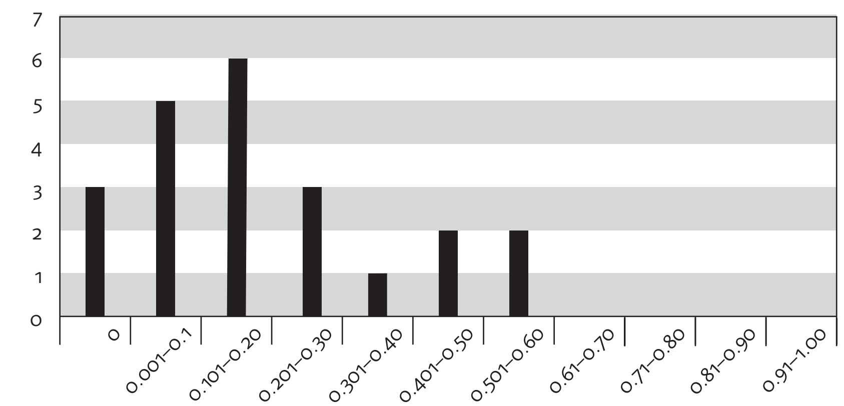
Jaccard Similarity:
Forested Wetland

LESS ◄——► MORE

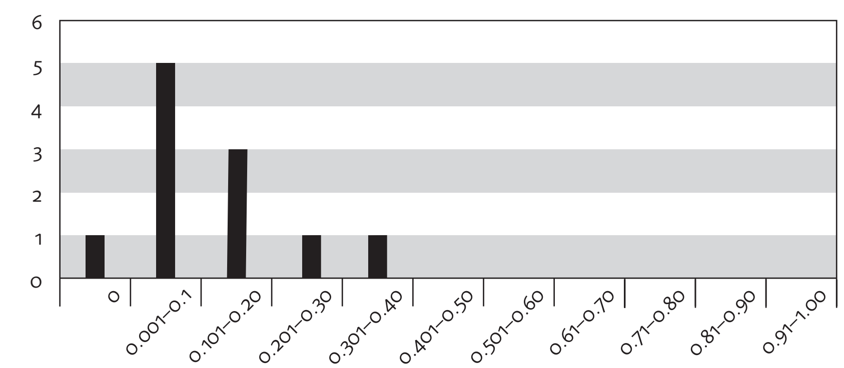
SIMILARITY



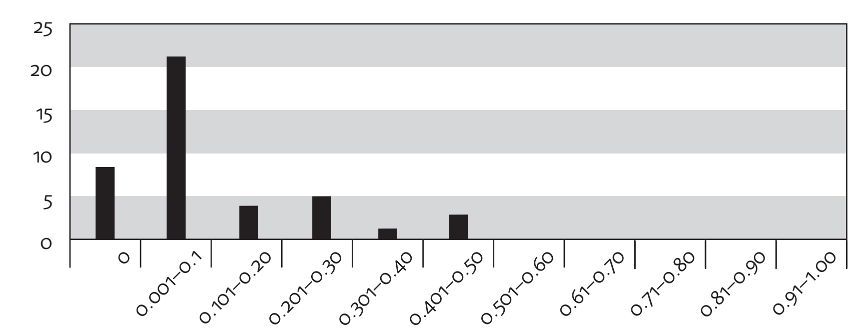
Bray-Curtis Similarity:
All Wetlands



Bray-Curtis Similarity:
Marsh



Bray-Curtis Similarity:
Shrub Swamp



Bray-Curtis Similarity:
Forested Wetland

LESS ◄——► MORE

SIMILARITY

Table 17: Jaccard Coefficients for Ref_type (Adjusted R^2=0.092)

	Estimate	Standard Error	t values	p (>|t|)
Intercept (ref.typeM)	0.19345	0.02408	8.034	<0.001*
Ref.typeSS	-0.07130	0.04295	-1.660	0.101
Ref.typeWS	-0.09381	0.03006	-3.121	0.002**

*significant at $p < 0.05$ **significant at $p < 0.05$

Table 18: ANOVA Table for Jaccard Index

	Difference	p
SS-M	-0.0713	0.227
WS-M	-0.0938	0.007*
WS-SS	-0.0225	0.839

*significant at $p < 0.05$

Table 19: Statistical Analyses for Bray-Curtis Similarity

Predictor Variable	Statisical Test	n	Probability
Population	Multiple Linear Regression	79	p=0.932
# of NOIs	Multiple Linear Regression	79	p=0.163
OOC REP_SIZE	Multiple Linear Regression	75	p=0.757
Quality NOI	Multiple Linear Regression	79	p=0.994
Quality OOC	Multiple Linear Regression	79	p=0.869
Quality Permitting	Multiple Linear Regression	79	p=0.744
Quality Monitoring	Multiple Linear Regression	79	p=0.625
OOC_Date	Multiple Linear Regression, ANOVA	64	p=0.947
Ref_type	Multiple Linear Regression, ANOVA	78	p=0.011*
Limited Project	Multiple Linear Regression	79	p=0.143

*significant at $p < 0.05$

Table 20: Bray-Curtis Coefficients for Ref_type (Adjusted R^2=0.084)

	Estimate	Standard Error	t values	p (>|t|)
Intercept (ref.typeM)	0.21979	0.03069	7.161	<0.001*
Ref.typeSS	-0.10250	0.05475	-1.872	0.065
Ref.typeWS	-0.11271	0.03831	-2.942	0.004*

*significant at $p < 0.05$

Table 21: ANOVA Table for Bray-Curtis Index

	Difference	p
SS-M	-0.1025	0.154
WS-M	-0.1127	0.012*
WS-SS	-0.0102	0.978

*significant at $p < 0.05$

G. Measures of Success: Similarity in Vegetation Wetness

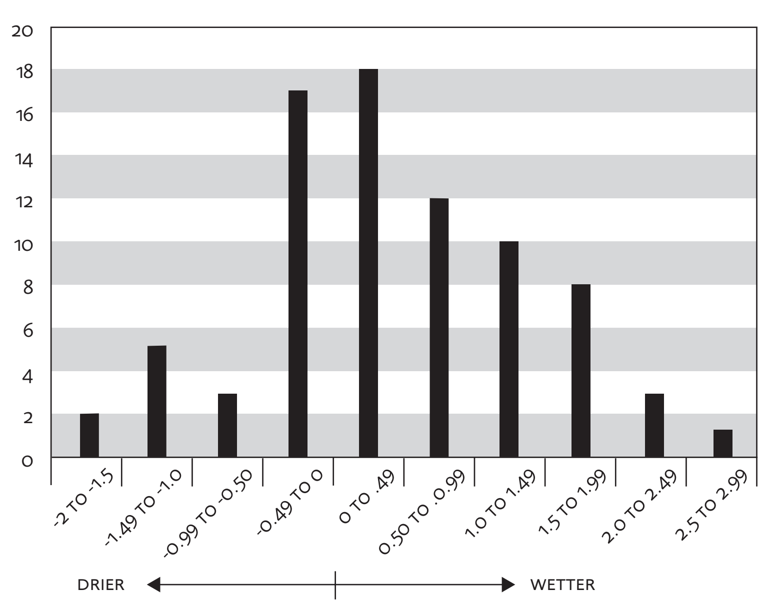
A weighted-average approach similar to the Prevalence Index was used to assess the "wetland affinity" of the vegetative communities in replacement areas compared to their corresponding reference sites. Lower Wetness Index numbers indicate a higher affinity for wetland conditions. The wetness index deviation represents the difference between the Wetness Index for reference and replacement areas and was calculated by subtracting the replacement index from the reference index. Positive deviations (reference index was higher than the replacement index) suggest that plants had a greater affinity for wetland conditions in the replacement area than for the reference area. Negative deviations indicate a lower affinity for wetland conditions in the replacement areas.

Multiple regression analyses suggest that two variables – quality of monitoring and reference wetland type – may have statistically significant relationships with Wetness Index Deviation. The coefficient for the quality of monitoring relationship was -0.091. This suggests a weak negative relationship between the quality of monitoring and wetland index deviation. Stated another way, there is evidence to suggest that sites that were well monitored had smaller deviations in wetness index, meaning that vegetation in replacement sites was more similar to vegetation in reference sites with regard to their affinity for wetland conditions. The relationship is quite weak and it is possible that the result is spurious due to the large number of statistical tests conducted.

The relationship between Wetness Index Deviation and reference wetland type was highly significant ($p<0.001$). There was a general tendency for the vegetation in replacement areas to demonstrate a greater affinity for wetland conditions than the vegetation in corresponding reference sites. This tendency is attributable to strong deviations in wetness index for forested wetlands (see table and figures below).

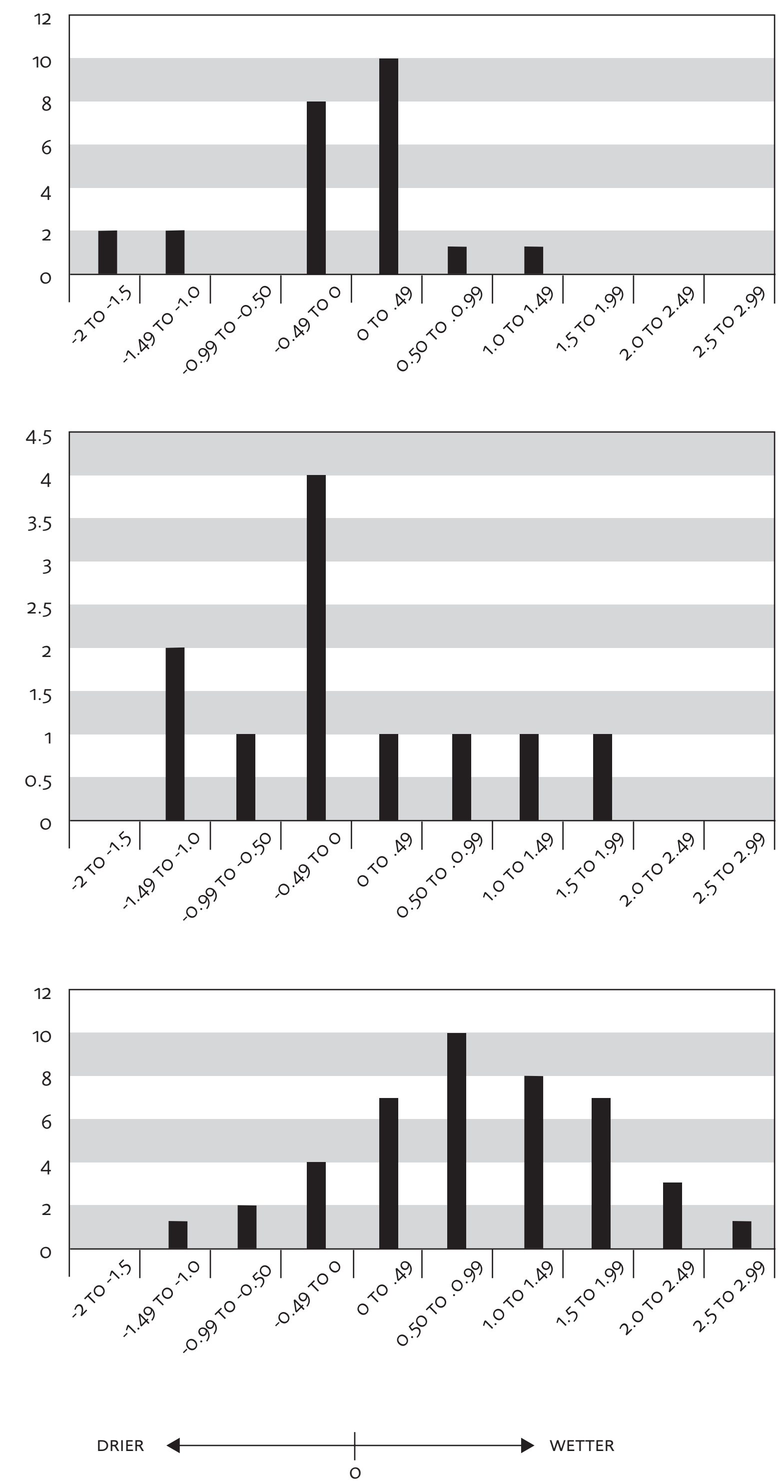
The Adjusted R^2 indicates that roughly 23 percent of the variation in wetness index deviation is due to the reference wetland type. The results indicate the Marsh (ref.typeM) coefficient representing the intercept is -0.18, indicating that the vegetation characteristics in replacement areas had a slightly lower affinity for wetlands than for the corresponding reference wetlands (average wetness index deviation of -0.18). Adding the coefficient for shrub swamps (Ref.typeSS) to the intercept coefficient yields an average wetness index deviation of -0.06, indicating that vegetation wetland affinity was quite similar between replacement and reference wetlands. The coefficient for forested wetlands (ref.typeWS) when added to the intercept coefficient results in an average wetness index deviation of 0.85. This value, because it is positive, indicates that the wetland affinity of vegetation in replacement areas is higher than for corresponding reference wetlands. Wetness index deviations for forested wetlands were significantly different (ANOVA, $p<0.01$) from deviations for marshes and shrub swamps.

Figure 10: Wetland Index Deviation



Wetness Index Deviation:
All Wetlands

Figure 11: Wetland Index Deviation of Marsh, Shrub Swamp, Forested Wetland



Wetlands Index Deviation: Marsh

Wetlands Index Deviation: Shrub Swamp

Wetlands Index Deviation: Forested Wetland

Table 22: Statistical Analyses for Wetness Index Deviation

Predictor Variable	Statisical Test	n	Probability
Population	Multiple Linear Regression	79	p=0.390
# of NOIs	Multiple Linear Regression	79	p=0.515
OOC REP_SIZE	Multiple Linear Regression	75	p=0.717
Quality NOI	Multiple Linear Regression	79	p=0.779
Quality OOC	Multiple Linear Regression	79	p=0.069
Quality Permitting	Multiple Linear Regression	79	p=0.075
Quality Monitoring	Multiple Linear Regression	79	p=0.046*
OOC_Date	Multiple Linear Regression, ANOVA	64	p=0.403
Ref_type	Multiple Linear Regression, ANOVA	78	P<0.001**
Limited Project	Multiple Linear Regression	79	p=0.062

*significant at $p < 0.05$ ** significant at $p < 0.01$

Table 23: Wetland Index Deviation Coefficients for Ref_type (Adjusted R^2=0.23)

	Estimate	Standard Error	t values	p (>|t|)
Intercept (ref.typeM)	-0.1834	0.1776	-1.033	0.305
Ref.typeSS	0.1238	0.3168	0.391	0.697
Ref.typeWS	1.0288	0.2217	-4.642	<0.001*

*significant at $p < 0.05$

Table 24: ANOVA Table for Wetness Index Deviation

	Difference	p
SS-M	0.1238	0.919
WS-M	1.0288	<0.001*
WS-SS	0.9050	0.008*

*significant at $p < 0.05$

Table 25: Success of Projects within Each MassDEP Region

Region	Success built	Success wetland	Success wetland + size	Success wetland + compliance	Success wetland + size + compliance
CERO	88.6 %	60.0 %	45.7 %	45.7 %	37.1 %
NERO	86.2 %	48.3 %	34.5 %	27.6 %	20.7 %
SERO	84.2 %	52.6 %	31.6 %	21.1 %	15.8 %
WERO	87.5 %	75.0 %	50.0 %	62.5 %	50.0 %
Overall	86.8 %	56.0 %	39.6 %	36.3 %	28.6 %

Table 26: Success by MassDEP vs. Conservation Commission

Regulatory Instrument	Success built	Success wetland	Success wetland + size	Success wetland + compliance	Success wetland + size + compliance
OOC	85.7 %	60.0 %	42.9 %	41.4 %	32.9 %
SOC*	87.5 %	37.59 %	25.0 %	12.5 %	12.5 %
Overall	86.8 %	56.0 %	39.6 %	36.3 %	28.6 %

*Sample size was very small (n=8). One should be cautious about drawing conclusions from these data, given the small number of projects that were permitted by SOC.

H. Success by MassDEP Regions

Table 25 contains data on mitigation success broken out by MassDEP regions. No statistical tests were performed on these data. In general, success was above average in the Western and Central regions and below average for the Northeast and Southeast regions for all categories of success.

I. Success based on whether the project was permitted by the Conservation Commission or MassDEP

The data, broken out by those projects permitted by conservation commissions via Orders of Conditions (OOC) and those permitted by MassDEP via Superseding Orders of Conditions (SOC), are presented in Table 26. Very few projects were permitted by MassDEP regional offices (n=8) and therefore no statistical analyses were conducted. One should be cautious about drawing conclusions from these data, given the small number that were permitted by SOC.

J. Certificates of Compliance

The final stage of the regulatory permitting process is the granting of Certificates of Compliance (COCs) for projects that have been completed in compliance with the MAWPA regulations. In many cases this final step is never completed. So, it would not be unusual for compliant projects to have never received COCs. Of the 24 replacement areas that achieved regulatory compliance, 14 (58.3%) received COCs. Certificates of Compliance were also issued for many non-compliant projects. [21]

16.7% of projects for which replacement areas were never built (2 of 12) received COCs

32.1% of projects with replacement areas that failed to produce wetlands (9 of 28) received COCs

30.2% of projects with replacement areas that were not at least 90% of their required size received COCs (13 of 43)

28.3% of projects that created replacement areas but did not fully meet the regulatory requirements of the Wetlands Protection Act received COCs (13 of 46)

32.1% of projects that created replacement areas that either failed to fully meet the regulatory requirements of the Wetlands Protection Act or were less than 90% of the size required in the OOC received COCs (17 of 53)

It is worth noting that there were no COC denials found during the municipal file review and only one COC request where only a partial COC was issued. The reason for the partial COC was not given.

21 Note that the project files in general did not contain enough data to determine if projects were permitted as limited projects that did not have to meet performance standards.

V. Discussion

A. Comparison with the Brown and Veneman Study

One objective of this study was to compare rates of wetland replacement success for projects permitted from 2004 through 2008, a period after MassDEP issued its guidance document on wetland replacement, with those documented by Brown and Veneman for a period (1983-1994) that predated the guidance document. An important difference between the current study and the Brown and Veneman study is that the Brown and Veneman study determined success of replacement areas solely on the basis of wetland vegetation, while the current study evaluated success using the presence or absence of hydric soils and/or indicators of hydrology, as well as wetland vegetation (i.e., at least 50% indigenous wetlands vegetation (310 CMR 10.55(2)(c)).[22] Differences in determining what constitutes success in wetland creation make it difficult to directly compare results of this study with those of Brown and Veneman.

One solution to this problem would be to use results on the percentage of replacement areas from this study that met the wetland vegetation criterion for comparison with the Brown and Veneman results. However, to do so, certain replacement areas included in this study would have to be deemed as "successes" even though they failed to meet scientific and regulatory criteria for wetlands. An alternative approach uses the proportion of replacement areas in this study that met the wetland vegetation criterion but that were not, in fact, wetlands (i.e., those that lacked hydric soils and indicators of wetland hydrology) to adjust the Brown and Veneman numbers so that they can be compared with our results.

22 The difference in success standards between the two studies may be due to the revision in the regulatory definition of bordering vegetated wetlands that was promulgated in 1995. This 1995 revision required that the bordering vegetated wetland boundary be defined by saturated or inundated conditions in addition to the pre-1995 wetland vegetation criteria. The Brown and Veneman Study was first published in 1998 and does not mention this change in regulatory standard. Thus it is unknown if this change was relevant to the study.

Table 27: Wetland Mitigation Success: Results from this Study Compared to those from Brown and Veneman

Measure of Success	Brown & Veneman	This Study Vegetation Only	Adjusted Brown & Veneman*	This Study Vegetation and Hydrology
Success – Built	77.1%	86.0%	---	86.0%
Success – Wetland	87.0%	97.5%	58.4%	64.6%
Success – Built + Wetland	67.0%	83.8%	45.0%	55.6%
Success – Built + Wetland + Appropriately Sized	45.9%	54.7%	30.8%	38.6%
Success – Built + Wetland + Regulatory Compliant	43.1%	36.9%	28.9%	34.6%
Success – Built + Wetland + Appropriately Sized + Regulatory Compliant	--	27.9%	--	26.8%

*Adjustments were made by multiplying the published Brown and Veneman value by 0.671 [23], which is the proportion of replacement areas in this study meeting the wetland vegetation criterion that also had hydric soils or other indicators of wetland hydrology.

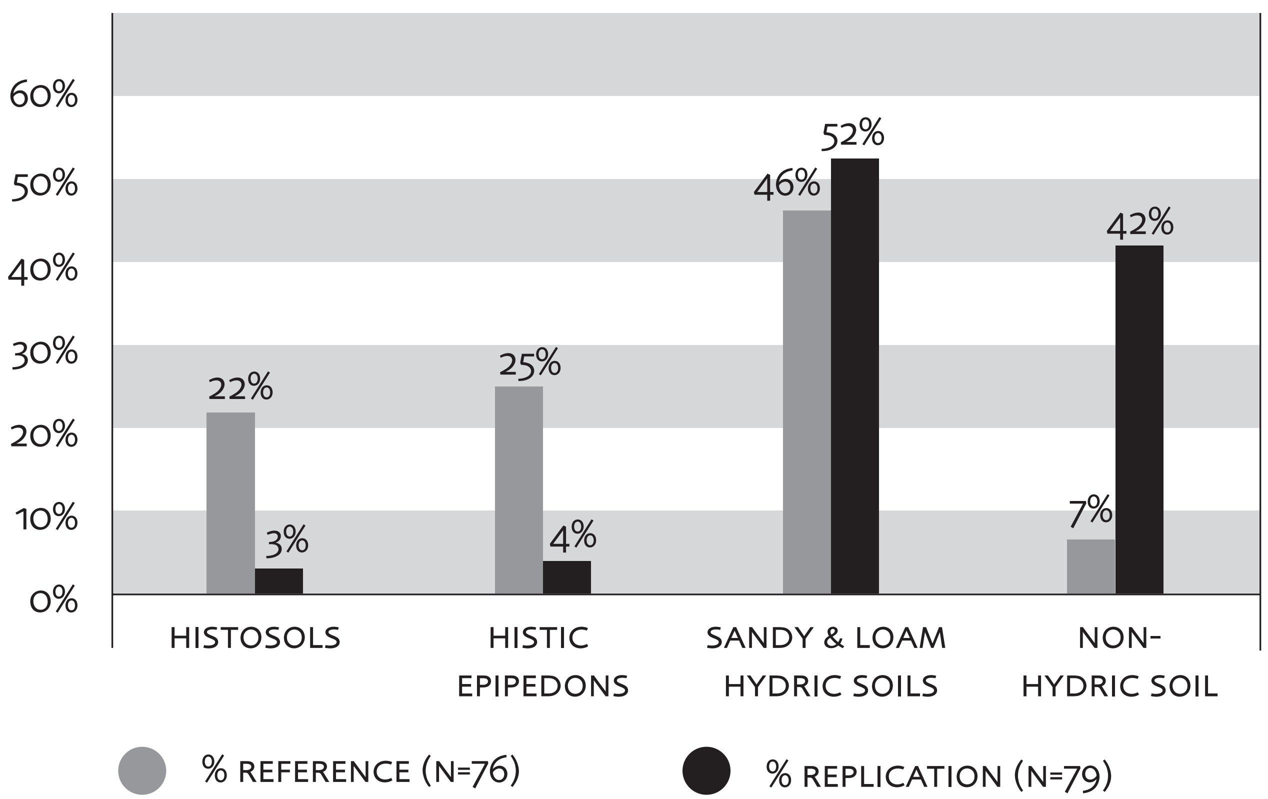
Table 27 presents results of this study and the Brown and Veneman study in a way that allows both comparisons. The second column ("Brown & Veneman") and the third column ("This Study Vegetation Only") allow comparisons using vegetation only as the measure for successful wetlands creation. Columns 4 and 5 allow comparisons using a more rigorous standard for wetland success that includes both vegetation and indicators of hydrology (including hydric soils). Column 4 is a projection of what the Brown and Veneman results would have been if the percentage of replacement areas with wetland vegetation lacking appropriate wetlands hydrology was the same as that found in this study. These comparisons should be used with caution because the actual percentage of successful wetlands in the Brown and Veneman study that lacked hydric soils and/or indicators of wetland hydrology is unknown.

Both approaches generally show a small increase in wetland replacement success during the period 2004-2008 when compared to the period studied by Brown and Veneman (1983-1994).

B. Regulatory Compliance: Built and Built to Size

In 1998, Brown and Veneman concluded that a substantial improvement could be achieved simply by ensuring that replacement areas were actually built whenever they were permitted, and that they were built as large as proposed. In this study, it was

Figure 12: Hydric Soils of Reference and Replacement Areas[26]



found that 86.0% of wetland replacement areas were built when they were permitted, but the percent of replacement areas that are built in accordance with the required permits should be 100%. Of the replacement areas that were built (regardless of whether they were wetlands), 30.6% were built less than 90% of the required size. However, this doesn't mean that 69.4% (100 – 30.6%) were successful because many of these failed to produce wetlands. It should be noted that no attempt was made to delineate a wetland boundary within the replacement area that may have been smaller than the replacement area. Because most wetland replacement areas are less than 5,000 sf in size, they are relatively small to begin with. Based on our observations, there were only a few sites that may have had a smaller area within them that qualified as wetland.

C. Hydric Soils and Indicators of Hydrology

Without a doubt, the most significant finding of this study is that the majority of wetland replacement areas that were unsuccessful failed to produce wetlands because they lack appropriate hydrology, as indicated by the lack of hydric soil development (i.e., characteristics indicative of saturation and anaerobic conditions) and other indicators of hydrology. Replacement areas lacking appropriate hydrology resulted from poor site design and/or poor implementation of the proposed wetland replacement plan. Of the 79 wetland replacement projects where field assessments were completed, only 10% of project applications included details about the hydrology of the proposed replacement area.

Proposed grading of replacement areas should be established based on site-specific knowledge of seasonal high and average groundwater elevations. As part of the design process, groundwater elevations should be determined through the installation of piezometers or shallow groundwater wells with regular monitoring, and through evaluation of soil pits within the proposed replacement area. Once the seasonal high and average groundwater elevations are identified, the design of the wetland replacement area, including proposed excavation depths and the upper elevation of placed soils, can then be determined to create the type of wetland community desired (e.g., emergent marsh, shrub swamp, forested wetland).

23 76 sites had wetland vegetation. Of these 51 sites also had wetland hydrology. 51/76 = 0.671.

This study documented a loss of hydric soils at the replacement areas when compared to the soils at the reference sites. Of the sites where field assessments were conducted, approximately 58.3%[24] of wetland replacement sites had representative soil profiles that were considered hydric, whereas 93.4% of reference site representative soil profiles were considered hydric[25] (see section on Wetland Boundary Delineation for more discussion on reference site soils). Although a slightly higher percentage of replacement areas had sandy and loamy hydric soils compared to reference sites, the percentage of sites with organic soil (i.e. histosols) was 22% at the reference sites compared to 3% (2 sites) at the wetland replacement sites. The percentage of sites containing hydric soils with histic epipedons similarly dropped from 25% at reference sites to 4% (3 sites) at replacement sites. Given the age of the replacement areas, it is likely replacement area soils with thick O horizons were translocated – either from the impact wetland or from offsite.

Based on field observations, human-transported material in the replacement areas, such as loam mixtures, had soil textures that typically did not correspond to soils in the associated reference wetlands. It appears that contractors often did not use the soils from impacted wetlands in the creation of wetland replacement areas. In some cases, it may not have been prudent or permitted to use soils from the impacted wetlands due to presence of invasive species and the potential for spread of those species to the wetland replacement area. In cases where issuing authorities required greater than 1:1 wetland replacement, there may not have been enough hydric soil from the impacted wetland to adequately cover the entire replacement area without soil amendments. Cases were observed where the Order of Conditions required use of soils from the impacted wetland but that condition was not implemented.

Wetland designers, construction personnel and issuing authorities should ensure that appropriate substrate is present in the replacement area to support wetland replacement success. Use of the original wetland topsoils may accelerate development of wetland soil microbes and provide a suitable rooting medium for wetland vegetation, but designers must ensure that the topsoil used does not currently support invasive plants, is not contaminated by chemical pollutants, and contains appropriate characteristics such as organic carbon content.[27] Prolonged saturation that forms anaerobic conditions is critical in developing and maintaining a hydric soil that can support a functioning wetland ecosystem. Thus, the key is to ensure that the land is graded so that the uppermost portion of the soil profile intercepts the groundwater table for a sufficient period to produce saturation and anaerobic conditions and promote a hydrophytic plant community.

The presence of hydric soils was assessed to determine if sites exhibited evidence of hydrology (MassDEP 1995). While the term "hydric soil" is not defined by Massachusetts Wetlands regulations, hydric soil indicators are described (MassDEP 1995). The Federal definition is "a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part" (59 Fed. Reg. 35680, 7/13/94). There is a paucity of research assessing how long it takes redoximorphic features that are indicators of hydric soil to form in newly placed soils used to replicate or create wetlands. While anecdotal evidence suggests that it may take multiple years, one study indicates that certain hydric soil indicators can form in 7 to 14 days in soils that are ponded or flooded (Vespraskas and others 1995). In evaluating soils in wetland replacement areas, researchers looked below the uppermost horizon of the soil (i.e., placed soil) because the uppermost horizon generally consisted of material that had been transported to and placed in the replacement area. In some cases, it was found during our study that the soil was translocated from the wetland impact area to the replacement area; however, in most cases it appeared, based on our observations, that the uppermost horizon of soil was brought in from off-site and consisted of a soil mixture (soil amendments) that varied from sandy loam to organic rich loam. We found that the layer of soil below the uppermost horizon generally represented the extant (i.e., native) soil on the site. If indicators of saturation and anaerobic conditions were not found in the extant soil directly below the topsoil, then there is no reason to believe that saturation or anaerobic conditions occurred in the fill soil above it unless there is a surface water source sufficient to create and maintain hydric conditions. Thus, if the underlying extant soil shows

24 An additional 6.3% of replacement sites (5 sites) had other indicators of hydrology, based on our single observation.

25 Note that the reference site soils analysis included 76 sites; three sites were excluded because the reference site soils data were not documented.

26 This graphic depicts histosol sites as separate from histic epipedon sites and thus there is no overlap or double-counting.

27 The Army Corps of Engineers New England District Compensatory Mitigation Guidance, 7-20-2010 has detailed requirements for compensatory mitigation soils, including the requirement that manmade topsoil consist of a mixture of equal volumes of organic and mineral materials. See page 20-21, Section 4.d. Soil.

no evidence of saturation or anaerobic conditions, then one should be skeptical that hydric soil indicators will ever develop in the uppermost horizon. With these considerations in mind, the approach that MassDEP took to evaluate soils within mitigation areas was to dig a soil pit that was deep enough to observe the characteristics of the uppermost horizon (placed soil) as well as the characteristics of the extant subsoil (i.e. the undisturbed soil that developed in place and still exists on the site) to observe whether any indicators of saturation or anaerobic conditions were visible. [28]

The scope of this study allowed for one site visit per wetland replacement area. Determining the presence of wetland hydrology based on a one-time site visit may not be adequate if the indicators are developing or are otherwise not clear. During post-construction monitoring, additional techniques for measuring saturation and/or the development of anaerobic conditions may be considered. One approach might be to measure organic carbon (or organic matter) in the surface horizons of the replacement wetland after construction, and then again at distinct points in the future (say, 3 years, 5 years, 10 years). A measureable increase in organic carbon over time would indicate that the soil is substantially anaerobic in the surface horizon and "naturally" accreting soil organic matter. A newer technology is to use what are referred to as IRIS (Indicator of Reduction In Soils) tubes, which are polyvinyl chloride (PVC) tubes coated with iron (Fe) oxide paint.[29] When IRIS tubes are placed in a soil with anaerobic properties, Fe oxide is reduced over time. Upon removal, zones where the Fe oxide paint has become removed can be documented and quantified to determine the degree of saturation that exists. Another approach is the use of platinum electrodes to measure reduction potential (Eh) in the soil. This technique involves measuring the voltage difference between a pair of buried electrodes using a volt meter. Another approach is the use of the chemical alpha-alpha dipyridyl (dye or strips), which reacts with the reduced form of iron that results from saturation in the soil to produce a deep red color indicating the presence of that reduced iron. These approaches, in combination with piezometers or shallow groundwater wells to determine saturation, can provide useful information in determining whether wetland hydrology has developed. Although these approaches may be appropriate for individual project evaluations over a period of time, they require specialized training and equipment to implement.

In summary, hydric soils play an important role in the physical filtration of water and providing a substrate for soil microbes. Organic soils are important because they sequester carbon and support microbes that oxidize and reduce substances (e.g., pollutants), and carry out denitrification. Therefore, creating the hydrologic conditions that can develop and or support a hydric soil is a critical component of a successful wetland mitigation project.

D. Plant Communities

Comparisons of replacement areas with their associated reference wetlands found very little similarity in their respective plant communities. This was particularly true for forested wetlands, which typically occur on the drier end of the wetness gradient among wetland types. An evaluation of the indicator statuses of plants that occurred in replacement areas suggested a greater affinity for wetland conditions than for their associated reference wetlands. Here again, the discrepancy was greatest for forested wetlands.

Of the 79 replacement areas that were field assessed as part of this study, 51 successfully created wetlands (i.e., ≥50% wetland plants and hydric soils or other indicators of hydrology). Of the 28 sites that failed to create wetlands, only three did not meet the wetland plant criterion but 100% failed to meet the criterion for hydric soils or other indicators of wetland hydrology. This means that 25 sites possessed plant communities that were characteristic of wetlands (≥50% of the plant community made up of wetland indicator plants) but did not have the hydrology necessary to be considered a wetland. Given these circumstances it would be easy to imagine that an issuing authority (conservation commission or MassDEP) assessing a wetland replacement area could identify these sites as wetlands with an evaluation based only on plants with no consideration of soils or other site characteristics.

28 In determining what soil characteristics should be used as indicators of saturation and anaerobic conditions, MassDEP relied on the characteristics ("indicators") described in MassDEP, 1995, *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act, A Handbook*. For situations where it was not clear, the following publication was consulted: NRCS, 2010, *Field Indicators of Hydric Soils in the United States: A Guide for Identifying and Delineating Hydric Soils, Version 7.0*, and/or U.S. Army Corps of Engineers, 2012, Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region, Version 2.0

29 Protocol for Using and Interpreting IRIS Tubes, Rabenhorst, 2008; Hydric Soils Technical Note 11: Hydric Soils Technical Standard and Data Submission Requirements for Field Indicators of Hydric Soils (see References).

Based on the details presented in the NOIs and observed conditions, many sites used a purchased "wetland seed mix" following excavation and placement of wetland soils. Such commercial wetland seed mixes contain native seeds from a variety of wetland plant species that are specifically chosen for wetland creation sites. Based on our observations, it appears that wetland seed mix can also grow successfully in locations that do not have wetland hydrology, particularly in wetland replacement areas where competition with upland plants is limited. This was documented by the number of sites where wetland vegetation was observed to be present and well established but no evidence of wetland hydrology could be found.

The results of this study suggest that highly effective wetland seed mixes and nursery stock can result in the establishment of vigorous wetland plant communities even in areas that lack wetland hydrology. The fact that the vegetation wetness index (weighted average) tended to suggest a greater affinity for wetland conditions in replacement areas than reference sites, even when many of the replacement areas lacked wetland hydrology, further supports the idea that vegetation can be a misleading criterion for judging mitigation success. This highlights the need during compliance inspections for issuing authorities to evaluate soils and look for other indicators of hydrology. Not only is the establishment of wetland vegetation insufficient on its own for determining the success or failure of wetland replacement projects, vegetation in wetland replacement areas may be an unreliable indicator of overall wetland conditions.

Wetland seed mixes have value. They can jump-start vegetation establishment at successful sites (those with appropriate hydrology) and provide dense ground cover that can inhibit the establishment of invasive species (e.g., common reed (*Phragmites australis*) or purple loosestrife (*Lythrum salicaria*)). Seed mix can also lead to erroneous conclusions regarding the success and viability of replacement areas. After two growing seasons, a dense growth of emergent wetland plants (e.g., sedges and hydrophilic grasses) may exist, but do they exist because they were planted, or because the hydrology is right? Where a wetland seed mix is used, attention should be paid to the pioneer (volunteer) species that are becoming established on the site. If upland species are becoming established even though many of the wetland seed mix species are still present, it may be an indication that the site is on a trajectory to being an upland plant community.

The majority of the sites evaluated were approximately 3-7 years old, and in many cases remnant wetland seed mix species existed right next to upland plant species such as white pine (*Pinus strobus*), King's Cure-all [30](*Oenothera biennis*) and even sweet fern (*Comptonia peregrina*). As sites without appropriate hydrology progress over time, they are likely to continue to transition to drier and drier plant communities. Brown and Veneman noted that the drier vegetation wetland index values for older projects may indicate that replacement wetlands are becoming drier over time. It could be that wetland seed mixes and nursery stock plantings initially provide a misleading appearance of wetland hydrology, and that over time, drier plant communities develop that are better suited to the drier hydrology of the replacement areas. This would suggest that some replacement areas deemed by Brown and Veneman to have successfully created wetlands may have lacked the appropriate wetland hydrology.

E. Wetland Boundary Delineations and Replacement Area Success Criteria

Another issue identified in the course of this study was questionable boundary delineations. In some cases, it appeared that the original wetland boundary was delineated upgradient of the true wetland boundary. During permitting, some wetlands were delineated larger than they actually were and included areas of upland. This was evidenced by 5.3% of reference sites with soil profiles that were determined not to be hydric, and did not contain other indicators of wetland hydrology. This may have been done inadvertently by consultants without adequate expertise, or by consultants and/or issuing authorities who intentionally took a more conservative approach to wetland delineation. While the intent may have been to be more protective of the original wetland, it can result in some wetland replacements being constructed in upland areas well away from adjacent wetlands and with no source of surface water or groundwater to sustain them. The field assessments conducted for this study were based on the wetland boundary that was delineated on the approved plans; the boundaries were not re-delineated even when they appeared to field staff collecting data to be incorrect.

30 Formerly known as Evening Primrose (*Oenothera biennis*)

F. Similarity of Replacement and Reference Sites

Based on Jaccard and Bray-Curtis similarity tests, plant communities in replacement areas differed from the plant communities in their associated reference wetlands. It is inherently difficult to compare early successional wetlands to more mature wetlands because species composition, diversity, and structural composition can change over time. This difference may be expected to be even more pronounced in replacement areas where a forested wetland is attempted (it takes many years for mature trees and dense understory to become established). Differences in plant community composition may result from project proponents that relied on purchased wetland mixes and standardized plantings instead of planting species that were found in the impacted wetland. They may also be due to replacement sites being wetter or drier than their associated reference sites. While replacement wetlands should ideally have similar vegetative communities to the lost wetland (or at least to similar healthy native wetland communities nearby), vegetation alone does not assure that a replacement wetland will function like a lost wetland. Landscape position, soil composition and microbial fauna are also likely to affect functions.

Many NOI applications failed to even identify the type of wetland being lost. It was simply referred to as a "BVW." Thus, it is possible that, in some cases, replacement area design did not take into account the plant community within the adjacent wetland, or any of the other characteristics of wetlands that would allow it to function similar to the lost wetland (e.g., landscape position, etc.). In some cases, vegetation in the impacted wetland may have been non-native or invasive, in which case it would not be appropriate to establish these same plants in the replacement areas. In these situations, project proponents should use plant communities in healthy wetlands nearby to serve as a model for revegetating replacement areas. Interestingly, plants in wetland replacement areas tend to have a greater affinity for wetland conditions than those in associated reference sites, as determined by the vegetation wetness index. This could be explained by the prevalence of sturdy purchased wetland seed mixture varieties where progression to the final plant communities has not occurred.

The MAWPA regulations required that wetland replacement areas function in a manner similar to that of the filled wetland. Wetland replacement efforts should focus on design characteristics and careful construction that strive to replicate a wetland's capacity to perform these functions. Few NOIs included an evaluation of the functions and associated characteristics of the impacted wetlands or how they would replace them. As stated above, they didn't even identify what type of wetland was being impacted. Under the MAWPA regulations (310 CMR 10.55(4)(b)), it was intended that the seven performance standards for replacement wetlands, plus any additional conditions deemed necessary by the issuing authority, would be used to achieve function-al equivalence. *The 2002 Guidelines* contain more detailed information on designing wetland replacement areas to replicate wetland functions. However, the results of this study suggest that most replacement areas failed to meet the seven performance standards specified at 310 CMR 10.55(4)(b) and that little attention is being paid to how replicated wetlands would function.

G. Certificates of Compliance

By 2012, when all file reviews had been completed for this study, 61.5%[31] of wetland replacement projects where permission to access was obtained and the status of the replacement area could be determined did not have COCs. It should be noted that 13 projects had permits that had not yet expired. As discussed in the Results section, COCs were issued to projects where wetland replacement areas were required but not built, and where wetland replacement areas were built but were not wetlands or did not meet the performance standards. Many of these projects appeared to qualify as limited projects even though there was no specific indication of this in the file. Nonetheless, full wetland replacement should be required of limited projects when possible. Of the 35 replacement areas for which COCs were issued, only 14 (40.0%) were in compliance with both the MAWPA regulations and OOC. Of the 91 replacement areas assessed, 12 were never built yet two received COCs.

H. Environmental Monitor

Of the 91 replacement projects assessed, 36 (39.6%) were required to have an environmental monitor with specified expertise. There was likely a wide range of expertise and effort expended by environmental monitors and in the commitment by applicants (e.g., funding of environmental monitor and support of goals) to fulfilling the mitigation requirements. In many cases monitoring reports were required but never submitted.

Of those projects where an environmental monitor was required by the OOC, 31 of 36 replacement areas (86.1%) were actually built, a rate comparable to that for all projects (86%). 20 out of 36 (55.6%) were successful in creating wetlands and 18 of 36 (50%) met the seven specific performance standards in the MAWPA regulations. When environmental monitors were involved and replacement areas were built (n = 31), the success rate for those projects in creating wetlands was not higher than the success rate for all projects (64.5% versus 65%). When the standard for success was full regulatory compliance (not just whether they were built or created wetlands), the success rate for those projects that were built and involved environmental monitors was quite a bit higher (58.1%) than for all projects (36%). Although only 39.6% of replacement areas involved environmental monitors, these areas accounted for 54.5% of those areas considered to have been regulatory compliant. Although it can be assumed that requiring an environmental monitor would improve success, this was only the case for the test of whether replacement areas achieved all 7 performance standards.

I. Were the Massachusetts Inland Wetland Replication Guidelines Followed?

In response to the issues identified by Brown and Veneman in their 2002 report, MassDEP developed *the Guidelines*. *The Guidelines* were designed to assist Conservation Commissions, MassDEP staff, and applicants by providing information about the proper design, implementation, and monitoring of wetland replacement projects, with the goal of increasing the effectiveness of wetlands replacement mitigation. One aspect of this current study was to determine whether or not *the Guidelines* achieved that goal. While there is no way to empirically document the implementation of *the Guidelines*, information gathered in the course of this study allows us to infer the extent to which it was applied.

One part of this study was to track whether Notices of Intent and Orders of Conditions contained specific details about how proposed wetland replacement areas would be constructed (e.g., plantings, soils, invasive species control, erosion control, groundwater elevations, and long term monitoring). These details – collected during review of the project files – allowed us to speculate on whether recommendations contained in *the Guidelines* were followed. The vast majority of projects contained some specific information about the proposed wetland replacement, such as a narrative description, a detailed plan for the proposed replacement area including cross-sections, and specific information about proposed plantings. Because this information was often lacking in the past, it is likely the guidance document was being read and that some components of the guidance were being incorporated into the permitting process. Although it appears that issuing authorities and applicants were more aware of the need to provide technical data, including soils, hydrology and plantings, in order to create successful wetland replacement areas, follow-through was sporadic.

Unfortunately, inference can be made that not all the recommendations in *the Guidelines* were implemented. One of the most important points in Section 2.3.1 of *the Guidelines* was the importance of establishing proper hydrology, including the depth to groundwater in the area of the proposed replacement area, to ensure the replacement area was excavated to the proper depth. Very few did it. Only 17 of the 178 (9.5%) Notice of Intent site files assessed contained information about groundwater levels in the area of the proposed replacement area prior to its construction. Without knowing the depth to groundwater in the proposed replacement area, the degree of excavation necessary to intercept the water table and achieve proper wetland hydrology becomes a hit-or-miss proposal. The field work conducted in this study identified lack of wetland hydrology as the primary reason for wetland replacement failure. While soil translocation (i.e., the relocation of wetland soils from the impact area to the replacement area) is recommended (Section 2.3.2 of *the Guidelines*), very few examples of it were observed in the field. In most cases "loam" or "topsoil" was brought in from outside sources. Researchers did not observe any NOIs for proposed replacement areas that included a soil profile from the wetland to be lost or any attempt to replicate the soil characteristics.

The Guidelines also emphasize the need to evaluate the existing conditions and functions of the impacted wetland and then propose specific characteristics of the replacement wetland to replicate those lost functions. Yet when the Notice of Intent filings were reviewed, no examples of functional assessments conducted for the

31 46/79 sites field assessed plus 10/12 sites field assessed where replacement area not built

Table 28: Wetland Acreage Replaced

Sites	Wetlands Impacted (acres)	Required Replacement (acres)	Wetland Created (acres)	Wetland Created and Meeting the 7 Performance Standards (acres)
50 sites	4.15	5.78	3.68	2.39
Outlier Site	0.74	1.29	2.29	2.29
4 Variance Sites (greater than 1:1)	9.15	13.68	13.61	11.57 [34]
Total Acreage of 50 sites, outlier site and variance sites	14.04	20.75	19.58	16.25
Total Acreage of 50 sites and outlier site extrapolated to statewide basis, plus variance sites	48.27	70.24	61.37	49.01

impacted wetland were found. A site-specific functional assessment of the wetland area to be altered should have included details such as the soil characteristics, wildlife habitat features, degree to which the wetland stores floodwater, density of the wetland vegetation, depth to groundwater, degree of groundwater discharge or recharge, etc. The purpose of wetland replacement was to replace the functions of the altered area, but if no functional assessment of the lost area was conducted, then it can't be determined whether the replacement area successfully replaced those functions.

Another problem is that while many municipalities required monitoring, as suggested in Section 4 of *the Guidelines*, only 35% of the projects actually received monitoring reports. So while most issuing authorities are aware of the need for monitoring, it was found to have only occurred in a small percentage of the projects that were reviewed.

If Applicants followed the recommendations of *the Guidelines* more carefully, success rates would probably have been better. However, we do not know why the recommendations in that guidance document were not used more often.

J. Meeting No Net Loss

The creation of a replacement area that does not meet the regulatory definition of a wetland or the performance standards is unquestionably a failure. Table 28 presents data on the wetland acreage created and the acreage created that meets BVW performance standards, along with the total number of acres impacted and the acres of wetland replacement required by issuing authorities for the study period. The table presents 50 replacement areas, and an outlier site[32] that successfully created wetlands, from the 44-town analysis. The table also includes 4 replacement wetlands created for projects permitted during the study period through the variance process. [33]Variance projects represent the largest projects in the state with the largest wetland losses. They also represent the largest wetland replacement areas with extensive resources put toward them. Typically, wetland variance projects have greater than 1:1 replacement to impact ratios.

When only the 50 sites are considered, 63.7% of the wetland replacement acreage required was built and functioned as wetland, and only 41.3% of required wetland replacement acreage was built to meet all performance standards. But these statistics only tell part of the story. Overall, conservation commissions and MassDEP are requiring wetland replacement areas to be larger than the size of the wetland impact. As a statewide ratio, issuing authorities required approximately 1.36:1 mitigation-to-impact ratio. So when the acreage of wetland replacement is compared to the acreage of wetland impacted, 88.6% of the wetland acreage impacted was replaced as a wetland, and 57.6% of wetland acreage impacted was replaced with wetlands built to meet all performance standards. When the additional wetland variance acreage and the outlier site are added, lost wetlands were fully replaced statewide with wetlands that meet all performance standards, even when extrapolated to a statewide basis. However, these data indicate that the smaller on-site wetland replacement projects, taken on their own, are not succeeding in replacing the acreage or function of impacted wetlands.

32 The Encarta Dictionary defines an outlier site as "a value far from others…". In this case the outlier site was an anomaly because it was an unusually large wetland replacement project that was also being permitted as a Water Quality Certification. Although much of the impact was isolated vegetated wetland, not protected under state law, the replacement was created as BVW.

33 Projects include MassDOT Middlesex Turnpike Improvements Phase 2, Pittsfield Airport Runway Safety Areas, Hanscom Airport Runway 5/23 Safety Areas, and North Adams Runway Safety Areas. While these variance project replacement areas were not assessed like those in the 44 municipalities presented in this study, their status is known through regular monitoring and reporting.

34 Acreage adjusted to represent ongoing invasive species management some of these sites.

K. Recordkeeping

Since the Brown and Veneman report was published with a recommendation for better recordkeeping, MassDEP obtained a federal grant and built a new Wetlands Program database with a geospatial map viewer. This new database became live in 2009, and older files were migrated from the prior database with very little data. Whether or not a file contained wetland replacement was not contained in the older database, and the pre-2009 files were not geolocated in the new database. Thus, the NOI files that were examined in this study were only those that were present in the municipal files. Lists of NOIs were generated from MassDEP's database prior to visiting the towns, and NOIs on those lists were cross-checked with the town files. A small number of NOIs could not be found. In a couple of municipalities, researchers were told that they had no projects with wetland replacement and were not invited to double-check their files. It is possible that a file was missed, as approximately 5,000 were reviewed. MassDEP's current database has the capability to identify projects with wetland replacement areas, and geospatially locates those areas. The database also contains the impact and replacement acreage of all resource areas. Future studies requiring more detailed information would likely still require review of municipal files.

VI. Recommendations

The MAWPA regulations state that, "Where a proposed activity involves the removing, filling, dredging or altering of a Bordering Vegetated Wetland, the issuing authority shall presume that such area is significant to the interests specified in 310 CMR 10.55(1)" (i.e., public or private water supply, to groundwater supply, to flood control, to storm damage prevention, to the prevention of pollution, to the protection of fisheries, and to wildlife habitat). These presumptions are rarely, if ever, overcome. Additionally, wetlands play an important role in sequestering carbon in their soils and biomass, thereby helping to offset increasing emissions that are warming our planet. Successfully replacing unavoidable wetlands loss will help to ensure that wetland functions are protected. However, successfully replacing the physical, biological and chemical characteristics of wetlands is difficult to do and requires extensive resources and expertise. The goals of this study were to assess the success of wetland replacement in Massachusetts and make recommendations for improvement.

As documented in this study, wetland replacement continues to be less successful than is required by the MAWPA regulations. The MAWPA regulations promote avoidance of wetland impacts as perhaps the best policy to pursue because of the difficulty in successfully replacing wetlands. In Massachusetts cases, where wetland impacts cannot be avoided, project proponents are required to replace the altered wetland with one that functions in a similar manner. There was much discussion on whether the requirement of wetland replacement serves as a disincentive to wetland fill. The data indicate that during the Brown and Veneman study period (1983-1994), there were approximately 319 wetland replacement projects (27 per year) versus the current study period (2004-2008) when there were approximately 176 wetland replacement projects (44 per year). The percentage of the total number of applications that were wetland replacement projects was higher during the Brown and Veneman study period (9.1% of 3,519 filings) than in this study period (3.5% of 5,090 filings) . However, the addition of Riverfront Area regulations to the MAWPA may account for the much larger number of filings during this time period. Another reason for the increased number of filings may involve a reduction in readily available land located outside of wetland jurisdiction. Thus, it is unclear whether or not the wetland replacement requirement serves as a disincentive, but it certainly cannot be a desirable condition of any permit due to the cost and resources required to do it successfully. Nonetheless, 176 wetland replacement areas were approved during the 2004-2008 study period. Each subsequent year, additional wetland replacement areas are required to be built, monitored, and in many cases remediated. While exceptions exist, in general it has not been a priority of permittees to provide the resources and expertise required to construct each wetland replacement area successfully. Additionally, government agencies are unable to provide the oversight needed due to lack of staffing and resources and, in some cases, expertise.

Because it is widely recognized that hydrology is the driving force behind wetlands, it can be concluded that the most important consideration in achieving a successful wetland replacement area is to get the hydrology right. With proper hydrology, a wetland will develop, even if the plantings or placed soils are not ideal. However, even proper plantings and placement of appropriate soil material will fail to create a wetland if the hydrology is not appropriate for a wetland ecosystem. One factor that may have contributed to the failure of replacement wetlands was inadequate evaluation of the proposed wetland replacement site during design to identify where the hydrology will come from (e.g., groundwater monitoring wells, soil profiles, and evaluation of adjacent surface waters).

An equally important factor contributing to failure was inadequate documentation of inundation, saturation and anaerobic conditions in the constructed wetland replacement area. Post-construction documentation of inundation, saturation and anaerobic conditions should include demonstration of one or more of the following: 1) characteristics of hydric soils, 2) groundwater within a major portion of the root zone, or 3) observation of prolonged, frequent flowing or standing surface water. Documentation of inundation, saturation and anaerobic conditions should be provided in addition to documentation that at least 75% of the surface of the replacement area is reestablished with indigenous wetland plant species. Follow-up by issuing authorities to require documentation of inundation, saturation and anaerobic conditions could be a significant factor in increasing the success rate of replacement areas. Additionally, more specificity in the MAWPA regulations and/or guidance may be necessary to better achieve functional replacement.

Greater expertise in designing and building the replacement wetland is also needed, as well as greater oversight. Conservation Commissions and MassDEP should make it a priority to carefully review and condition projects that involve wetland impacts and replacement, and monitor those projects to ensure that replacement areas are constructed and create wetlands. Without proper project oversight, wet-land resources will be lost without effective replace-ment, undermining the "no net loss" policy pursued since the 1980's by federal and state regulators. Projects where wetland replacement is required should have an experienced environmental monitor. However, the fact that having an environmental monitor didn't improve the percentage of replacement areas built or establishing wetlands suggests that perhaps some of those environmental monitors may never have been hired, were insufficiently funded, or lacked the authority to ensure that replacement areas were correctly built. There are a number of ways environmental monitoring could be strengthened that would be likely to improve success of wetland replacement areas. These include: 1) the requirement that replacement projects have an environmental monitor; 2) standards for environmental monitor expertise and experience; 3) a clear scope of work describing the level of effort expected of the environmental monitor; 4) follow-up by the issuing authority to ensure that monitoring reports are submitted, especially during and within one week after construction, to ensure that grades, soils and plantings are constructed as approved; and 5) timely issuance of COCs or action to require remedial action where it is warranted.

Additionally, the duration of monitoring should allow sufficient time for the replacement wetland to develop the desired characteristics. The BVW performance standards in the MAWPA regulations at 310 CMR 10.55(4)(b)6 require that "at least 75% of the surface of the replacement area shall be reestablished with indigenous wetland plant species within two growing seasons." In most cases, two growing seasons is insufficient time to ensure that the appropriate hydrology and plantings have been established, and that invasive species did not take root. Given the apparent effectiveness and persistence of wetland seed mixes and nursery stock, it may take more than two (2) years to determine whether a wetland plant community has been truly established. It also may take longer to determine if appropriate hydrology is present or hydric soils are forming. For most projects, a five (5) year monitoring period would allow for better oversight and a perhaps greater likelihood of success. In the case of forested-wetland replacement wetlands, a 5-year monitoring period would provide additional time to determine if the replacement area is on a trajectory to become a forested wetland.

It is also problematic that many municipalities that required monitoring reports did not receive them. The reason why is unclear. Many conservation commissions have part-time or even no staff, so the ability to follow up on that requirement may have been limited. In some cases, the environmental consultant who prepared the Notice of Intent may have included a commitment to monitor the project, but that environmental consultant was no longer associated with the project once the permitting was completed. Regular follow up by the issuing authority to require monitoring reports and as-built plans would improve the likelihood of replacement areas being built and built to size. However, many municipalities do not appear to have sufficient resources to provide adequate compliance monitoring.

The requirement of a COC is a final step that issuing authorities should follow to ensure wetland replacement compliance. However, in many cases, COC's were not issued or were issued inappropriately. There are a couple of ways that the process might have broken down: 1) Applicants did not request and/or issuing authorities failed to issue Certificates of Compliance; and 2) When Certificates of Compliance were issued, sites were not being properly assessed to determine whether the wetland replacement area was successful. This report provides considerations for conservation commissions and MassDEP regional offices to ensure that wetland replacement areas are appropriately assessed prior to issuance of COCs.

The following recommendations have been developed to improve Massachusetts wetland mitigation policy and regulation, and to provide technical recommendations to improve the success of wetland replacement.

Considerations for the Commonwealth of Massachusetts to Improve Wetland Mitigation Policy and Regulation

1. Strengthen Avoidance and Minimization regulations (10.55 (4)(a)&(b)) by making them more prominent in the regulations and requiring an alternatives analysis.

2. Increase the required mitigation-to-impact ratios. Consider revising the Variance regulations at 310 CMR 10.05(10) to require that wetland variance projects have greater than or equal to a 2:1 mitigation-to-impact ratio. Also consider revising the BVW standards at 310 CMR 10.55(4)(b)(1) to require a greater than 1:1 ratio of the surface of the replacement area to the area that will be lost.

3. Provide clarification on how to measure that at least 75% of the surface of the replacement area is reestablished with indigenous wetland plant species within two growing seasons.

4. Require a Financial Assurance Mechanism (FAM).

FAM's, such as performance bonds, have been required by other regulations (e.g., 314 CMR 5.15(4)-(6)). A FAM, in certain circumstances, would allow the issuing authority to remediate wetland replacement areas that are unsuccessful. FAMs should be evaluated to determine if they would help to ensure compliance, especially in instances where properties get sold before unsuccessful mitigation is identified.

5. Update the Performance Standards to Ensure Successful Hydrology

The performance standard at 310 CMR 10.55(4)(b) 2 currently requires that "the groundwater and surface elevation of the replacement area shall be approximately equal to that of the lost area"; more specificity is needed to ensure that hydrology is designed properly. In addition to the existing language, the performance standard should reflect that the hydrologic regime of the replacement area must be saturated, flooded or ponded long enough to develop an anaerobic condition within the top 12 inches of the soil profile.

6. Ensure that Performance Standards for Hydrology are Successfully Met

This study has established that more effort is needed to ensure that issuing authorities require data and plans prior to issuance of the Order of Conditions, demonstrating that the replacement area will have appropriate wetlands hydrology, as well as evidence of inundation, saturation and anaerobic conditions within the constructed wetland replacement areas, prior to issuance of a Certificate of Compliance. As a minimum for NOI submission, there should be a requirement for specific information on the proposed hydrological conditions to be produced in the wetland replacement area. Observations of prolonged or frequent flowing or standing surface water immediately adjacent to the site, groundwater monitoring data, soil profiles, and in some cases additional data collection to establish that anaerobic conditions exist, should be used by qualified personnel to assess hydrology for design purposes. In some cases, if the soils clearly depict the fluctuation of the groundwater table, an appropriate number of properly located soil profiles conducted by qualified personnel along with observations of prolonged or frequent flowing or standing surface water immediately adjacent to the site may be adequate. MassDEP should check for this information and when it is missing, provide appropriate comments to applicants and conservation commissions when file numbers are provided. Orders of Conditions should include a requirement that applicants provide evidence of appropriate hydrology in the wetland replacement area as part of the request for Certificate of Compliance. Indicators of these conditions would include: a) groundwater, including the capillary fringe, within a major portion of the root zone; b) observation of prolonged or frequent flowing or standing water; and/or c) characteristics of hydric soils. During construction, monitoring requirements should ensure that the excavation and final grading elevations are completed in accordance with the approved design. Groundwater monitoring wells or other techniques for measuring saturation and/or development of anaerobic conditions should be implemented. See Section V.C. for additional recommendations

7. **Revise performance standards to allow more flexibility in locating replacement areas (within the same town or watershed or stream system)**

Implementing this recommendation would require a change in 310 CMR 10.55(4)(b) 3, 4, and 5 to allow for more strategic location of wetland replacement in areas with less development, where they may be more likely to succeed. Flood storage and stormwater functions would still need to be provided on or near the site of the wetland loss. Wetland replacement areas that are appropriately located (i.e., away from developed areas) can avoid some of the secondary impacts that may occur to wetland replacement areas due to close proximity to development, such as changes in hydrology due to drainage systems, encroachment by invasive species, and human disturbance.

As we consider the concerns about how replacement areas might be less effective when they are built in close proximity to the development that necessitated them, it is important to recognize that the development is likely to degrade remaining natural wetlands as well. Thus, greater emphasis on avoidance of wetland impacts and adoption of performance standards, or enhancing the existing narrative standard for buffer zone projects, would help to address both of these concerns.

8. **Improve specifications for Forested Wetland Replacement Areas in Performance Standards and/or Guidance.**

In addition to ensuring proper hydrology and soil structure, forested-wetlands designers should specify number, density, type and size of plantings, including shrub and understory layers in the replacement area, and describe the intended process of succession to a forested wetland community. Plantings should be as mature as possible to reduce temporal functional loss. However, precisely mimicking a mature forested plant community is not as important as getting the hydrology and soil structure right. The use of purchased wetland seed mix should be limited and alternatives to wetland seed mixes should be considered. In forested wetlands, use of leaf litter as mulch might be equally effective in inhibiting invasive species and providing stabilization and cover.

9. **Require an Environmental Monitor either through Regulatory Revision or Permitting**

Although this study concluded that having an environmental monitor did not correlate with success, the study did not evaluate the quality or expertise of the environmental monitors that were required. There are currently no standards for expertise, nor requirements for monitoring frequency or reporting. Development of standards and criteria for environmental monitors may result in improved success. It is recommended that a minimum number of years of experience in wetland replacement design and construction oversight be established for an environmental monitor (e.g., MassDEP has required 10 years of experience for Variance projects). Environmental monitors should be able to provide examples of successful wetland replacement areas they have worked on. It is also desirable to have the environmental scientist that designed the wetland replacement area also supervise construction and post-construction monitoring of the replacement area. Consideration may be given to allowing limited flexibility for a qualified environmental monitor to make minor adjustments to the design based on site specific conditions observed during construction (e.g., groundwater is higher or lower than anticipated during design). Such adjustments should be reported and approved by the issuing authority.

10. **Extend the Timeframe for Monitoring from Two to Five Years**

This extended timeframe will allow greater time for the issuing authority to assess success and for the applicant to implement remediation.

11. **Revise Wetland Boundary Requirement**

Wetland boundaries must be delineated in accordance with 310 CMR 10.55(2)(c)1-3. The first option (i.e., (2)(c)1) states that the boundary, as determined by 50% or more wetland indicator plants, shall be presumed accurate if all dominant species have an indicator status of OBL, FACW+, FACW or FACW- and a distinct or abrupt slope is present between the upland and wetland; work is in the buffer zone only; or the issuing authority determines that sole reliance on wetland indicator plants will yield an accurate delineation. This study documented that many wetland replacement sites met the wetland vegetation criterion for delineation with no hydric soils or other indicators of wetland hydrology. Consider eliminating 310 CMR 10.55(2)(c) 1, and requiring the provisions of 310 CMR 10.55(2)(c)2 or 3 for all wetland delineations. This will require that the boundary be defined as the line within which 50% or more of the vegetative community consists of wetland indicator plants and saturated or inundated (ponded or flooded) conditions exist long enough to develop an anaerobic condition within the top 12 inches of the soil profile. Thus vegetation and indicators of saturation and inundation would need to be evaluated.

12. **Consider allowing a small amount of temporary alteration (that would not count toward the 5000 sf limit) as part of the replacement area design, to provide the appropriate grades to connect the replacement area to the original wetland.**

13. **Revise the MAWPA regulations and/or forms to require greater oversight of wetland replacement area construction (e.g. measure rough/finished grades, verify size, verify planting and maintenance, etc.);**

14. **Revise the MAWPA regulations and/or forms to require that wetland replacement areas be constructed before or coincident with wetland alteration where feasible.**

15. **Consider revising the MAWPA regulations to allow for other strategies that do not require on-site in-kind replacement for all projects.**

Some of these strategies include: 1) establishing a category of smaller projects (i.e. either a project type, a size etc.) for which other types of mitigation could be allowed (e.g. restoration, enhancement), and above which replacement is required;2) Consider alternatives that would allow wetland mitigation areas to be consolidated into one or more off-site mitigation areas for long linear projects. Alternatively, allow applicants with long, linear projects to provide wetland mitigation prior to impact via "banking;" and 3) consider onsite mitigation for a limited number of wetland functions (flood control, storm damage prevention, pollution prevention and groundwater recharge) coupled with off-side restoration for biological functions (shellfish, fish and wildlife habitat).The goal of this recommendation is to reduce the number of wetland replacement areas that need to be designed, built and monitored by applicants, their consultants or environmental monitors, and reviewed for compliance by Conservation Commissions or MassDEP. Because it takes several years to achieve a successful wetland replacement area, an accumulation over time of sites that require attention by the agencies can exceed the resources available for compliance monitoring. By reducing the overall number of wetland replacement areas built, more attention can be focused on those that are built.

16. **Condense and revise the 2002 Wetland Replication Guidance and incorporate the relevant guidelines for BVW from the 2006 Wildlife Habitat Protection Guidelines for Inland Wetlands. Make appropriate regulatory revisions.**

Considerations for Conservation Commissions to Improve Wetland Mitigation Success

1. Review the recommendations for the Commonwealth of Massachusetts (above), as well as *the Guidelines*, March 2002.

2. Require demonstration of avoidance and minimization (10.55 (4)(a)&(b) text below Standard 7) and only allow wetland loss where it is unavoidable.

3. Require that Notices of Intent include evidence of anaerobic conditions (from soil profiles,

IRIS tubes, etc.) and saturation (from piezometers, groundwater monitoring wells) within the proposed replacement area at the depth to which excavation is proposed, as well as observations and data on adjacent surface waters, to demonstrate that the replacement area will have the appropriate hydrology.

The hydrology of the replacement area should be similar to that of the lost area. If this is not feasible due to site-specific constraints, it should be similar to the adjacent BVW. For some projects, if deemed acceptable by the issuing authority and if hydric soils can be clearly identified at the depth to which excavation is proposed, an appropriate number of properly located soil profiles conducted by qualified personnel, and/or observations and data of prolonged frequent flowing or standing surface water immediately adjacent to the site, may be adequate to assess hydrology for design purposes.

4. After the wetland replacement area is built, applicants should be required to document:

1) that at least 75% of the surface of the required replacement area is reestablished with indigenous wetland plant species and

2) evidence of appropriate hydrology in the wetland replacement area exists, by documenting one or more of the following:

a) the presence of characteristics of hydric soils within the top 12 inches;

b) groundwater, including the capillary fringe, within a major portion of the root zone; and

c) observation of prolonged or frequent flowing or standing surface water. [35]

These characteristics should be documented during post-construction monitoring and as part of the request for Certificate of Compliance. Presence of these characteristics in wetland replacement areas would increase the likelihood of wetland replacement success.

5. Use the "Consultants Fee Statute" for outside review of mitigation plans

(M.G.L. 44 §53G). Refer to MassDEP Wetlands Program Policy 08-1 entitled: Lack of Information Necessary for Conservation Commission Decisions. *http://www.mass.gov/eea/agencies/massdep/water/regulations/wetlands-program-policy-08-1.html*

35 b) and c) should be present long enough during the growing season to produce anaerobic conditions in the upper part of the soil profile.

Also, see the Massachusetts Association of Conservation Commissions document entitled Model Rules for Hiring Outside Consultants under G.L. Ch. 44§ 53G at *https://www.maccweb.org/general/custom.asp?page=ResWPA*

6. Require environmental monitors and specify credentials (e.g. experience in design, construction and monitoring of wetland replacement) (see discussion above).

7. Orders of Conditions should include the following elements:

- preconstruction meetings;
- supervision of excavation and subgrade inspection and survey to confirm appropriateness of subsoils and hydrology;
- topsoil and finish grade inspections to confirm substrate appropriateness, application, and grading;
- inspection of plant materials and oversight of plantings, seeding and/or mulching;
- post-construction monitoring for 2-5 growing seasons to evaluate vegetation and hydrology, including soils as well as invasive species; and
- specified intervals for submission of reports (e.g. bi-weekly during active construction, monthly off-season, and annual monitoring report to compile the biweekly/monthly reports).

8. Inspect sites post-construction and follow up on the requirement to obtain a Certificate of Compliance.

VII. Closing Summary

Successfully replacing unavoidable wetlands loss will help to ensure that wetlands are conserved. However, successfully replacing the physical, biological and chemical characteristics of wetlands is difficult to do and requires extensive resources and expertise. Similar to the Brown and Veneman study completed over 18 years ago, this study found that wetland replacement is less successful than desired, and less successful than required by the MAWPA regulations. Because of the difficulty in constructing successful wetlands, emphasis should be placed on avoidance and minimization first, followed by an improvement in the required performance standards, and finally, expansion of BVW mitigation options while working to achieve no net loss of wetlands (acreage and/or function).

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APPENDIX A: 310 CMR 10.55

10.55: Bordering Vegetated Wetlands (Wet Meadows, Marshes, Swamps and Bogs)

(1) Preamble. Bordering Vegetated Wetlands are likely to be significant to public or private water supply, to ground water supply, to flood control, to storm damage prevention, to prevention of pollution, to the protection of fisheries and to wildlife habitat.

The plants and soils of Bordering Vegetated Wetlands remove or detain sediments, nutrients (such as nitrogen and phosphorus) and toxic substances (such as heavy metal compounds) that occur in run-off and flood waters.

Some nutrients and toxic substances are detained for years in plant root systems or in the soils. Others are held by plants during the growing season and released as the plants decay in the fall and winter. This latter phenomenon delays the impacts of nutrients and toxins until the cold weather period, when such impacts are less likely to reduce water quality.

Bordering Vegetated Wetlands are areas where ground water discharges to the surface and where, under some circumstances, surface water discharges to the ground water.

The profusion of vegetation in Bordering Vegetated Wetlands acts to slow down and reduce the passage of flood waters during periods of peak flows by providing temporary flood water storage and by facilitating water removal through evaporation and transpiration. This process reduces downstream flood crests and resulting damage to private and public property. During dry periods the water retained in Bordering Vegetated Wetlands is essential to the maintenance of base flow levels in rivers and streams, which in turn is important to the protection of water quality and water supplies.

The Act defines freshwater wetlands by hydrology and vegetation. Hydrology is the driving force which creates wetlands, but it is a transient, temporal parameter. The presence of water at or near the ground surface during a significant portion of the year supports, and in fact promotes, the growth of wetland indicator plants. Prolonged or frequent saturation or inundation also produces hydric soils, and creates anaerobic conditions that favor the growth of wetland indicator plants. Hydric soils are direct indicators of long-term hydrologic conditions and are present throughout the year.

Wetland vegetation supports a wide variety of insects, reptiles, amphibians, small mammals and birds which are a source of food for important game fish. Bluegills (*Lepomis macrochirus*), pumpkinseeds (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*) and all trout species feed upon nonaquatic insects. Large-mouth bass (*Micropterus salmoides*), chain pickerel (*Esox niger*) and northern pike (*Esox lucius*) feed upon small mammals, snakes, nonaquatic insects, birds and amphibians.

Wetland vegetation provides shade which moderates water temperatures important to fish life. Wetlands flooded by adjacent water bodies and waterways provide food, breeding habitat and cover for fish. Fish populations in the larval stage are particularly dependent upon food provided by over-bank flooding which occurs during peak flow periods (extreme storms) because most river and stream channels do not provide sufficient quantities of the microscopic plant and animal life required for food.

Bordering vegetated wetlands are probably the Commonwealth's most important inland habitat for wildlife. The hydrologic regime, plant community composition and structure, soil composition and structure, topography, and water chemistry of bordering vegetated wetlands provide important food, shelter, migratory and overwintering areas, and breeding areas for many birds, mammals, amphibians and reptiles. A wide variety of vegetated wetland plants, the nature of which are determined in large part by the depth and duration of water, as well as soil and water composition, are utilized by varied species as important areas for mating, nesting, brood rearing, shelter and food (directly and indirectly). The diversity and interspersion of the vegetative structure is also important in determining the nature of its wildlife habitat. Different habitat characteristics are used by different wildlife species during summer, winter and migratory seasons.

Although the vegetational community can often be analyzed to establish an accurate wetland boundary, sole reliance on the presence of wetland indicator plants can be misleading because some species thrive in both uplands and wetlands. Gently sloping areas often produce large transitional zones where the vegetational boundary is difficult to delineate. Hydrology can supplement vegetative criteria to enhance the technical accuracy, consistency, and credibility of wetland boundary delineations, and are especially useful for analyzing disturbed sites.

(2) Definition, Critical Characteristics and Boundary.

(a) Bordering Vegetated Wetlands are freshwater wetlands which border on creeks, rivers, streams, ponds and lakes. The types of freshwater wetlands are wet meadows, marshes, swamps and bogs. Bordering Vegetated Wetlands are areas where the soils are saturated and/or inundated such that they support a predominance of wetland indicator plants. The ground and surface water regime and the vegetational community which occur in each type of freshwater wetland are specified in M.G.L. c. 131, § 40.

(b) The physical characteristics of Bordering Vegetated Wetlands, as described in 310 CMR 10.55(2)(a), are critical to the protection of the interests specified in 310 CMR 10.55(1).

(c) The boundary of Bordering Vegetated Wetlands is the line within which 50% or more of the vegetational community consists of wetland indicator plants and saturated or inundated conditions exist. Wetland indicator plants shall include but not necessarily be limited to those plant species identified in the Act. Wetland indicator plants are also those classified in the indicator categories of Facultative, Facultative+, Facultative Wetland-, Facultative Wetland, Facultative Wetland+, or Obligate Wetland in the *National List of Plant Species That Occur in Wetlands: Massachusetts (Fish & Wildlife Service, U.S. Department of the Interior*, 1988) or plants exhibiting physiological or morphological adaptations to life in saturated or inundated conditions.

1. Areas containing a predominance of wetland indicator plants are presumed to indicate the presence of saturated or inundated conditions. Therefore, the boundary as determined by 50% or more wetland indicator plants shall be presumed accurate when:

a. all dominant species have an indicator status of obligate, facultative wetland+, facultative wetland, or facultative wetland- and the slope is distinct or abrupt between the upland plant community and the wetland plant community;

b. the area where the work will occur is clearly limited to the buffer zone; or

c. the issuing authority determines that sole reliance on wetland indicator plants will yield an accurate delineation.

2. When the boundary is not presumed accurate as described in 310 CMR

10.55(2)(c)1.a. through c. or to overcome the presumption, credible evidence shall be submitted by a competent source demonstrating that the boundary of Bordering Vegetated Wetlands is the line within which 50% or more of the vegetational community consists of wetland indicator plants and saturated or inundated conditions exist. The issuing authority must evaluate vegetation and indicators of saturated or inundated conditions if submitted by a credible source, or may require credible evidence of saturated or inundated conditions when determining the boundary. Indicators of saturated or inundated conditions sufficient to support wetland indicator plants shall include one or more of the following:

a. groundwater, including the capillary fringe, within a major portion of the root zone;

b. observation of prolonged or frequent flowing or standing surface water;

c. characteristics of hydric soils.

3. Where an area has been disturbed (e.g. by cutting, filling, or cultivation), the boundary is the line within which there are indicators of saturated or inundated conditions sufficient to support a predominance of wetland indicator plants, or credible evidence from a competent source that the area supported or would support under undisturbed conditions a predominance of wetland indicator plants prior to the disturbance.

(3) Presumption. Where a proposed activity involves the removing, filling, dredging or altering of a Bordering Vegetated Wetland, the issuing authority shall presume that such area is significant to the interests specified in 310 CMR 10.55(1). This presumption is rebuttable and may be overcome upon a clear showing that the Bordering Vegetated Wetland does not play a role in the protection of said interests. In the event that the presumption is deemed to have been overcome, the issuing authority shall make a written determination to this effect, setting forth its grounds (Form 6).

(4) General Performance Standards.

(a) Where the presumption set forth in 310 CMR 10.55(3) is not overcome, any proposed work in a Bordering Vegetated Wetland shall not destroy or otherwise impair any portion of said area.

(b) Notwithstanding the provisions of 310 CMR

10.55(4)(a), the issuing authority may issue an Order of Conditions permitting work which results in the loss of up to 5000 square feet of Bordering Vegetated Wetland when said area is replaced in accordance with the following general conditions and any additional, specific conditions the issuing authority deems necessary to ensure that the replacement area will function in a manner similar to the area that will be lost:

1. the surface of the replacement area to be created ("the replacement area") shall be equal to that of the area that will be lost ("the lost area");

2. the ground water and surface elevation of the replacement area shall be approximately equal to that of the lost area;

3. The overall horizontal configuration and location of the replacement area with respect to the bank shall be similar to that of the lost area;

4. the replacement area shall have an unrestricted hydraulic connection to the same water body or waterway associated with the lost area;

5. the replacement area shall be located within the same general area of the water body or reach of the waterway as the lost area;

6. at least 75% of the surface of the replacement area shall be reestablished with indigenous wetland plant species within two growing seasons, and prior to said vegetative reestablishment any exposed soil in the replacement area shall be temporarily stabilized to prevent erosion in accordance with standard U.S. Soil Conservation Service methods; and

7. the replacement area shall be provided in a manner which is consistent with all other General Performance Standards for each resource area in Part III of 310 CMR 10.00.

In the exercise of this discretion, the issuing authority shall consider the magnitude of the alteration and the significance of the project site to the interests identified in M.G.L. c. 131, § 40, the extent to which adverse impacts can be avoided, the extent to which adverse impacts are minimized, and the extent to which mitigation measures, including replication or restoration, are provided to contribute to the protection of the interests identified in M.G.L. c. 131, § 40.

(c) Notwithstanding the provisions of 310 CMR 10.55(4)(a), the issuing authority may issue an Order of Conditions permitting work which results in the loss of a portion of Bordering Vegetated Wetland when:

1. said portion has a surface area less than 500 square feet;

2. said portion extends in a distinct linear configuration ("finger-like") into adjacent uplands; and

3. in the judgment of the issuing authority it is not reasonable to scale down, redesign or otherwise change the proposed work so that it could be completed without loss of said wetland.

(d) Notwithstanding the provisions of 310 CMR 10.55(4)(a),(b) and (c), no project may be permitted which will have any adverse effect on specified habitat sites of rare vertebrate or invertebrate species, as identified by procedures established under 310 CMR 10.59.

(e) Any proposed work shall not destroy or otherwise impair any portion of a Bordering Vegetated Wetland that is within an Area of Critical Environmental Concern designated by the Secretary of Energy and Environmental Affairs under M.G.L. c. 21A, § 2(7) and 301 CMR 12.00: *Areas of Critical Environmental Concern*. 310 CMR 10.55(4)(e):

1. supersedes the provisions of 310 CMR 10.55(4)(b) and (c);

2. shall not apply if the presumption set forth at 310 CMR 10.55(3) is overcome;

3. shall not apply to work proposed under 310 CMR 10.53(3)(l); and

4. shall not apply to maintenance of stormwater detention, retention, or sedimentation ponds, or to maintenance of stormwater energy dissipating structures that have been constructed in accordance with a valid order of conditions.

Effective 10/24/2014

APPENDIX B: Town Data Form

APPENDIX A: SITE DATA FORM

Site ID Number		NOI File Number:		Town:	
Site Address					
Applicant					
Applicant Address					
Wetland Loss Type : (MassDEP/Cowardin)			Proposed Wetland Replacement Type:		
Impact Size:			Replacement Area Size:		
NOI Date:			OOC Date:		
SOOC?			COC?		
NOI PLAN DATA					
Replacement Plan Show Site?	Y	N	Description of Site Prep?	Y	N
Construction Details?	Y	N	Planting Information?	Y	N
Erosion Control Plan?	Y	N	Invasive Species control?	Y	N
Soil Details?	Y	N	Groundwater elevations provided?	Y	N
Replacement plan shows horizontal configuration?	Y	N	Monitoring Information?	Y	N
ORDER OF CONDITIONS DATA					
Approved Mitigation Plan Present	Y	N			
Specific replacement conditions	Y	N	Site prep conditions? (grading, soils)	Y	N
Plant Conditions?	Y	N	Construction Conditions?	Y	N
Monitoring/Maintenance Cond?	Y	N	If yes, who?		
What was monitored?					
Have Monitoring Reports been submitted? Y N					
Were As-Built Plans required? Y N					
Were As-Built Plans submitted? Y N					
DEP Staff:	Date:		Copy of OOC?	Y N P	

Comments:

PHOTO CHECKLIST:

NOI (first page)_______ Locus Map (from NOI)______________

OOC____________ COC_______________

SITE PLAN (showing whole project)_________________

REPLICATION AREA PLAN (detail)___________________

AS-BUILT (if available)________________

APPENDIX C

RAPID ASSESSMENT FIELD DATA FORM for Sites Visible from a Public Way

MANDATORY GUIDELINES:

- **DO NOT ENTER PROPERTY IF "NO TRESPASSING" SIGN IS PRESENT OR THE SITE IS GATED;**
- **IF LANDOWNER DENIES ACCESS, DO NOT PROCEED WITH THE RAM IF SITE IS VISIBLE FROM THE HOUSE**

DEP File #:________________ Project location: ___________________________________

Date: ____________________

Property Owner:____

MassDEP Staff: _________________________________

Project Built: _________ Replacement Area Built_________

List Dominant Plant Species Observed:

__________________________ ______________________________

__________________________ ______________________________

__________________________ ______________________________

__________________________ ______________________________

__________________________ ______________________________

__________________________ ______________________________

Additional Field Data to Determine Adherence to the
Massachusetts Inland Wetlands Replication Guidelines

1. Is replacement area deeper than the adjacent wetland? ________

2. Any evidence of dieback resulting from prolonged periods of inundation?

3. Any evidence of drying out of adjacent wetland?

4. Is replacement area not excavated deeply enough?

5. Any evidence that replacement area is converting to a non-jurisdictional wetland? (i.e., upland plants becoming predominant; isolated from adjacent wetland or waterbody, etc.)

6. Does replacement area have a seasonal source of groundwater and surface water source other than a stormwater discharge or does it appear to be fed by precipitation and sheet runoff flow only? ______________________________

7. Does replacement area have unrestricted hydraulic connection to neighboring water body or waterway and wetland (contiguous, isolated, channel connection): ______________

8. Are any drainage features that supply water to the replacement areas free-flowing without clogging from sediments, trash or other impediments? ________________________

9. Does replacement area contain invasive species listed in replacement guidance? _______

10. Any evidence of stormwater discharge to the replacement area that is not treated prior to discharge? _______

11. Are all erosion controls removed and any soils surrounding the replacement area stabilized?

12. Are all embankments stable and properly vegetated? _______

13. Are the plants in the replacement area common in nearby wetlands?_______

    If No, list dominant plants in nearby wetlands:

    _________________________ _____________________________

    _________________________ _____________________________

    _________________________ _____________________________

    _________________________ _____________________________

    _________________________ _____________________________

14. Any signs of human disturbance impacting wetland area and/or functions?

15. Were photos of the replacement area taken? ____ Were photos of the adjacent wetland taken? ____

ATTACHMENT C CONTINUED

LIMITED WINDSHIELD ASSESSMENT FORM for Sites Visible from a Private Way

MANDATORY GUIDELINES:

- **DO NOT ENTER THE PROPERTY IF "NO TRESPASSING" SIGN IS PRESENT OR THE SITE IS GATED;**
- **AFTER KNOCKING ON THE DOOR, IF LANDOWNER IS NOT HOME, IMMEDIATELY RETURN TO THE VEHICLE;**
- **DO NOT LEAVE THE VEHICLE TO CONDUCT WINDSHIELD ASSESSMENT;**
- **IF LANDOWNER DENIES ACCESS, WINDSHIELD ASSESSMENT SHOULD NOT BE CONDUCTED**

DEP File #:________________ Project location: ___________________________________

Date: ___________________

Property Owner: ____

MassDEP Staff: _________________________________

Project Built: _________ Can Replication Area be seen? _________

If Yes, Does it appear to be the size and shape depicted on the plans? _________

Can Dominant Vegetation be observed? ______________

If yes, list vegetation:

_______________________________ ______________________________

______________________________ ______________________________

_______________________________ _______________________________

_______________________________ _______________________________

_______________________________ _______________________________

Were photos of replacement area taken? _____

Were photos of the adjacent wetland taken? ______

Field Data Form Sheet 1

Appendix D: Field Data Form

DEP File #:_______________ Project location: ____ Date: _________

Property Owner:____ Project Built: _________ Replacement Area Built_________

Replacement Area Size:______________ MassDEP Staff: __________________________________

Plant Species (scientific name)	Percent Cover	Wetland Indicator Category*	Index Value	(% Cover)x(Index Value)

* *Use an asterisk to mark wetland indicator plants: plant species listed in the Wetlands Protection Act (MGL c.131, s.40); plants in the genus Sphagnum; plants listed as FAC, FAC+, FACW-, FACW, FACW+, or OBL; or plants with physiological or morphological adaptations. If any plants are identified as wetland indicator plants due to physiological or morphological adaptations, describe the adaptation next to the asterisk. Use additional sheets as needed.*

Plant Sheet _____ of ______
Point Intercept Field Data Form Sheets 2-5

Point Intercept Field Data Sheet

Point #	Plant Species Present	Wetland Plant Present? Y or N
1		
2		
3		
4		
5		
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Field Data Form Sheet 6

Calculate the weighted average Wetlands Index (WI) of each plot based on the following formula:

WI = $\frac{\sum_{i=1}^{n}(IVi*WISi)}{100}$; Where,

IVi = Importance value (measured by percent cover) of species i in that sample, which is calculated by dividing the cover of each species in each plot by the total cover of all plants in that plot; and

WISi = the wetland indicator status of that species, determined from *National List of Plant Species That Occur in Wetlands: Massachusetts*)

Field Data Form Sheet 7

AREA CALCULATIONS:

Is the Site:

Rectangular:__________ Circular__________ Triangular_____________

Oval____________________ Trapezoidal_________________ Irregular______________

Sketch Site and provide all measured distances:

Area Calculation Formula:

Field Data Form Sheet 8

SOILS:
Sketch soil profile, at a minimum identifying depth and texture of O, A, and B horizon and depth of any redoximorphic features.

Is the soil a Histisol? ________________
Histic Epipedon present? _____________
Is the soil: Mottled? ____________ Gleyed?______________
Matrix Color: _________________ Mottle Colors:_________________________
Other Hydric Soil indicators: ____
Is the hydric soil criterion met?_____________________________

HYDROLOGY:
Record the presence of any indicators of wetlands hydrology, such as: water stains, standing water, adventitious rooting, buttressing, oxidized rhizopheres, etc.

Field Data Form Sheet 9

Additional Field Data to Determine Adherence to the *Massachusetts Inland Wetlands Replication Guidelines*

1. Is replacement area deeper than the adjacent wetland? ________
2. Any evidence of dieback resulting from prolonged periods of inundation?
3. Any evidence of drying out of adjacent wetland?
4. Is replacement area not excavated deeply enough?
5. Any evidence that replacement area is converting to a non-jurisdictional wetland? (i.e. upland plants becoming predominant; isolated from adjacent wetland or waterbody, etc.)

6. Does replacement area have a seasonal source of groundwater and surface water source other than a stormwater discharge or does it appear to be fed by precipitation and sheet runoff flow only? ______________________________

7. Does replacement area have unrestricted hydraulic connection to neighboring water body or waterway and wetland: (Contiguous, isolated, channel connection): ______________

8. Are any drainage features that supply water to the replacement areas free-flowing without clogging from sediments, trash or other impediments? ______________________

9. Evidence of hydrology: Is soil saturated? __________ If not, what is the depth to groundwater (use a soil pit dug by soil hand auger)? _______________________ Were oxidized rhizospheres or redoximorphic features observed? __________

10. Do the soil profiles at the replacement site approximate the soil profiles at the nearest undisturbed existing wetland? Record the depth of each layer at a representative test pit in the replacement area and the remnant wetland ___________________________

11. Record the Munsell hue, value and chroma, and any evidence of mottles, concretions or gleying

____

Field Data Form Sheet 10

12. Is the consistency of the replacement area soil loose to friable? Is texture loamy sand to silt loam? Are redoximorphic features forming?

13. Does replacement area contain invasive species listed in replacement guidance? ________

14. Any evidence of stormwater discharge to the replacement area that is not treated prior to discharge? ________

15. Are all erosion controls are removed and any soils surrounding the replacement area stabilized? _____

16. Are all embankments stable and properly vegetated? ________

17. Are the plants proposed for the replacement area common in nearby wetlands?________

18. Any signs of human disturbance impacting wetland area and/or functions?

APPENDIX E
MITIGATION SUMMARY DATA FORM USER GUIDE
October 16, 2013

SITE/FILING INFORMATION

NOI_NUM: The DEP File Number of the Notice of Intent that is being reviewed.
TOWN: The Town Name
SITE ADDRESS: The address of the project as it appears in the Notice of Intent.
APPLICANT: Name of the applicant as it appears on the Notice of Intent.
A_ADDRESS: Address of the Applicant as it appears in the Notice of Intent
Population: UMass has data and will enter
DEP Region: UMass has data and will enter
Ecoregion: UMass has data and will enter
NOI_Date: The date that the Notice of Intent was filed.
OOC_Date: The Date that the Order of Conditions was issued.
OOC_COPY: a “yes/no” field. Enter yes if a copy of the Order of conditions was acquired. Enter “n” if it was not. Enter “P” if partial OOC was obtained.
SOOC: a “yes/no” field. “Y” meaning a superseding Order of Conditions was issued. “N” meaning any superseding order was issued.
COC: The date that a certificate of compliance was issued. If no certificate of compliance has been issued, then enter “0” (zero).
DEP_Staff: the person(s) who conducted the research
DATE: The date the staff went to the town hall to gather the information.

IMPACT/REPLACEMENT TYPE/SIZE DATA

IMP_TYPE: The wetland impact type, using the MassDEP Wetlands Classification Annotation and the Cowardin Wetland Classification. If the Notice of Intent does not identify the wetland type then the annotation is: “na” (not available).
REP_TYPE: The wetland type proposed in the replacement area, using MassDEP Wetlands Type Annotation and Cowardin Classification. If no wetland type is specified then the annotation is: “na” (not available).
IMP_SIZE: The size, in square feet, of the wetland area to be filled from OOC. If not available in OOC, enter size proposed in NOI or depicted on the plan, in square feet.

REP_SIZE: insert size in square feet of approved replication area as per OOC. If not available in OOC, enter size proposed in NOI or depicted on the plan, in square feet.

REP_Size_Actual Enter measured size of wetland replacement area from Field Data Form Sheet 7, in square feet. [In situations where the site is irregular, the notes are confusing, or there appears to be a significant discrepancy between the impact size and the replication size, aerial imagery of the site should be reviewed in order to confirm field measurements.]

NOI QUALITY DATA

The following data is derived from the Site Data Sheet that was developed in the course of the Town Hall permit research. In all cases, a "1" is equal to a "yes" on the form and a "0" is equal to a "no" .

NOI_PLAN: a "1/0" field. If there is a plan showing the location of the replacement site enter "1". If there is no replacement site plan enter "0".
NOI_PREP: If there is a description of the site preparation for the proposed replacement area then enter "1". If there is no description enter "0".
NOI_CONST : a "1/0" field. Enter 1 if the plan calls for specific construction techniques. Enter "0" if it does not.
NOI_PLANT: a "1/0" field. Enter 1 if the plan calls for specific planting materials. Enter '0" if it does not.
NOI_EROSN: a "1/0"field. Enter "1" if an erosion control plan is part of the application. Enter "0" if there is no erosion control plan.
NOI_INVAS: a "1/0" field. Enter "1" if the plan calls for specific measures to control invasive plant species. Enter "0" is there is no specific plan.
NOI_SOIL: a "1/0" field. Enter "1" if the plan provides details about the soils in the replacement area. Enter "0" if it does not.
NOI_WATER: a "1/0" field. Enter "1" if the plan provides details about the ground water elevations in the replacement area. Enter "0" if it does not.
NOI_HORIZ: a "1/0" field. Enter "1" if the replacement area plan provides horizontal views of the replacement area. Enter "0" if it does not.
NOI_MON: a "1/0" field. Enter "1" if the plan calls for monitoring and/or maintenance. Enter "0" if it does not.

ORDER OF CONDITIONS QUALITY DATA:

OOC_PLAN: a "1.25/0" field. Enter "1.25" if an approved replacement plan is present, enter "0" if not.

OOC_COND: a "1.25/0" field. Enter "0" if there are no specific conditions regarding the wetlands replacement. Enter "1.25" if there are specific conditions.
OOC_PREP: a "1.25/0" field. Enter "0" if there are no conditions specific to site preparation (e.g. grading, soils). Enter "1.25" if there are specific conditions. Enter "1.25" if the NOI_PREP field has "1" entered.
OOC_PLANT: a "1.25/0" field. Enter "0" if there are no conditions that require specific planting requirements. Enter "1.25" if there are specific conditions. Enter "1.25" if the NOI_PLANT field has "1" entered.
OOC_CONSTRCT: a "1.25/0" field. Enter "0" if there are no specific conditions related to the construction of the replacement area. Enter "1.25" if there are. Enter "1.25" if the NOI_CONST field has "1" entered.
OOC_MON: a "1.25/0" field. Enter "0" if there are no specific conditions that require monitoring and/or maintenance of the replacement area. Enter "1.25" if there are. Enter "1.25" if the NOI_MON field has "1" entered.
OOC_MONWHO: If monitoring or maintenance is a part of the OOC enter the name of the position, individual or organization conducting that monitoring or maintenance. If no monitoring or maintenance is proposed leave this field blank. If monitoring/maintenance is required but no one is specified then enter "ns" (not specified).
OOC MONWHO-Q : a "1.25/0" field. Enter "1.25" if monitoring or maintenance of the wetland replacement area is a part of the NOI or OOC, if an individual or organization is specified that must conduct the monitoring or maintenance and if the individual or organization specified is one of the following: Wetland Scientist, Biologist, Conservation Agent, Consultant, Environmental Monitor, Registered Professional Engineer or other similar professional. Enter "0" if any one of the three previously stated parameters are not met.
OOC_ASBUIL: a "1.25/0" field. Enter "1.25" if an as-built plan is required. Enter "0" if no as-built plan is required.

MONITORING QUALITY DATA

OOC_MONWHAT: Wetlands replacement monitoring will consist of monitoring plants and or soils and/or hydrology. List each one that is proposed for monitoring, separate by a forward slash (/) if there is more than one.
OOC_MONWHAT Q: a "3.33/0" field. Enter "3.33" if the OOC specifies monitoring for replication, plants, soils, vegetation, invasives or other similar language specific to the replication area. Enter "0" if the OOC does not specify what should be monitored, or if it specifies only erosion controls or other language not specific to the wetland replacement area.
OOC_MONSUB: A "3.33/0" field. Enter "3.33" if monitoring reports were submitted. Enter "0" if no monitoring reports were submitted.
ASBUILT_SUB: A "3.34/0" field. Enter "3.34" if as-built plans were submitted. Enter "0" if no as-built plans were submitted.

ANALYSES

Quality NOI: Enter a number between 0 and 10. This field represents the sum of the 10 columns under NOI Quality Data, where each of the 10 columns has a 0 or a 1. A 10 is the highest and a 0 is the lowest score possible. 10 would represent the best NOI.
Quality OOC: Enter a number between 0 and 10. This field represents the sum of 8 columns under OOC Quality Data, where each of the 8 columns would have a 0 or a 1.25. A 10 is the highest and a 0 is the lowest possible score. 10 would represent the best OOC.
Quality Monitoring: Enter a number between 0 and 10. This field represents the sum of 3 columns under Monitoring Quality Data (OOC_MONWHAT Q; OOC_MONSUB; ASBUILT_SUB) where each of the 3 columns would have a 0 or a 3.33. A 10 is the highest and a 0 is the lowest possible score. 10 would represent the best monitoring effort.

Built? A "yes/no" field. Enter "Y" if a replacement area was built, regardless of the quality of the replacement area (i.e. even if it was not built correctly as a wetland, or was built too small). Enter "N" if no replacement area was not built.
Dom % VEG _Point: This value uses the point-intercept transect data and represents the total number of the points where 50% or more plant species are designated as wetland indicator plants (i.e. FAC, FAC+, FACWET, or Obligate). This number will be between 0 and 100.
Dom % VEG _ Cover: This value uses the vegetation percent cover data. To derive this latter figure, the percent cover for all plants (using the front page of the Field Data From) is totaled. Next, the percent cover for only the plants designated as wetland indicator plants is totaled. Finally, the total percent cover for wetland indicator plants is divided by the total percent cover of all plants. This number is entered as a percentage. See example below:

Plants	**Wet Indicator Status**	**% Cover**
Typha latifolia*	OBL	38
Lythrum salicaria*	FACW+	25
Rhamnus frangula*	FAC	12
Comptonia peregrina	UPL	10
Polygonum cuspidatum	FACU+	32

Total Percent Cover= 117
*Total % Cover for Plants Designated as Wetland Indicator Plants: 75

75/117= .64 x 100 = <u>64</u>

VEG: a "1/0" field. If either number in the Dom%Veg_Point field, or the Dom%Veg_Cover field in the preceding two columns is greater than 50, enter "1." If both numbers in the preceding column are less than 50, enter "0."
HYDRO: a "1/0" field. On the Field Data Form, Sheet 8, if the answer to the question "*Is the hydric soil criterion met*?" is "*Yes*", enter "1" into this field. If the answer is "No", look at the next section entitled "HYDROLOGY." If other indicators of wetland hydrology are noted, enter "Y". If there are no other indicators of wetland hydrology, the entry should be "0." In summation, if hydric soils <u>or</u> indicators of wetland hydrology are present enter "1". If neither is present enter "0".
Wetland Created: a "1/0" field. If both entries in the two preceding fields entitled **VEG** and entitled **HYDRO** are "1", enter 1, if either field has a "0," enter "0"(i.e. multiply VEG x HYDRO and the result will either be 1 (yes) or 0 (no)).
Field Data Form Questions
FQ1 DEEP a "Y/N" entry; Enter response from Field Data Form
FQ2 INUND a "Y/N" entry; Enter response from Field Data Form
FQ3 DRY a "Y/N" entry; Enter response from Field Data Form
FQ4 NOTDEEP a "Y/N" entry; Enter response from Field Data Form
FQ5NONJUR a "Y/N" entry; Enter response from Field Data Form
FQ6GW_SW a "Y/N" entry; Enter response from Field Data Form (If replacement area has seasonal source of groundwater or surface water other than stormwater, precipitation or sheet runoff enter "Y." If not, enter "N."
FQ7HYDCONN a "Y/N" entry; Enter response from Field Data Form
FQ8FRFLOW a "Y/N" entry; Enter response from Field Data Form
FQ9-AHYDROSAT a "Y/N" entry; Enter response from Field Data Form
FQ9-BHYDROGWDEPTH Enter response from Field Data Form – entry should be a number in inches
FQ9-CHYDROREDOX a "Y/N" entry; Enter response from Field Data Form
FQ10SOILSREF a "Y/N" entry; Enter response to first question from Field Data Form
FQ11MUNS Enter response from Field Data Form
FQ12CONSIS Enter response from Field Data Form (i.e. consistency/texture); Redox already addressed above

FQ13INVAS a "Y/N" entry; Enter response from Field Data Form
FQ14SWDIS a "Y/N" entry; Enter response from Field Data Form
FQ15E/SREM a "Y/N" entry; Enter response from Field Data Form
FQ16EMBSTAB a "Y/N" entry; Enter response from Field Data Form
FQ17PLCOMM a "Y/N" entry; Enter response from Field Data Form
FQ18HUM_DIS a "Y/N" entry; Enter response from Field Data Form
HCONFIG: a "Y/N" field. Based on the wetland replacement plan, enter "Y" if the overall horizontal configuration and location of the replacement area with respect to the bank is similar to the lost area; enter "N" if it is not.
REACH: a "Y/N" field. Based on the wetland replacement plan, enter "Y" if the replacement area is located within the same general area of the water body or reach of the waterway as the lost area. Enter "N" if not.

Reg Compliance: a number field. That number will range from 0 to 7. It is calculated by the following:

1. If the number in the **REPLC_SIZE Actual** field is greater than or equal to the number in **IMP_SIZE** field; or is no more than 10% less than **IMP_SIZE** field; then a value of 1 is assigned. Otherwise the value is 0; and
2. If the entry in the FQ2, FQ3, and FQ4 fields is all "No.", then a value of 1 is assigned. Otherwise the value is 0; and
3. If the entry in the **HCONFIG** field is "Y" then a value of 1 is assigned. Otherwise the value is 0; and
4. If the entry in the **REACH** field is "Y", then a value of 1 is assigned. Otherwise the value is 0; and
5. If the entry in the **FQ7HYCONN** field is "Y" then a value of 1 is assigned. Otherwise the value is 0; and
6. If the number in the **Dom%Veg_Point** column or the number in the **Dom%Veg_Cover** is greater than 75 then a value of one is assigned. Otherwise the value is 0;
7. If the field entitled **HYDRO** is "1" then a value of 1 is assigned. Otherwise the value is 0;

In summary, the number entered for the **Reg Compliance** column is the sum of the seven values assigned above.

PI: Prevalence Index – to be completed by UMass

COMMENTS: a general comment field where any relevant data can be entered