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Massachusetts Wetlands Restoration Study: SITE IDENTIFICATION AND EVALUATION REPORT

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The purpose of this study was to assist the Wetlands Restoration and Banking Program (MWRP) in developing a science based method for identifying potential restoration sites and functional deficits (water quality, flood storage, and habitat) in a watershed and screening the sites for the potential to meet those deficits. The study was conducted under the authority contained in the Section 22 Planning Assistance to States Program.

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Table of Contents

Table of Contents (continued)

Appendicies

List of Tables

List of Figures

Chapter One
Introduction and Purpose

1.1 Study Authority

Authority to conduct this study is contained in Section 22 of the Water Resources Development Act of 1974, Public Law 93-251, as amended. The Section 22 Planning Assistance to States Program authorizes the Corps to assist states in the preparation of plans for the development, utilization, and conservation of water resources.

This report is part two of a four part effort conducted by the New England Division of the U.S. Army Corps of Engineers at the request of the Commonwealth of Massachusetts, Executive Office of Environmental Affairs (EOEA) Wetlands Restoration and Banking Program. Part four is a case study in the Neponset River Watershed using the site selection methodology developed in this report. Part one explored options for wetlands banking in Massachusetts. Part three consists of an evaluation of restoration project monitoring strategies for the Commonwealth.

1.2 Background (Prepared by Massachusetts Wetlands Restoration and Banking Program)

Massachusetts has reported an estimated loss of 28% of its pre-colonial wetlands acreage. The state has adopted a goal of "no net loss of wetlands in the short-term and a net gain in the long-term." EOEA established the Wetlands Restoration and Banking Program (WRBP) in 1994 to supplement its wetlands regulatory program in achieving this goal. WRBP's two-part mission is to: 1) determine whether wetlands mitigation banking can improve mitigation success and 2) establish a proactive[1] (non-compensatory) wetlands restoration program for the Commonwealth. This report supports the development of this mission.

[1] Proactive restoration is conducted solely to improve the value of the resource. Compensatory restoration serves as compensation for unavoidable wetland impacts as a result of a permit action under a regulatory program.

The fundamental principles established by WRBP in support of their wetlands restoration efforts are:

- o a landscape approach to managing wetland resources can gain functional improvements at the watershed or coastal drainage area level thus mitigating some of the effects of cumulative wetland loss;
- o where there may be competing restoration opportunities and limited resources, wetlands restoration goals and restoration project priorities should be established by local watershed interests;
- o wetlands restoration should be emphasized over wetland creation because of the higher likelihood of success;
- o building partnerships among agencies of all levels and among the public, private and independent sectors achieves the highest level of coordination, cooperation and efficiency; and
- o application of the best available science will ensure program credibility and success in achieving wetlands goals.

The WRBP's proactive wetlands restoration projects will be initiated on a voluntary basis by sponsors who want to bring back wetlands to help solve community water quality or local flooding problems or to restore lost wildlife or fisheries habitat. These projects will increase wetland acreage in the Commonwealth and improve the functions of degraded wetlands. Initiation of these projects will not be dependent on any losses or degradations that result from activities subject to state regulation (i.e., compensatory mitigation for permitted projects or unauthorized activities). Therefore, proactive restoration contributes to achieving the State's policy goal of a net gain in wetlands.

WRBP uses the following planning steps to develop its Watershed Wetlands Restoration Plans.

1. WRBP will contact conservation commissions and watershed associations.
2. Identify other interests and conduct public meetings.
3. Establish a network of pertinent parties.

4. Identify potential restoration sites and functional deficits (water quality, flood storage, and habitat) in the watershed by applying the methodology developed in this report.

5. WRBP will screen the sites for the potential to meet watershed functional deficits.

6. WRBP will prepare the draft watershed wetland restoration plans based on a prioritized list of wetlands that meet watershed goals.

7. Pertinent parties will review and comment on watershed wetland restoration plans.

8. WRBP will finalize the plan and distribute.

9. WRBP will seek funding for projects; initiate restoration projects; and periodically update the plan.

Wetland restoration can contribute to reversing the damage of cumulative wetland losses and other impacts to Massachusetts watersheds. While individual wetland restoration sites, unless they are quite large, are unlikely to have a noticeable effect on the watershed, many actions taken over time will have an impact. The Commonwealth of Massachusetts has adopted the approach that wetland restoration should be implemented as part of a comprehensive strategy for wetlands and watershed management.

1.3 National Perspective

Three reports in particular have summarized the importance of watershed based wetlands management: 1) *Wetland Creation and Restoration - Status of the Science* (Kusler and Kentula, 1990); 2) *Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy* (National Research Council, Committee on Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy (NRC), 1992); and 3) the present Administration's *Five Principles for Federal Wetlands Policy* (Protecting America's Wetlands: A Fair, Flexible, and Effective Approach, August 24, 1993). *Wetland Creation and Restoration - Status of the Science* indicated that:

> "Wetland design should consider relationships of the wetland to the watershed water sources, other wetlands in the watershed, and adjacent upland and deepwater habitat."

The National Research Council (1992) advocated the integration of water and land use planning. They indicated that restoration of aquatic systems requires replacing the watershed hydrologic conditions, potentially including the alteration of land uses, reestablishment of vegetation, and fundamental corrective ecological attention. While it may be an unusual case where all of these actions are achievable, consideration of the interrelationships among wetlands and between wetlands and other landscape elements will help to maximize the benefits of most restoration efforts. Among the conclusions of the report of the National Research Council, Committee on Restoration of Aquatic Ecosystems (NRC, 1992) were:

- Use a landscape-level approach (at the biogeographic region or watershed scale), with advance identification of sites that will provide the largest gains after restoration.

- Inventory biogeographic regions and establish sites with restoration potential. Develop priorities for restoration within each region.

- Integrate the restoration project with the rest of the landscape; use regional and watershed approaches in setting restoration objectives.

On the Federal level, *Five Principles for Federal Wetlands Policy* based on the input of a Federal interagency workgroup states that:

> "...advance planning; wetlands restoration, inventory, and research; and public/private cooperative efforts must be encouraged to...accomplish long-term wetlands gains;"

and

> "The Federal government should expand partnerships with State, Tribal, and local governments, the private sector and individual citizens and approach wetlands protection and restoration in an ecosystem/watershed context."

The Administration's position indicates that the Clean Water Act should authorize the development of State watershed protection programs and that wetlands should be incorporated into the overall watershed approach, with minimum standards for wetlands protection and restoration planning. Advance planning can be used to identify appropriate locations for, and uses of, wetland banks. Comprehensive advance planning involves identification, mapping, and preliminary assessment of relative wetland functions within the planning area. The objectives of the methodology presented in this report are consistent with these principles.

1.4 The Goal of Watershed-Based Wetland Restoration

There are two perspectives on the relationship between wetlands and other watershed resources. Wetlands affect other components of the watershed (e.g., improve water quality of surface waters) and are affected by other components (e.g., degraded by inflow of contaminants). To achieve the highest overall level of environmental quality in a watershed, controlling or reducing contaminant discharges are better approaches to improving water quality than restoring streamside wetlands. Although the pollutants may be removed from the surface water by a wetland, the wetland will be adversely affected by the increase in pollutants in the plants or substrate. By taking a watershed approach to resource management, both the effects of the wetland on the watershed and the effects of the watershed on wetlands can be considered.

The benefits of considering wetland restoration and management in a watershed context are:

- the best sites with the highest potential value can be prioritized;
- appropriate functions can be maximized at each site;
- sites are more likely to reach full potential because design considers all of the related elements within the watershed;
- overall health or quality of the resources within the watershed can be improved by focusing on limiting factors;
- a synergistic effect can be achieved resulting in a level of functioning within the watershed greater than the sum of the individual restorations projects.

Wetland restoration is just one of the tools available for the management of wetlands or watershed resources. Comprehensive wetland management should consider the full range of tools available for managing the resource (i.e., acquisition and protection of wetlands and surrounding upland and deep water habitats, enhancement, creation, and control and management of pollutants and water quantity). These tools are beyond the scope of this document, but should be considered by the agencies involved in wetland restoration and management.

1.5 Report Purpose

The purpose of this report is to present a science-based method for carrying out Steps 4 and 5 of the WRBP watershed wetlands planning process. The strategy outlined in this report is based on a review of a number of reports that describe wetland restoration in general or present specific methods for various parts of the process of wetland restoration site selection. An extensive literature search was not conducted, but the list of references was reviewed by the State's Science Peer Review Committee to ensure completeness.

This report is intended to provide a framework for wetland restoration site identification and evaluation that will become improved with each application. Pilot projects are planned for the Neponset and Connecticut River watersheds. These projects will test the methodology, demonstrate one potential use of the method and allow the development of refinements to the method.

The method described in this report is intended to be flexible, practical, and easy to implement. A framework or guide for evaluating a watershed and its potential restoration sites is presented, rather than a rigid methodology. It can be adapted to the different watershed and wetland conditions and settings that exist across the state. It does not preclude sites identified outside of this framework from restoration, nor does it generate an overall ranking of sites. By relying on existing reports and information as much as possible, it takes advantage of comprehensive, high quality information, integrates wetland restoration into other watershed management efforts, and avoids duplication of effort. This emphasis has resulted in a relatively comprehensive, low cost framework for identifying and evaluating restoration sites.

Many of the methods reviewed for various parts of the site selection process are time consuming and therefore costly to implement. The general lack of a firm understanding of wetland functions[2] limits even the most detailed evaluation methodologies. Given these limits, excessive effort at the planning stage would not be cost effective. Therefore, the site selection strategy proposed in this report relies on the use of existing information and generalized assessment procedures.

[2] Wetland functions are the physical, chemical, and biological processes or attributes of wetlands that are vital to the integrity of the wetland system, and operate whether or not they are viewed as important to society (e.g., flood water storage, etc). Values are wetland attributes that are not necessarily important to the integrity of the wetland system, but are perceived as important to society (e.g., provision of recreational opportunities, etc.) (Adamus et al., 1991).

Chapter Two
Wetland Restoration Overview

2.1 Wetland Restoration Defined

The Massachusetts Wetlands Banking and Restoration Program (MWRBP) supplied the definition of Wetland Restoration for this report based on the input of its Steering and Technical Review Committees:

> "**Wetlands Restoration Definition:** For purposes of the Massachusetts Wetlands Restoration and Banking Program, wetlands restoration is the act, process, or result of returning a wetland or a former wetland to a close approximation of its condition prior to disturbance."

The MWRBP has defined two types of wetland restoration: Type 1 Restoration consists of "reestablishing a wetland in a former wetland site that is presently non-wetland," and Type 2 Restoration consists of "returning a damaged, degraded, or otherwise functionally impaired wetland to its prior (pre-disturbance) condition or one similar to it."

A complete definition is provided in Appendix A.

2.2 Categories of Wetland Restoration Projects

Restoration projects can be grouped into four categories based on the type of actions necessary to effect restoration:

1. reestablishing or managing wetland hydrology,

2. restoration of wetland substrate,

3. reestablishing and managing native biota,

4. eliminating or controlling chemical or other contaminants affecting wetlands.

The restoration categories described in this section are not mutually exclusive; they reflect the major focus of the action needed to implement the restoration. For instance, removal of fill from a wetland will result in restored hydrology, but the main focus of the corrective action will be to reestablish the substrate, whereas a project that is intended to restore the tidal regime to a tide gated salt marsh has as its main implementation focus, restoration of hydrology.

Reestablishment or management of wetland hydrology. Reestablishment or management of wetland hydrology includes projects aimed at restoring lost hydrologic characteristics of the wetland. Examples include: restoration of the former hydrologic regime to tide-gated salt marshes or drained wetlands where physical manipulation of the substrate is not required to restore the desired wetland conditions.

Hydrologic restoration projects could include creation of fringing wetlands along reservoir shorelines to replace wetlands that formerly bordered the impounded channel. These new wetland subimpoundments would not occur in the original location of the affected wetland, but would reproduce the quality or pattern of the original fringing riverine wetlands. Wetlands generally do not form along the edge of flood control or water supply reservoirs with widely fluctuating water levels. This type of action is generally considered creation rather than restoration, but could be considered restoration in the ecosystem context.

Restoration of the former wetland substrate characteristics. Substrate restoration involves reestablishing the previously existing wetland surface by either excavation or filling. No further manipulation of the hydrologic characteristics of the site are required. Examples of this type of restoration include regrading of filled wetlands to attain wetland elevations, reestablishing the elevation of existing wetlands, or reestablishing wetlands that have been eliminated by erosion through dredged material placement. Substrate restoration also would include modification of the physical and natural chemical characteristics of wetland soils.

Reestablishing biota. Restoration of biota involves manipulating the vegetation community to restore previously existing conditions. Examples include the use of herbicides or mowing to eliminate undesirable plant species, restoring the open water:vegetation ratio, and planting or stocking to restore more desirable wetland plant and animal communities. Information on reintroducing animals to restored wetlands is extremely limited, but the importance of considering other organisms in addition to plants has been demonstrated (NRC, 1992).

Eliminating or controlling chemical or other contaminants. Chemical restoration projects involve sites where high levels of contamination are impacting or have the potential to impact functioning of a wetland system. Examples include the alteration of stormwater inflow and removal or remediation of contaminated sediments.

These projects differ from the other types discussed since the alteration required to effect restoration is normally conducted outside of the wetland. When the goal is to reduce the influx of a contaminant to a wetland, remediation may involve the construction or creation of a new wetland to treat the waste stream prior to entering the object wetland. Site selection (Brodie, 1989), monitoring (Hicks and Stober, 1989), and other elements of the design of wetlands for wastewater treatment are presented in *Constructed Wetlands for Wastewater Treatment: Municipal, Industrial, and Agricultural* (Hammer, 1989). Corps of Engineers, Wetlands Research Program Technical Note WQ-SW-3.1. *Design of Constructed Wetlands Systems for Nonpoint Source Pollution Abatement* describes design considerations.

Where the level of contamination is very high (e.g., hazardous waste sites), complex and expensive remediation such as in situ treatment or the removal and replacement of contaminated sediments may be required. These categories of restoration are beyond the scope of this report, although the elements of hydrologic, substrate or biotic restoration apply to these sites when the contamination has been addressed.

Whatever the required modifications, various levels of restoration are possible from a functional perspective. Under most conditions, it is probably not possible to restore a degraded wetland to its full former level of functioning in the short term. A number of considerations will be involved in setting the goals and objectives of restoration projects. Under some circumstances it may be practical to achieve only a portion of a wetland's former level of functioning due to limits of cost, potential offsite impacts, or natural ecological limits on wetland development. In addition, if the goal is to restore certain wetland functions, design modifications may be made to change the way that the full former level of functioning is achieved. For instance, if a wetland provided a sediment/toxicant removal function because of the width of its vegetated zone, but it is not possible to restore the former width because of bordering development, the former capacity for sediment toxicant removal may be restored by creating a smaller outlet. The goal would be to balance the amount of functional loss due to loss of width. This would involve a decision to modify the former condition of the site to obtain a former level of function. In other words, restoration of functions does not always result from exactly replacing the structural characteristics of the former wetland.

2.3 The Wetland Restoration Process

Site selection is part of the overall wetland restoration process which consists of the following phases:

1. site selection,
2. project planning and evaluation (includes regulatory compliance and permitting,
3. design,
4. construction or implementation, and
5. monitoring.

Although listed last, monitoring and reevaluation are conducted throughout the process to provide information for mid-course corrections and management as needed. A full restoration sequence is described in Appendix B.

Before restoration sites are selected, overall project goals are specified. Then, potential sites are identified and evaluated against those goals. For the proactive restoration efforts described in this report, goals are based on watershed-level problems and opportunities. In the regulatory context, project goals will most often relate to the impacts of the proposal requiring compensatory mitigation.

Site-level planning, evaluation, and design are conducted once sites are selected. The specific sequence of activities will depend upon the cost, complexity, likelihood of success, and potential environmental effects of the project. For instance, the National Research Council (1992) highlighted the following considerations for large scale restoration plans:

> "Because our limited knowledge of how to restore ecosystems makes it impossible to guarantee that objectives can be fulfilled, projects should include an *initial experimental phase* for the more risky aspects. The restoration plan should be *adaptive*, supporting the acquisition of new information and its use in project implementation and long-term management. A plan that has *flexibility* and relies on *informed decision making* should best be able to accommodate difficulties during construction and follow-up monitoring. As a restoration proceeds, managers can *reevaluate* whether the degree of restoration achieved is acceptable or if new techniques should be introduced. For those situations in which unexpected benefits develop,...an adaptive management program is essential in order to capitalize on those events and to expand and revise restoration objectives appropriately."

In all cases, functional goals and objectives are established for the site and alternatives to meet the goals and objectives are developed. A monitoring plan, reflecting project goals and objectives, may also be developed early in planning. Specific performance standards or criteria may be established during design as objective measures of success. The establishment of goals, objectives, and performance criteria is the key link between the planning and monitoring phases (NRC, 1992).

Low cost projects with a high potential for success may proceed directly from planning and evaluation to implementation. More complex projects requiring a large commitment of resources, may be divided into evaluation, design, and implementation phases. A feasibility study may be conducted to consider alternatives and develop a preliminary design. A feasibility study should include baseline studies and an assessment of environmental effects. An analysis of the environmental benefits versus financial costs can be performed to identify the most cost efficient alternatives. The information developed during a feasibility study is used to select the best alternative to implement.

There are a number of references available that describe design requirements in detail. A partial bibliography is provided at the end of this report. A more comprehensive wetland creation/restoration database is maintained by the U.S. Fish and Wildlife Service. A copy of the bibliographic material contained in the database is also available (Schneller-MacDonald et al., 1989).

2.4 Site Identification and Evaluation

Site selection involves inventory, goal setting, evaluation, and prioritization. This report describes a site identification and evaluation process consisting of the following five major steps (Figure 1):

1. Identify degraded and former wetlands within the watershed.

2. Set watershed goals by identifying functional deficits and opportunities.

3. Evaluate degraded wetland sites to assess their functional capacity to meet watershed goals.

4. Screen sites against other ecological, logistical, and constraining factors.

5. Display results.

These steps are expanded and discussed in detail in Chapter three.

The site identification and evaluation procedures in this report are organized into steps. The purpose, background, and procedures are presented for each step. Steps are further broken down into tasks that can be conducted to generate information for site selection. Some steps are also broken into substeps.

Steps 1 and 2 can be applied simultaneously. Step 1 is conducted to identify the universe of degraded wetland sites within the watershed. Step 2 is a basin-wide evaluation of wetland related watershed problems (functional deficits) and opportunities that will identify priority wetland functions. Functional deficits serve as the basis for setting goals and objectives. The sites identified in Step 1 are evaluated in Step 3 to identify those that can address the watershed goals. For instance, if a watershed has flooding problems, sites that will have appropriate characteristics when restored to provide the flood storage/desynchronization function will be identified.

Once these watershed scale evaluations are complete, the sites are screened in Step 4 against other factors that may affect restoration potential. For instance, the restoration of publicly owned sites will usually be easier and potentially less costly than the restoration of privately owned sites. The results of Steps 1-4 are displayed in a matrix in Step 5 to guide site selection. Detailed site specific evaluations must precede implementation because the initial watershed level screening will not give quantitative indications of the level of functioning.

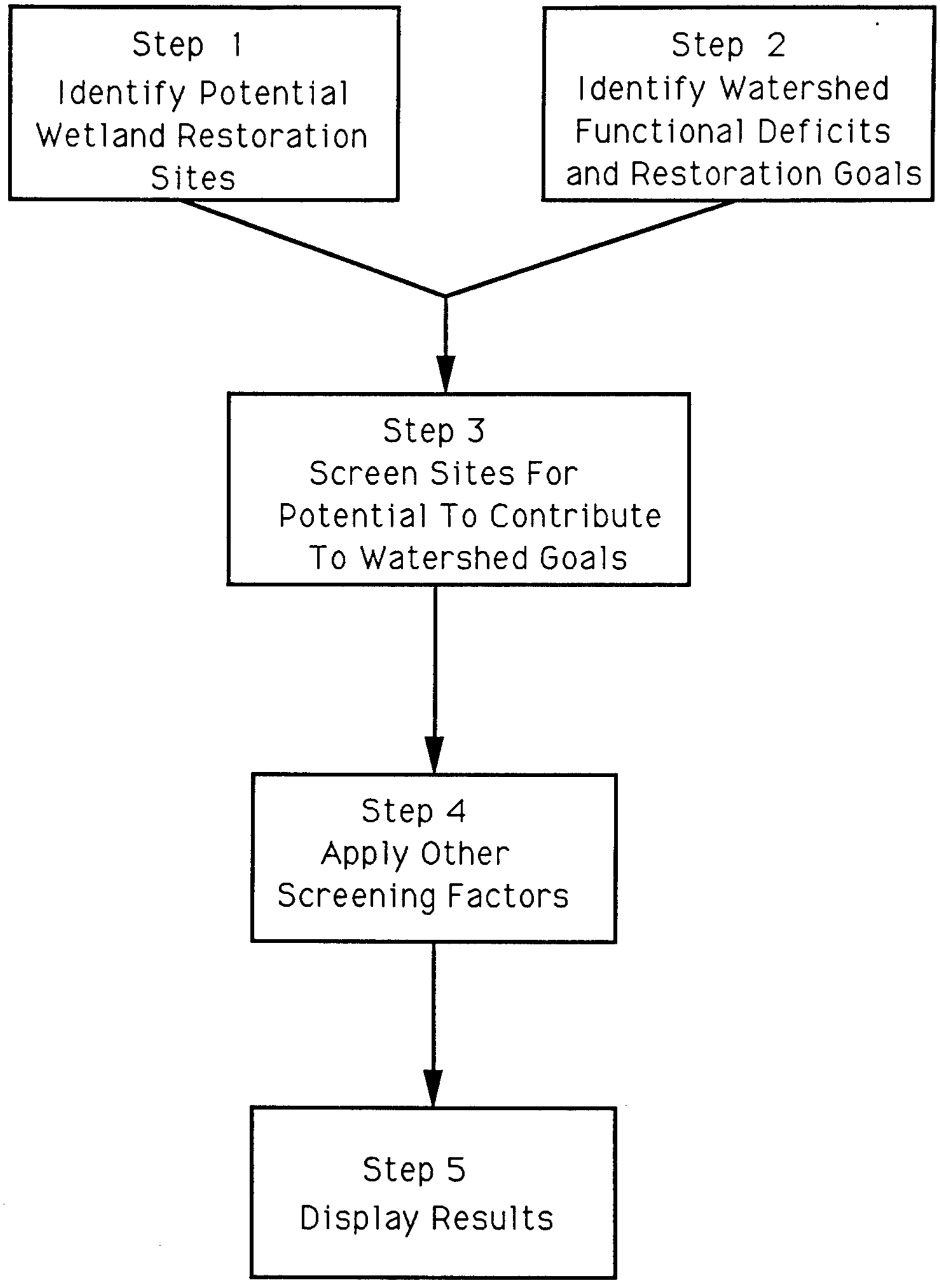


Figure 1
Site Selection Process

Chapter Three
Site Identification and Evaluation Methodology

The five steps in the site identification and evaluation process are described in this section. The results of all of the evaluations conducted are recorded in the display matrix provided in Appendix C. More detailed supplementary information that can be used guide the process is provided in Appendix D.

3.1 Step 1: Identification of Degraded and Former Wetland Sites.

Purpose

The purpose of this step is to identify all degraded and former wetlands in the watershed with restoration potential. The inventory of potential wetland restoration sites is the most important step in the process because it provides the baseline for all further steps. The sequence of activities for this step is shown in Figure 2.

Background

Filled and degraded wetlands can then be identified using one or more of the sources of information described in Chapter four. Planners must be familiar with typical impacts to recognize degraded and filled wetlands. To guide the identification of potential restoration sites, impacts normally associated with particular wetland types are summarized in Chapter five. Planners should review this information at the start of the watershed evaluation process to develop a "search image" for the general pattern of impacts associated with particular wetland types.

Procedures

1a. Review Chapter four to determine the sources of information available for the watershed and most appropriate for the planning team conducting the study. Select and obtain as many of the types of information as needed.

1b. Select an appropriate base map to display sites and roughly delineate the watershed boundary on information sources to define the site identification area.

1c. Review the patterns of wetland impacts described in the Chapter five to become familiar with the characteristics of impacts to various wetland classes in Massachusetts. (Massachusetts wetland classifications are described in Appendix E.)

1d. Identify degraded and former wetlands in the watershed based on the characterization of impacts by class in Chapter five using the information sources and techniques described in Chapter four. Visit all sites in the field to confirm the extent and nature of the degradation.

1e. Record the location, class (see Appendix E), hydrogeomorphic type, and nature of the impact on the watershed matrix (Appendix C).

1f. Identify priority wetland restoration sites.

3.2 Step 2: Identification of Watershed Functional Deficits

Purpose

The purpose of this step is to evaluate the magnitude of watershed problems that can be improved by restoring wetlands. The information generated in this step will be used to set watershed-based restoration goals. The sequence of activities for this task is shown in Figure 3. The problems, identified as functional deficits, may have resulted from prior cumulative damage to wetland functions. The term functional deficit used in this report refers to impairment of wetland functions evident at the watershed scale.

Background

The identification of watershed functional deficits has been divided into three parts. In Massachusetts, water quality status is well documented and the evaluation relies on existing information. Where flooding has generated significant problems, the problem has often been studied in detail and is described in reports that can be obtained from water resource agencies. In contrast, the status of wetland dependent wildlife populations is not well documented and the evaluation relies on goal setting by agencies and watershed groups.

Step 1
Identify Restoration Sites

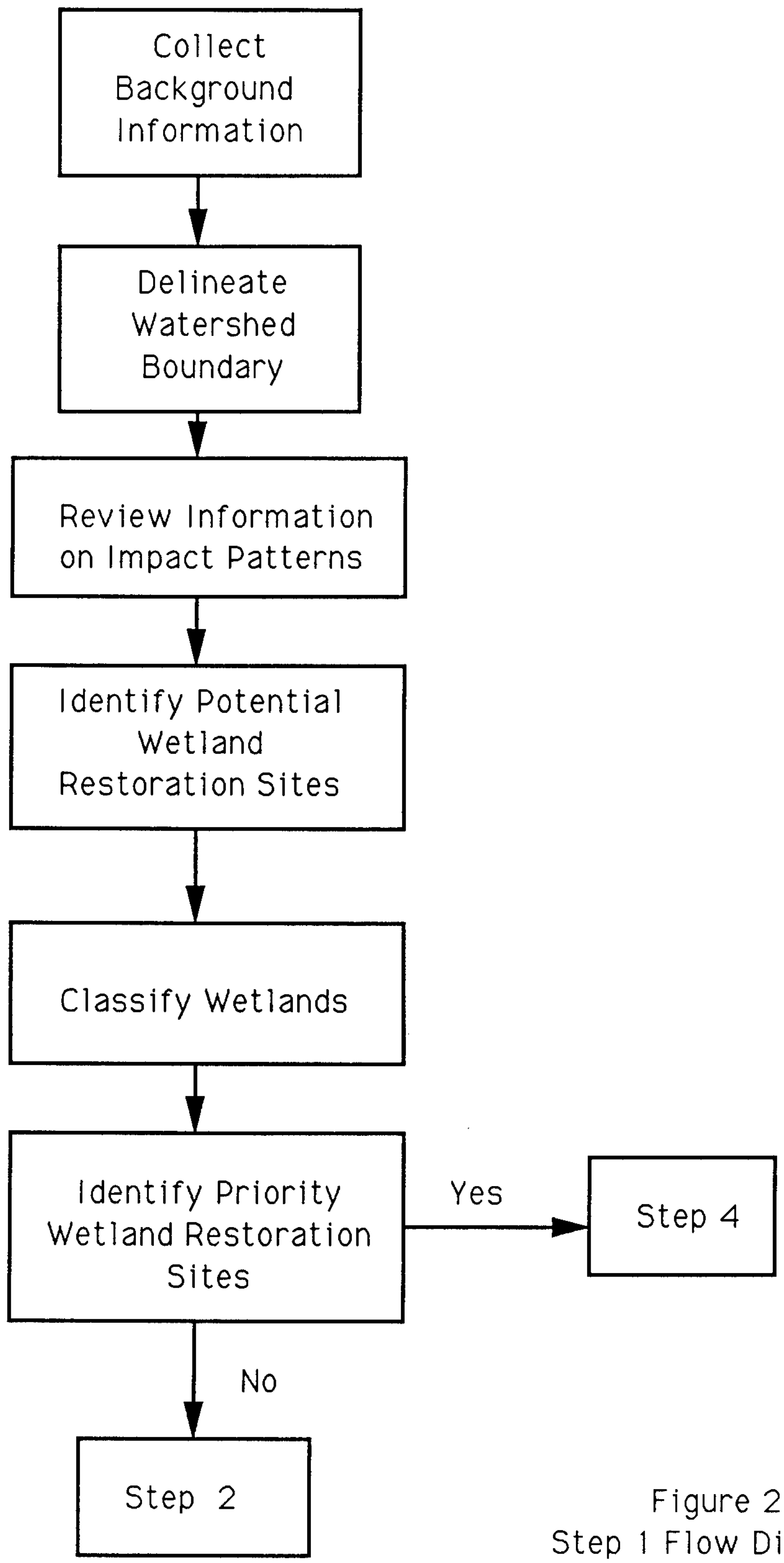


Figure 2
Step 1 Flow Diagram

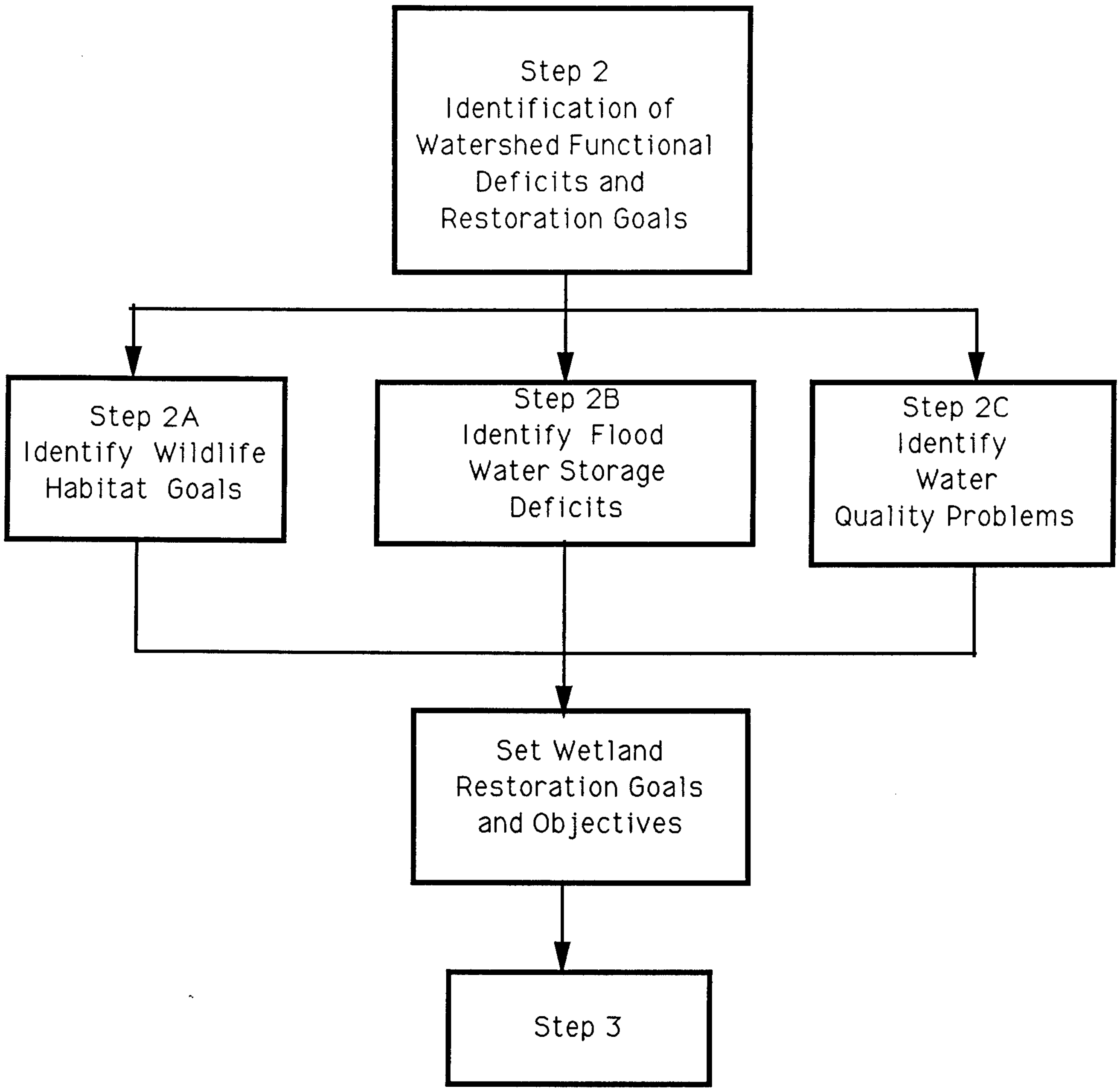


Figure 3
Step 2 Flow Diagram

3.2.1 Step 2A Identify Wildlife Habitat Goals

Purpose. The purpose of this step is to establish watershed-based wetland wildlife habitat goals. The sequence of activities in this step is shown on Figure 4. A similar sequence of activities can be applied to establish fishery goals in relation to wetland restoration.

Background. Watershed level inventories of wildlife to compare among watersheds, or with expected values for a watershed, are generally not available. Comparison of wildlife communities among watersheds would also be confounded by inherent physical and biological differences in wildlife habitat. Some obvious differences in the quality of habitats can be observed (e.g., habitat on the North and South Rivers is less disturbed than that on the Mystic River), but these comparisons do not necessarily result in information that would be useful for establishing watershed goals. Habitat assessment techniques are costly to apply to all wetlands in a watershed. Therefore, interviews with resource groups should be the primary mechanism for establishing wetland wildlife habitat restoration goals.

Procedures:

2Aa. Interview conservation agencies, groups, and individuals to identify wildlife habitat objectives and priority wildlife species in terms of diversity, connectivity, and quality.

2Ab. If diversity is identified as a habitat objective, determine the least abundant wetland types by measuring or estimating the area of each type.

2Ac. If improving connectivity is an objective, identify wetlands with the highest habitat value, especially wetlands within conservation areas, through interviews or assessment.

2Ad. Identify degraded wetlands that will improve the connections between high value sites.

3.2.2 Step 2B: Identify Flood Water Storage Deficits and Opportunities

Purpose. The purpose of this step is to identify flood water storage related flooding problems in the watershed. The sequence of activities for this step is shown in Figure 5.

Background. Some wetlands (and adjacent riparian uplands) provide a floodflow alteration function whereby peak flows are stored or delayed from moving downstream. This allows floodflows to be "desynchronized." Desynchronization is the process by which flood waters are stored in numerous wetlands within a watershed, then gradually released in a staggered manner. These processes reduce the peak height of floodwaters, but increase the duration of flooding (Adamus et al., 1991). At the watershed scale, a deficit in this function could be demonstrated by chronic flooding problems that are related to storage capacity. If flooding problems are related to flood storage capacity, any restoration that increases storage area will incrementally improve flooding conditions.

Procedures.

2Ba. Obtain existing flood damage reports to determine the nature and magnitude of flooding problems in a watershed wherever possible.

2Bb. If existing information is not available, contact town or city and state officials (town or city managers, planners, or department of public works representatives or the Massachusetts Department of Environmental Management (MDEM)) familiar with flooding problems in the area.

2Bc. If a flooding problem is not confirmed, determine whether there is a reason for further consideration. If so, use mapping, such as Flood Insurance Maps, and a stream hydrograph to make an assessment of the nature of the flooding problem.

3.2.3 Step 2C: Identify Wetland-Related Water Quality Problems and Opportunities.

Purpose. The purpose of this step is to identify water quality problems in the watershed that can be at least partially addressed through wetland restoration. The sequence of activities is shown in Figure 6.

Background. Wetlands provide two water quality improvement functions: 1) nutrient removal/transformation and 2) sediment/toxicant retention (Adamus et al., 1991). They have greater potential to provide a significant water quality improvement function if they are located in urban or developed areas or along agricultural corridors where sediment or nutrients would otherwise be exported to open water.

Step 2A Identify Fish and Wildlife Habitat Deficits

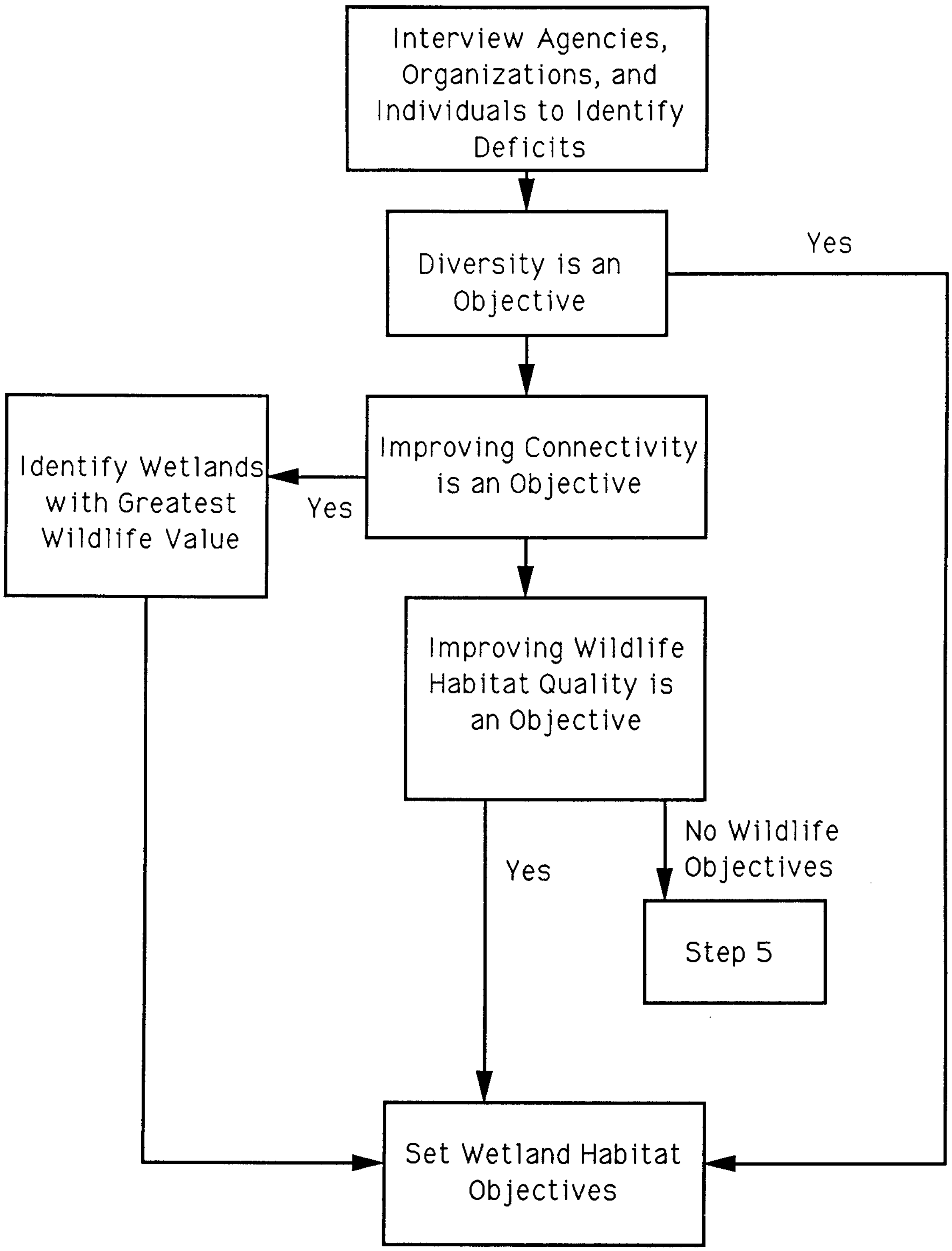


Figure 4
Step 2A Flow Diagram

Step 2B Identify Flood Water Storage Deficits and Opportunities

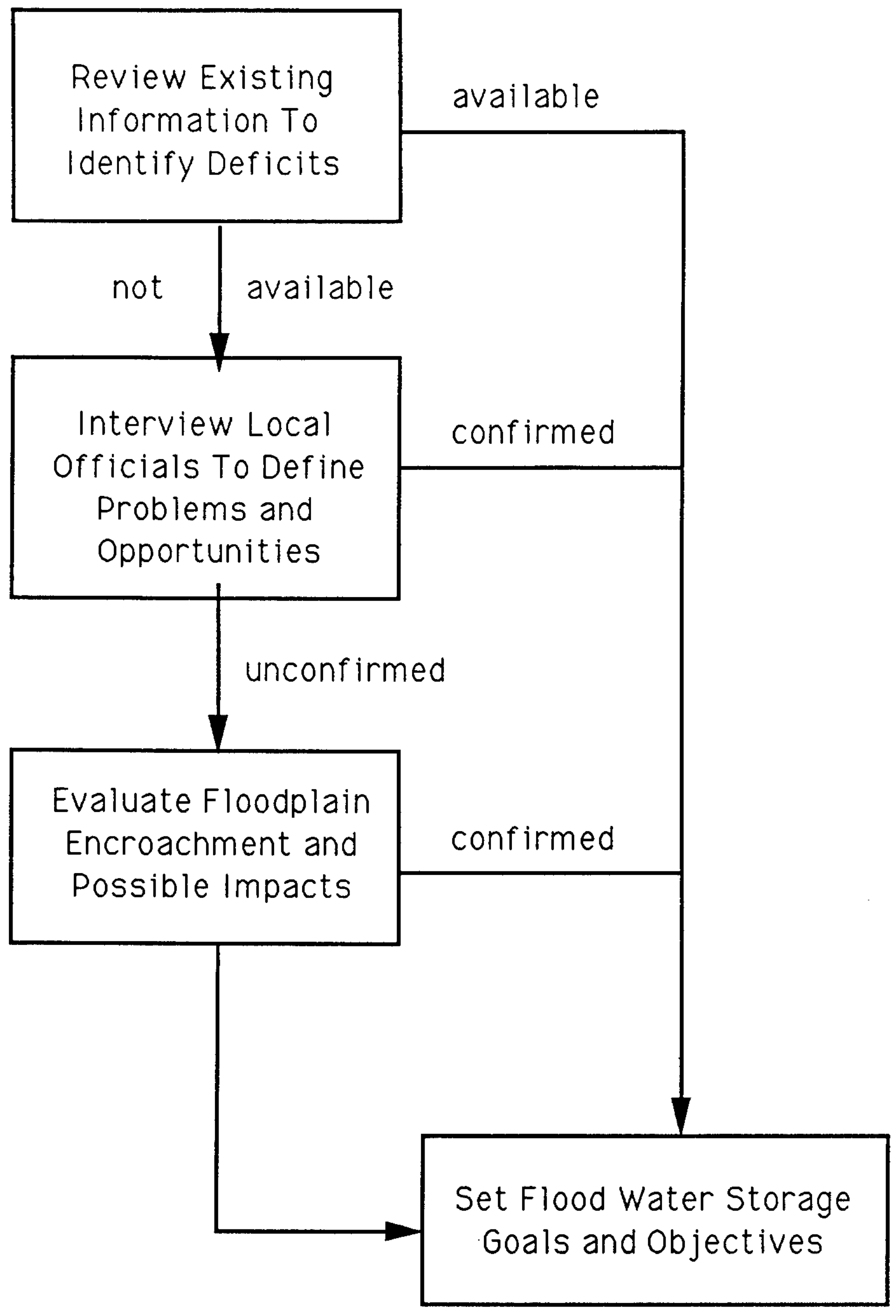


Figure 5
Step 2B Flow Diagram

Step 2C Identify Wetland Related Water Quality Problems

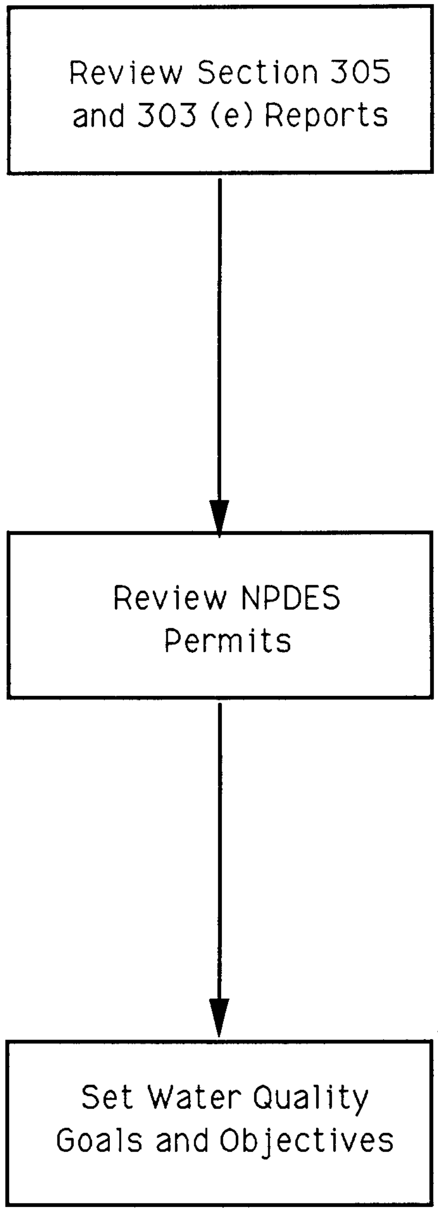


Figure 6
Step 2C Flow Diagram

The WPA recognizes wetlands for their ability to protect water supply. To provide this function, they must be located in the watershed upstream of the water supply. Wetlands may also export products, such as chemical oxygen demand (COD), that can degrade water quality; potential adverse effects should be considered when wetland restoration is proposed near water supplies.

Procedures.

2Ca. Review Clean Water Act Section 303(e) and/or Section 305 water quality reports prepared by the Massachusetts Office of Watershed Management to identify problem pollutants and areas in the watershed.

2Cb. Identify major NPDES permit discharges and areas of dense development to delineate specific water quality problem areas.

3.2.4 Set Watershed Wetland Restoration Goals and Objectives.

Based on the evaluations in this section, set the goals and objectives for wetland restoration in the watershed. The goals refer to the functions that should be restored (i.e., wetland wildlife habitat, flood storage, or water quality). The objectives indicate the specific characteristics and locations in the watershed to be restored. For instance, the goals for a watershed may be to restore the water quality function to wetlands and increase the quality of wetland habitats. In this case, the objectives might be to restore the nutrient removal function in the upper one-third of the mainstem and restore the waterfowl habitat value to marshes in a subbasin.

3.3 Step 3: Watershed Functional Replacement Screening

Purpose

Evaluate the list of potential restoration sites from Step 1 based on their relative capacity to address watershed functional deficits. The sequence of activities for this step is shown in Figure 7.

Background

Restoration sites are evaluated to determine their likelihood of filling watershed deficits by determining their likely future capacity to supply deficit functions. These evaluations require prediction of the future restored conditions of the site. Historic aerial photography can be used to help predict the future restored conditions based on historic conditions. To accomplish flood storage and water quality evaluations, factors are applied to the sites to estimate their capacity to supply functions. The wetlands or network of wetlands that best supply the deficit function will depend on their location relative to the functional deficit.

The wildlife habitat assessments will be handled differently. Sites that individually have the potential to become high quality habitat, such as large (Foreman and Godron, 1986; Golet et al., 1994) or diverse wetlands (Golet et al., 1994), should be selected in watersheds with relatively few high value habitats. Wildlife habitat evaluations can be conducted using the Golet (1976) Wetland Wildlife Evaluation Method, Habitat Evaluation Procedures, or another appropriate model. If the diversity of wildlife habitats is low, sites that will improve overall wetland watershed diversity should be selected. Diversity will be considered by identifying scarce wetland types. If improvements of gaps in the connections between wetland habitats was identified as an objective, sites that will fill these gaps should have high priority for restoration. In all likelihood, individual restoration sites will supply more than one of these wildlife habitat characteristics.

3.3.1 Step 3A: Evaluate Wetland Wildlife Habitat Potential

Purpose. The purpose of this step is to group and evaluate wetlands based on their capacity to provide restored wildlife habitat. The sequence of activities for this step is shown in Figure 8.

Procedure.

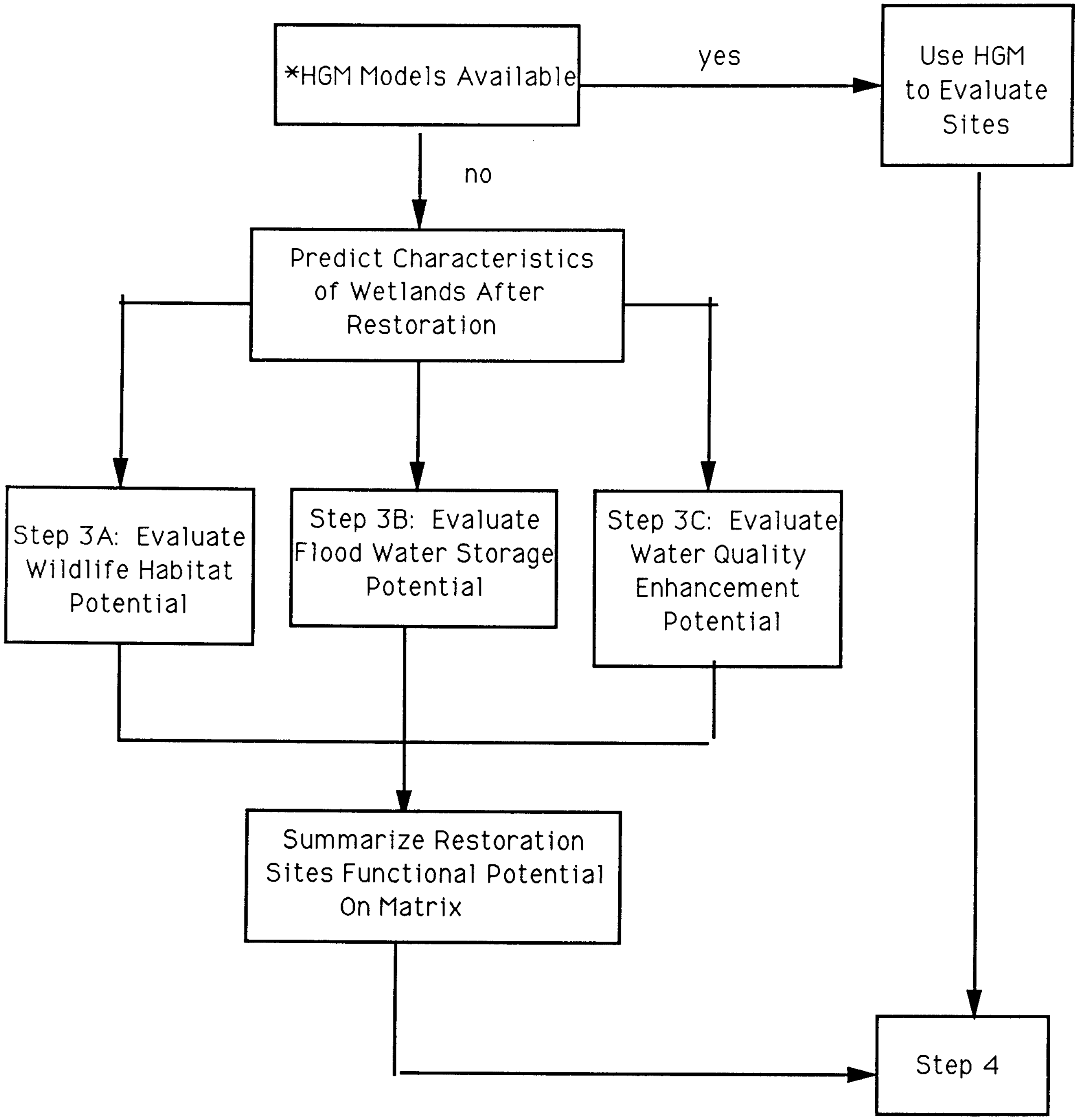
3Aa. Predict future restored characteristics at the restoration site. Where possible use aerial photography or other documentation of prior conditions to guide the prediction of future conditions.

3Ab. Identify watershed goals and objectives established in Step 2.

3Ac. Evaluate the potential of each wetland site to contribute to meeting habitat objectives.

3Ac-1. If wildlife habitat quality was listed as an objective in Step 2, select an appropriate evaluation method based on the goals.

Step 3 Watershed Functional Replacement Screening



* Note: Reviewer may want to consult with NED's Regulatory Division to verify the current accepted wetland assessment method required for its regulatory program.

Figure 7
Step 3 Flow Diagram

Step 3A Evaluate Wetland Fish and Wildlife Habitat Potential

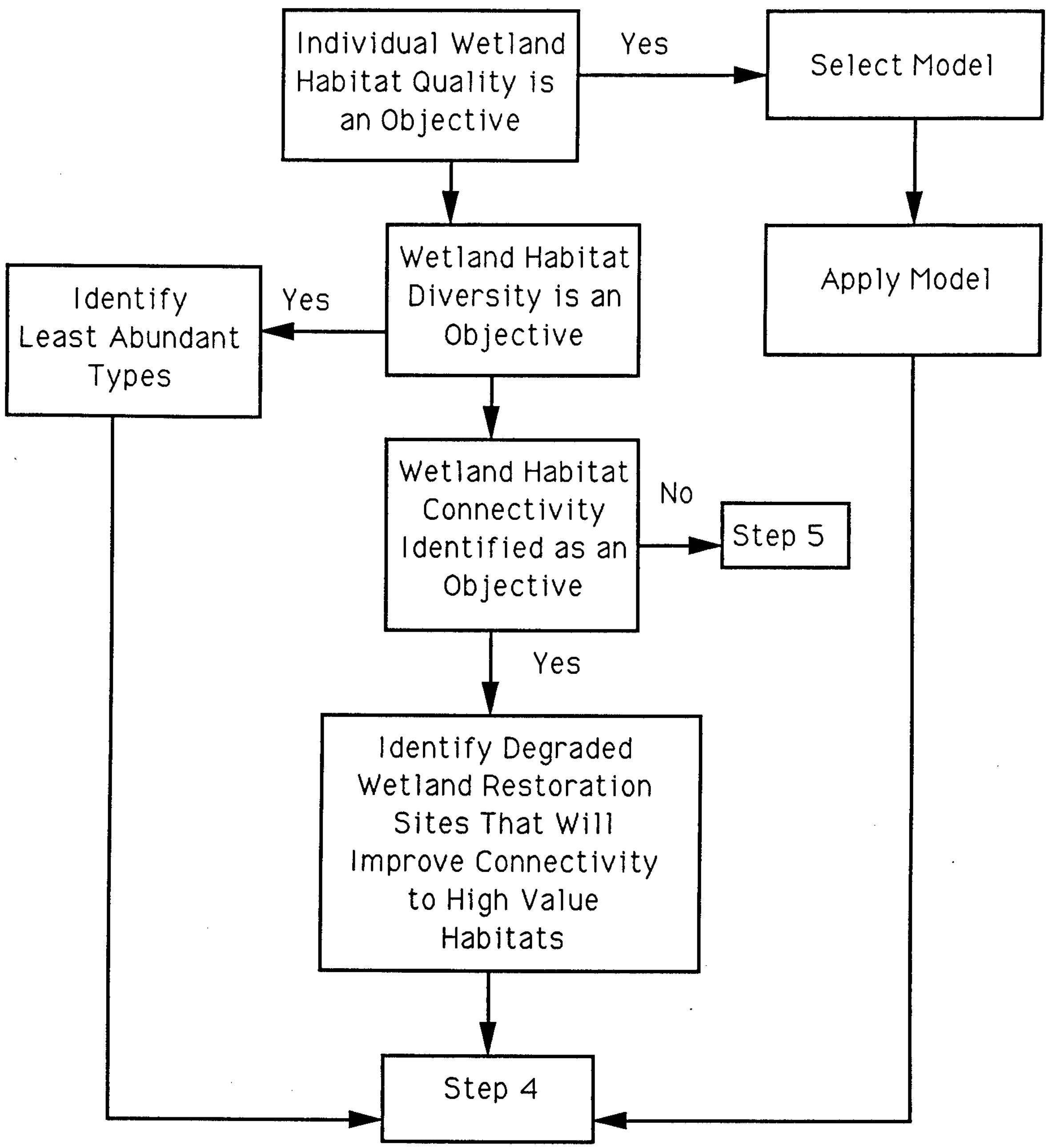


Figure 8
Step 3A Flow Diagram

3Ac-1a. If the diversity and abundance of wildlife was the watershed goal, evaluate sites using Golet (1976), Ammann and Stone (1991), or other appropriate wildlife evaluation models. Record the predicted scores.

3Ac-1b. If habitat for a particular species or species group is identified as the goal, use the appropriate HEP models or appropriate substitute to determine potential habitat units for each site. Record the predicted scores.

3Ad. If wildlife habitat diversity was listed as an objective in Step 2, identify the sites that may support the least abundant wetland types. Use the Wetlands Conservancy Program maps (where available; NWI maps as substitute) to determine wetland class diversity. Measure and list the wetland classes by area or other abundance measure to determine which types are least abundant. Compare this number to other watersheds (as more watersheds are assessed) assess the relative diversity of the study watershed to other watersheds in the State.

3Ae. If wildlife habitat connectivity improvement was identified as an objective in Step 2, identify two or more high habitat value wetlands, especially wetlands within conservation areas. Identify degraded wetlands that will improve the connections between these high value sites.

3.3.2 Step 3B: Evaluate Flood Water Storage Potential

Purpose. The purpose of this step is to evaluate the capacity of restoration sites to contribute the flood water storage function.

Procedure.

3Ba. Refer to the watershed goals and objectives established in Step 2 to determine whether the flood water storage functions are listed as goals and locations of concern. Estimate the potential future restored wetland condition of upstream wetlands.

3Bb. List all sites located upstream of an identified flooding problem.

3Bc. Determine whether each site is located in the 100-year floodplain (Roth et al., 1993). Indicate yes or no for each site.

3Bd. Determine whether a constricted outlet is present or could be designed for each site. Indicate yes or no for each site.

3Be. Using Table 1 (Marble, 1992), determine whether the site has a low gradient or could be designed to have a low gradient. Generally gradients that adhere to those shown in Table 1 will produce sheet flow conditions. Indicate yes or no for each site.

3Bf. Determine whether the site supports or can be designed to support dense vegetation. Indicate yes or no for each site.

3Bg. Rate sites located upstream of a flooding problem based on number of yes answers to 3B: c, d, e, and f and wetland size (i.e., potential storage area). Largest sites with yes answers have the greatest potential for this function.

3.3.3 Step 3C: Evaluate Water Quality Enhancement Potential

Purpose. The purpose of this step is to evaluate restoration sites based on their capacity to contribute to water quality functions.

Procedure.

3Ca. Refer to the watershed goals and objectives established in Step 2 to determine whether the nutrient reduction or sediment/toxicant reduction water quality functions are listed as goals. Predict the potential future restored wetland condition.

3Cb. If improvement of the nutrient removal/transformation function is an objective, evaluate and rank each potential restoration site against the following factors:

<u>Nutrient Removal/Transformation</u>

3Cb-1. Surface water is the primary water source. Indicate yes or no for each site.

Gradient necessary to create depositional velocity conditions.*				
Mean Depth(ft)	Densely Wooded Floodplains	Densely Vegetated Emergent Wetlands not Totally Submerged by Floodflow	Moderately Vegetated or Totally Submerged Emergent Wetlands, or with Boulders	Unobstructed Channels
<0.5	<0.0250	<0.0100	<0.0038	<0.0018
0.5 - 1	<0.0150	<0.0060	<0.0023	<0.0012
1 - 2	----------	<0.0030	<0.0012	<0.0006
2 - 3	----------	<0.0017	<0.0006	<0.0003
3 - 4**	----------	<0.0013	<0.0005	<0.0002
4 - 6**	----------	<0.0008	<0.0003	<0.0001
6 - 8**	----------	<0.0006	<0.0002	<0.0001
8 - 10**	----------	<0.0004	<0.0002	--------
10 - 12**	----------	<0.0003	<0.0001	--------

* Interpreted form SCS curves for channel flow and Manning's roughness coefficients.
** Assumes width, perpendicular to flow is less than 8 feet. If channel is 8 - 20 feet wide, the value in the row immediately below the value identified should be used.

Source: Adamus et al., 1987

Table 1. Gradients necessary to create depositional velocity conditions for use in Steps 3B and 3C.

Source: Marble, 1992.

New England Division

US Army Corps of Engineers

3Cb-2a. Phosphorus removal is a watershed goal:

Site primarily contains alluvial, alfisols, ferric, clay or other fine soils or these soils can be provided. Indicate yes or no for each site.

3Cb-2b. Nitrogen removal is a watershed goal:

Soils are primarily organic or organic soils can be added. Indicate yes or no for each site.

3Cb-3. Water regime is or can be designed to be seasonally or permanently flooded or permanently saturated. Indicate yes or no for each site.

3Cb-4. Determine whether the site has a low gradient or could be designed to have a low gradient. For channels less than 20 feet wide use Table 1. Generally gradients that adhere to those shown in Table 1 will produce sheet flow conditions. For channels greater than 20 feet wide, determine if the peak annual flow velocity in the basin is less than 1.5 feet/second. Indicate yes or no for each site.

3Cb-5. Determine whether the site has channelized flow and the width of the outlet is less than 1/3 the average width of the wetland at ordinary high water, and/or the cross sectional area of the outlet is less than 1/3 the cross sectional area of the inlet or wetland has no channel flow and the outlet is less than 1/10 the average width of the wetland or have no outlet from the wetland. Indicate yes or no for each site.

3Cb-6. Dense emergent or woody vegetation is present or can be planted. Indicate yes or no for each site.

3Cb-7. Rate sites with yes answers to 3Cb: 1, 2, and 3 (required characteristics) based on wetland size and number of yes answers to 3Cb: 4, 5, and 6. Largest sites with yes answers are priorities for further investigation.

3Cc. If improvement of the sediment/toxicant retention function is an objective, evaluate and rank each potential restoration site against the following factors:

Sediment/Toxicant Retention

3Cc-1. The wetland is located downstream of a sediment or contaminant source. Indicate yes or no for each site.

3Cc-2. Wetland is lacustrine or palustrine. Indicate yes or no for each site.

3Cc-3. Determine whether the site has a low gradient or could be designed to have a low gradient. For channels less than 20 feet wide use Table 1. Generally gradients that adhere to those shown in Table 1 will produce sheet flow conditions. For channels greater than 20 feet wide, determine if the peak annual flow velocity in the basin is less than 1.5 feet/second. Indicate yes or no for each site.

3Cc-4. Determine whether the site has channelized flow and the width of the outlet is less than 1/3 the average width of the wetland at ordinary high water, and/or the cross sectional area of the outlet is less than 1/3 the cross sectional area of the inlet or wetland has no channel flow and the outlet is less than 1/10 the average width of the wetland or have no outlet from the wetland. Indicate yes or no for each site.

3Cc-5. Surface water is primary water source. Indicate yes or no for each site.

3Cc-6. Site is or can be designed to be seasonally or permanently flooded. Indicate yes or no for each site.

3Cc-7. Dense emergent or woody vegetation is present or can be planted. Indicate yes or no for each site.

3Cc-8. Site contains or may be designed to contain organic soils or silt-clay soils with high organic content. Indicate yes or no for each site.

3Cc-9. Depressions are present or can be designed at the site.

3Cc-10. Rate sites with yes answers to 3Cc: 1, 2, 4, 5, and 8 (required characteristics) based on wetland size and number of yes answers to

3Cc: 3, 6, and 7. Largest sites with greatest number of yes answers are priorities for further investigation.

3.4 Step 4: Additional Site Screening.

Purpose

The purpose of this step is gather information and evaluate potential restoration sites based on factors unrelated to the watershed evaluations.

Background

At this point in the process, a list of potential sites has been established and evaluated based on their capacity to reduce watershed functional deficits. The previous steps were concerned strictly with technical factors and watershed level considerations; however, a number of other considerations enter into the site selection process. This step outlines additional considerations for site selection. Use the background information summary in Appendix C to guide the evaluation. Some of the considerations listed in this section are exclusionary and others are merely constraints.

Procedures

4a). Determine and record public/private ownership of each site by examining MassGIS landuse maps. The scale of these maps is small, so sites that do not clearly fall within one type of ownership may require a more detailed evaluation. Detailed evaluations can be performed by examining plans at the county registry of deeds. Restoration planners may also perform title searches on the proposed site and adjacent lands to identify ownership, easements, rights-of-way, covenants, water rights, liens, and other emcumberances that may affect the suitability of a site (Hammer, 1992). Record the method used to identify ownership on the matrix.

4b. Estimate the cost of restoration and rate the sites based on these very general criteria: high cost - >$100,000; moderate cost - $10,000-$100,000: low cost - <$10,000. Costs should include planning, design, permitting, and implementation costs. The cost of land acquisition may also be recorded, but should be specifically noted if included.

4c. Evaluate site accessibility for construction equipment and study teams to identify obvious problems that would affect implementation. Record any obvious problems in the Comments column of the matrix.

4d. Refer to Section 2.2 and record the type of manipulation (hydrologic, substrate, biotic, management, or chemical) required to effect restoration.

4e. Record the target wetland class of the wetland to be restored. Group the wetlands into the following categories to roughly indicate the level of difficulty in achieving restoration.

Less difficult: marsh and wet meadow.
More difficult: shrub and deciduous forested swamps.
Most difficult: bogs, fens, and Atlantic white cedar swamps.

4f. Rate and record the degree of disturbance to the surrounding landscape as slight, moderate, or high. Lower levels of disturbance surrounding a restoration site may lead to greater potential for success.

4g. Examine nearby and hydrologically connected wetlands to evaluate the potential susceptibility of newly restored wetlands to invasion by exotic or undesirable species, such as purple loosestrife (Lythrum salicaria) and common reed (Phragmites australis).

4h. Record the function(s) to be restored at each restoration site. Group the functions into the following categories to roughly indicate the level of difficulty in achieving restoration.

Less difficult: flood storage, sediment retention, waterfowl production. More difficult: wildlife, fish, food chain support, other water quality functions. Most difficult: groundwater functions.

4i. Record whether sensitive resource areas such as rare species habitat and outstanding resource waters are located in close proximity to the restoration site. Wetlands can protect sensitive resource areas by buffering them from adverse impacts, or implementation of restoration projects can disturb sensitive resources. Record the type of resource and nature of the concern in the comments column of the matrix.

4j. Record whether landfills or hazardous waste sites are located in close proximity to the restoration site. Landfills and hazardous and toxic waste sites are potential sources of contaminants to the restored wetland and restoration in proximity to these sites should consider whether pollutants will be mobilized due to restoration project implementation.

4k. Determine the development pressure for each city or town in the watershed by determining the number of building permits and/or wetland permits for the previous three years. Contact each town to estimate building permits. Contact the regional Massachusetts DEP office or Corps of Engineers Regulatory Division for the number of wetland permits. List the towns and the number of permits for each town. Group the restoration sites according to high, medium or low development pressure by listing the number of permits by town and creating three subdivisions to correspond to high, medium or low development pressure. Subdivisions can be of equal size or grouped according to obvious changes in the number of permits by town.

4l. Identify any sites that will provide overriding benefits at a scale larger than the watershed scale. Waterfowl habitat, for instance, is important at the flyway or international scale; control of introduced species, such as purple loosestrife is of National importance; and threatened and endangered species are important at the state or National level.

4m. Identify any special regulatory constraints that would affect project implementation.

4n. Identify the level of public support for various sites in the comments column of the matrix.

3.5 Step 5: Display Results

Purpose

To provide a concise, easily reference for potential restoration sites to aide site selection.

Background

Restoration priorities will vary among watersheds based on technical factors, public perceptions, funding opportunities and other factors. Therefore, the information provided through the steps in this process is intended to guide rather than dictate site selection. It is also important to note that most of the assessments discussed in this report will not yield quantitative results. Detailed site specific evaluations will be necessary to assess the actual conditions and level of functioning of recommend restoration sites. These assessments should be conducted as part of a detailed investigation or through the permitting process.

Procedures

Display the results of the watershed based assessment on the matrix shown in Appendix D. Review the matrix and fill in any gaps as soon as possible before finalizing the analysis. Graphically display site locations on a base map and note any obvious patterns or relationships between sites in the comments column and/or a summary report.

Chapter Four
Sources of Information for Identifying Restoration Sites

Brief descriptions of information to use to identify degraded or former wetland sites in Step 1 are provided in the following paragraphs. All map products are limited by the quality and accuracy of the information used to prepare them. Planners should recognize this level of inaccuracy inherent in all map products. The evaluation of information should be hierarchical, obtaining generalized information early on (e.g., maps) and adding information that is more difficult to obtain or interpret (e.g., aerial photography) as the number of sites to be evaluated is reduced. The information described in the following paragraphs is roughly organized by the ease with which it is obtained. *Leibowitz et al.* (1992) also provided a comprehensive list of sources of wetland information some of which are included in this section.

National Wetlands Inventory Maps. National Wetlands Inventory (NWI) maps have been produced by the U.S. Fish and Wildlife Service since 1974. These maps provide information on the characteristics and extent of wetland resources to foster wise use of wetlands (Tiner, 1984). NWI maps use U.S. Geological Survey topographic maps as the basemap. Wetlands are classified according to the methods of the "Classification of Wetlands and Deepwater Habitats of the United States" (Cowardin et al., 1979). The entire state of Massachusetts has been mapped on NWI maps and updated maps are available for most of the coastal zone of Massachusetts, excluding Cape Cod.

NWI maps may be used to identify degraded wetland sites. The Cowardin et al. system includes Special Modifiers that can be used to identify potential restoration sites. The Special Modifiers are: excavated, impounded, diked, partly drained, farmed, and artificial. If these Special Modifiers are attached to a map unit, attention should be given to closely examining the wetland and, particularly in the case of impounded or diked wetlands, surrounding or downstream wetlands to assess the wetland quality. Presently, only the Bristol County, Massachusetts NWI maps include these modifiers and data is available for portions of the North Shore (Tiner, R.W., U.S. Fish and Wildlife Service, pers. comm., 1994). Future NWI mapping of Massachusetts wetlands should include these modifiers to allow for the identification of potential restoration sites.

The NWI maps can also be used to identify unusual patterns in map units that may indicate degraded wetland sites. For example, as shown in Figure 9a, estuarine emergent wetland (E 1 or 2 EM) that abuts a barrier, such as a roadway or dike, with a palustrine emergent wetland (PEM) upstream may indicate a tidally restricted marsh. Where the Cowardin et al. salinity modifiers have been applied, they will supply supplementary evidence of this potential problem. Similar modifications of hydrology due to linear obstructions may result in wetland class changes in inland situations that may warrant investigation to determine its potential for restoration.

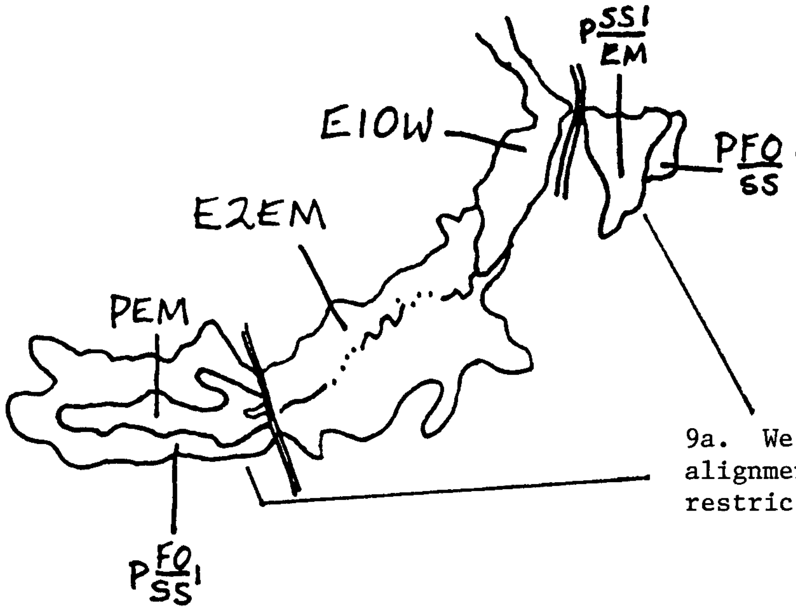
Figure 9b shows another indicator of degradation, in this case filled wetland. Wherever the usual irregular edge is interrupted, a potential for fill removal exists. Obviously, further evaluation of sites displaying this indicator would be required to evaluate the existing use of the site. For instance, filled wetlands with buildings are obviously not suitable for restoration but fill sites supporting old field vegetation may be suitable for restoration.

Other indicators of potential wetland alteration are alignment changes in a stream system which looks man-made (i.e., extremely straight channel having a meandering flow pattern located upstream or downstream). Wetlands contiguous to the straight section may have been cut off from the natural flow pattern. Any geometrically regular channel network with streams entering at right angles also suggests alteration has occurred. The natural dendritic flow pattern may have been compromised affecting wetland sheetflow characteristics, a strong indicator of potential degradation.

U.S. Geological Survey (USGS) Maps. The primary base maps for preliminary planning will be USGS topographic maps. These maps are available from the USGS in Reston, Virginia and are often on file at government offices. They can be used to delineate the watershed boundary and watercourses and, in combination with NWI maps, locate wetlands. According to the USGS topographic map legend, forested areas at the time of mapping are shown in green. The relative level of development can be assessed by counting the numbers of buildings in an area or heavily developed areas of over a square mile in size can be identified by their pink color. Modifications of the landscape as of the most recent revision can be identified as those areas in purple.

The USGS also produces land use and land cover maps. They classify various types of land use and vegetation including wetlands at a scale of 1:250,000. They may be useful for examining the level of development in a watershed to generally assess the potential effects of watershed conditions on wetlands.

Massachusetts Wetlands Conservancy Program Maps. These maps are more accurate and provide a higher level of detail than the NWI maps. Wetlands Conservancy



9a. Wetland classification alignments suggesting tidal restriction.

9b. Wetland map shape suggesting fill.

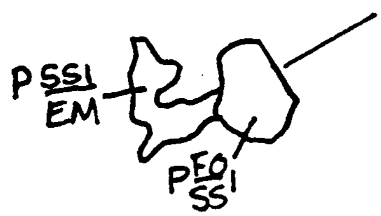


Figure 9. 9a shows estuarine classifications separated from palustrine classifications by roads. This alignment suggests tidal restriction. 9b shows straight lines on an otherwise irregular wetland edge suggesting wetland filling.

New England Division

US Army Corps of Engineers

Maps are prepared from 1:12,000 scale aerial photography. Wetlands are classified according to the designations shown in Appendix E. Where available, these maps should serve as the primary wetland maps. Approximately one-third of the state has been mapped. The Commonwealth should consider incorporating modifiers, such as the Special Modifiers under the U.S. Fish and Wildlife Service (Cowardin et al. 1979) system, to identify altered and degraded wetlands in ongoing mapping efforts. The one-third of the state that has been mapped, which includes all of the coast of Massachusetts, should be re-examined to add the modifiers. Any remapping should also be made compatible with the requirements of selected assessment methodologies. Similar to NWI maps, conservancy maps can be used to identify unusual patterns of vegetation and shapes that may indicate that wetlands were altered.

State Land Use and Vegetative Cover Maps. Land use and vegetative cover maps were prepared for the Commonwealth in the 1930's and periodically updated since the 1950's. The land/cover designations are overlain on USGS topographic quadrangle maps and depict various types of agricultural, recreation, urban, mining and waste disposal, and forest types, including wetlands. Current maps are useful for comparing with hydric soil map units. Earlier versions are useful for showing changes in land use, but not for identifying current site potential. These maps are available from the University of Massachusetts Remote Sensing Project (Professor William MacConnell), Holdsworth Hall, Amherst, Massachusetts 01003.

Federal/State Priority Wetlands Plans. The USFWS is required by Section 301 of the Emergency Wetlands Resources Act of 1989 to develop Regional Wetlands Concept Plans prepared in cooperation with the state fish and wildlife agency and other State and Federal agencies. The Plan discusses the National wetland resources within the region that should be given priority consideration for acquisition (USFWS, 1989).

Statewide Comprehensive Outdoor Recreation Plan. States are required by the Federal Land and Water Conservation Fund Act to prepare a Statewide Comprehensive Outdoor Recreation Plan (SCORP) in order to participate in the National Park Service grant program. Section 303 of the Emergency Wetlands Resources Act of 1986 requires that SCORPs include wetland components or a State Wetlands Priority Plan as an addendum. The wetlands component should, at a minimum, provide wetland acquisition goals, objectives and strategies. Sites acquired through this program may provide an important link between restored and natural wetlands in the watershed. Priority is given to wetland sites that: 1) include predominantly rare or declining wetland types; 2) are threatened with loss or degradation; and 3) have had all of the functional values considered for equal priority and are recognized, identified, or listed as important for at least two functional values. Sites requiring restoration may be included in the State Wetlands Priority Plan (USFWS, 1989). The latest edition of the Massachusetts SCORP was prepared in 1988. An updated version including wetlands restoration information is expected to be available in 1995. Development of recommendations for the Massachusetts SCORP should include the consideration of restoration and be coordinated with the MWRBP.

North American Waterfowl Management Plan. The North American Waterfowl Management Plan is an international plan developed to address the need for protecting, restoring, and managing wetlands of importance to waterfowl and other wildlife species. The Plan identifies thirty-four priority habitats in the United States and Canada (USFWS, 1989). The Atlantic Coast was identified as one of six priority habitats in need of immediate attention. All of Massachusetts lies within the Atlantic Coast Joint Venture Area which contains waterfowl wintering and migration habitat along the Atlantic Coast and additional inland areas important to the production of black ducks and other waterfowl. The Massachusetts Focus Area lists 32,000 acres for protection and 12,650 acres for enhancement (USFWS, 1988). The sites are shown in Appendix F. Since these sites have already been identified for their importance at a landscape scale (flyway), they can be given immediate priority for implementation.

EPA Priority Wetlands. Each EPA Regional Office is required to prepare a list of priority wetlands in its region for priority protection under the Section 404 regulatory program. The lists contain wetlands that are valuable and threatened (USFWS, 1989). Region I of the EPA prepared a report entitled "Priority Wetlands in New England" (EPA Region I, September 1987) that lists these sites. These sites should be given consideration in ranking restoration sites, but the list does not address the need for restoration.

SCS Soil Surveys. Soil surveys of Massachusetts are prepared by county by the U.S. Soil Conservation Service. The surveys contain maps generated from aerial photography and field surveys with a 3-acre minimum map unit. Wetlands and hydric soils, are identified and soil properties such as frequency, duration, and timing of flooding, permeability, and water table characteristics are described for each soil type.

These maps should be used with the Wetlands Conservancy Maps or NWI maps to identify filled wetlands and gain further information about soils at the degraded sites and within the watershed. Areas mapped as hydric soil that are not identified as wetland on wetland maps (i.e., drained or filled hydric soils) may have been altered and should be identified for further evaluation. Evidence of drained hydric soils includes:

- Presence of ditches or canals of sufficient depth to lower the water table below the major portion of the root zone of prevalent vegetation.
- Presence of dikes, levees, or similar structures that obstruct normal inundation of an area.
- Presence of a tile system to promote subsurface drainage.
- Diversion of upland surface runoff from an area.

Unusual patterns and straight lines classified as Urban Land bordering wetland soils can also be identified as potential filled wetlands.

Geographic Information Systems. The Commonwealth of Massachusetts, Executive Office of Environmental Affairs maintains a statewide geographic information system (GIS), referred to as MassGIS, which contains information useful for the identification and selection of wetland restoration sites. In terms of degraded site information, MassGIS contains delineations of drainage basins and land use, including publicly owned land, which can be used to delineate assessment area boundaries and the type and level of development in the watershed. Information generated in watershed wetland restoration investigations should be added to the system.

Local Experts. Individuals with personal knowledge of an area, such as local landowners, conservation commission members, harbor masters, town officials, Division of Fisheries and Wildlife, Division of Marine Fisheries, and Department of Environmental Protection staff, can provide information about degraded wetlands that is not available from other sources. Surveys and interviews should be conducted to identify interested people with this information.

Aerial Photography. Interpretation of aerial photography can provide detailed information about degraded wetland sites. Because it is somewhat more difficult to obtain and interpret than maps, it should be used to more closely examine sites identified though other methods.

Aerial photography is available in various scales and colors, including black and white, true-color, and false color infrared. Scale, color, and time of year should all be considered when obtaining aerial photography to identify and evaluate degraded wetlands. An appropriate scale for delineating wetlands and evaluating the extent and causes of degradation is 1:12,000 or 1: 24,000. The most appropriate color of the photography and time of year depends on the type of degradation to be identified. Spring black and white or false color infrared photography is useful for identifying structural modifications to wetlands such as ditching, water control structures, and fill because the leaves are off the trees and the degree of wetness of the substrate is visible. Fall false color infrared photography is excellent for evaluating the extent and effects of ditching or hydraulic restrictions on salt marshes. The time of day that photography is taken is important in the coastal zone because of the potential for tidal flooding. True color photography taken during July and August is excellent for identifying purple loosestrife. In the absence of the availability of suitable aerial photography, an overflight by a wetland ecologist can identify degraded wetlands.

Chapter Five
Impact Characterizations

The following paragraphs summarize the types of impacts affecting various wetland classes in Massachusetts. This information should be reviewed to develop a search image for typical wetland impacts before reviewing the information sources described in Chapter five.

Impacts affecting all wetland classes. Wetlands in Massachusetts have been affected by hundreds of years of intense land use resulting in an almost complete lack of pristine wetlands. Identification of very subtle impacts due to these long-term indirect effects would be extremely difficult. Some of the subtle effects of ecosystem stressors include following: 1) reduced internal material cycling; 2) reversion of the community to earlier successional stages (which may or may not have an adverse effect from a landscape perspective); 3) decreased efficiency of resource use, and 4) increased parasitism (Odum, 1985 in Leibowitz et al., 1992). At a practical level, it is difficult to recognize and attribute these characteristics to stress. Degraded wetlands are more easily identified by obvious changes in the structure of wetland characteristics (e.g., filled areas, tree removal, etc.), but planners should keep in mind that more subtle effects exist.

In most of the Northeast, urbanization is now responsible for more inland wetland losses than all other causes combined (Golet et al., 1993). Leibowitz et al. (1992) provided tables displaying expected relationships between impacts and wetland degradation that can be used to identify various impacts affecting wetlands. Many of these impacts, such as acidification and light reduction (Leibowitz et al., 1992), are subtle and can be addressed by remedial actions taken outside the wetland. The identifiable impacts are discussed below.

Obviously, large scale fill to create developable upland affects all wetland types similarly. This category of impact is identified by abrupt changes in topography adjacent to wetlands and straight wetland borders where an irregular border would normally occur. Any road crossing of a wetland has a potential to change wetland hydrology and function. Fills and road crossings can be identified on any of the maps discussed in the following sections.

Non-point and point source discharges of pollutants, including sediments, heavy metals, organics, and nutrients, also affect all wetland classes. The most obvious and easily addressed impact in this group is sedimentation. Large fans of deposited sediments can be identified on aerial photography (or in the field) as triangular-shaped, light-toned areas lacking vegetation. Pollutants can build up in wetland sediments and may accumulate in plants, potentially affecting fish and wildlife and magnifying in the food web. Identify the potential for this impact by examining maps to determine the level of surrounding development. Nutrients may fertilize a wetland causing changes in plant species composition and eutrophication of adjacent and enclosed waters. It is difficult to identify this impact in vegetated wetlands; examine enclosed open water areas within or adjacent to the wetland to determine whether aquatic vegetation is very dense. This may suggest that nutrient input is high. This effect is addressed through off-site measures.

Wetland conversion for agriculture historically was a major cause of wetland loss in the Northeast (Golet et al., 1993) and cranberry farming is still has an impact (Tiner, R. W. pers. comm. June 1995). Farmed hydric soils on Soil Survey maps indicate areas impacted by agricultural conversion.

Tidal wetlands. The alterations of coastal and estuarine marshes generally include dikes and improperly sized or flap gated drainage culverts, mosquito ditching, salt marsh haying, and alteration of the sediment regime. Dikes and road crossings with inadequately sized culverts or bridges are frequently associated with a lowering of soil water salinity levels and a change in plant species composition (Niering and Warren, 1980; Roman et al., 1984; Sinicrope et al., 1980). The reduced tidal range can also result in a reduction in primary productivity (Steever et al., 1976; Mendelssohn and Seneca, 1980; Odum, 1980) Often, the change in plant species composition results in the dominance of common reed (Phragmites australis), which is generally considered a lower value, nuisance plant species (NRC, 1992). The restriction of tidal range always, by definition, results in at least a temporal reduction in estuarine habitat area.

Mosquito ditches are identified by geometrically arranged straight ditches in a marsh. They result in a less diverse vegetation pattern than un-ditched marshes and a decrease in the amount of open water. If they are not properly maintained, they can also result in increased mosquito populations since they may become clogged and hold temporary standing water. This impact can be addressed through the implementation of open marsh water management (OMWM) which can restore marsh diversity and wildlife value as well as significantly lower mosquito populations. According to *Golet et al.* (1993), mosquito control ditches have also been constructed in red maple swamps in southern New England.

Aside from the periodic disturbance to marsh inhabitants from operation of mowing machinery, harvesting of salt hay results in the removal of organic material. Organic material is important to accretion of salt marshes with sea level rise. Hayed marshes often have a different tone on aerial photography than surrounding salt marshes and vegetation appears less dense in the field.

Warren and Niering (1993) identified impacts to a salt marsh in Connecticut due to a reduction in sediment input. The sediment reduction resulted in submergence of the marsh surface relative to sea level and a reduction in plant productivity. Diversions in sediment input, as a result of levees, dams, and land use changes, and coastal erosion can affect the ability of a marsh to maintain itself with sea level rise. Restoration of sediment regime can be conducted as a restoration project. This effect can be identified on periodic aerial photography by identifying areas of erosion, vegetation change and wetter (i.e., darker) substrates, or increased open water depressions.

Depressional wetlands, including bogs and fens. Bogs and fens are particularly sensitive to changes in water chemistry because of the acidic, low nutrient nature of the peat (Damman and French, 1987). According to *Laderman* (1989), "Residential development is accompanied by an increase in species richness, with an initial increase in drier-site species followed by large increases in non-indigenous species as native plants disappear." Studies in the New Jersey Pinelands indicated that suburbanization eliminates the species characteristically associated with Atlantic white-cedar wetlands and degrades water quality (Laderman, 1989). Water chemistry, including parameters such as acidity, nutrient concentrations, and sediment load, is impacted by storm drainage and, in particular, direct runoff. Water chemistry must be considered in restoration projects involving bogs and fens. Restoration of buffer zones that maintain water quality is important component of bog and fen protection and restoration.

Depressional wetlands, including bogs, fens, marshes and swamps, may have been drained or altered for agricultural use (NRC, 1992). According to *Golet et al.* (1993), "Most of the managed cranberry bogs in the Northeast have been developed in former palustrine vegetated wetlands." *Laderman* (1989) indicated that cultivation and draining levels the topography of cedar wetlands and may destroy the soil microstructure irreversibly. As previously noted, red maple swamps may also have been ditched for mosquito control.

Riverine, lacustrine and fringing palustrine wetlands. Wetlands associated with rivers have been impacted by disposal of liquid pollutants, dams, water diversion, dikes, channelization, bank stabilization, dredging and development in the watershed. Wetlands associated with lakes and ponds are affected by shoreline development, pollutant discharges, and eutrophication (NRC, 1992). Impoundment construction results in the flooding of wetlands associated with rivers and may affect water and sediment regimes of downstream wetlands. Similarly, road culverts too small to allow normal flows to pass can result in an increased level of flooding on the upstream side and a decreased level of flooding on the downstream side (Golet et al., 1993). Once a stream is impounded, wetlands can form along the reservoir perimeter if water levels are relatively stable. Often these wetlands achieve high quality and failure or removal of the dam results in the loss of high value wetlands. Reservoirs with fluctuating water levels, where wetlands are less likely to form, also present an opportunity for functional replacement through the creation of wetland subimpoundments with more stable water levels. Wetlands in the vicinity of cranberry bogs have been impounded to provide irrigation water (Golet et al., 1993).

Chapter Six
Summary

This report presents a watershed-based framework within which sites are identified and evaluated for proactive restoration. Site identification and evaluation is composed of a sequence of five steps: 1) identification of degraded wetland sites; 2) identification of watershed functional deficits; 3) screening to evaluate the potential of sites to address watershed functional deficits; 4) screening against other site selection factors; and 5) displaying the results.

Step 1. After selecting the watershed, the first step is to identify degraded wetlands or former wetlands that can be restored. This is the most important and time consuming step. It is particularly important because it provides the baseline for subsequent steps and it is not likely to be repeated as conditions in the watershed require a reevaluation of other steps.

The major activities in this Step 1 are to develop an image of the visible characteristics of degraded wetlands and collect and analyze sources of information to locate degraded wetlands. In Massachusetts, the major degraded wetland types that can be readily identified are: filled wetlands; tidally restricted salt marshes; ditched salt marshes; freshwater marshes and wet meadows overcome by purple loosestrife; drained wetlands; wetlands that were drowned by impoundments; wetlands that formed behind impoundments that were subsequently drained; and bog and fens affected by water chemistry changes. The sources of information identified in this report range from national wetlands inventory maps to field inspections. A specific sequence of activities is not provided so that methods can be selected based on the background and skills of the watershed study team and the availability of information.

An important activity in Step 1 is to identify wetlands that already have been prioritized for restoration, such as North American Waterfowl Management Plan sites. These sites have significance at a scale larger than the watershed and, therefore, already have restoration priority.

Step 2. Step 2 links individual sites to watershed function by establishing goals and objectives. Goals are the watershed functions that should be restored. The objectives are the specific wetland or functional characteristics and locations in the watershed to be restored. The basis for goal setting is the evaluation of watershed functional deficits, which are impaired wetland functions evident at the watershed level. Functional deficits are identified for three wetland functions: wildlife habitat; flood water storage; and water quality improvement.

Three considerations apply to setting wildlife habitat goals and objectives: habitat quality, diversity, and connectivity. These goals are primarily set by interviewing resource groups in the watershed, since comprehensive evaluation techniques are either time consuming or nonexistent. Diversity is relatively simple to evaluate; the least abundant wetland types are identified. If improving the quality of individual wetlands in the watershed is an objective, a watershed deficit evaluation is not required, but the habitat quality goal should specify an appropriate measure of quality. Measures of quality could be an increase in the diversity and abundance of wildlife or increases in the abundance of some particular species or species group. Connectivity is difficult to address; the method proposes identifying the higher value wetlands in the watershed and improving their habitat value by restoring wetlands between them.

Wetlands can help control unwanted flooding by temporarily storing flood waters on their surface. A deficit in wetland function would be demonstrated by flooding of developed properties due to a lack of storage area. The identification of flood water storage deficits involves a hierarchical process whereby the least costly to the most costly information is screened to confirm the presence of a storage area related flooding problem. First, existing reports are reviewed to identify flooding problems and their cause. If completed reports do not exist, local officials are interviewed in an attempt to define flooding problems. If these activities do not identify storage related flooding problems and there is a reason to believe a lack of storage area is a problem, the extent of floodplain encroachment and hydrographs can be used to further evaluate the potential importance of this function.

Water quality information is readily available for Massachusetts watersheds. Reports prepared by the Massachusetts Office of Watershed Management and U.S. Environmental Protection Agency are reviewed to establish water quality goals and objectives, including the identification of specific problem areas. Goals can be further refined by reviewing National Pollutant Discharge Elimination System (NPDES) permits.

Step 3. Once the universe of potential restoration sites is identified and goals are established for the watershed, the sites are screened to assess their capacity to address functional deficits. Again, three separate substeps are applied for three wetland functions: wildlife habitat; flood water storage; and water quality improvement. The procedure applied to assess functional replacement capacity is expected to change when the Hydrogeomorphic

Method (HGM), being developed by the Corps of Engineers, is completed. This method uses reference wetlands, regional models, and functional capacity to assess relative wetland functioning. Until HGM is available, a conglomeration of methods based on the Wetland Evaluation Technique (WET) is proposed. For all methods, the future restored condition of sites must be projected to perform many of the evaluations required in this step.

Evaluating wetland wildlife habitat potential, involves addressing the objectives specified through interviews with interested groups. If increasing the value of individual wetland habitats is a goal, an appropriate model must be selected and applied to identify the highest potential habitat value sites. If increasing wetland habitat diversity is an objective, less abundant wetland types should be restored. If improving the value of existing high value wetlands through improved connections is a goal, sites that best fill existing gaps are identified.

The evaluations of functional capacity replacement potential for the flood storage and water quality functions are conducted by comparing the future characteristics of sites to evaluation factors. The lists of evaluation factors were developed using information from WET, revised approaches to WET developed by *Marble* (1992) and the New England Division, Corps of Engineers, and factors presented by *Roth et al.* (1993). Sites are evaluated based on size and positive answers to questions about wetland characteristics.

Step 4. The results of the screening conducted in Step 3 will only tell the likelihood of sites to improve watershed level functions. Many other factors affect site selection, such as ownership, cost, the likelihood of success, development pressure, and regulatory considerations. These factors are considered in Step 4. Summaries of the information concerning these factors are presented for use in developing general rankings.

Step 5. The results of all four steps are displayed in a matrix in Step 5. A rigid ranking scheme is not proposed, since it would not be possible to consider perhaps the most important considerations: the presence of a project sponsor and public support. All of the basic information involved in site selection will be available to decision makers to guide site selection.

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APPENDIX A

Wetland Restoration Definition

draft 12/7/94

WETLANDS RESTORATION & BANKING PROGRAM

Wetlands Restoration Definition: For purposes of the Massachusetts Wetlands Restoration & Banking Program (WRBP), wetlands restoration is the act, process, or result of returning a wetland or a former wetland to a close approximation of its condition prior to disturbance.[1]

Types of Wetlands Restoration: Given the wide range of activities meeting this definition, wetlands restoration should be classified based on the intended purpose of the restoration project: Type 1 Restoration - reestablishing a wetland in a former wetland site that is presently non-wetland, and Type 2 Restoration - returning a damaged, degraded, or otherwise functionally impaired wetland to its prior (pre-disturbance) condition or a one similar to it. Type 1 restorations result in an increase in wetland acreage by recreating a wetland at the site of a former wetland (historic wetland). Type 2 restorations cause a change in the type or condition of an existing wetland, typically with no gain in wetland acreage. Type 2 restorations are, therefore, more qualitative changes that attempt to return the condition and functions of an altered wetland to those that existed prior to disturbance. Restoration projects may involve both types of restoration.

General Aims and Components of Wetlands Restoration: Wetlands restoration seeks to restore prior wetland functions, including water quality improvement, flood storage and flood protection, and fish, shellfish, and wildlife habitat. The basic components of wetlands restoration are: (1) restoring hydrology (e.g., through improved culvert sizing and eliminating flow restrictions), (2) restoring substrate characteristics (e.g., removal of fill, reestablishing original topography and physical configuration, and returning hydric soils), (3) reestablishing native biota (e.g., controlling exotic/invasive species and reintroducing native or other ecologically beneficial vegetation through seeding and plantings), and (4) restoring the chemical integrity (e.g., by reducing pollutants, eliminating contamination sources, and returning sufficient salt water to degraded salt marshes). These components are not mutually exclusive since manipulation of one of these components often affects another. Restored wetlands should be persistent and self-sustaining.

The following activities are not considered proactive wetlands restoration: (1) conversion of vegetated wetland to open water for recreation, livestock watering or aesthetics, (2) armoring river, stream, or coastal banks with rip-rap or gabion for flood and erosion control, and (3) any action taken to comply with water quality control and other applicable regulations and policies (e.g., removing unauthorized fill from a wetland per state order to comply with state regulations or compensatory mitigation).

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[1] This definition is essentially the same as the one presented in the wetlands chapter of "Restoration of Aquatic Ecosystems" published by the National Research Council (1992).

Wetlands creation differs from wetlands restoration in that it is the construction of a wetland at a non-wetland site that was never wet enough to support a wetland. Creation projects are not considered wetlands restoration, although some restoration projects may involve some wetland creation. There are varying definitions of wetland enhancement. WRBP supports wetland enhancements only if they meet the definition for wetlands restoration.

General Guidance: The Wetlands Restoration & Banking Program and its advisory committees have adopted the terms "compensatory mitigation" and "proactive restoration" to distinguish between two purposes for wetlands restoration. Compensatory mitigation is wetlands restoration required by a permit or a regulatory enforcement action. Proactive wetlands restoration is performed simply and solely to restore one or more wetland functions for the benefit of society and the natural environment.

Wetlands restoration projects should comply with the requirements of applicable wetlands laws and regulations. Projects that do not should only be considered and pursued where there is an overriding public interest and a significant environmental gain.

WRBP supports a holistic approach to wetlands restoration that requires consideration of the regional context for wetlands restoration, especially factors contributing to wetland loss and degradation in the watershed. WRBP encourages the development of regional (watershed or other ecologic unit) wetlands restoration plans that set forth regional goals for wetlands functions to be restored (such as water quality or wildlife habitat improvements).

Restoration projects should strive for the permanent return of wetland functions and public benefits. Consequently, Massachusetts should favor projects on public lands and projects with perpetual easements on private property over restoration projects with short-term easements.

Literature Cited: National Research Council. 1992. Restoration of Aquatic Ecosystems. Science, Technology, and Public Policy. Chapter 6. Wetlands. National Academy Press, Washington, DC. pp. 262-340.

APPENDIX B

Technical Note: WG-RS-3.1
"Wetlands Engineering:
Design Sequence for Wetlands Restoration
and Establishment"

WRP Technical Note WG-RS-3.1
May 1992

Wetlands Engineering: Design Sequence for Wetlands Restoration and Establishment

PURPOSE: This technical note describes a sequence of activities for design and selection of construction techniques for wetlands restoration and establishment. The design sequence includes consideration of wetlands needs, site characteristics, and design criteria; fill or excavation equipment and techniques for wetlands soils; water and erosion control structures for wetlands hydrology; and techniques and materials for establishing wetlands vegetation. Duplicative and unnecessary design evaluations can be avoided by following the guidance in this technical note (TN).

BACKGROUND: Guidelines pertaining to various aspects of wetlands design are available [Environmental Laboratory (1978), Federal Highway Administration (1990), Soil Conservation Service (in preparation)], and additional guidance is being developed as a part of the WRP Restoration and Establishment Task Area. This TN supplements the currently available guidance by describing a design sequence for wetlands establishment and restoration projects.

DESIGN SEQUENCE: The flowchart shown in Figure 1 illustrates the design activities for a wetlands restoration and establishment project and the sequence in which the activities should be considered. The overall sequence is based on the concept that design activities associated with establishing wetland substrate soils and hydrology should precede those associated with establishing wetland vegetation.

The numbered blocks in the flowchart in Figure 1 are referenced to the following brief descriptions of the activities:

(1) Conduct an initial evaluation of wetlands needs for the area under consideration for the restoration/establishment project.

(2) Select a desired set of wetlands functions and values for the project.

(3) Perform a baseline site survey in the project area to determine initial topographic, hydrologic, soils, and vegetative conditions.

(4) Prioritize and select specific sites for restoration and establishment within the project area.

(5) Determine design criteria for soils, hydrology, and vegetation based on desired functions and values and site characteristics as determined in Step 2.

(6) Determine if existing substrate soils and hydrology meet the design criteria. If substrate soils and criteria are adequate, proceed to Step 22 to evaluate wetlands vegetation requirements.

(7) Determine if substrate fill or excavation will be required. If existing substrate elevation and grading are adequate, proceed to Step 17 to evaluate water and erosion control measures.

(8) If fill or excavation will be required, determine substrate elevation and grading requirements to meet the design criteria (i.e. design the new substrate topography).

(9) Select borrow material sources for fill requirements and placement sites for any excavated material (preferably within the restoration/establishment site).

(10) Determine the most desirable fill or excavation process (i.e. hydraulic fill or conventional soils handling). If a conventional soils handling process is chosen, proceed to Step 14 to select soils handling requirements.

(11) If hydraulic fill is the desirable approach, determine if retention of the material will be required. If not, proceed to Step 15 to select the appropriate hydraulic dredging equipment.

(12) If retention of hydraulic fill is required, design the retention dike or structure.

(13) Design the retention area for initial volume of material to be placed hydraulically and for retention of suspended solids during placement.

(14) If conventional soils handling is the desirable approach, determine soils handling requirements.

(15) Select equipment for hydraulic placement or placement using conventional soils handling techniques.

(16) Predict consolidation of fill and account for consolidation in fill elevation and grading.

(17) Evaluate requirements for water control. If water control structures are not required, proceed to Step 19 to evaluate erosion control requirements.

(18) Design any required water control structure(s).

(19) Evaluate requirements for erosion control. If erosion control measures are not required, proceed to Step 21 to evaluate overall suitability of the substrate design.

(20) Design necessary measures for erosion control.

(21) Evaluate compatibility of all design components pertaining to substrate soils and hydrology. If compatible, proceed to Step 22 to evaluate vegetation requirements. If not, return to Step 6 to reevaluate requirements or designs associated with substrate soils and hydrology.

(22) Determine if adjacent vegetation is adequate and will colonize the restoration/establishment site in an appropriate time frame without active planting. If adequate, proceed to Step 29 to evaluate overall compatibility of design components.

(23) If active planting is required, select species for planting.

(24) Select method of vegetating (e.g. seeds, propagules, etc.)

(25) Determine source(s) of plant materials.

(26) Select equipment for planting.

(27) Determine planting schedule.

(28) Determine site preparation requirements.

(29) Evaluate overall compatibility of all components of design (soils, hydrology, vegetation). If not compatible, return to Step 6 to reevaluate requirements or designs.

(30) Complete overall design.

(31) Develop management and monitoring plan to include appropriate remedial actions.

Future TN's in the WRP series will provide more detailed information on the various activities included in this design sequence.

CONCLUSION: By following an efficient sequence of activities for design, unnecessary evaluations can be avoided and a fully integrated design will result.

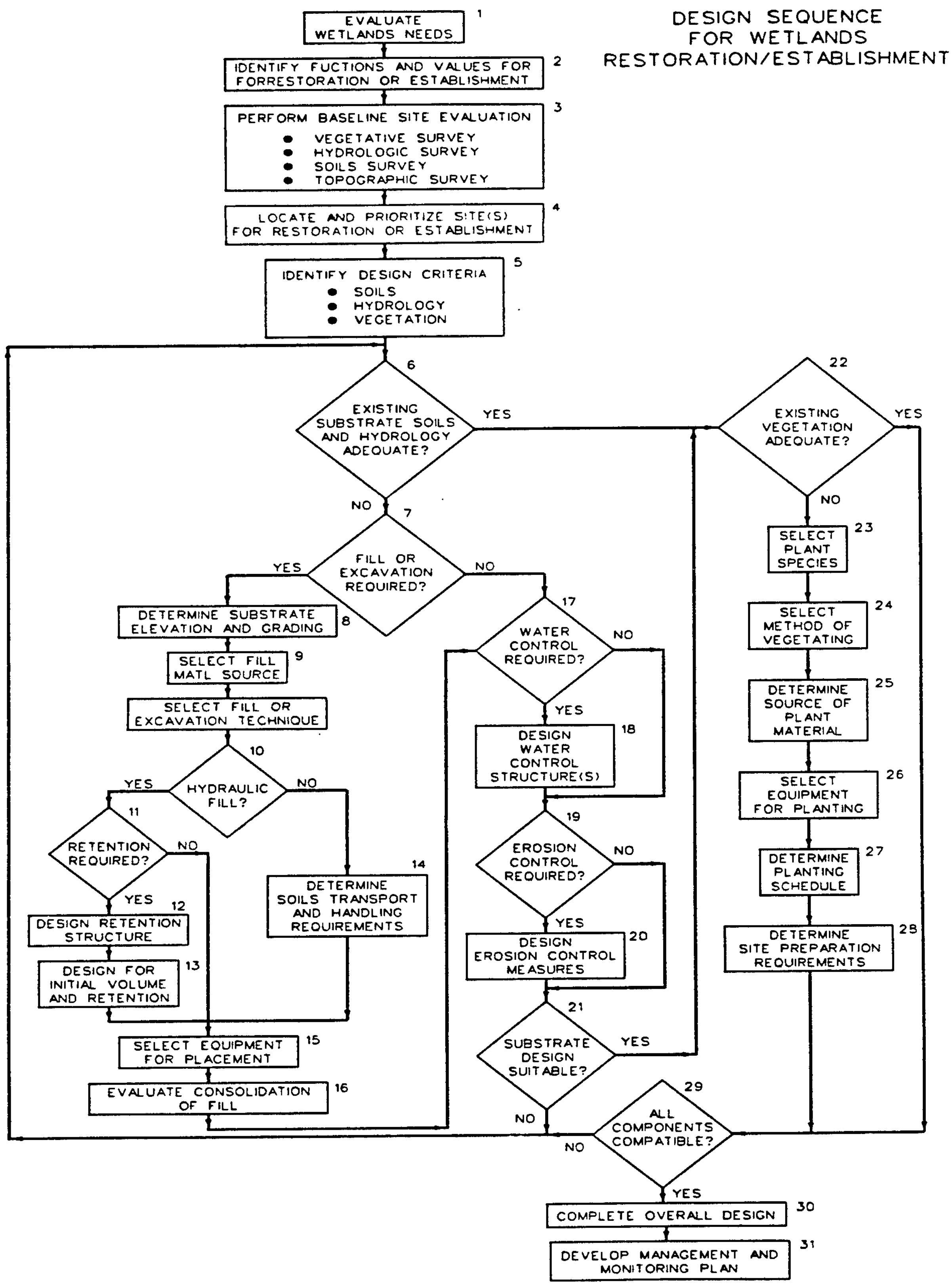

Figure 1. Flowchart illustrating design sequence for wetlands restoration and establishment projects

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APPENDIX C

Display Matrix

WATERSHED NAME: DATE:
PREPARED BY:
WATERSHED GOALS AND OBJECTIVES:

SITE NAME & LOCATION	WETLAND CLASS	HGM TYPE	IMPACT DESCRIPTION
example bog, Smith St Xville	PEM/marsh	fr/sur/bi	alt. hydro. regime

FUNCTION POTENTIAL				
WILDL. POTENTIAL Qual./Diver./Conn.	FLOOD POTENTAL	WQ POTENTIAL Nutr/Sed-Tox	OWNERSHIP	COST RANK (w/o acquisition)
36HU/high/na	18	10/na	public	m

SUCCESS RANK

FIX TYPE	CLASS DIFFICULTY	LAND DIST	EXOTICS	FUNCTION	DEVELOPMENT POTENTIAL
hydrologic	less difficult	moderate	high	Wtrfwl-less	med

PUBLIC SUPPORT	COMMENTS
high	Landfill nearby but downstream.

APPENDIX D

Background Information
for the
Site Identification and Evaluation Methodology

Background Information for the Site Identification and Evaluation Methodology

The following sections provide more detailed information to support the process of identifying and evaluating restoration sites and watersheds in the methodology described in Chapter three of the main report.

Step 1: Identification of Degraded and Former Wetland Sites.

Background

The purpose of this step is to identify all degraded and former wetlands in the watershed with restoration potential. The framework for identifying filled and degraded wetlands involves collecting and using existing information (described in Chapter four) and interviews with local experts to identify typical impacts to Massachusetts wetland classes (using the impact characterizations described in Chapter five). This inventory of potential wetland restoration sites is the most important step in the process because it provides the baseline for all further steps.

Task Descriptions

1a. Review Chapter four to determine the sources of information available for the watershed and most appropriate for the planning team conducting the study. For instance, some higher quality information may not be available for the watershed under consideration requiring the substitution of lower quality information. Or, a study team with skill in aerial photography interpretation may emphasize this information source over mapped information. Select and obtain as many of the types of information as needed.

1b. Select an appropriate base map and delineate the watershed boundary on information sources to define the site identification area. The appropriate watershed scale for these evaluations is dictated by the availability of existing information. In general, the water basins used by the Massachusetts Office of Watershed Management for its Clean Water Act, Section 303(e) reports, or the twenty-eight watersheds as defined by the Massachusetts Water Resources Commission (Figure D-1) should be used.

1c. Review the patterns of wetland impacts described in the Chapter five to become familiar with the characteristics of impacts to various wetland classes in Massachusetts. (Massachusetts wetland classes are described in Appendix E.) For the purposes of impact identification, wetlands are grouped into the following categories: 1) Tidal wetlands; 2) bogs, fens, and isolated palustrine wetlands; and 3) fringing palustrine, riverine, and lacustrine wetlands.

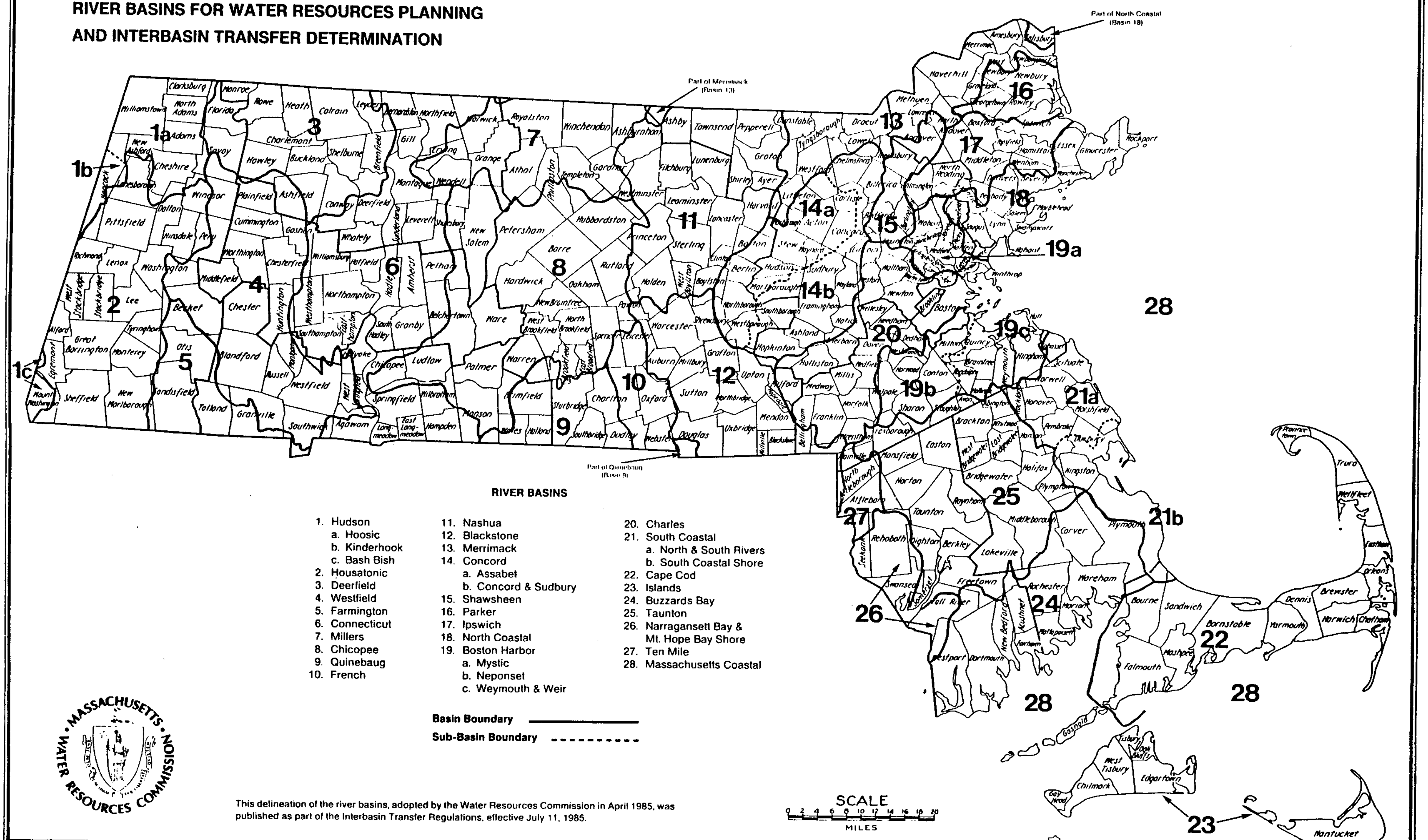
1d. Identify degraded and former wetlands in the watershed based on the characterization of impacts by class in Chapter five using the information sources and techniques described in Chapter four or the techniques used in the Neponset River watershed pilot study.

1e. Some wetlands will be degraded in such way that they should be restored regardless of the overall watershed priority. For instance, wetlands dominated by purple loosestrife should be addressed as soon as possible where they have a potential to cause this species to spread regardless of the results of the watershed evaluation. In this case, the scale of importance of this degradation is National.

Identify former salt marshes, sites dominated by purple loosestrife (Lythrum salicaria), common reed (Phragmites australis) dominated coastal marshes, sites that contain threatened or endangered species critical habitat, and North American Waterfowl Management Plan sites or other officially designated priority sites for special consideration. These sites should have immediate restoration priority due to their importance at a scale larger than the watershed scale. Coastal wetland restoration planning should give at least as much consideration to the connection to coastal and marine environments as to the watershed or basin. The overriding consideration in selecting salt marsh restoration sites will most often be the enhancement of estuarine aquatic productivity and estuarine fish and wildlife communities. For salt marsh restoration, the coastal zone should be considered the watershed and these projects should be encouraged to proceed in advance of watershed-based site selection. This should not be construed to indicate that other watershed linkages should be ignored, however.

1f. After identifying potential degraded wetlands in the office or laboratory, visit all sites in the field to confirm the extent and nature of the degradation. All map products have inaccuracies and any inventory conducted without field verification will also contain inaccuracies. In addition, many types of degraded wetlands will not be

RIVER BASINS FOR WATER RESOURCES PLANNING AND INTERBASIN TRANSFER DETERMINATION



RIVER BASINS

1. Hudson
   a. Hoosic
   b. Kinderhook
   c. Bash Bish
2. Housatonic
3. Deerfield
4. Westfield
5. Farmington
6. Connecticut
7. Millers
8. Chicopee
9. Quinebaug
10. French
11. Nashua
12. Blackstone
13. Merrimack
14. Concord
    a. Assabet
    b. Concord & Sudbury
15. Shawsheen
16. Parker
17. Ipswich
18. North Coastal
19. Boston Harbor
    a. Mystic
    b. Neponset
    c. Weymouth & Weir
20. Charles
21. South Coastal
    a. North & South Rivers
    b. South Coastal Shore
22. Cape Cod
23. Islands
24. Buzzards Bay
25. Taunton
26. Narragansett Bay & Mt. Hope Bay Shore
27. Ten Mile
28. Massachusetts Coastal

Basin Boundary ————————

Sub-Basin Boundary - - - - - - - - - -

This delineation of the river basins, adopted by the Water Resources Commission in April 1985, was published as part of the Interbasin Transfer Regulations, effective July 11, 1985.

Executive Office of Environmental Affairs • Water Resources Commission

Prepared by the Department of Environmental Management • Division of Water Resources

Figure D - 1

discernable on with office or laboratory techniques, so additional wetlands can be identified through field work.

Record the location, class (as used by the Wetlands Conservancy Program - see Appendix E or Cowardin et al., 1979), hydrogeomorphic type, and nature of the impact on the matrix provided in Appendix D.

Step 2: Identification of Watershed Functional Deficits

Background

The purpose of this step is to evaluate the magnitude of watershed problems that can be improved by restoring wetlands. The information generated in this step will be used to set watershed-based restoration goals. The problems, identified as functional deficits, may have resulted from prior cumulative damage to wetland functions. The term functional deficit used in this report refers to impairment of wetland functions evident at the watershed scale.

The Massachusetts Wetlands Protection Act recognizes eight interests provided by wetlands and protected by the Act:

- protection of public and private water supply;
- protection of ground water supply;
- flood control;
- storm damage prevention;
- prevention of pollution;
- protection of land containing shellfish;
- protection of fisheries;
- protection of wildlife habitat.

Watershed deficits in these functions may be reflected by degraded or threatened surface or ground waters, chronic storm damages, and the absence or unusually low representation of shellfish, fish, or wildlife. This report focuses on selection of sites that can enhance the wildlife, water quality and flood storage functions.

Approaches to identifying watershed functional deficits considered for this method are summarized in Appendix D-1. Comprehensive methodologies that did not provide information specifically focused on restoration were rejected for this methodology. Because the information to be generated will apply only to wetland restoration, methods that required the evaluation of all wetlands in the watershed were not selected. Time consuming techniques that do not result in information that directly describes the magnitude of a watershed functional deficit were also rejected.

The identification of watershed functional deficits has been divided into three parts. In Massachusetts, water quality status is well documented and the evaluation relies on existing information. Where flooding has generated significant problems, the problem has often been studied in detail and is described in reports that can be obtained from water resource agencies. In contrast, the status of wetland dependent wildlife populations is not well documented and the evaluation relies on goal setting by agencies and watershed groups.

Step 2A Identify Wildlife Habitat Goals

Background

The purpose of this step is to establish watershed-based wetland wildlife habitat goals. A similar sequence of activities can be applied to establish fishery goals in relation to wetland restoration. Watershed level inventories of wildlife to compare among watersheds, or with expected values for a watershed, are generally not available. Comparison of wildlife communities among watersheds would also be confounded by inherent physical and biological differences in wildlife habitat. Some obvious differences in the quality of habitats can be observed (e.g., habitat on the North and South Rivers is less disturbed than that on the Mystic River), but these comparisons do not necessarily result in information that would be useful for establishing watershed goals. Habitat assessment techniques are costly to employ. Therefore, interviews with resource groups should be the primary mechanism for establishing wetland wildlife habitat restoration goals. These discussions should identify priority wetlands and goals in terms of the following elements:

1) Diversity;

2) Connectivity; and

3) Quality.

The following paragraphs provide background information on wildlife value.

The quality or value of the individual wetlands in a watershed influences the overall value of the habitat in the watershed. If a watershed contains a large number of wetlands with high wildlife value, the overall wildlife value of the watershed will be high. The habitat quality of individual wetlands can be evaluated using various methods (e.g., Habitat Evaluation Procedures (HEP), Golet Method, Wetland Evaluation Technique (WET), WEThings) depending on the measure of quality selected. For instance, HEP can be used to evaluate habitat for a particular species or species group; the Golet Method measures maximum wildlife abundance and diversity, WET can be used to evaluate wetland habitats for diversity and abundance of wetland-dependent birds; and WEThings predicts habitat suitability for 59 species of wetland-dependent reptiles, amphibians and mammals. A watershed level assessment of habitat quality is not recommended, unless there are a very large number of degraded sites.

The overall wetland habitat value of the watershed may also depend on the diversity of wetlands. Individual wetlands that contain diverse habitats have the potential to support a more diverse and abundant wildlife community (Golet, 1976); the same is true for a watershed with a high diversity of wetlands (Golet et al., 1994). Diversity of wildlife communities increases with the diversity of the habitat and rare wetland classes represent an important element of wildlife diversity because they often support rare species (Golet et al., 1993). Applying this at the watershed level, watersheds with a greater number of wetland classes will have an enhanced ability to support a diverse and abundant wildlife community.

Also important in setting watershed priorities are the connections and interrelationship among wetlands and other habitats and land uses (Foreman and Godron, 1986). The placement of wetlands within the watershed will allow the flow of genetic material and migration of wildlife between sites for different life requisites and help to maintain population levels nearer to carrying capacity (NRC, 1992). However, this element is the most difficult to consider.

The National Research Council (1992) stated that,

> "Knowledge of the migratory routes of birds and fish, and of dispersal patterns for invertebrate larvae and seeds, is critical in determining what scale to use in planning aquatic restorations."

However, knowledge of these patterns is lacking. Foreman and Godron (1986) indicated,

> "At present, generalizations about movements of communities of animals should be considered hypotheses."

Leibowitz et al. (1992) stated,

> "Defining the boundary for habitat processes is more problematic than for other functions. Biotic factors operate on scales defined by the ranges of wetland dependent species. Given the diversity of species, no single spatial unit can encompass all species' ranges for a particular study area."

Consideration of connectivity points out the limits inherent in a plan that considers only wetland restoration - sites can only be restored (and improve connectivity) where degraded wetlands are present. In addition, because this report focuses on restoration of <u>wetlands</u>, the importance of connections for wetland dependent wildlife will be emphasized. This means species that require a continuous band of upland forest on one side of a stream corridor and species requiring upland habitat adjacent to wetland habitat such as amphibians, may not be considered. Eventually, other tools (e.g., acquisition, protection, and management of wetlands and uplands) must be considered.

From a landscape perspective, the main parts of a habitat are patches, corridors, and matrix. Patches are areas of distinct habitat communities surrounded by another habitat type. Corridors are linear features of habitat. Narrow or line corridors support only edge species, while wider strip corridors may also support interior species. Stream corridors are the bands of vegetation along a stream that differ from the surrounding habitat. Matrix is the most extensive and connected landscape element. It appears as the background within which other landscape elements (often wetlands) are viewed. One of its key characteristics is that it usually exceeds the total area of other landscape elements (Foreman and Godron, 1986). Matrix is the landscape element least affected by wetland restoration.

An important consideration in landscape ecology, and one that complicates management of the landscape for a variety of species, is the grain size of a species. The grain size is the distance or area to which a species is sensitive in carrying out its functions. To consider the variety of animals making up a wetland community, their differing grain sizes must be considered. Animals move in the landscape in three ways: within a home range, in dispersal (one way movement of an animal from its home range to a new home range), and in migration (Foreman and Godron, 1986). All of these forms of movement must be supported by elements in the landscape. For instance the home range of river otters is linear and commonly 30 to 80 km long. They will cross roads and uplands as wide as several hundred meters (Foreman and Godron, 1986). Wetland dependent birds that require multiple wetlands during the breeding season generally need wetlands to be located within 0.5 to 25 kilometers of each other (Leibowitz et al., 1992). The matrix between habitats is probably not as important for birds. Amphibians and reptiles require the habitats making up their life requisites in even closer proximity (Leibowitz et al., 1992). Obviously, it would be difficult to restore a system of habitats for all these species without emphasizing the species with the smallest grain size requirements. Foreman and Godron (1986) indicated that,

> "Until more is known relative to use of landscape features, in landscape planning and management it is best to enumerate all species of interest and determine their expected responses individually."

In general, interruptions between wetlands or natural corridors will be less of a problem for birds because they can cross disturbed areas by flying. At the other extreme, many small mammals, reptiles and, in particular, amphibians will not be able to cross even very small separations. Therefore, the emphasis on connecting wetland sites may best be placed on large and medium sized mammals, for instance otters.

Task Descriptions

2Aa. Interview conservation agencies and groups to identify wildlife habitat goals and priority wildlife species. These interviews should center on the topics of wetland habitat diversity, connections between wetlands or the level of isolation of important wetlands (i.e., connectivity), and the quality of individual wetland habitats in the watershed. Improvement of any or all of these aspects of wetland wildlife habitat will increase the overall value of wildlife habitats in the watershed.

2Ab. Watersheds with diverse wetlands are likely to support a diverse wildlife community. The diversity of wetlands in a watershed is increased by increasing the number and area of less abundant wetland classes. If increasing diversity is identified as a habitat objective, determine the least abundant wetland types by measuring or estimating the area of each wetland type.

2Ac. Improvements in the connections between wetlands in a watershed will facilitate the interaction of wildlife communities. Improvement of connections, in essence, can make smaller wetlands larger and increase the availability of habitat to maximize wildlife use and allow the flow of genetic information. Almost any restoration project will improve habitat connections since it fills a gap where a formerly valuable habitat existed. To maximize the value of existing habitats, restoration projects can be located between the higher value wetlands in the watershed. Through interviews or assessment, identify wetlands with the highest habitat value, especially wetlands within conservation areas. The connections between these wetlands should be improved through restoration projects.

2Ad. Identify degraded wetlands that will improve the connections between high value sites. If priority wildlife species are identified through the interview process, use home range and distance requirements from HEP models to guide site selection. Foremen and Godron (1986) provided the following information which can be used as rough criteria to guide the selection process: Two lane roads are not barriers to large animals. Streams are generally not barriers, but large rivers are. Streams and rivers do not serve as significant conduits. Stream corridors should be wide enough to cover the floodplain, both banks, and an area of upland - at least on one side - that is wider than an edge. An apparent threshold for species richness in corridors may occur at 12 meters (Foremen and Godron, 1986).

The assessment of wildlife habitat connectivity can also be conducted by comparing the level of connections to nearly ideal conditions. Under the best circumstances for a developed watershed, there would be no completely isolated (by human development) wetlands (i.e., all wetlands would be connected by natural habitat). Most wetland corridors would be wide enough (>12 meters) to support interior as well as edge species. There would be no complete barriers to dispersal or gene flow (e.g., cities surrounding a stream with no undeveloped stream banks) along wetland corridors, or large high quality wetlands would be separated by smaller wetlands that provide stopover points for wildlife. Buffers would be wider in areas of higher disturbance. Connections between habitats would consist of varying habitat types to allow different species to travel among the wetlands. Various types and sizes of high quality habitats would be connected by natural habitats.

The relative degree to which this condition is achieved can be assessed by viewing basinwide habitat maps. Restoration sites should be evaluated to determine whether they improve these conditions in the watershed.

Step 2B: Identify Flood Water Storage Deficits and Opportunities

Background

The purpose of this step is to identify flood water storage related flooding problems in the watershed. Some wetlands (and adjacent riparian uplands) provide a floodflow alteration function whereby peak flows are stored or delayed from moving downstream. This allows floodflows to be "desynchronized." Desynchronization is the process by which flood waters are stored in numerous wetlands within a watershed, then gradually released in a staggered manner. These processes reduce the peak height of floodwaters, but increase the duration of flooding (Adamus et al., 1991). At the watershed scale, a deficit in this function could be demonstrated by chronic flooding problems that are related to storage capacity. If flooding problems are related to flood storage capacity, any restoration that increases storage area will incrementally improve flooding conditions.

Task Descriptions

2Ba. Wherever possible, use existing information to determine the nature and magnitude of flooding problems in a watershed. The New England Division of the Corps of Engineers maintains planning and design documents that contain hydrologic information that can be used to identify watershed flooding problems. General Design Memoranda for flood control projects usually describe flooding frequencies and durations for a project area, often a water basin. The extent of flooding is sometimes indicated according to an elevation of certain flood frequencies. These reports often pinpoint many of the impacted flood areas and reasons for flooding. Local knowledge should again be used to verify the existence and possible causes of these flooding problems. Similar documents can be obtained from the Soil Conservation Service Small Watershed Program and Massachusetts Department of Environmental Management in Boston.

Specific flood hydrograph information is often provided in these reports. The hydrograph is a graphical representation of the time distribution of runoff at a given point in a basin, usually the outlet (Figure D-2). Similarly, the unit hydrograph represents the surface runoff resulting from one inch of excess rainfall over a defined time interval. The unit hydrograph can be used to transform one inch of rainfall to direct surface runoff (water which travels laterally over land or in the surface soil to the stream channel). Existing flood hydrograph information should be examined for shape of the curve. In general, a hydrograph with quickly rising and receding limbs indicates a lack of attenuation of floodwaters in the watershed, often resulting from a lack of upstream flood storage. A hydrograph with gradual rising and receding limbs indicates an attenuation of floodwaters, usually caused by upstream flood storage. Use this information to identify the extent of flooding problems in a watershed or smaller area. The presence of flooding problems in a watershed is sufficient information to include the flood storage function in the evaluation of restoration sites.

2Bb. If existing information is not available, interviews with local officials can be conducted to estimate wetland storage potential, but the lack of identified flooding problems suggests that flood storage is not a significant functional deficit in the watershed. The cost and difficulty of making a planning level determination of the storage needs is increased when reports are unavailable. In this case, first contact town or city officials (town or city managers, planners, or department of public works representatives) familiar with flooding problems in the area. Next contact the Massachusetts Department of Environmental Management (MDEM) to determine if flooding information is available. Ask the officials if the problem results from a lack of floodplain storage or from local drainage problems. These officials may confirm the existence of a storage-related flooding problem. This confirmation is sufficient prioritize this function for Step 3.

2Bc. If a flooding problem is not confirmed, determine whether there is a reason for further consideration. Use mapping, such as Flood Insurance Maps or USGS quadrangles, to make an assessment of the nature of the flooding problem. Some flooding may be due to local drainage problems (e.g. an under-sized culvert). Assess local drainage problems on flood insurance maps by locating sharp increases in the size of the regulated floodplain upstream of a crossing. Other flooding problems may be the result of encroachment on the floodplain. Identify flood plain encroachment by examining flood insurance maps or other mapping resources of the watershed for development in the floodplain. Floodplain development suggests that additional flood storage may be needed in the watershed. Identification of significant floodplain encroachment is sufficient to prioritize the flood storage function for Step 3.

2Bd. Even if a detailed analysis of the watershed has not been completed and there is reason to believe that flooding is a problem, a hydrograph for a significant rainfall event can be roughly constructed using existing gage data for the watershed in question. A sharply rising and receding hydrograph suggests that there is a lack of storage area in the watershed. Construction of a hydrograph from stream gauge data should be conducted by an engineer or qualified water resource planner. USGS gage data is available for various sites throughout the State and is published annually in the yearly water data reports. These reports, available from the USGS in Marlborough, Massachusetts or other water resource agencies, list mean daily discharges at the gage. Hourly discharge estimates can sometimes be obtained by contacting the Massachusetts USGS office.

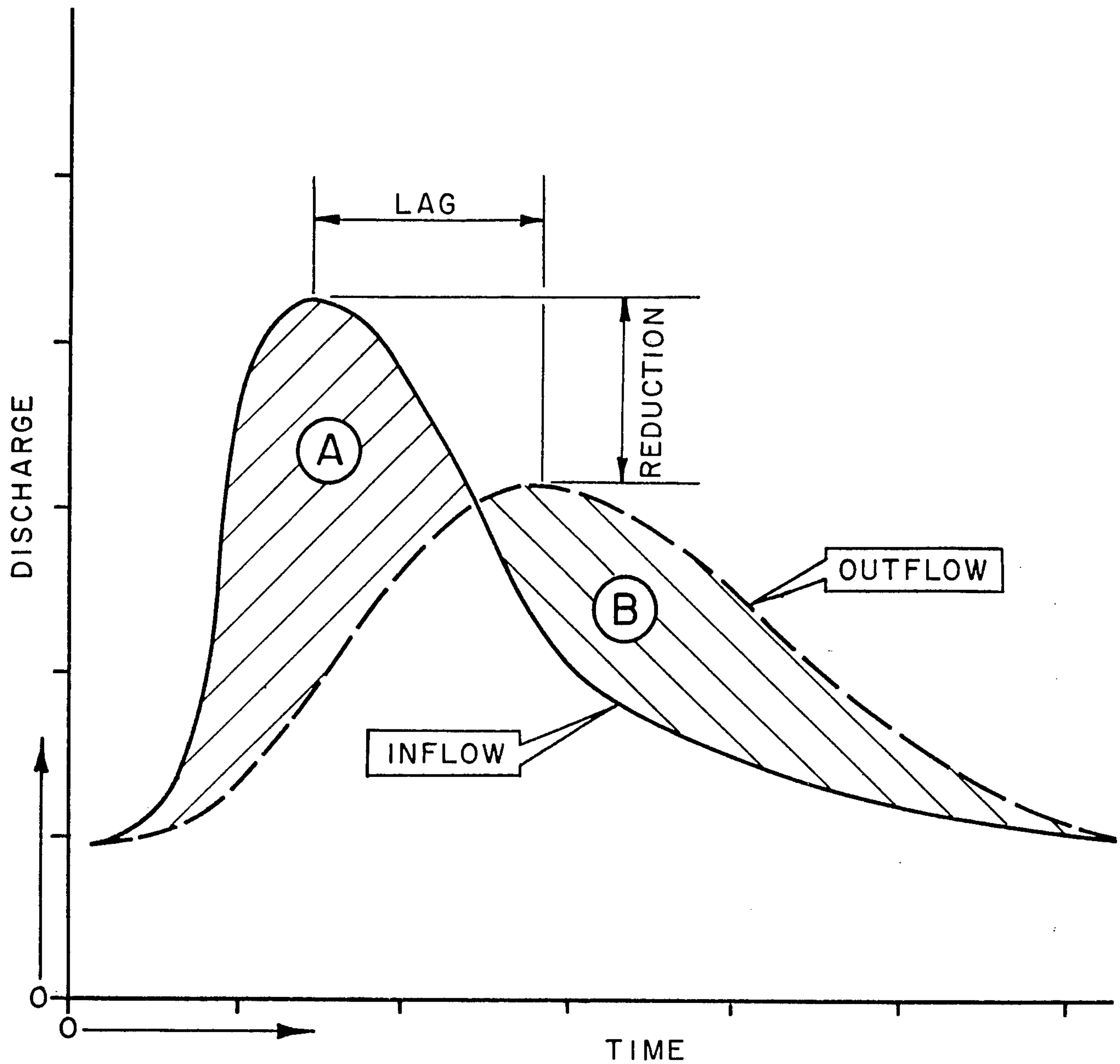


Figure D-2. The typical flood hydrograph shows the relationship between discharge and time. The hatched area "A" represents the amount of water stored and the hatched area "B" represents the amount of water released in a particular reach. The effect of a flood storage area is to cause a lag and reduction in the peak discharge

New England Division

US Army Corps of Engineers

Step 2C: Identify Wetland-Related Water Quality Problems and Opportunities.

Background

The purpose of this step is to identify water quality problems in the watershed that can be at least partially addressed through wetland restoration. Wetlands provide two water quality improvement functions: 1) nutrient removal/transformation and 2) sediment/toxicant retention (Adamus et al., 1991). They have greater potential to provide a significant water quality improvement function if they are located in urban or developed areas or along agricultural corridors where sediment or nutrients would otherwise be exported to open water.

The WPA recognizes wetlands for their ability to protect water supply. To provide this function, they must be located in the watershed upstream of the water supply. Wetlands may also export products, such as chemical oxygen demand (COD), that can degrade water quality; potential adverse effects should be considered when wetland restoration is proposed near water supplies.

Background

2Ca. The general status of water quality in a watershed can be gauged through examination of the water quality classifications for its water bodies and the current status of water quality reported in the biennial report on water quality required by Section 305 of the Clean Water Act. The Massachusetts Department of Environmental Protection, Office of Watershed Management (OWM) prepares these reports for the EPA with input from other agencies. Section 305 reports address the condition of surface waters, ground water, and wetlands and can be used for a first cut in identifying water bodies with a lower classification than natural conditions would dictate. Use these reports to identify areas where water quality standards are not being met.

2Cb. The OWM also prepares five-year updates to its water quality management plans under Section 303(e) of the Clean Water Act to guide pollution abatement activities. These reports describe the characteristics of the water basin, pollutant sources, the natural limits on water quality in a water basin, and the current water quality conditions. The reports are prepared on a three year cycle. Field work is conducted during the first year. During the second year of the cycle, the data is analyzed and interpreted and decisions are made as to how to manage water quality in the basin. During the third year of the cycle, National Pollutant Discharge Elimination System

(NPDES) and water withdrawal permits are issued and Section 319 grants are awarded based on the results of the work of the previous two years. The schedule for these evaluations in the state is shown in Appendix D-2. The parameters and analytical methods listed in Table D-1 are used by the OWM in sampling and analysis. Watershed evaluations for wetland restoration should follow as closely behind the second year of the OWM's three-year cycle as possible to take advantage of the information generated and allow wetland restoration to play a part in achieving water quality goals.

The natural limits on water quality in a basin are based partly on the results of ecoregion based analyses of water quality. Although the limits of water basins and ecoregions do not coincide, ecoregion-based water quality influences are considered by the OWM in determining natural limits on water quality. The natural limits information in water quality management plans is used to define expectations or appropriate baseline water quality conditions and goals. This information can also be used to identify basins where wetlands can be restored to improve, or where they have the potential to degrade, water quality. Use the Section 303(e) reports to identify watersheds and areas within watersheds that are not meeting water quality goals.

2Cc. Further information about whether restoration sites may affect water quality can be developed by examining NPDES permits and land use information. NPDES permit records can be used to identify major point sources upstream from wetland systems which may have a harmful effect. For non-point sources, screening should identify those areas where existing development surrounds or is adjacent to the wetland. If development is not immediately adjacent to wetlands, locate any wetland whose upstream tributary area has been heavily developed. Pay specific attention in both cases to areas that are commercially or industrially zoned. Use this information to identify specific areas for restoration.

Set Watershed Wetland Restoration Goals and Objectives.

Based on the evaluations described in this section, set the goals and objectives for wetland restoration in the watershed. The goals refer to the functions that should be restored (i.e., wetland wildlife habitat, flood storage, or water quality). The objectives specify the specific characteristics and locations in the watershed to be restored. For instance, the goals for a watershed may be to restore the water quality function to wetlands and increase the quality of wetland habitats. In this case, the objectives might be to restore the nutrient removal function in the upper one-third of the mainstem and restore the waterfowl habitat value to marshes in a subbasin.

Step 3: Watershed Functional Replacement Screening

During this step, potential restoration sites from Step 1 are evaluated based on their relative capacity to address watershed functional deficits. The wetlands or network of wetlands that best supply the deficit function will depend on the location of restoration sites relative to the area affected by the functional deficit. These evaluations are conducted by predicting the future restored characteristics of the site. Historic aerial photography can be used to help predict the future restored conditions based on historic conditions.

The Corps Wetlands Research Program is developing a procedure for functional assessment based on hydrogeomorphic classification of wetlands, functional indices similar to those used in Habitat Evaluation Procedures (HEP) (see Appendix D-1 for a description of HEP), and reference wetlands. The new method, called the Hydrogeomorphic Method or HGM (see Appendix D-1), results in Functional Capacity Units that incorporate quality and area. FCUs are determined based on a Functional Capacity Index (FCI) that provides a measure of the capacity of a wetland to perform a function relative to similar wetlands in the region on a scale of 0.0 to 1.0. HGM provides a more precise measure of the level of wetland functioning relative to other wetlands in the region. When this technique is completed and regional models are available, it may be substituted for the evaluations in Step 3.

Step 3A: Evaluate Wetland Wildlife Habitat Potential

Background

The purpose of this step is to group and evaluate wetlands based on their capacity to provide restored wildlife habitat. The goals and objectives established for the watershed during Step 2 must be reconsidered to screen sites for their likelihood of restoring watershed wildlife value.

Sites that individually have the potential to become high quality habitat, such as large (Foreman and Godron, 1986; Golet et al., 1994) or diverse wetlands (Golet et al., 1994), should be selected in watersheds with relatively few high value habitats. If the diversity of wildlife habitats is low, sites that will improve overall wetland watershed diversity should be selected. Diversity will be considered by identifying scarce wetland types. If gaps in the connections between wetland habitats were identified as a potential functional deficit, sites that will fill these gaps should have high priority for restoration. A procedure is described for identifying wetlands to fill priority gaps. In all likelihood, individual restoration sites will supply more than one of these wildlife habitat characteristics.

Task Descriptions

3Aa. Predict future restored characteristics at the restoration site. Where possible use aerial photography or other documentation of prior conditions to guide the prediction of future conditions.

3Ab. Identify watershed goals and objectives established in Step 2.

3Ac. Evaluate the potential of each wetland site to contribute to the following habitat characteristics.

3Ac-1. If wildlife habitat quality was listed as an objective in Step 2. Select an appropriate evaluation method based on the goals.

3Ac-1a. If the diversity and abundance of wildlife was the watershed goal, evaluate sites using Golet (1976), Ammann and Stone (1991), or other appropriate wildlife evaluation models. Record the predicted scores.

3Ac-1b. If habitat for a particular species or species group is identified as the goal, use the appropriate HEP models or appropriate substitute to determine potential habitat units for each site. Record the predicted scores.

3Ad. If wildlife habitat diversity was listed as an objective in Step 2, identify the sites that may support the least abundant wetland types. Where available, the Wetlands Conservancy Program maps should be used to determine wetland class diversity. For unmapped portions of the state, the NWI maps may be substituted. (Any inaccuracies in mapping will affect diversity measurements.) Measure and list the wetland classes by area to determine which types are least abundant. Compare this number to other watersheds (as more watersheds are assessed) assess the relative diversity of the study watershed to other watersheds in the State. Most projects will restore early successional stage wetlands; therefore, since the dominant wetlands in Massachusetts are red maple swamps, most restoration projects will increase the diversity of wetlands in the watershed. Similarly, salt marsh restorations will probably always increase diversity.

3Ae. If wildlife habitat connectivity improvement was identified as an objective in Step 2, identify two or more high habitat value wetlands, especially wetlands within conservation areas. Identify degraded wetlands that will improve the connections between these high value sites. If priority wildlife species are identified through the interview process, use home range and distance requirements from HEP models to guide site selection. In addition, use the following criteria from Foremen and Godron (1986) as rough criteria to guide the selection process: 1) Two lane roads are not barriers to large animals. 2) Streams are generally not barriers, but large rivers are. 3) Streams and rivers do not serve as significant conduits. 4) Stream corridors should be wide enough to cover the floodplain, both banks, and an area of upland - at least on one side - that is wider than an edge. 5) An apparent threshold for species richness in corridors may occur at 12 meters (Foreman and Godron, 1986).

Step 3B: Evaluate Flood Water Storage Potential

The purpose of this step is to evaluate the capacity of restoration sites to contribute the flood water storage function. This is a preliminary planning level evaluation; detailed evaluations would be required to determine the actual flood storage potential. Potential restoration sites with the greatest capacity to store flood water are identified by applying criteria which reflect flood water storage capacity. This process must include an assessment of the location of the restoration site relative to the flooding problem.

Task Descriptions.

3Ba. Refer to the watershed goals and objectives established in Step 2 to determine whether the flood water storage functions are listed as goals for the watershed. For some features, the potential future restored wetland condition must be considered rather than the existing degraded condition.

3Bb. List all sites located upstream of an identified flooding problem. These sites can help to alleviate flooding problems.

3Bc. Determine whether each site is located in the 100-year floodplain. These sites have a greater opportunity to store flood waters (Roth et al., 1993). Indicate yes or no for each site.

3Bc. Determine whether a constricted outlet is present or could be designed for each site. These sites have a greater tendency to retain flood waters. Indicate yes or no for each site.

For wetlands with channel flow, a constricted outlet should be less than 1/3 the average width of the wetland at the time of the selected flood or storm event or the cross sectional area of the outlet should be less than 1/3 the cross sectional area of the inlet. For wetlands with no channel flow, the width of the outlet should be less than 1/10 the average width of the wetland (Marble, 1986).

3Bd. Using Table 1 (main report), determine whether the site has a low gradient or could be designed to have a low gradient. Generally gradients that adhere to those shown in Table 1 will produce sheet flow conditions. These sites have a greater tendency to retain flood waters because flow velocity is reduced. Indicate yes or no for each site.

3Be. Determine whether the site supports or can be designed to support dense vegetation. Dense vegetation slows the velocity of flow. Indicate yes or no for each site.

3Bf. Rate sites with any yes answers to 3, 4, and 5 based on wetland size (i.e., potential storage area). Largest sites with yes answers have the greatest potential for this function.

Step 3C: Evaluate Water Quality Enhancement Potential

Background

The purpose of this step is to evaluate restoration sites based on their capacity to contribute to water quality functions. Potential restoration sites with the greatest capacity to improve water quality are identified by applying criteria which reflect nutrient removal/transformation and sediment/toxicant retention capacity. This process must include an assessment of the location of the restoration site relative to the water quality problem.

Task Descriptions.

3Ca. Refer to the watershed goals and objectives established in Step 2 to determine whether the nutrient reduction or sediment/toxicant reduction water quality functions are listed as goals. Predict the potential future restored wetland condition.

3Cb. If improvement of the nutrient removal/transformation function is an objective, evaluate and rank each potential restoration site against the following factors:

Nutrient Removal/Transformation

3Cb-1. List all sites located downstream of a nutrient-related water quality problem identified in Step 2.

3Cb-2. Surface water is the primary water source. Indicate yes or no for each site.

3Cb-3a. Phosphorus removal is a watershed goal:

Site primarily contains alluvial, alfisols, ferric, clay or other fine soils or these soils can be provided. Indicate yes or no for each site.

3Cb-3b. Nitrogen removal is a watershed goal:

Soils are primarily organic or organic soils can be added. Indicate yes or no for each site.

3Cb-3. Water regime is or can be designed to be permanently saturated or permanently flooded. Indicate yes or no for each site.

3Cb-4. Determine whether the site has a low gradient or could be designed to have a low gradient. For channels less than 20 feet wide use Table 1 of the main report. Generally gradients that adhere to those shown in Table 1 will produce sheet flow conditions. For channels greater than 20 feet wide, determine if the peak annual flow velocity in the basin is less than 1.5 feet/second. Indicate yes or no for each site.

3Cb-5. Determine whether the site has channelized flow and the width of the outlet is less than 1/3 the average width of the wetland at ordinary high water, and/or the cross sectional area of the outlet is less than 1/3 the cross sectional area of the inlet or wetland has no channel flow and the outlet is less than 1/10 the average width of the wetland or have no outlet from the wetland. Indicate yes or no for each site.

3Cb-6. Dense emergent or woody vegetation is present or can be planted. Indicate yes or no for each site.

3Cb-7. Rate sites with yes answers to 3Cb: 2, 3, and 4 (required characteristics) based on wetland size and number of yes answers to 3Cb: 5, 6, and 7. Largest sites with yes answers are priorities for further investigation.

3Cc. If improvement of the sediment/toxicant retention function is an objective, evaluate and rank each potential restoration site against the following factors:

Sediment/Toxicant Retention

3Cc-1. List and evaluate all potential restoration sites located downstream of a sediment or contaminant source. Indicate yes or no for each site.

3Cc-2. Wetland is lacustrine or palustrine. Indicate yes or no for each site.

3Cc-3. Determine whether the site has a low gradient or could be designed to have a low gradient. For channels less than 20 feet wide use Table 1 of the main report. Generally gradients that adhere to those shown in Table 1 will produce sheet flow conditions. For channels greater than 20 feet wide, determine if the peak annual flow velocity in the basin is less than 1.5 feet/second. Indicate yes or no for each site.

3Cc-4. Determine whether the site has channelized flow and the width of the outlet is less than 1/3 the average width of the wetland at ordinary high water, and/or the cross sectional area of the outlet is less than 1/3 the cross sectional area of the inlet or wetland has no channel flow and the outlet is less than 1/10 the average width of the wetland or have no outlet from the wetland. Indicate yes or no for each site.

3Cc-5. Surface water is primary water source. Indicate yes or no for each site.

3Cc-6. Site is or can be designed to be seasonally flooded. Indicate yes or no for each site.

3Cc-7. Dense emergent or woody vegetation is present or can be planted. Indicate yes or no for each site.

3Cc-8. Site contains or may be designed to contain organic soils or silt-clay soils with high organic content. Indicate yes or no for each site.

3Cc-9. Depressions are present or can be designed at the site.

3Cc-10. Rate sites with yes answers to 3Cc: 1, 2, 4, 5, and 8 (required characteristics) based on wetland size and number of yes answers to 3, 6, and 7. Largest sites with greatest number of yes answers are priorities for further investigation.

Step 4: Additional Site Screening.

At this point in the process, a list of potential sites has been established and evaluated based on capacity to reduce watershed functional deficits. The previous steps were concerned primarily with watershed level considerations; however, a number of other considerations enter into the site selection process. The purpose of Step 4 is to evaluate potential restoration sites based on factors unrelated to the watershed evaluations. The following paragraphs provide supporting information for the screening conducted in Step 4. This information should be reviewed to guide the evaluation process.

Information Summary

Ownership, cost, and logistical considerations. Hammer (1992) stated that, "Ownership and availability (i.e., willing sellers or lengthy and costly legal maneuvers) may be the most crucial factor in selecting a site." Certainly, outside of the possibility of condemning land and acquiring a site by eminent domain, the disposition of the present owner will have the greatest impact on the availability of the site for restoration. Restoration planners should perform title searches on the proposed site and adjacent lands to identify ownership, easements, rights-of-way, covenants, water rights, liens, and other emcumberances that may affect the suitability of a site (Hammer, 1992).

The ownership and use of surrounding lands may affect the cost and acceptability of a restoration site. Developed areas surrounding a potential restoration site must be considered where wetland hydrology is to be restored. Features to control the undesirable elements of wetlands such as mosquitoes may need to be implemented if a wetland is to be restored in a developed area. If land acquisition is required, restoration of wetlands near urban areas may be more expensive because of the cost of land (NRC, 1992). The cost of restoration will also be influenced by the amount of grading and excavation required. Hammer (1992) indicated that grading costs are second only to land costs for most projects.

Estimate the cost of restoration and rate the sites based on these very general criteria: high cost - >$100,000; moderate cost - $10,000-$100,000: low cost - <$10,000.

Site accessibility must also be considered. Most wetland restoration projects will require access for construction equipment, as well as scientists involved in planning, designing and monitoring the project. Land acquisition or easements may be required to supply access (Hammer, 1992).

Record whether the site is publicly or privately owned in the appropriate column. Rate sites as high medium or low cost. Note any logistical problems in the comments section.

Likelihood of successful restoration. An important consideration in weighing the pros and cons of competing wetland restoration projects is the potential for success. The likelihood of successful restoration depends upon the wetland type, the successional state of the wetland, the degree of disturbance to the wetland and its surroundings (NRC, 1992) and the function or functions to be restored (Kusler and Kentula, 1990).

Most wetland restoration professionals agree that hydrology is the key element to successful restoration. By definition, restoration projects will be located in sites where wetland hydrology formerly existed or is still present. Sites where only wetland hydrology has been impacted should be given preference based on the relative ease of restoring hydrology. Large and relatively inexpensive restorations can be performed where only the hydrology has been affected.

Certain wetland types are generally regarded as having a higher likelihood of success in terms of reestablishing vegetation. One of the key considerations is the "successional stage" of the wetland to be restored. Earlier successional stages are generally easier to restore (NRC, 1992). Intuitively, it is easier to restore less developed wetland classes, such as marsh and wet meadow, than wetlands that take a greater time to develop, such as shrub and forested swamps. Kusler and Kentula (1990) noted a relatively high degree of success has been achieved with restoration of marshes because elevations are less critical than for forested wetlands. They noted a lack of success with forested wetlands due to their sensitive long term hydrologic requirements and their slow rate of maturity. Goal setting and expectations should be established recognizing that mature ecosystem attributes take a long time to develop. Obviously, restoration of a mature forested wetland would take at least as long as the age of the oldest trees. Garbisch (1986) suggested that, "Consideration might be given to the long term development of swamps by initial establishment of a marsh community [which is easier to establish] followed by the introduction of saplings of desired woody plants." However, the NRC (1992) also pointed out that, since the total ecosystem is not transplanted, there is no guarantee that the missing components will develop with time.

Restoration of later successional stage species may be even more difficult because changes in the habitat by earlier successional stages may be prerequisites to their establishment. Complete development includes the stage of development of the soils, plants, and animals. Some components of a wetland (i.e., deep organic soils and soil structure, mature trees, and complex food webs) require a great deal of time to develop (NRC, 1992) and restoration of habitat for ecologically sensitive species of plants and animals is particularly difficult (Kusler and Kentula, 1990). Although these more difficult projects should not be avoided entirely, the effects of wetland type and rate of development should be considered in selecting projects as well as setting goals, setting up an appropriate project team, and determining funding requirements.

The likelihood of achieving success also depends on the degree of disturbance to the wetland and its surrounding landscape. Sites that have been modified only slightly and that occur in a surrounding landscape with little disturbance have a good chance of restoration success. For instance, sites where wetland soils still exist may be easier to restore. Highly degraded sites in urbanized regions have a much lower likelihood of success (NRC, 1992). The National Research Council (1992) report provided a figure (Figure D - 3) showing the relationship between the level of surrounding development and the potential for successful wetland restoration. Sites intermediate between the two extremes on both scales have moderate chances for success. Urban areas have generally experienced extreme alteration of the hydrologic characteristics, sediment dynamics, water quality, and habitats and buffers that complicate restoration (NRC, 1992). However, the importance of various functions varies with the location in relation to human-induced development. Some wetland functions, such as sediment retention and flood storage, may be more valuable in proximity to development and are not necessarily more difficult to restore in an urbanized area. If the goal is water quality enhancement, the vegetative composition and, therefore, habitat value, will not necessarily be a major concern. In addition, to serve as conduits through developed areas, natural corridors must be located in them.

Newly restored wetlands may be susceptible to invasion by exotic or undesirable species, such as purple loosestrife (Lythrum salicaria) and common reed (Phragmites australis) (NRC, 1992). Consideration should be given in planning and selecting sites to avoid or reduce the potential for invasion by undesirable species. Proximity to existing wetlands dominated by nuisance species such as purple loosestrife should be considered in site selection (Hammer, 1992).

According to Kusler and Kentula (1990), the ability to restore particular functions is influenced by: 1) the amount of basic scientific knowledge about the function; 2) the ease or cost of restoring certain wetland characteristics; and 3) varying probabilities that structural characteristics will give rise to specific functions. The probability of success for the function to be restored and the wetland type should be considered in selecting projects. Kusler and Kentula provided a list (they noted it is for illustrative purposes only) of the ease with which certain functions could be restored. Flood storage, sediment trapping, and waterfowl production can be restored with a fair amount of confidence. Aesthetics, fisheries, food chain, and some water quality functions are sometimes difficult to restore, and groundwater functions are difficult to restore.

Ability to protect sensitive resource areas such as rare species habitat and outstanding resource waters. Wetlands can protect sensitive resource areas by buffering them from adverse impacts. While it is still difficult to restore wetlands to support endangered species (NRC, 1992), sites can be selected based on their potential to provide a natural buffer to endangered species habitats. The location of a wetland relative to a sensitive resource area and its size will affect its value as a buffer. A review of the requirements of riparian buffer strips was prepared by the New England Division of the Corps of Engineers for the state of Vermont (USACE, 1991). Restoration sites that are located in a site that will protect outstanding resource waters should be located through Steps 2 & 3.

Proximity to landfills and hazardous waste sites. Sanitary landfills can cause considerable harm to wetlands through habitat alteration or migration of contaminants (Herndon et al., 1990). Hazardous and toxic waste are also potential sources of contaminants. Restoration in proximity to these sites should consider whether pollutants will be mobilized or cause impacts through bioaccumulation in organisms.

Development pressure and current and future threats to watershed-level and site specific functions. Kentula et al. (1992) discussed procedures for identifying areas with wetlands at greatest risk. They suggested surveying people involved in wetlands permitting. In Massachusetts, this would include the Corps of Engineers, the Department of Environmental Protection, and local conservation commissions. Since institutional memory is often lacking in permitting agencies, examination of actual records of wetland losses and growth and development will probably be required (Kentula et al., 1992). The Department

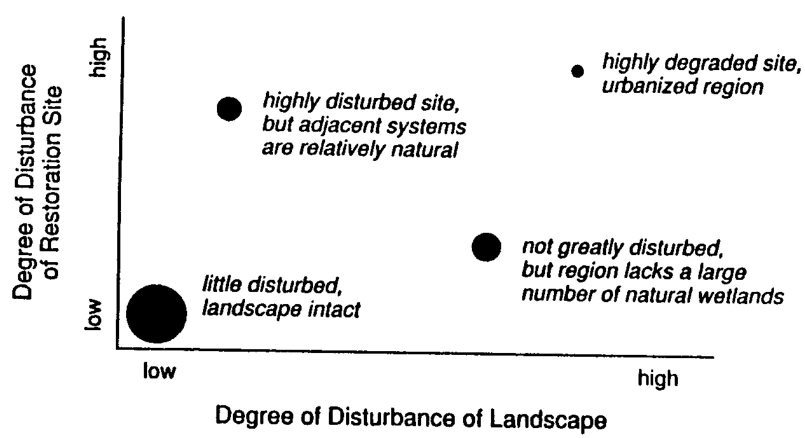


Figure D - 3. Hypothesized model of restoration potential for wetlands differing in degree of disturbance and landscape condition. Large dot indicates high potential for successful restoration; smaller dots indicate comparatively lower potentials.

Source: NRC, 1992.

US Army Corps of Engineers
New England Division

of Environmental Protection maintains databases of permits in its regional offices. The New England Division, Corps of Engineers also maintains a permit database that can be sorted by municipality and watershed. Cities and towns in the watershed could be surveyed to determine the number of building permits issued as an additional gauge of development pressure.

Ability to supply functions measured at a scale larger than the watershed scale. Some functions and values of wetlands are important at a scale larger than the watershed. Waterfowl habitat, for instance, is important at the flyway or international scale; control of introduced species, such as purple loosestrife is of National importance; and threatened and endangered species are important at the state or National level. Sites that will supply these or other functions and values important at a scale larger than the watershed should be considered in site selection.

Federal regulatory considerations. The preamble to the Section 404(b)(1) guidelines (40CFR Part 230) discusses Habitat Development and Restoration of Waterbodies (Appendix D-3). This information and the Guidelines themselves, as well as all applicable State requirements should be considered in reviewing potential restoration projects.

Public support. The level of public support for various sites can be gaged through surveys and public notices and public workshops. Public support is a key component to most restoration projects.

APPENDIX D-1

Review of Assessment Methodologies

This appendix summarizes the wetland assessment approaches considered in this study for developing a watershed-based site selection procedure. Since the purpose of this review was to identify appropriate methods for use in the watershed based evaluation, rather than provide a comprehensive review of techniques, the descriptions are not equally detailed for the various methods. The first three methods described are watershed or landscape based, while the remaining methods are more site specific in their evaluation.

There are relatively few comprehensive wetland evaluation methods presently available. Data requirements vary depending on the method that is implemented and the scale of the project. A review of 17 methods by the Corps of Engineers found four methods designed for generalized use: Habitat Evaluation Procedures (HEP), Wetland Evaluation Technique (WET), Habitat Assessment Technique (HAT), and the Ontario Method. WET and HEP are considered in this appendix.

A Synoptic Approach to Cumulative Impact Assessment. "A Synoptic Approach to Cumulative Impact Assessment" (the Synoptic Approach) (Leibowitz et al., 1992) was developed by the U.S. Environmental Protection Agency to evaluate cumulative effects on wetland functions at a landscape scale. The Synoptic Approach can be used to compare the relative level of functioning among landscape units (e.g., subbasins in a watershed). It has been used to rank portions of a defined geographic area based on their relative potential to supply improved wetland functions through restoration.

The Synoptic Approach is a framework for organizing comparisons among landscape subunits by evaluating one or more synoptic indices for each subunit. Synoptic indices are defined as landscape variables used in a synoptic assessment as a basis for comparing landscape subunits (e.g., sub-basins within a watershed). Assessments are prepared for an entire state, region, watershed or other landscape unit by a team composed of a manager, a resource specialist, and a technical analyst familiar with database management and GIS. The Synoptic Approach does not provide a quantitative assessment of the deficit in wetland function in an evaluation area. It provides an indication of the level of functioning compared to other subunits rather than an indication of the specific need for a function. Regional or statewide maps are produced that rank portions of the landscape according to the synoptic indices.

There are five basic steps requiring twenty-seven procedures involved in performing the Synoptic Approach. The steps are shown in Figure D - 1a. Synoptic indices are identified in Step 2 of an assessment. There are four general synoptic indices: function, value, functional loss, and replacement potential. One or more of these general indices are replaced by specific indicators when an assessment is conducted. In other words, the functions, values, significant impacts that can cause functional loss, and the potential to replace functions are more accurately defined. Landscape indicators are selected in Step 3. They are the actual measures used to estimate synoptic indices. For instance, vegetated floodplain area may be used as an indicator of water quality function.

The quality of the information for these assessments depends on the quality of the data and indicators applied. The authors (Leibowitz et al., 1992) discussed an example application where the water volume passing through a drainage area was estimated based on USGS discharge data. The capacity of wetlands within the subunit to remove nitrates was compared to this information to determine if the potential of the hydrologic function was being fully realized. For restoration projects, we are not as concerned with whether there has been cumulative loss as with whether the functions provided by wetlands could be improved through implementation of restoration projects.

Our review suggested that the effort required to apply the Synoptic Approach may exceed the value of the output data because of limits on assessment methods and data availability. This assessment method could also use a large portion of a planning budget before specific restoration sites are identified since the Synoptic Approach is not intended to identify specific sites that will replace functions. Sites within an identified subdivision would still have to be screened for their functional replacement capability. In addition, individual sites in a lower priority subdivision could provide a higher level of function. In general, this framework is not recommended for watershed screening.

A GIS-Based Model for Habitat Assessment of Freshwater Wetlands. Wetland habitat quality, diversity and connectivity can all be assessed to some extent with a method developed and presently being implemented in Rhode Island by the University of Rhode Island, Department of Natural Resources Science for the RI Division of Freshwater Wetlands (Golet et al., 1994). This method, "A GIS-Based Model for Habitat Assessment of Freshwater Wetlands," evaluates seven attributes (see Table D - 1a) that affect the capacity of a wetland to support a diversity and abundance of wetland wildlife within its borders and one attribute that evaluates a wetland's relative contribution to wetland habitat diversity and abundance over a local geographic area. Emphasis is on the diversity of individual wetlands which may or may not be necessary at the watershed level since clusters of individually monotypic but collectively diverse wetlands can also support a diversity of wildlife (Weller, 1979 in Golet et al., 1994). In addition, some species with very local or restricted distributions may not occur in areas of high species richness and may require individual attention (Scott et al., 1993). Although this method considers the connections between wetlands in the juxtaposition attribute, it does not consider some of the importance of bordering upland to wildlife migration. Complete application of this method may be appropriate for watersheds with a large number of degraded wetlands, but the reasoning behind some of the variables can be applied outside of the structure of this technique.

Gap Analysis. Gap analysis (Scott et al., 1993) is a comprehensive technique intended to identify gaps in the representation of biological diversity in areas managed for biodiversity to identify acquisition sites. Vegetation types and vertebrate and butterfly species are used as indicators of biological diversity. This method involves fifteen steps including a fair amount of field work and would be too involved for restoration site identification.

Steps in conducting a synoptic assessment.

Steps	Procedures
1. Define Goals and Criteria	1.1 Define Assessment Objectives
	1.2 Define Intended Use
	1.3 Assess Accuracy Needs
	1.4 Identify Assessment Constraints
2. Define Synoptic Indices	2.1 Identify Wetland Types
	2.2 Describe Natural Setting
	2.3 Define Landscape Boundary
	2.4 Define Wetland Functions
	2.5 Define Wetland Values
	2.6 Identify Significant Impacts
	2.7 Select Landscape Subunits
	2.8 Define Combination Rules
3. Select Landscape Indicators	3.1 Survey Data and Existing Methods
	3.2 Assess Data Adequacy
	3.3 Evaluate Costs of Better Data
	3.4 Compare and Select Indicators
	3.5 Describe Indicator Assumptions
	3.6 Finalize Subunit Selection
	3.7 Conduct Pre-Analysis Review
4. Conduct Assessment	4.1 Plan Quality Assurance/Quality Control
	4.2 Perform Map Measurements
	4.3 Analyze Data
	4.4 Produce Maps
	4.5 Assess Accuracy
	4.6 Conduct Post-Analysis Review
5. Prepare Synoptic Reports	5.1 Prepare User's Guide
	5.2 Prepare Assessment Documentation

Figure D - 1a. Steps in conducting a synoptic assessment.

Source: Leibowitz et al. 1992

New England Division

US Army Corps of Engineers

Table D - 1a. Attributes and Variables used in a GIS-Based Model for Habitat Assessment of Freshwater Wetlands in the Pawcatuck River Watershed (Golet et al., 1994).

Attribute	Variables
Wetunit size	Wetunit size
Wetland class diversity	Wetland class richness Wetland class evenness
Wetland class rarity	Rare class richness Rare class area
Wetland class edge complexity	Edge density Edge richness Edge evenness
Hydrologic setting	Hydrologic class Hydrologic edge index
Surrounding upland habitat	Upland habitat richness Upland habitat evenness Upland habitat quality index
Wetland juxtaposition	Distance to nearest wetunit Inverse distance weighted sum Hydrologic linkage index
Contribution to local wetland diversity and abundance	Diversity contribution index Area contribution index

Wetland Evaluation Technique (WET). The Wetland Evaluation Technique (WET) is the most comprehensive technique currently available for the evaluation of wetlands (USACE, 1994) and has been adapted for use in site selection. WET is a rapid, systematic procedure for the assessment of eleven wetland functions and values. Functions and values are evaluated by responding to questions about certain attributes of a wetland. Results of the evaluation are in the form of qualitative probability ratings of high, moderate, or low. This technique and HEP are the most well known methods available and are the focus of the section of the report.

WET can be used to evaluate wetland habitats for diversity and abundance of wetland-dependent birds. WET considers the area size; availability of cover, food, and specialized habitat needs; the spatial and temporal arrangement of these elements; isolation from disturbance, and absence of contaminants in determining habitat value. Application of this technique to all of the wetlands in a watershed to determine overall quality of the wetlands in a watershed would be time consuming.

Marble (1992) presented an alternative procedure for using WET for site selection described in "A Guide to Wetland Functional Design." The framework is intended to aide in selecting a site to replace wetlands on a functional basis. The predictors and keys used in WET are taken apart and used to identify design elements and site selection criteria for wetland functions. The predictors (wetland attributes) of high ratings were identified by working each function key backwards. The flood water storage and water quality enhancement functions are included in the application described by Marble (floodflow alteration, and sediment toxicant retention-nutrient removal/transformation). These predictors, other elements of WET, and elements from the New England Division of the Corps of Engineers evaluation method are used to evaluate the potential restoration sites for these functions.

New England Division's "Descriptive Approach". The Corps of Engineers, New England Division (Regulatory Division) uses a function-value assessment methodology which is based on the same scientific information about structure and function of wetlands as other methods previously mentioned in this Appendix. This method is structured so that a maximum amount of descriptive information on a particular site is provided to the reviewer on a single page. Rather than rate wetlands or assign weights to functions, this methodology is intended to provide as much hydrologic, biologic, and cultural information about each wetland as possible. Using a standardized evaluation form the impacted wetland is evaluated for thirteen possible functions and values. Each of these criteria is evaluated using a series of considerations designed to help the reviewer make a proper judgement regarding each function or value.

Habitat Evaluation Procedures (HEP). Habitat Evaluation Procedures (HEP) is a widely accepted technique for the assessment of wildlife value of wetland habitats. HEP was developed by the U.S. Fish and Wildlife Service as a method to assess the impacts of major water resources projects. It is based on models that can be applied to particular habitats to develop a habitat suitability index (HSI). The HSI is a measure of habitat quality which rates the value of the habitat between 0.0 (unsuitable) and 1.0 (optimal). A number of evaluation species or species groups are chosen and the habitat suitability models for these species are applied to the habitat types in the study area. The HSI for each cover type is multiplied by the area evaluated to determine the number of habitat units (HU). One HU is equal to one acre of optimal habitat. Applying this technique to the evaluation of restoration projects, the future conditions with the restoration project must be predicted to determine its potential value. The data required for HEP analyses varies according to the model for the species being evaluated. Most habitat variables, such as percent tree canopy closure or average height of the shrub canopy in the beaver model, must be measured in the field, but some can be measured from maps. The Fish and Wildlife Service published a report describing field techniques to measure variables included in HEP models.

HEP is most valuable when there is a particular species or species group of concern. For instance, HEP can be used to assess the number of HUs in a watershed for a particular species or species group. If a certain population size is desired for the watershed, restoration projects can be targeted at the addition of HUs for that species.

The Hydrogeomorphic Method (HGM). The Corps Wetlands Research Program is developing a procedure for functional assessment based on hydrogeomorphic classification of wetlands, functional indices similar to those used in Habitat Evaluation Procedures (HEP), and reference wetlands. The new method, called the Hydrogeomorphic Method or HGM, results in Functional Capacity Units that incorporate quality and area.

The evaluation of wetlands in HGM is focused by grouping wetlands into five hydrogeomorphic classes (depression, slope-flat, riverine, fringe, and extensive peatlands) based on geomorphic setting, water source, and hydrodynamics. Regional subclasses will eventually be developed to further focus evaluations.

HGM measures wetland functions in terms of functional capacity. Functional capacity incorporates the inherent capacity of a wetland to perform a function and the degree to which the function is actually being performed. A functional capacity index (FCI) is developed by comparing the wetland being evaluated to reference wetlands based on graphical representations. The reference wetlands are usually of the same regional hydrogeomorphic class. The FCI provides a measure of the capacity of a wetland to perform a function relative to similar wetlands in the region. Assessment models that define the relationship between ecosystem variables and functional capacity are used to determine the FCI on a scale of 0.0 to 1.0. The relationship is established for the model using reference wetlands. An FCI of 1.0 corresponds to the level of functional capacity that exists under attainable conditions for the reference domain and an FCI of 0.0 reflects the absence of functional capacity. The FCI is converted to functional capacity units (FCU) by multiplying the FCI by the area of the wetland. FCUs incorporate quality and area.

HGM provides a more precise measure of the level of wetland functioning relative to other wetlands in the region. When this technique is completed and regional models are available, it should be substituted for the WET-based evaluations in Step 3. Note, however, that the Regulatory Division of the Corps of Engineers, New England Division may continue to use the "Descriptive Approach" described above unless the use of HGM becomes mandatory. Early coordination with Regulatory Division staff is recommended to verify their current method.

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APPENDIX D-2

Office of Watershed Management
Study Schedule

THE MASSACHUSETTS WATERSHED MANAGEMENT PROGRAM

The Massachusetts Clean Water Strategy

A comprehensive water resource protection agenda is set forth in the "Clean Water Strategy" developed by the Department of Environmental Protection (DEP). The centerpiece of this strategy is a watershed approach to resource management. To this end, the watershed has been designated as the fundamental planning unit upon which integrated water quality management activities will be based. To implement the strategy, the DEP is reshaping its monitoring, permitting, compliance, enforcement, and public outreach programs. In addition, the Massachusetts Geographic Information System (GIS) provides a state-of-the-art assessment tool for setting water resource protection priorities. GIS mapping capabilities will assist DEP staff to identify sensitive watersheds through overlays detailing water resource attributes of state-wide importance. By pinpointing resource areas in this way, regulators can target them for added protection through designation as Areas of Critical Environmental Concern, or as prime sites for land aquisition by the Commonwealth.

The Watershed Protection Approach

In 1993, the DEP took the initial steps toward implementation of the Clean Water Strategy by synchronizing four functions according to a watershed-oriented regimen that had previously been performed in isolation. These are: water quality monitoring and assessment, water withdrawal permitting, nonpoint source pollution control, and wastewater permitting under the National Pollutant Discharge Elimination System (NPDES). Furthermore, this watershed-based assessment and permitting strategy provided the basis for the establishment of a new Office of Watershed Management within the DEP to bring the above-mentioned programs together into one organizational unit. By coordinating these programs, and focusing their activities in a particular watershed, the relationship between water quality and water quantity, and point and nonpoint source pollution will be better understood and more effectively communicated to the public.

A phased program for watershed-based assessment, permitting, and nonpoint pollution control has been adopted. Water quality and biomonitoring surveys will be carried out in respective river basins two years prior to the year in which NPDES and water-withdrawal permits are to be issued for the entire basin. The scope of the field assessments will vary depending upon the resources available and the important water quality issues within each watershed. Input from outside agencies and the general public will be actively solicited in order to gain further insight with respect to water quality goals and use-objectives for Massachusetts surface waters, and to build partnerships with "stake-holders" who will play an increasingly important role in protecting these waters as the focus of water pollution abatement continues to shift to nonpoint source control measures. Survey data analysis, including, where applicable, the determination of site-specific water quality criteria, calculation of total maximum daily loads (TMDL), and the derivation of load/wasteload allocations and instream flow requirements will be completed during the year prior to permit issuance. Finally, the third phase will involve meeting with the permittees and issuing final wastewater and water withdrawal permits. In addition, this phase will include the targetting of priority waterbodies exhibiting nonpoint pollution problems for the implementation of Best Management Practices (BMP) or other control strategies.

Wastewater Discharge Permitting

All wastewater discharges to surface waters in Massachusetts are governed by permits which are issued jointly by the United States Environmental Protection Agency (USEPA) and the Massachusetts Department of Environmental Protection in accordance with guidelines set forth as part of the National Pollutant Discharge Elimination System (NPDES). This system establishes levels of effluent quality that must be achieved at municipal and industrial treatment facilities to ensure that water quality standards are met in the receiving waters. Because Massachusetts has not been delegated the authority to issue these permits, USEPA permit writers draft them and submit them to the DEP for review and state certification. This process results in a final discharge permit which is valid under both Federal and State law, and as such, each permitting agency has the independent right to enforce its terms and conditions. The Clean Water Act (CWA) requires that discharges satisfy both minimum technology and water quality requirements.

During the 1970's the Massachusetts Division of Water Pollution Control published river basin plans for over twenty river basins and coastal drainage areas in accordance with the requirements of Section 303(e) of the 1972 Federal Water Pollution Control Act (PL92-500). As part of this planning process, low-flow steady-state simulation models were developed for those basins where wasteload allocations were needed for the derivation of NPDES permit limits. While these models focussed primarily on predicted impacts from conventional pollutants such as biochemical oxygen demand, they provided the basis for permit limits and treatment technologies at municipal and selected industrial facilities that are still in place today.

The 1980's saw an increased emphasis on the identification and control of toxic pollutants in the aquatic environment. During this time EPA announced the publication of 65 individual ambient water quality criteria documents for pollutants listed as toxic under Section 307(a)(1) of the CWA. These criteria were not rules, and did not have regulatory impact. However, these and subsequent criteria documents were used by the DEP to screen ambient water quality data and wastewater discharge data to provide water toxics information to the EPA in 1989 in accordance with the requirements of Section 304(l) of the CWA. Specifically, waterbodies impacted by toxic pollutants and wastewater discharges in need of "individual control strategies" for toxic pollutants were identified and prioritized for implementation. Most of these control strategies involved the issuance of NPDES permits with whole-effluent toxicity testing requirements and, in some cases, individual numerical effluent limits for toxic contaminants.

Water Withdrawal Permitting

The Massachusetts Water Management Act (WMA), enacted in 1985, regulates all withdrawals from ground and surface water sources which exceed an average annual volume of 100,000 gallons per day. The WMA allowed all withdrawals of this magnitude that existed between 1981 and 1985 to be registered. New withdrawals sought after 1985 and exceeding the threshold volume were required to apply for a withdrawal permit. The application review process is being carried out watershed by watershed throughout Massachusetts. This process includes an analysis of the potential local impacts that may result from the proposed withdrawal. Included in this local impact analysis is the identification of resources affected by water level fluctuations and a determination of acceptable groundwater levels for those resources. The impact of water withdrawals on surface water quantity and quality, as well as the affects of induced infiltration on the quality of the withdrawal water are considered as a part of the review.

Nonpoint Pollution Control: Linking Land Use to Water Quality

Nonpoint source pollution results from the flow of rainfall or snow melt over and through the ground and the subsequent transport of contaminants from natural and anthropogenic sources into surface or ground water. Atmospheric deposition, in-place sediments, and hydrological modifications are also sources of nonpoint pollution. In the past, EPA and the states have focused water pollution abatement programs on the control of point sources through waste load allocation and NPDES permitting. Nonpoint source pollution is not as easily assessed nor controlled, for it is intricately linked with the use of the land, and land-use decisions are made at the local level. For this reason, Federal and State efforts are aimed at educating local officials and the public at large with respect to the importance of land-use planning and zoning, the use of best management practices (BMP) to control stormwater, and other measures for preventing nonpoint pollution. Critical to the success of this approach is the establishment of partnerships between all of the parties that have an interest in the process. By bringing these parties together, problems are identified and prioritized, and innovative solutions are developed. Moreover, the watershed represents a logical planning unit in which to focus this effort.

Unfortunately, impacts from nonpoint sources and the effectiveness of control measures are not easily determined, and monitoring and assessment methodologies are required that differ from those traditionally employed. Whereas the worst effects of point sources are typically exhibited at critical low-flow receiving stream conditions associated with summer-time dry weather, effects of non-point pollution are linked to the occurrence of storms and other climatic factors such as snow melt. The magnitude and frequency of rainfall and the degree to which natural runoff patterns have been altered through changes in land use all play a major role in determining the quality of receiving waters.

While the relationship between land use and water quality in the watershed is generally recognized, scientifically valid approaches to identifying and quantifying nonpoint pollution sources, and predicting the results of proposed control measures on downstream water quality are not well developed. Nonetheless, several watershed-scale models have been developed in recent years which can be used as screening tools for predicting nonpoint pollution loadings from storm events based on a knowledge of land use characteristics. These screening procedures require little input data or calibration and verification, and consequently, output is not highly accurate. Nonetheless, they can be used to make relative comparisons between subwatersheds and to highlight areas for more intensive data gathering and modeling efforts. It is anticipated that the control of nonpoint pollution will be an iterative process whereby the implementation of BMPs will be followed by monitoring to measure their effectiveness, and to identify needs for further loading reductions.

Massachusetts Nonpoint Source Management Plan

The Nonpoint Source Management Plan was originally developed by the DEP in 1988 pursuant to Section 319 of the CWA. This plan, which is undergoing revision at the present time, sets forth an integrated strategy for the prevention, control, and reduction of pollution from nonpoint sources in an effort to protect and improve the quality of the waters of the Commonwealth. Each year the Congress appropriates funds under Section 319 to assist the states with the implementation of their approved Nonpoint Source Management Plans. Implementation activities include regulatory enforcement, technical assistance, education, training, technology transfer, and demonstration projects. Only those implementation strategies identified in the Management Plan are eligible for federal funding.

As stated above, the state Nonpoint Source Management Plan is implemented on a prioritized watershed basis. This pertains to the core Nonpoint Source Program funded under Section 319 of the CWA. Not all of the ancillary state programs that address nonpoint source pollution are similarly focused. Nevertheless, the DEP will promote the use of a watershed approach by other state agencies and public entities in the implementation of the Nonpoint Source Management Plan.

The enactment by Congress of the 1990 amendments to the Coastal Zone Act (CZARA) has significant implications for the Massachusetts Nonpoint Management Plan. Section 6217 of CZARA includes the requirements and specifications for the development of state coastal nonpoint source management plans in accordance with program guidance from NOAA and technical guidance from EPA. The technical guidance contains requirements, or management measures, for nonpoint source controls which state programs must ensure will be implemented in an enforceable manner. The coastal management plans must assess the enforceability and effectiveness of existing programs for controlling nonpoint source pollution, and propose changes to correct gaps in legislative or regulatory authorities for addressing nonpoint source pollution. In Massachusetts, the DEP and the Office of Coastal Zone Management (CZM) have agreed that the coastal nonpoint pollution control program will be an integral part of the comprehensive state Nonpoint Source Management Plan. The provisions of the coastal plan will thus be implemented state-wide to maintain consistency of purpose and applicability of nonpoint source management strategies. This agreement has been formalized in a Memorandum of Understanding which establishes a working relationship between the two agencies, and clarifies their roles with regard to the development and implementation of the Coastal Nonpoint Pollution Control Plan.

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Department of Environmental Protection
Office of Watershed Management

William F. Weld
Governor
Trudy Coxe
Secretary, EOEA
Thomas B. Powers
Acting Commissioner

Watershed Program Schedule 1993-1999

Basin	Field	Planning	Permitting WMA	Permitting NPDES
Connecticut	93	94	94	95
Chicopee	93	94	94	95
Nashua	93	94	95	95
Blackstone	93	94	95	95
Merrimack	94	95	95	96
Neponset	94	95	95	96
French & Quinebaug	94	95	95	96
Boston Harbor	94	95	96	96
Cape Cod	94	--	96	--
Narragansett	94	--	96	--
Parker	94	--	96	--
Ipswich	95	96	95	97
Deerfield	95	96	97	97
Millers	95	96	99	97
Buzzards Bay	95	96	97	97
Islands	95	--	97	--
Shawsheen	95	96	97	97
Taunton	96	97	96	98
SUASCO	96	97	97	98
S. Coastal	96	97	96	98
Westfield	96	97	98	98
Farmington	96	--	98	--
Ten Mile	97	98	97	99
Housatonic	97	98	98	99
Hoosic	97	98	99	99
Charles	97	98	99	99
N. Coastal	97	98	00(95)	99
Stony Brook	97	98	00(95)	99

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APPENDIX D-3

Section 404(b)(1) Guidelines
Habitat Development and Restoration of Water Bodies

are statistically significant in the laboratory are significantly adverse in the field.

Section 320.10(d) uses the term "minimize" to indicate that all reasonable reduction in impacts be obtained. As indicated by the "appropriate and practicable" provision, steps which would be unreasonably costly or would be infeasible or which would accomplish only inconsequential reductions in impact need not be taken.

Habitat Development and Restoration of Water Bodies

Habitat development and restoration involve changes in open water and wetlands that minimize adverse effects of proposed changes or that neutralize or reverse the effects of past changes on the ecosystem. Development may produce a new or modified ecological state by displacement of some or all of the existing environmental characteristics. Restoration has the potential to return degraded environments to their former ecological state.

Habitat development and restoration can contribute to the maintenance and enhancement of a viable aquatic ecosystem at the discharge site. From an environmental point of view, a project involving the discharge of dredged and fill material should be designed and managed to emulate a natural ecosystem. Research, demonstration projects, and full scale implementation have been done in many categories of development and restoration. The U.S. Fish and Wildlife Service has programs to develop and restore habitat. The U.S. Army Engineer Waterways Experiment Station has published guidelines for using dredged material to develop wetland habitat, for establishing marsh vegetation, and for building islands that attract colonies of nesting birds. The EPA has a Clean Lakes program which supplies funds to States and localities to enhance or restore degraded lakes. This may involve dredging nutrient-laden sediments from a lake and ensuring that nutrient inflows to the lake are controlled. Restoration and habitat development techniques can be used to minimize adverse impacts and compensate for destroyed habitat. Restoration and habitat development may also provide secondary benefits such as improved opportunities for outdoor recreation and positive use for dredged materials.

The development and restoration of viable habitats in water bodies requires planning and construction practices that integrate the new or improved habitat into the existing environment. Planning requires a model or standard, the achievement of which is attempted by manipulating design and implementation of the activity. This model or standard should be based on characteristics of a natural ecosystem in the vicinity of a proposed activity. Such use of a natural ecosystem ensures that the developed or restored area, once established, will be nourished and maintained physically, chemically and biologically by natural processes. Some examples of natural ecosystems include, but are not limited to, the following: salt marsh, cattail marsh, turtle grass bed, small island, etc.

Habitat development and restoration, by definition, should have environmental enhancement and maintenance as their initial purpose. Human uses may benefit but they are not the primary purpose. Where such projects are not founded on the objectives of maintaining ecosystem function and integrity, some values may be favored at the expense of others. The ecosystem affected must be considered in order to achieve the desired result of development and restoration. In the final analysis, selection of the ecosystem to be emulated is of critical importance and a loss of value can occur if the wrong model or an incomplete model is selected. Of equal importance is the planning and management of habitat development and restoration on a case-by-case basis.

Specific measures to minimize impacts on the aquatic ecosystem by enhancement and restoration projects include but are not limited to:

(1) Selecting the nearest similar natural ecosystem as the model in the implementation of the activity.

Obviously degraded or significantly less productive habitats may be considered prime candidates for habitat restoration. One viable habitat, however, should not be sacrificed in an attempt to create another, i.e., a productive vegetated shallow water area should not be destroyed in an attempt to create a wetland in its place.

(2) Using development and restoration techniques that have been demonstrated to be effective in circumstances similar to those under consideration wherever possible.

(3) Where development and restoration techniques proposed for use have not yet advanced to the pilot demonstration or implementation stage, initiate their use on a small scale to allow corrective action if unanticipated adverse impacts occur.

(4) Where Federal funds are spent to clean up waters of the U.S. through dredging, scientifically defensible levels of pollutant concentration in the return discharge should be agreed upon with the funding authority in addition to any applicable water quality standards in order to maintain the desired improved water quality.

(5) When a significant ecological change in the aquatic environment is proposed by the discharge of dredged or fill material, the permitting authority should consider the ecosystem that will be lost as well as the environmental benefits of the new system.

Dated: December 12, 1980.

Douglas M. Costle,

Administrator, Environmental Protection Agency.

Part 230 is revised to read as follows:

PART 230—SECTION 404(b)(1) GUIDELINES FOR SPECIFICATION OF DISPOSAL SITES FOR DREDGED OF FILL MATERIAL

APPENDIX E

Wetlands Conservancy Program
Wetland Classifications

Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Department of Environmental Protection

William F. Weld
Governor
Trudy Coxe
Secretary, EOEA
Thomas B. Powers
Acting Commissioner

WETLANDS CONSERVANCY PROGRAM

The Wetland Conservancy Program maps wetland resources. Wetland resources are areas where there is an interface between land and water. There are two broad categories of wetland resources, freshwater and coastal. Freshwater wetlands are areas where there are plants that commonly grow under wet conditions, soils that are frequently saturated, and water that is at or near the surface during most of the growing season. Coastal wetlands are landforms which are subject to coastal processes such as tides, waves, or flooding due to storm events.

INLAND WETLANDS

The Wetland Conservancy Program maps 10 categories of inland freshwater wetlands. They are:

Marsh (M): A marsh is a wetland vegetated by herbaceous plants, such as cattails, grasses, or sedges. The water table may be above the surface of the ground during the spring, but typically it recedes to below the surface of the ground during the growing season. A wet meadow is a type of marsh.

Deep Marsh (DM): A deep marsh is a wetland dominated by herbaceous plants, such as pondlilies or pickerelweeds. There is usually standing water in a deep marsh throughout the growing season. Deep marshes are often present along the edges of ponds and rivers.

Open Water (OW): Open water is an area where there is permanent standing water which is usually too deep to support plants which can reach to the surface. Examples include ponds, lakes, and rivers.

Shrub Swamp (SS): A shrub swamp is a wetland dominated by woody vegetation which is less then twenty feet tall. Examples can include stands of alders, buttonbush, or red maple saplings.

Wooded Swamp (WS): Wooded swamps are wetlands dominated by woody vegetation which is greater then twenty feet tall. The Wetland Conservancy Program identifies three different types. A WS1 is dominated by deciduous trees, such as red maple. A WS2 is dominated by evergreen trees, such as white cedar. A WS3 is a mix of both deciduous and evergreen, such as a red maple/white cedar

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complex.

Bog (BG): A bog is a wetland where the surface of the ground is covered by a dense mat of sphagnum moss (peat). That mat may be several feet thick, and in some cases is actually floating over a pocket of water. The growing conditions can be harsh in a bog, and some of the plants have developed unusual adaptations, such as the insect eating pitcher plants and sundews.

Cranberry Bog (CB): A cranberry bog is an area which is being used for the commercial production of cranberries. The soils and water levels are often manipulated and altered.

Hydrological Connection (---): Hydrological connections are areas where surface water flows within a defined channel. The water flow may be permanent or intermittent. Examples of hydrological connections include: streams, ditches and creeks.

COASTAL WETLANDS

The Wetlands Conservancy Program maps eight categories of coastal wetlands. They are:

Tide Flat (TF): Tide flats are nearly level intertidal areas adjacent to coastal waters. They often occur in sheltered areas, and are typically exposed at low tide. The sediment is usually fine grained materials such as silt or clay. They often contain shellfish beds.

Beaches (BE): Beaches are gently sloping areas adjacent to coastal waters. They are usually exposed to wave action. The sediment is typically coarser material such as sand, gravel, or cobbles.

Dunes (D): Dunes are mounds or hills of sandy material adjacent to beaches. Constant wind and wave action can serve to push the sand landward, forming the mounds. A dune may be vegetated by dune grass, or it may be unvegetated.

Salt Marsh (SM): A salt marsh is a vegetated wetland adjacent to coastal waters. Because the salt content in these waters is so high, only plants that can tolerate such saline conditions can survive. The two most common examples of salt tolerant plants are saltwater cordgrass and saltmeadow cordgrass (Spartina spp.).

Barrier Beach (BB): A barrier beach is a narrow, low-lying strip of land which generally consists of beaches and dunes. A barrier beach generally separates the open ocean from an embayment, salt pond, or estuarine area. Plum Island on the North Shore, and Duxbury Beach on the South Shore are good examples of a barrier beach.

Rocky Shore (RS): Rocky shores are rocky or boulder strewn areas between mean high water and mean low water. In other words, they are inundated during high tide, but are exposed during low tide. The rocks or boulders are often covered by barnicles or algae.

Coastal Bank (BA): A coastal bank is the seaward face of an elevated landform adjacent to coastal waters. The slope is usually somewhat steep, and is generally subject to flooding or the pounding of waves during heavy storms. Sea cliffs and bluffs are examples of coastal banks.

Open Water (OW): Open water is areas that are below mean low water. In other words, they are not normally exposed during low tides. Salt ponds, tidally influenced rivers, and the open ocean are examples of open water.

Additionally, the Wetlands Conservancy Program uses the symbol "U" to denote uplands. Uplands are lands where there is generally no direct interface with water, and therefore they are not wetland resources. Uplands may be natural, or they may be a result of human activity.

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PLEASE NOTE:

The wetlands boundaries shown on this map have been determined by photographic interpretation. They do not, and should not be used as, wetlands delineations under the Massachusetts Wetlands Protection Act (M.G.L. C.131.S40).

Further information about the Wetlands Conservancy Program and its mapping protocols and conventions is available by calling Charles Costello at 617-292-5907.

APPENDIX F

Atlantic Coast Joint Venture Sites

North American Waterfowl Management Plan

Atlantic Coast Joint Venture

This focus area contains the 4,662 acre Parker River National Wildlife Refuge and 1,700 acres in state wildlife management areas, but thousands of acres remain in private ownership.

2. <u>Greater Boston Area</u> (Essex, Suffolk Counties)

Located immediately north of Boston, the marshes along the Pines and Saugus Rivers are the last remaining tracts of extensive salt marsh in the greater Boston metropolitan area. Dissected by roads and degradated by illegal dumping and the invasion of <u>Phragmites</u>, the area never-the-less provides habitat for a variety of wildlife. A remnant flock of 120 - 180 black ducks winter in an area that supported 500 birds 20 years ago. This flock has been growing in recent years and has potential for considerably larger flock size. Common terns nest around the General Edwards bridge. The proposed Saugus River Flood Damage Reduction project will likely increase development pressures on lands adjacent to the marsh. Approximately 1,500 acres of salt marsh would be affected. Lynn Harbor, a low-tide feeding site for black ducks and winter habitat for a variety of diving duck species, has been proposed for dredging projects which would eliminate important mussel flats. Twelve hundred acres of open water and flats need to be protected. This area is included in a state designed Area of Critical Concern.

The much smaller salt marsh area (220 acres) located on the north end of Quincy Bay, coupled with the tidal flats of the region, provides winter habitat for several hundred black ducks, 1,000 - 3,000 Atlantic brant, and a growing flock of Canada geese. Assorted diving ducks use the area including a flock of greater scaup, a species declining in southern New England.

3. Duxbury Marshes/Bay, Kingston Bay (Plymouth County)

An important wintering site for black ducks and a variety of diving duck species, Canada geese, and brant. The thin strips of remaining salt marsh are endangered by shoreline development. The tidal flats along the bay shorelines are particularly important to wintering black ducks. Arctic, common, and least terns, all listed as state "special concern," are found here as are piping plovers, listed as both state and federally threatened. Roseate terns, a state- and federally-listed endangered species, utilize the area. Critical migratory stop-over habitat for the red knot lies within this focus area. Approximately 1,500 acres should be protected (750) or enhanced (750).

4. Barnstable Marshes (Barnstable County)

Development pressures on Cape Cod are escalating and the quality of the salt marsh is threatened by shoreline development. While some area is protected state property, more than 5,000 acres remain in private property. The marshes winter a thousand or more black ducks as well as other species and provides nesting for common and least terns.

Piping plovers (state and federally threatened) also utilize the area and it is home to the state-threatened diamondback terrapin and eastern spadefoot toad. The decodon stem borer moth (state threatened) is found here as is salt reed grass, a species of special concern in the state. A total of 6,700 acres need to be protected (4,300) or enhanced (2,400) in this area.

5. Outer Cape Cod (Barnstable County)

Although the Cape Cod National Seashore protects much of outer Cape Cod, black ducks, Canada geese, and brant winter in Pleasant Bay outside the seashore boundaries. The tidal flats and salt marsh around Sipson Meadow and Strong Island are among the most important wintering habitats in Massachusetts. Ospreys (special concern), diamond-back terrapins (state threatened), and short-eared owls (state endangered) all are found in the area. Salt marshes on the bay side of the Cape have been ditched and diked, and should be restored to a more natural state. Phragmites control is needed in several areas. Seventeen hundred acres are targeted for protection and 800 for enhancement.

6. Westport Rivers (Bristol County)

Black ducks winter in the southern portions of the east branch of the Westport River, especially around Big Ram Island, and they also utilize nearby Allens Pond. Use of the west branch of the Westport is more pronounced in the upper reaches. The area is an important black duck wintering site in the Massachusetts' Buzzards Bay area. The area also winters as many as 6,000 Canada geese. There is a coastal heron rookery in the area and nesting osprey. Other species of special concern or threatened include diamond-back terrapins, king rails, least terns, and piping plovers. Protection efforts are needed on 1,050 acres.

7. <u>Inland Rivers</u> (Blackstone, Nashua, and Sudbury-Assabet-Concord Rivers)

The Blackstone River and its watershed is one of the last significant black duck production areas in Worcester County. Production appears associated with old impoundments created by industry at the turn of the century. The impoundments are now falling into disrepair and in danger of being drained, resulting in loss of valuable marshland. Mallards and wood ducks also nest in the region as well as rails and other marsh birds. The river valley is a migration corridor. The recently established Blackstone Valley Heritage State Park affords some protection to the Rice City impoundment but several others, including the now drained Fisherville Pond, require protection and management.

The Nashua River in Middlesex County, one of the few northward flowing rivers in the state and once was one of the most polluted rivers in the state, has been greatly cleaned up and now carries a Class B rating in many sections. The upstream portions of the river pass through or along the Fort Devens Military Reservation, the Oxbow NWR, and the state's Bolton Flats Wildlife Management Area. The Nashua is one of the few rivers in eastern Massachusetts that still meanders through relatively undeveloped rural habitat. Downstream of Fort Devens is a large section of oxbows, tributaries, channels, and bays with potential for habitat development. The area, however, is almost entirely in private ownership. Acquisition or easements are needed to ensure the area remains relatively undisturbed. Species of special concern found in the watershed include American bittern and water shrew, while the Blandin's turtle, least bittern, and pied billed grebe are on the state's threatened list, and the swollen wedge mussel is on the state's endangered.

Some of the most productive waterfowl habitat in Massachusetts is found in the river valleys of the eastern coastal plan in the Sudbury-Assabet-Concord river systems. Although black duck production has declined with urbanization, wood ducks, mallards, and Canada geese are plentiful. Least and American bitterns, spotted and Blandins turtles, the king rail, and common moorhen are all species either listed as state threatened or of special concern found in the valley. The Great Meadows NWR owns 1,587 acres in scattered parcels of property along the Sudbury River, and the Massachusetts Division of Fisheries and Wildlife owns a 410-acre wildlife management area that it is seeking to partially impound. One area of concern on the river is infestation of what were formerly wild rice beds with the exotic plant water chestnut (Trapa natans). There is a need to both acquire more property to protect the river corridor and to institute control measures for water chestnut and purple loosestrife.

Approximately 5,000 acres require protection and 2,000 require enhancement.

MASSACHUSETTS FOCUS AREA SUMMARY

Focus Area	Acreage Needs Protect	Acreage Needs Enhance	Acreage Needs Total
North Shore Marshes	17,090	6,700	23,790
Greater Boston Area	2,920		2,920
Duxbury Marshes	750	750	1,500
Barnstable Marshes	4,300	2,400	6,700
Outer Cape Cod	1,700	800	2,500
Westport River	1,050		1,050
Inland Rivers	5,000	2,000	7,000
Total	32,810	12,650	45,460

D. Rhode Island

Thirteen priority focus areas have been identified for protection efforts in the state. Although some of these areas may seem small, they contain an important mosaic of wildlife habitats including barrier beaches, sand dunes, salt marsh, fresh marshes, small islands, upland woods, and fields. Rhode Island law prohibits the filling, dredging, or destruction of fresh or salt marsh wetlands; however, these important habitats are still subjected to erosion, sedimentation, runoff, and pollution from surrounding developments. The focus areas are: