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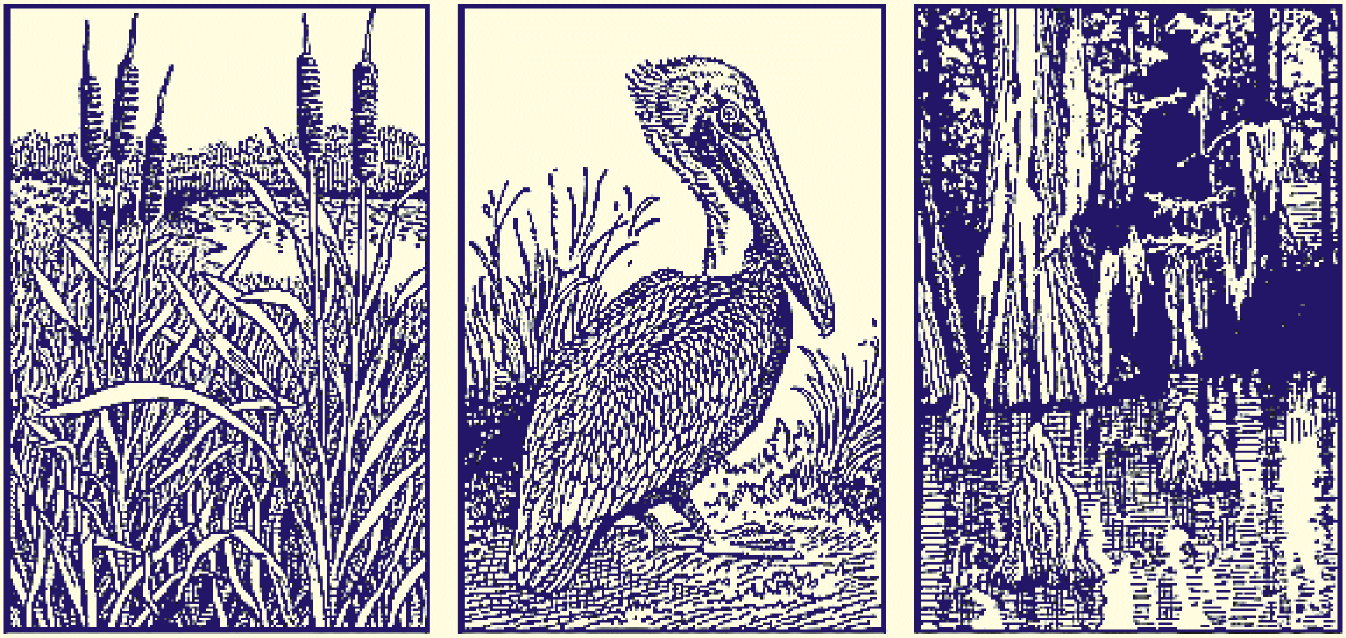
Wetlands Research Program Technical Report WRP-DE-9

An Approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices

by R. Daniel Smith, Alan Ammann, Candy Bartoldus, and Mark M. Brinson



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Wetlands Research Program

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October 1995

An Approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices

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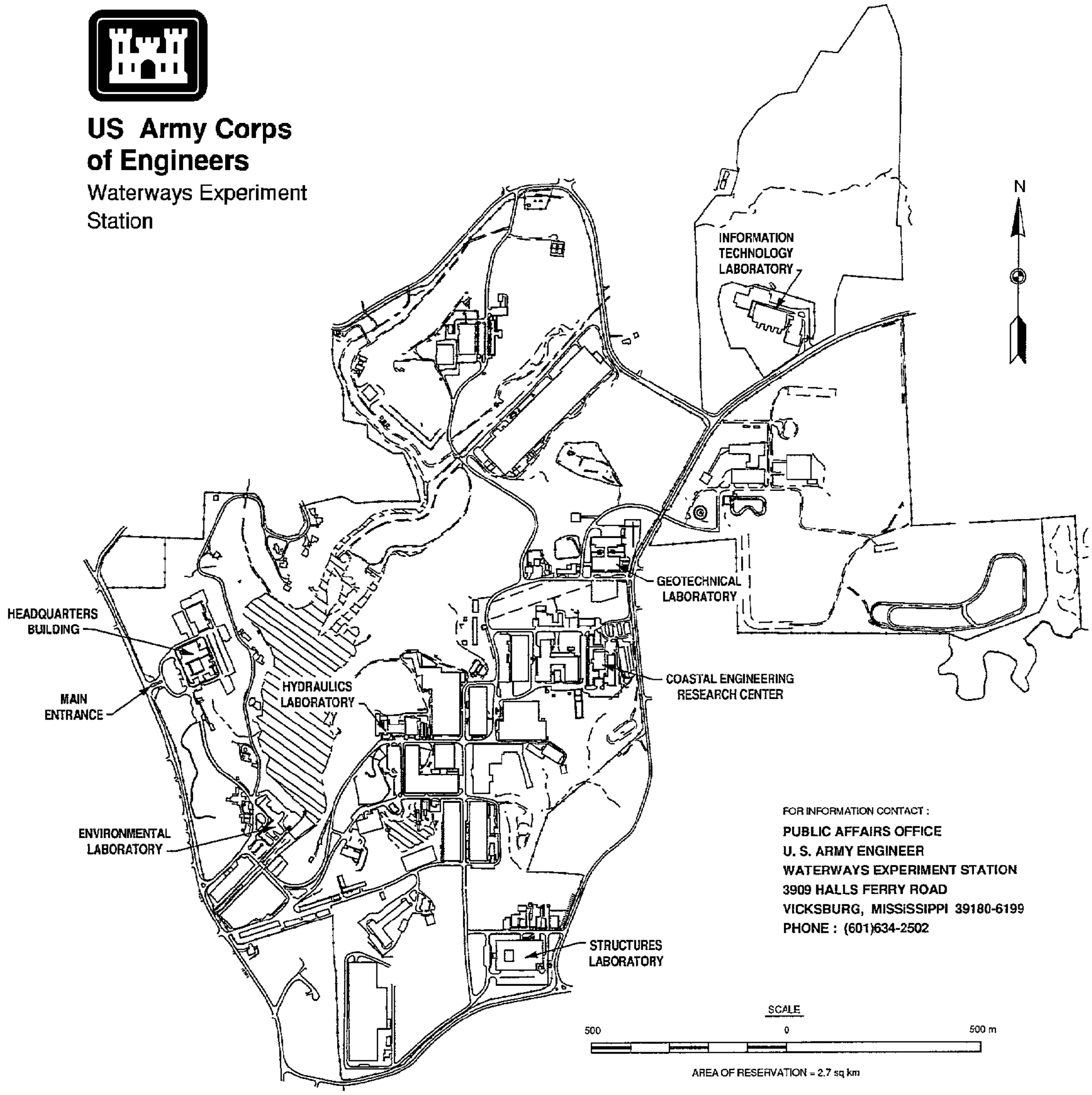

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Assessing Wetland Functions

An Approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices (TR WRP-DE-9)

ISSUE:

Section 404 of the Clean Water Act directs the U.S. Army Corps of Engineers to administer a regulatory program for permitting the discharge of dredged or fill material in "waters of the United States." As part of the permit review process, the impact of discharging dredged or fill on wetland functions must be assessed. Existing procedures for assessing wetland functions fail to meet the technical and programmatic requirements of the 404 Regulatory Program.

RESEARCH:

The objective of this research is to develop an approach for assessing the functions of wetlands in the context of the 404 Regulatory Program.

SUMMARY:

This report outlines an approach for assessing wetland functions in the 404 Regulatory Program as well as other regulatory, planning, and management situations. The approach includes a development and application phase. In the development phase, wetlands are classified into regional subclasses based on hydrogeomorphic factors. A functional profile is developed to describe the characteristics of the regional subclass, identify the functions that are most likely to be performed, and discuss the characteristics that influence how those functions are performed. Reference wetlands are selected to represent the range of variability exhibited by the regional subclass in a reference domain, and assessment models are constructed and calibrated by an interdisciplinary team based on reference standards and data from reference wetlands. Reference standards are the conditions exhibited by the undisturbed, or least disturbed, wetlands and landscapes in the reference domain. The functional indices resulting from the assessment models provide a measure of the capacity of a wetland to perform functions relative to other wetlands in the regional subclass. The application phase of the approach, or assessment procedure, includes the characterization of the wetland, assessing its functions, analyzing the results of the assessment, and applying them to a specific project. The assessment procedure can be used to compare project alternatives, determine the impacts of a proposed project, avoid and minimize impacts, determine mitigation requirements or success, as well as other applications requiring the assessment of wetland functions.

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Preface

The work described in this report was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), as part of the Delineation and Evaluation Task Area of the Wetlands Research Program (WRP). The work was performed under Work Unit 32756, “Evaluation of Wetland Functions and Values,” for which Mr. R. Daniel Smith, Environmental Laboratory (EL), U.S. Army Engineer Waterways Experiment Station (WES), was the Principal Investigator. Mr. John Bellinger (CECW-PO) was the WRP Technical Monitor for this work.

Mr. Dave Mathis (CERD-C) was the WRP Coordinator at the Directorate of Research and Development, HQUSACE; Dr. Willam L. Klesch (CECW-PO) served as the WRP Technical Monitor’s Representative; Dr. Russell F. Theriot, WES, was the Wetlands Research Program Manager; and Mr. Ellis J. Clairain, Jr., WES, was the Task Area Manager.

The work was performed under the direct supervision of Mr. Smith, and under the general supervision of Mr. Clairain, Acting Chief, Wetlands Branch; Dr. Conrad J. Kirby, Chief, Ecological Research Division; and Dr. John W. Keeley, Director, EL. Many individuals contributed ideas, comments, and criticism over the past several years to the assessment approach described in this report including the following: Paul Adamus, Bill Ainslie, Buddy Clairain, Mary Davis, Frank Golet, Jim Gosselink, Paul Garrett, Courtney Hackney, Gary Hollands, Chuck Klimas, Joe Larson, Mark LaSalle, Lyndon Lee, Bob Lichvar, Scott Liebowitz, Dennis Magee, Ed Maltby, Rob McInnes, Wade Nutter, Bruce Pruitt, Lauren Stockwell, and Dennis Whigham.

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1 Introduction

Over the past several decades, the scientific community, government agencies, and general public have become increasingly aware of the role wetland ecosystems play in maintaining environmental quality (Executive Order 11990 May 24, 1977; Conservation Foundation 1988; National Governors Association 1992; Soil and Water Conservation Society 1992; White House Policy Statement on Wetlands 1993). This awareness has led to expanded efforts in the stewardship and management of wetland resources, increased research into critical wetland processes (Leibowitz, Squires, and Baker 1991; U.S. Army Corps of Engineers 1992), and the enactment of Federal, State, and local laws to regulate impacts to wetlands.

The Clean Water Act (33 U.S.C.1344) plays a significant role in regulating impacts to wetlands at the national scale. Section 404 of the Act directs the U.S. Army Corps of Engineers (Corps), in cooperation with the U.S. Environmental Protection Agency (EPA), to administer a 404 Regulatory Program (404) for permitting the discharge of dredged or fill material in "waters of the United States," which, by definition, include wetlands and other special aquatic sites. Applications for a permit to discharge dredged or fill material in waters of the United States undergo a public interest review that includes assessing the impact of a proposed project on wetland functions and other factors related to the public interest. Results of the assessment are one of the factors considered in making the 404 permit decision.

A variety of methods have been developed over the past 15 years to assess wetland functions (World Wildlife Fund 1992; Lonard et al. 1981; U.S. Environmental Protection Agency 1984). However, none have received widespread use or acceptance in 404 because of a failure to satisfy one or more technical or programmatic requirements, which include applicability in a wide geographic area, the ability to assess a variety of wetland types and functions, and the ability to assess functions accurately and efficiently within the limited time and resources available. This report outlines an approach for assessing wetland functions that satisfies the technical and programmatic requirements of 404, as well as a variety of other regulatory, planning, and management situations requiring an assessment of wetland functions such as determination of minimal effects (U.S. Soil Conservation Service 1994).

The assessment approach includes a development phase that is carried out by an interdisciplinary assessment team, or A-team, and an application phase, or assessment procedure, that is carried out by a regulator, manager, consultant, or other end user (Figure 1). The development phase begins with the classification of wetlands into regional wetland subclasses based on hydrogeomorphic factors (Brinson 1993). The A-team then develops a functional profile that describes the physical, chemical, and biological characteristics of the regional subclass, identifies which functions are most likely to be performed, and discusses different ecosystem and landscape attributes that influence each function. The functional profile is based on the experience and expertise of the A-team along with information from reference wetlands. Reference wetlands are field sites that encompass the range of variability exhibited by wetlands in a regional subclass. Reference wetlands are selected from a defined geographic area, or reference domain, which may include all, or part, of the geographic area in which the regional subclass actually occurs.

Assessment Approach

Development Phase
(A-Team)

- Hydrogeomorphic Classification
- Development of Functional Profile
- Identification of Reference Wetlands
- Development of Assessment Models
- Calibration of Models Using Reference Wetlands

Application Phase
(Field Staff)

- "Assessment Procedure"
- Characterization
- Assessment
- Analysis

Figure 1. Overview of the assessment approach

The next task of the A-team is the development and calibration of assessment models. Assessment models define the relationship between attributes of the wetland ecosystem and surrounding landscape and the capacity of a wetland to perform a function. They are developed and calibrated based on the knowledge of the A-team and other experts, the literature, and data from reference wetlands. The assessment model results in a functional index, which estimates the capacity of a wetland to perform a function relative to other wetlands from the regional subclass in the reference domain. The standard of comparison used to scale functional indices are reference standards. Reference standards are the conditions under which the highest, sustainable level of function is achieved across the suite of functions performed by wetlands in a regional subclass.

Following completion of the development phase, the application phase, or assessment procedure, can be used to assess wetland functions in the context of a regulatory, planning, or management project. The assessment includes a characterization, assessment, and analysis component. Characterization involves describing the wetland ecosystem, the surrounding landscape, the proposed project, and its potential impacts. Assessment involves the application of assessment models and calculation of functional indices for a defined wetland area under existing (i.e., preproject conditions), and if appropriate, postproject conditions. Analysis involves the application of assessment results to the following:

- Determine the least damaging alternative for a proposed project.
- Describe the potential impacts of a proposed project.
- Describe the actual impacts of a completed project.
- Identify ways to avoid and minimize impacts of a proposed project.
- Determine compensatory mitigation for a proposed project.
- Determine restoration potential of a wetland.
- Develop design criteria for wetland mitigation or restoration projects.
- Plan, monitor, and manage wetland mitigation or restoration projects.
- Monitor success of compensatory mitigation efforts.
- Compare wetland management alternatives or results.
- Identify priorities for acquisition or set aside.

It is important at the outset to identify how the design of the assessment approach may limit its application in certain situations. First, the development phase of the approach must be completed before wetland functions can be assessed. The development phase requires a considerable investment of time and resources to identify regional wetland subclasses, develop functional profiles, identify reference wetlands and reference standards, and develop, calibrate, and test assessment models. However, once the development phase is completed, the time and resources required to apply the functional indices are consistent with what is typically available in the 404 public interest review process.

Another potential limitation is that the functional indices resulting from the development phase of the approach can be used to compare wetlands from the same regional subclass, but they cannot be used to compare wetlands from different regional subclasses within a region or similar wetlands from different regions. While it is theoretically possible to make these types of comparisons using absolute, empirical standards (e.g., number of cubic feet of water stored annually or the grams of carbon produced per year), the time and resources required to quantify these relationships are feasible only in the context of an intensive research project, and not the public interest review process.

A third potential limitation is that functional indices developed under this approach cannot be used to assess cumulative impacts of a proposed project as required by the public interest review process (33 CFR Section 320.4 (a)(3)). In assessing wetland functions, this approach considers the landscape surrounding the wetland in the context of how it influences the capacity of the wetland to perform functions. In assessing cumulative impacts, the focus shifts from the functions performed at the wetland ecosystem scale to the larger landscape or watershed scale. At these larger scales, the important question becomes how does the loss of wetland ecosystem function affect landscape or watershed processes? The functional indices in this approach can be used to estimate loss, or gain, of functions at the wetland ecosystem scale, but they cannot, in and of themselves, be used to determine how the loss of function will affect the landscape or watershed scale processes. The functional indices resulting from this approach may however be used in conjunction with methods designed specifically to assess cumulative impacts (Preston and Bedford 1988; Lee and Gosselink 1988; Leibowitz et al. 1992; Gosselink et al. 1990; and Gosselink and Lee 1989).

The last potential limitation is that the functional indices developed under this approach cannot be used to assign value to wetland functions in terms of economic (e.g., dollars) or other value units as required by the public interest review process (33 CFR Section 320.4 (a)(4)). Functional indices can be used to determine the loss or gain of wetland function; however, they cannot be used to assign a value to the loss or gain of function or compare the value of the loss to the value of benefits goods and services resulting from the proposed project. This requires other methods designed specifically for the purpose of assigning value (Luzar and Gan 1991; Shabman and Batie 1988; Henderson 1993).

This report is organized into the five chapters described below. Chapter 1 provides background information, objectives, a brief overview of the assessment approach, and inherent limitations of the approach. Chapter 2 discusses programmatic and technical requirements for assessing wetland functions in 404, existing procedures for assessing wetland functions, and why none have received widespread acceptance and use. Chapter 3 presents a conceptual framework for assessing wetland functions and includes discussions on the definition and classification of wetland ecosystems, wetland functions, the value of wetland functions, and the capacity of a wetland to perform functions. Chapter 4 discusses implementing the developmental phase of the approach and includes guidelines for identifying regional wetland subclasses, developing functional profiles, identifying reference wetlands and reference standards, and developing and calibrating assessment models. Chapter 5 presents the steps required to carry out the assessment procedure in a regulatory, planning, and management context.

2 Requirements for Assessing Wetland Functions in 404

The Clean Water Act (33 U.S.C. 1344) directs the Secretary of the Army, acting through the Chief of Engineers, to issue permits for the discharge of dredged or fill material in "waters of the United States" after notice and opportunity for public hearing. Wetlands and other special aquatic sites are, by definition, waters of the United States and therefore subject to jurisdiction under 404 (33 U.S.C. 1344, Section 328). Regulations governing the administration of 404 are outlined in the Corps Regulatory Program Regulations (33 CFR Sections 320-330) and the EPA 404(b)(1) Guidelines (40 CFR Section 230). These regulations and guidelines have been subject to interpretation through Regulatory Guidance Letters, interagency Memoranda of Agreement, and the courts.

Section 320.4 (a)(1) of the Corps regulations summarizes the objectives and requirements for determining whether a permit to discharge dredged or fill material in waters of the United States should be issued. As indicated in the following excerpt, a variety of factors are considered during the public interest review, although wetlands have become a primary focus of attention in the review process.

> The decision whether to issue a permit will be based on an evaluation of the probable impacts, including cumulative impacts, of the proposed activity and its intended use on the public interest. Evaluation of the probable impact which the proposed activity may have on the public interest requires a careful weighing of all those factors which become relevant in each particular case. The benefits which reasonably may be expected to accrue from the proposal must be balanced against its reasonably foreseeable detriments. The decision whether to authorize a proposal, and if so the conditions under which it will be allowed to occur, are therefore determined by the outcome of this general balancing process. That decision should reflect the national concern for both protection and utilization of important resources. All factors which may be relevant to the proposal must be considered including the cumulative effects thereof: among those are conservation, economics, aesthetics, general environmental concerns, wetlands, historic properties, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy

needs, safety, food and fiber production, mineral needs, considerations of property owners, and in general, the needs and welfare of the people.

The sequence for reviewing 404 permit applications is prescribed in the EPA 404(b)(1) Guidelines (40 CFR Part 230) and includes the following steps:

Step 1: Determine whether the proposed project is water dependent.

Step 2: Determine whether practicable alternatives exist for the proposed project.

Step 3: Identify the potential impacts of the proposed project on wetland functions in terms of project specific and cumulative effects.

Step 4: Identify how potential project impacts can be avoided or minimized in terms of project specific and cumulative effects.

Step 5: Determine appropriate compensatory mitigation for unavoidable project impacts.

Step 6: Grant or deny a permit to discharge dredged or fill material based on a comparison of the value of the benefits gained from the proposed project versus the value of benefits lost from the proposed project.

Step 7: If a permit is granted, monitor compensatory mitigation to determine compliance.

There are a number of steps in this sequence that require the assessment of wetland functions (Corps and EPA 1990 Mitigation MOA). For example, Step 2 requires that impacts associated with each alternative be assessed and then compared to determine the least damaging. Step 3 requires that wetland functions be assessed and compared under preproject and postproject conditions to determine what project specific and cumulative impacts may result. Steps 4 and 5 require that impacts to wetland functions be assessed to determine how to avoid or minimize impacts and what is appropriate compensatory mitigation for unavoidable impacts. Step 7 requires that wetland functions be assessed and compared before and after the mitigation project is completed to determine whether objectives have been met.

A number of methods have been developed during the past 15 years to assess wetland functions. Some were designed specifically for wetlands, while others were adapted from methods developed originally for upland or aquatic ecosystems. Lonard et al. (1981) reviewed the methods developed prior to 1981 to determine the feasibility of using them in 404. They concluded that none of the methods reviewed were appropriate in their current format and recommended specific revisions to make them more useful. U.S. Environmental Protection Agency (1984) also reviewed assessment methods to determine "...their potential ability to determine adverse effects of projects on wetland functions." They also concluded that none of the methods reviewed were appropriate.

A number of assessment methods have been developed, revised, or become available for the first time since these early reviews were completed. They include the following: (a) the Wetland Evaluation Technique (WET) by Adamus et al. (1987), a revision of Adamus (1983), and Adamus and Stockwell (1983), designed to rapidly assess a standard suite of functions in any wetland in the continental United States; (b) Hollands and Magee (1986), a method developed for use in the northeast and north-central United States; (c) the Connecticut Method (Ammann, Franzen, and Johnson 1986) developed for use in the New England area and recently adapted for use in the State of New Hampshire (Ammann and Lindley-Stone 1991); (d) and the Wetland Evaluation Method (Wells 1988), developed for use in the north-central United States. Many of these methods are reviewed in a recent World Wildlife Fund (1992) publication.

Despite the variety of methods that have been developed to assess wetland functions, none have received widespread acceptance or utilization in 404 at a national scale. The principal reason is that all fail to satisfy one or more of the basic programmatic or technical requirements of 404. These requirements include the following:

a. A standardized and documented approach.

b. Applicability throughout the public interest review sequence.

c. Applicability across the geographic extent of the Corps regulatory jurisdiction.

d. Applicability to a variety of wetland types.

e. Applicability to a variety of wetland functions.

f. Compatibility with the time and resources available for the public interest review process.

g. Accuracy and precision that is consistent with the time and resources available.

h. Sensitivity to different types of impacts at levels at which wetland functions are affected.

i. Adaptability to a variety of regulatory, management, and planning applications.

j. Defined standards of comparison.

k. Capability to incorporate new technical information as it becomes available.

l. Capability to incorporate new or changing programmatic requirements.

The challenge in meeting these programmatic and technical requirements, given the limited time and resources normally available for the public interest review, is to develop an assessment procedure that is simple and efficient and, at the same time, accurate and precise enough to detect functional change. The assessment approach presented in this document achieves these requirements through the use of hydrogeomorphic classification, functional indices, and reference wetlands.

Wetlands in the United States exhibit great variability in terms of their structural characteristics and processes (Mitsch and Gosselink 1993). This variability makes the assessment of wetland functions difficult because variability in structure and process leads to variability in function. In order to reduce variability to a level that can be addressed in 404, this approach classifies wetlands into regional wetland subclasses based on the hydrogeomorphic factors identified by Brinson (1993) and other factors of regional importance. The objective of classification is to identify a group of wetlands that are relatively homogeneous in terms of structure, process, and ultimately function. For example, Wharton (1978) identified a variety of wetland types on the Atlantic Coastal Plain including flatwoods, Carolina bays, tidal salt marshes, alluvial swamps, and others. The variability exhibited among these wetland types in terms of climatic conditions, species composition, soil type, hydrologic regime, biogeochemistry, and other factors is much greater than the variability exhibited within any one of these types alone. Reducing variability through classification simplifies the assessment process by focusing on the functions a wetland is most likely to perform and the characteristics most likely to influence those functions.

It is not feasible, given the time and resources that are normally available for public interest review, to conduct intensive data collection and analysis to determine how a proposed project will impact wetland functions. However, wetland functions should also not be assessed using undocumented or subjective methods. In this approach, functional indices are used as a basis for estimating change in the level of function. The use of functional indices is a compromise between these two extremes that attempt to reduce a large amount of information into a simpler form, while retaining the essence of the information (Ott 1978). Functional indices are based on assessment models that are calibrated using reference wetlands and make it possible to achieve an acceptable level of accuracy and precision with minimal data collection and analysis requirements. In addition, because assessment models are based on quantitative and qualitative field data from reference wetlands, functional indices have an objective basis and can be subjected to critical review and validation.

3 Conceptual Framework

Wetland Ecosystems

A system is a group of parts that interact through one or more processes (Odum 1983). The term ecosystem was introduced and defined by Tansley (1935), who as "a fundamental organizational unit of the natural world that includes both organisms and their spatial environment." Ecosystems have since been defined in various ways, and at different spatial and temporal scales (Golley 1993; O'Neill et al. 1986; Evans 1956). Some ecologists define ecosystems on the basis of biotic organisms, populations, or communities. For example, Hutchinson (1978) considered the ecosystem to be the environmental context in which population or community dynamics occur. Others define ecosystems in terms of their abiotic characteristics and processes (Rowe and Barnes 1994). For example, Lindeman (1942) defined ecosystems as "...the system composed of physical, chemical, and biological processes active within a space/time unit." Regardless of whether the emphasis is on biotic components or abiotic characteristics and processes of ecosystems, both remain integral to the concept of ecosystem. Rowe (1961) emphasized this when he defined ecosystems as "...a three dimensional segment of the earth where life forms and the environment interact."

Wetland ecosystems have been defined in a variety of ways by researchers, resource managers, and regulatory authorities, depending on their specific needs and objectives (Mitsch and Gosselink 1993, page 21). In the applied world of regulation, planning, and management, wetlands are usually defined in terms of their physical, chemical, and biological characteristics such as hydrologic regime, soil type, and plant species composition. For example, in classifying wetlands for mapping, inventory, and other purposes, Cowardin et al. (1979) defined wetlands as "...lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water..." that are characterized by the presence of hydrophytic vegetation, hydric soils, and surface water during the growing season. For the purposes of 404, the Corps and EPA define wetlands as "...areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Corps Regulation 33 CFR 328.3 and EPA Regulations 40 CFR 230.3).

Hydrogeomorphic Classification of Wetlands

Regardless of how they are defined, all wetlands share some common hydrologic, soil, and vegetative characteristics. Beyond these general similarities, however, wetlands exhibit wide variation in terms of their size, complexity, and physical, chemical, and biological characteristics and processes (Mitsch and Gosselink 1993; Cowardin et al. 1979). For example, wetlands occur as small, isolated depressions with a uniform soil, stable hydrologic regimes, and monotypic vegetation community, or as large, heterogeneous complexes that exhibit a wide range of soil types, hydrologic regimes, and plant species composition. The variation exhibited by wetlands reflects the wide range of climatic, geologic, geomorphic, and hydrologic conditions in which they can occur and still exhibit the same general hydrologic, soil, and vegetative characteristics that define wetlands. For example, coastal salt marshes, fens, bogs, prairie potholes, pocosins, Carolina bays, cypress domes, vernal pools, playa lakes, freshwater marshes, bottomland hardwoods, mangrove swamps, red maple swamps, and riverine swamps are all wetlands, despite the fact that they occur under greatly different hydrologic regimes, plant and animal communities, soils, and climatic conditions (Mitsch and Gosselink 1993, page 32).

Wetlands have been classified in a variety of ways to meet different objectives (Brinson 1993; Mitsch and Gosselink 1993). This assessment approach uses the hydrogeomorphic classification developed by Brinson (1993) to identify groups of wetlands that function similarly. The hydrogeomorphic classification is based on three fundamental factors that influence how wetlands function, including geomorphic setting, water source, and hydrodynamics. Geomorphic setting refers to the landform of a wetland, its geologic evolution, and its topographic position in the landscape. For example, a wetland may occur in a depressional landform or a valley landform and may occur at the top, middle, or bottom of a watershed. Water source refers to the location of water just prior to entry into the wetland. All water on the land originates as precipitation, but in many cases the water will follow a circuitous path prior to entry into a wetland (Fetter 1988, pg 38). For example, water may enter the wetland directly as precipitation, follow a less direct path over the surface of the ground as overland flow or overbank flow, follow a subsurface path as interflow, throughflow, or baseflow, or any combination of these (Figure 2). Hydrodynamics refers to the energy level of moving water, and the direction that surface and near-surface water moves in the wetland. For example, the level of energy of an isolated wetland is generally lower than a wetland on a river floodplain, and the movement of water in a riverine wetland is generally unidirectional and downstream. In the hydrogeomorphic classification, each of these factors is treated separately; however, considerable interaction is recognized given the multivariate nature of ecosystems.

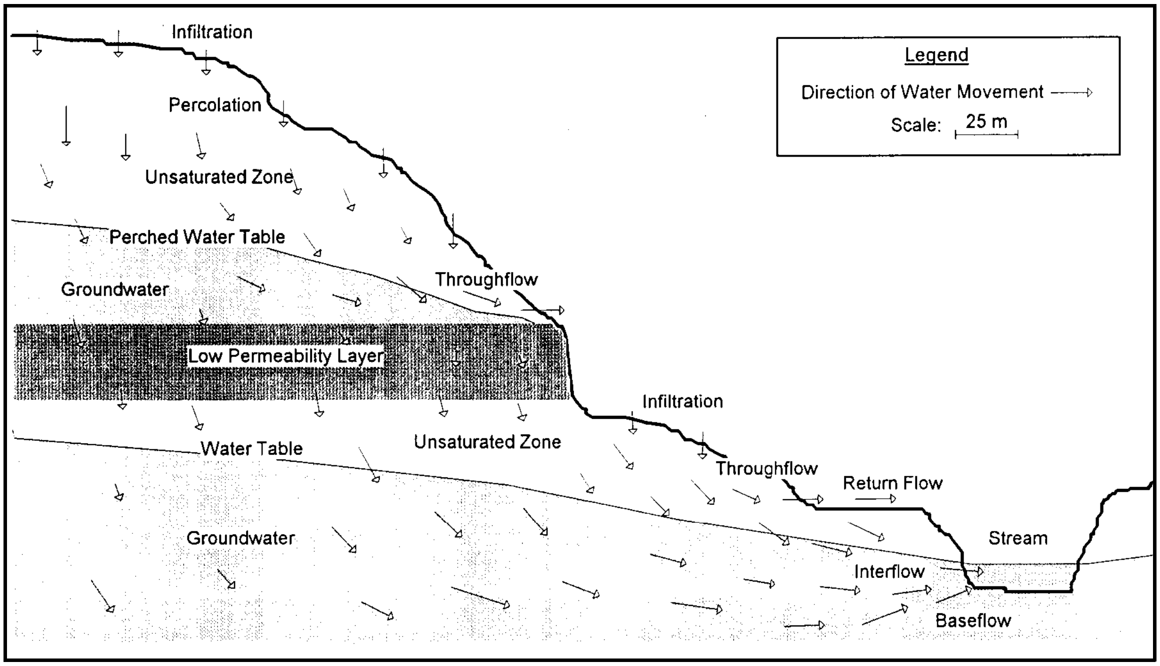

Figure 2. Potential water sources

At the highest level of hydrogeomorphic classification, wetlands are grouped into hydrogeomorphic wetland classes. Seven hydrogeomorphic classes including depression, lacustrine fringe, tidal fringe, slope, riverine, mineral flat, and organic flat are described below, and summarized in Table 1. Brinson (1993) discusses several of these classes in greater detail.

Depressional

Depressional wetlands occur in topographic depressions with a closed elevation contour that allows accumulation of surface water (Figure 3a). Dominant sources of water are precipitation, groundwater discharge, and interflow from adjacent uplands. The direction of water movement is normally from the surrounding uplands toward the center of the depression. Depressional wetlands may have any combination of inlets and outlets or lack them completely (Figure 3b-d). Depressional wetlands may lose water through intermittent or perennial drainage from an outlet, by evapotranspiration, and, if they are not receiving groundwater discharge, may slowly contribute to groundwater. Dominant hydrodynamics are vertical fluctuations, primarily seasonal. Peat deposits may develop in depressional wetlands. Prairie potholes are a common example of depressional wetlands.

Lacustrine fringe

Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland (Figure 4). In some cases, they consist

Table 1
Hydrogeomorphic Classes of Wetlands Showing Dominant Water Sources, Hydrodynamics, and Examples of Subclasses

Hydrogeomorphic Class (geomorphic setting)	Water Source (dominant)	Hydrodynamics (dominant)	Examples of Regional Subclass	
			Eastern USA	Western USA and Alaska
Riverine	Overbank flow from channel	Unidirectional and horizontal	Bottomland hardwood forests	Riparian forested wetlands
Depressional	Return flow from groundwater and interflow	Vertical	Prairie pothole marshes	California vernal pools
Slope	Return flow from groundwater	Unidirectional, horizontal	Fens	Avalanche chutes
Mineral soil flats	Precipitation	Vertical	Wet pine flatwoods	Large playas
Organic soil flats	Precipitation	Vertical	Peat bogs; portions of Everglades	Peat bogs
Estuarine fringe	Overbank flow from estuary	Bidirectional, horizontal	Chesapeake Bay marshes	San Francisco Bay
Lacustrine fringe	Overbank flow from lake	Bidirectional, horizontal	Great Lakes marshes	Flathead Lake marshes

of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional, usually controlled by water level fluctuations such as seiches in the adjoining lake. Lacustrine fringe wetlands are indistinguishable from depressional wetlands where the size of the lake becomes so small relative to fringe wetlands that the lake is incapable of stabilizing water tables. Lacustrine wetlands lose water by flow returning to the lake after flooding, by saturation surface flow, and by evapotranspiration. Organic matter normally accumulates in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are a common example of lacustrine fringe wetlands.

Tidal fringe

Tidal fringe wetlands occur along coasts and estuaries and are under the influence of sea level. They intergrade landward with riverine wetlands where tidal currents diminish and river flow becomes the dominant water source. Additional water sources may be groundwater discharge and precipitation. The interface between the tidal fringe and riverine classes is where bidirectional flows from tides dominate over unidirectional ones controlled by floodplain slope of riverine wetlands. Because they frequently flood and water table elevations are controlled mainly by sea surface elevation, tidal fringe wetlands seldom dry for significant periods. Tidal fringe wetlands lose water by tidal exchange, by saturation overland flow to tidal creek channels, and by evapotranspiration. Organic matter normally

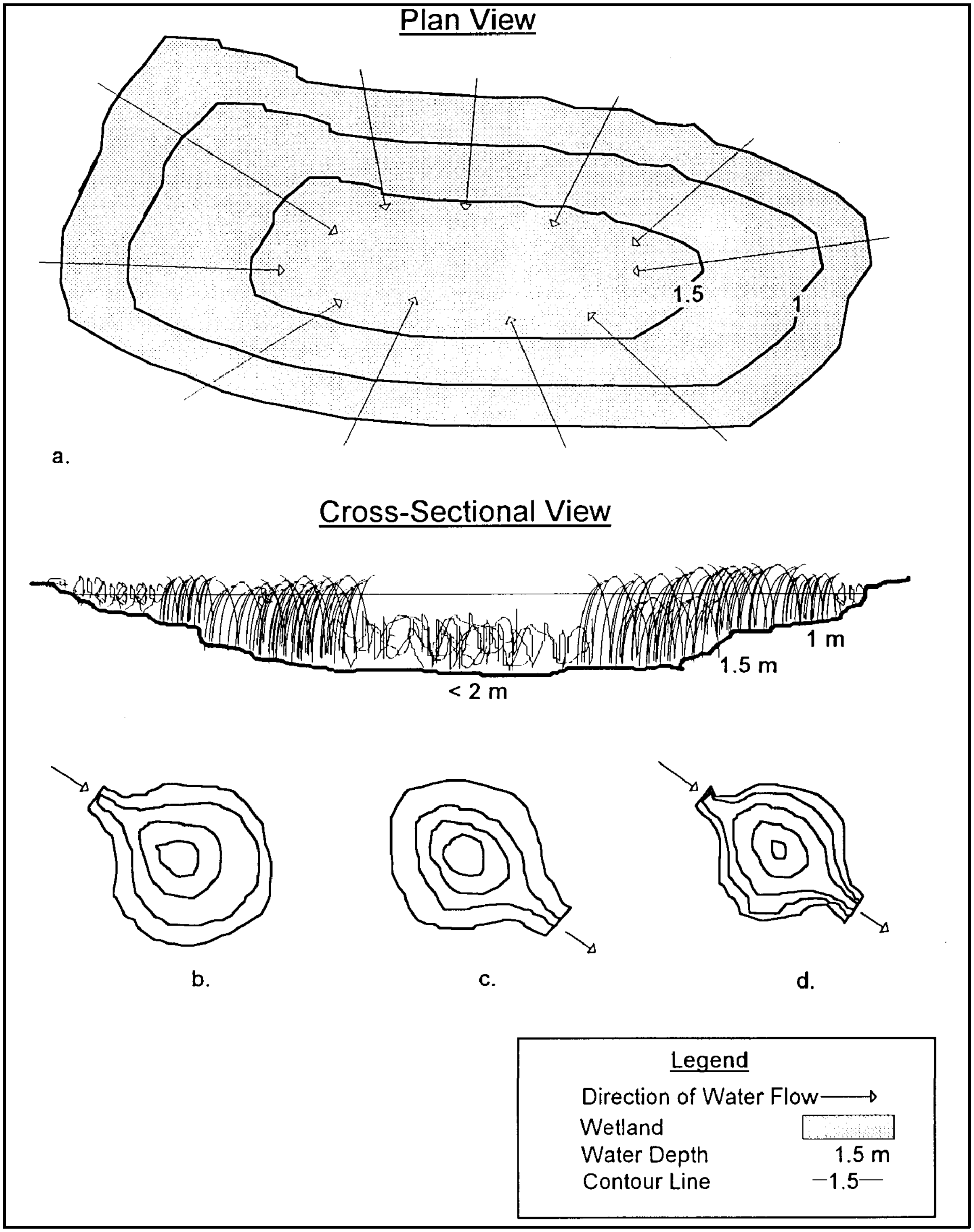

Figure 3. Depressional wetland in plan and cross-sectional view

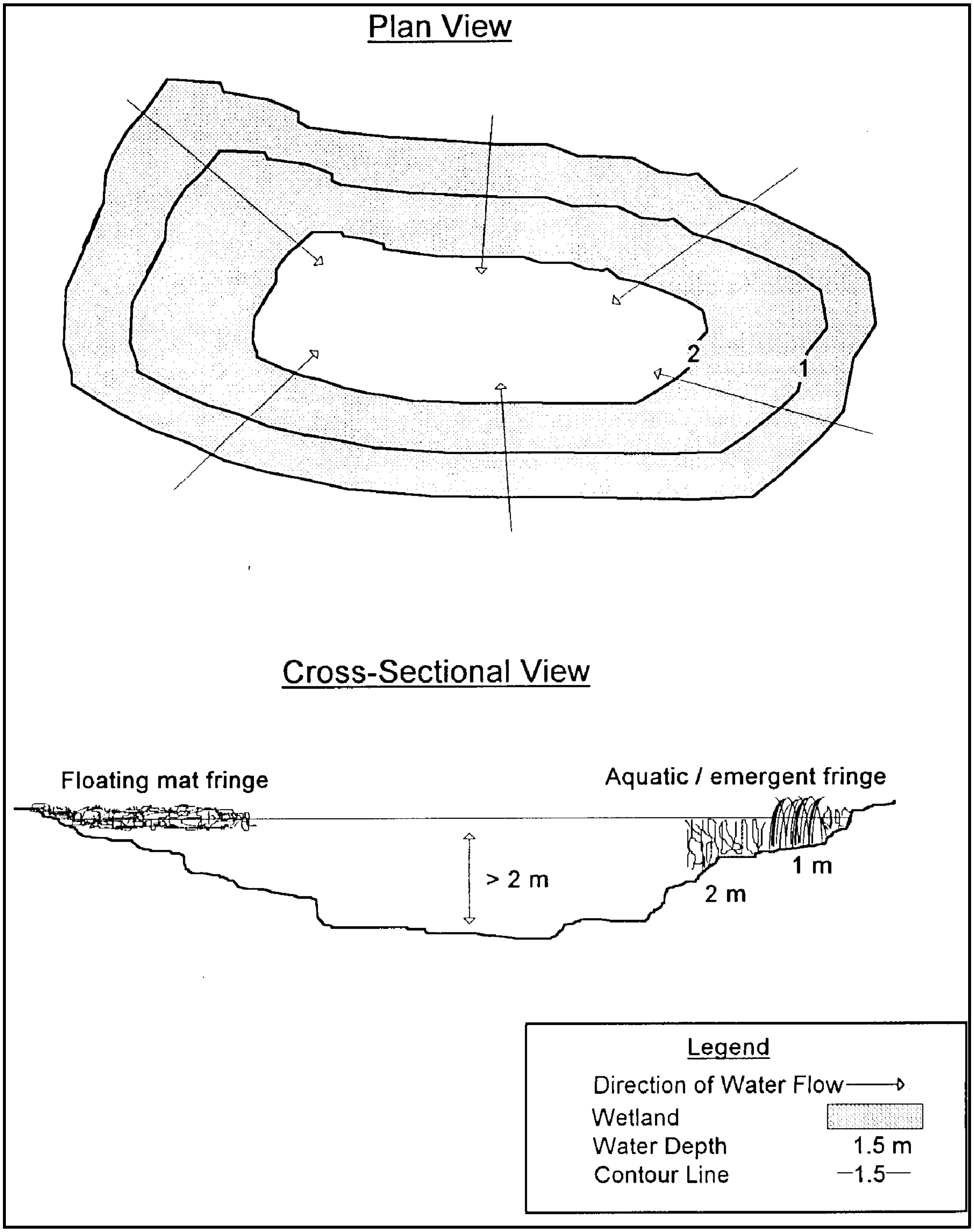

Figure 4. Lacustrine fringe wetland in plan and cross-sectional view

accumulates in higher elevation marsh areas where flooding is less frequent and they are isolated from shoreline wave erosion by intervening areas of low marsh. *Spartina alterniflora* salt marshes are a common example of estuarine fringe wetlands.

Slope

Slope wetlands normally are found where there is a discharge of groundwater to the land surface (Figure 5). They normally occur on sloping land; elevation gradients may range from steep hillsides to slight slopes. Slope wetlands are usually incapable of depressional storage because they lack the necessary closed contours. Principal water sources are usually groundwater return flow and interflow from surrounding uplands as well as precipitation. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturation subsurface and surface flows and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Fens are a common example of slope wetlands.

Riverine

Riverine wetlands occur in floodplains and riparian corridors in association with stream channels (Figure 6). Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional water sources may be interflow and return flow from adjacent uplands, occasional overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. At their headwater most extension, riverine wetlands often intergrade with slope or depressional wetlands as the channel (bed) and bank disappear, or they may intergrade with poorly drained flats or uplands. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through saturation surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evapotranspiration. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from riverine processes and subjected to long periods of saturation from ground-water sources. Bottomland hardwood floodplains are a common example of riverine wetlands.

Mineral soil flats

Mineral soil flats are most common on interfluves, extensive relic lake bottoms, or large floodplain terraces where the main source of water is precipitation (Figure 7). They receive virtually no groundwater discharge which distinguishes them

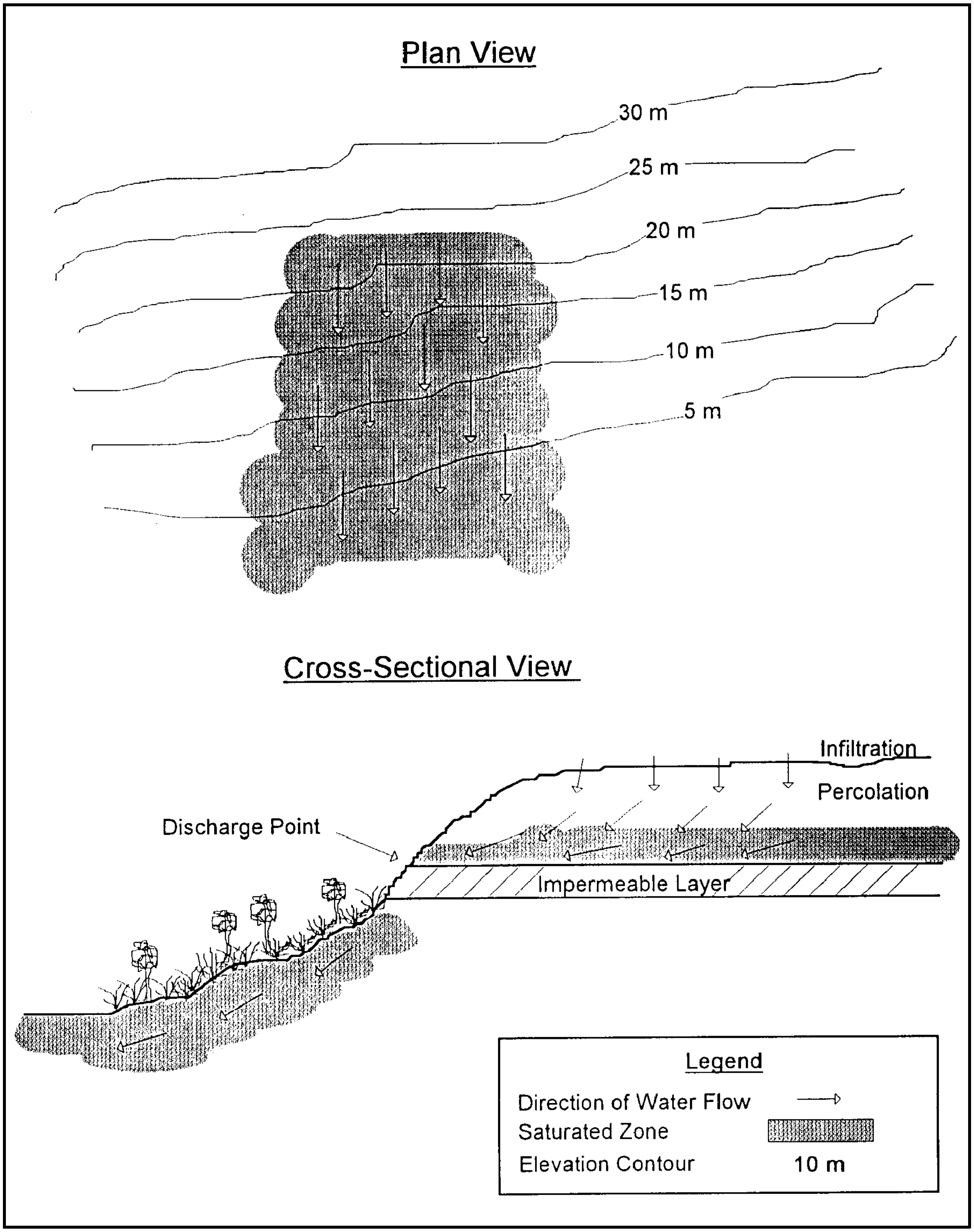

Figure 5. Slope wetland in plan and cross-sectional view

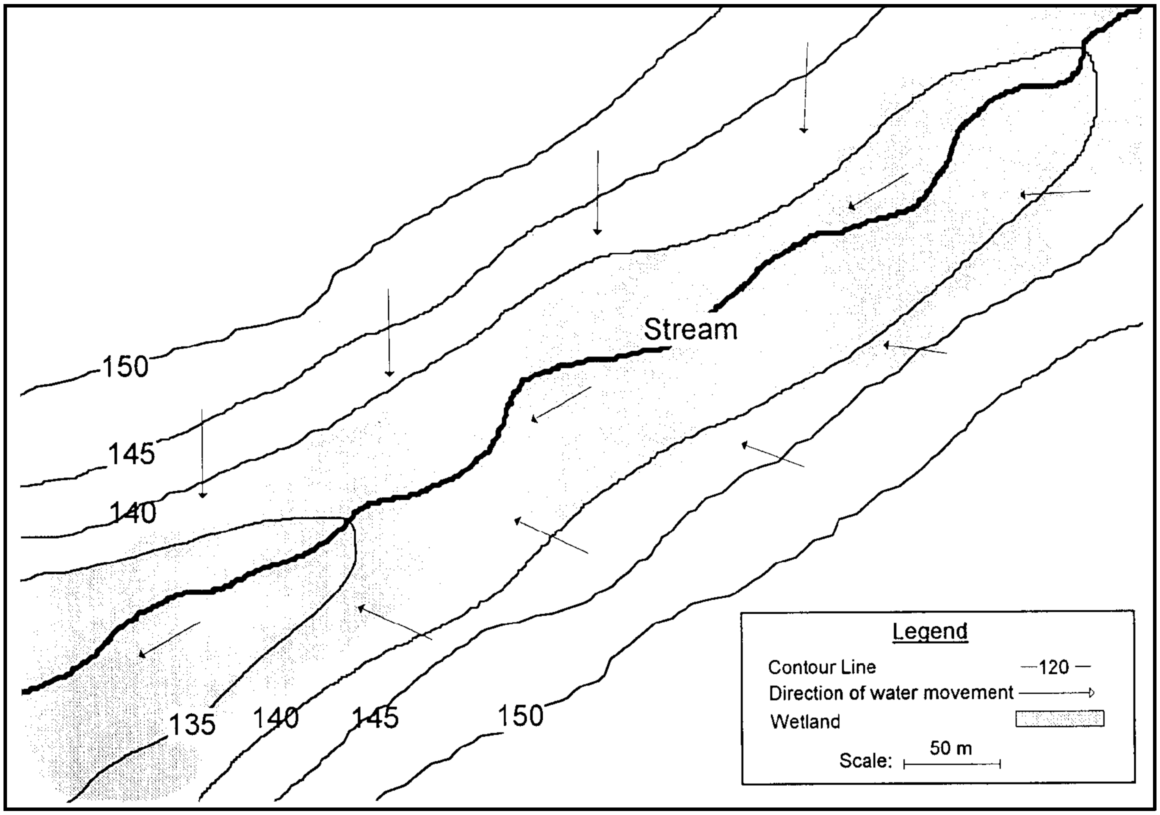

Figure 6. Riverine wetland in plan view

from depressions and slopes. Dominant hydrodynamics are vertical fluctuations. They lose water by evapotranspiration, saturation overland flow, and seepage to underlying groundwater. They are distinguished from flat upland areas by their poor vertical drainage, often due to spodic horizons and hardpans, and low lateral drainage, usually due to low hydraulic gradients. Mineral soil flats that accumulate peat can eventually become the class organic soil flats. Pine flatwoods with hydric soils are a common example of mineral soil flat wetlands.

Organic soil flats

Organic soil flats, or extensive peatlands, differ from mineral soil flats, in part, because their elevation and topography are controlled by vertical accretion of organic matter. They occur commonly on flat interfluves, but may also be located where depressions have become filled with peat to form a relatively large flat surface. Water source is dominated by precipitation, while water loss is by saturation overland flow and seepage to underlying ground- water. Raised bogs share many of these characteristics, but may be considered a separate class because of their convex upward form and distinct edaphic conditions for plants. Portions of the Everglades and northern Minnesota peatlands are common examples of organic soil flat wetlands.

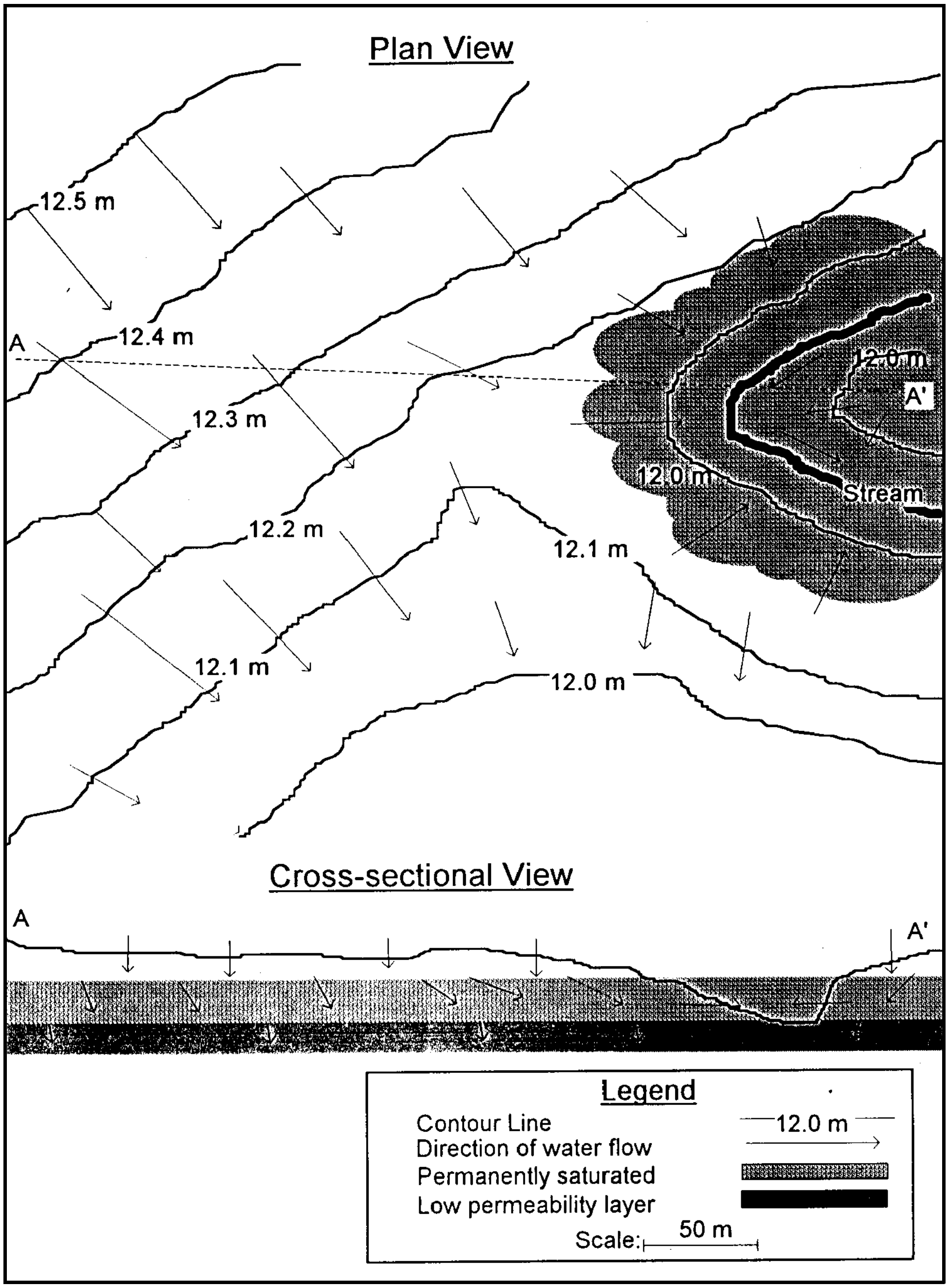

Figure 7. Mineral soil flats wetland in plan and cross-sectional view

Regional Wetland Subclasses

At a continental scale, the variability encompassed by a single hydrogeomorphic wetland class is great. For example, the depression wetland class includes wetland ecosystems as diverse as vernal pools in California (Zedler 1987), prairie potholes in North and South Dakota (Kantrud, Krapu, and Swanson 1989; Hubbard 1988), playa lakes in the High Plains of Texas (Bolen, Smith, and Schramm 1989), kettles in New England, and cypress domes in Florida (Kurz and Wagner 1953; Ewel and Odum 1984). In order to develop assessment models that are simple enough for use in the public interest review process, yet sensitive enough to detect change in function, the level of variability can be reduced by applying the hydrogeomorphic classification at a regional scale. Regions are defined as geographic areas that are relatively homogenous with respect to climate, geology, and other large-scale factors that influence wetland function (Hajic and Smith, In Preparation). For example, differences in precipitation (Munger and Eisenreich 1983; Groisman and Easterling 1994) and temperature may cause wetlands in the western United States to function differently from wetlands in the eastern United States. Similarly, the influence of glaciation in the Northeast may affect wetland function compared with wetlands in nonglaciated areas. A variety of regional classifications have been developed for the United States based on climatic, geologic, physiographic, and ecological criteria (Fenneman 1938; Atwood 1940; Bailey et al. 1994; Bailey 1994; Omernik 1987; U.S. Soil Conservation Service 1981). There is currently an interagency effort to integrate these regional classifications into a standard ecological map of the United States (U.S. Forest Service, U.S. Soil Conservation Service, and Bureau of Land Management 1994). These classifications are useful in helping to define the geographic area in which a regional subclass occurs.

There is considerable flexibility in defining wetland subclasses within a region. The hierarchical nature of the hydrogeomorphic classification makes it possible to work at different scales of resolution depending on the region, hydrogeomorphic class, or projects under consideration. The number of regional wetland subclasses defined will depend on a variety of factors such as the diversity of wetlands in the region, assessment objectives, the ability to actually measure functional differences with the time and resources available, and the predilection towards lumping or splitting. In many regions, wetland classifications have already been developed that account for interegional and intraregional differences in wetland ecosystems (Wharton 1978; Golet and Larson 1974; Stewart and Kantrud 1971). These classifications serve as a convenient starting point for identifying regional wetland subclasses.

Regional subclasses, like the hydrogeomorphic classes, are distinguished on the basis of geomorphic setting, water source, and hydrodynamics. However, additional ecosystem or landscape characteristics may also be useful in certain regions. For example, regional subclasses of depression wetlands could be based on water source (i.e., groundwater versus surface water) or the degree of connection between the wetland and other surface waters (i.e., the flow of surface water in or out of the depression through defined channels, Figure 3b,c,d). In the tidal fringe class, subclasses could be based on salinity gradients. In the slope class, subclasses could be based on the degree of slope, landscape position, the source of water (i.e., throughflow versus groundwater), or other factors. In the riverine class, subclasses could be based on water source, position in the watershed, stream order, watershed size, channel gradient, or floodplain width. Dichotomous key in Figure 8 shows an example of potential regional subclasses.

Wetland Functions

Ecosystems are normally characterized in terms of their structural components and the processes that link these components (Bormann and Likens 1969). Structural components of the ecosystem and the surrounding landscape, such as plants, animals, detritus, soil, and the atmosphere, interact through a variety of physical, chemical, and biological processes such as the movement of air and water and the flow of energy and nutrients. Understanding how the structural components of the ecosystem and the surrounding landscape are linked together by processes is the basis for assessing ecosystem functions.

Wetland functions are defined as the normal or characteristic activities that take place in wetland ecosystems or simply the things that wetlands do. Wetlands perform a wide variety of functions in a hierarchy from simple to complex as a result of their physical, chemical, and biological attributes (Figure 9). For example, the reduction of nitrate to gaseous nitrogen is a relatively simple function performed by wetlands when aerobic and anaerobic conditions exist in the presence of denitrifying bacteria. Nitrogen cycling and nutrient cycling represent increasingly more complex wetland functions that involve a greater number of structural components and processes. At the highest level of this hierarchy is the maintenance of ecological integrity, the function that encompasses all of the structural components and processes in a wetland ecosystem.

It is not possible in 404 to assess all wetland functions at all levels of complexity. Consequently, the public interest review process focuses on those functions that directly or indirectly benefit the public interest. The 404 Program Regulations (33 CFR, Section 320.4 (b)(2)) provide some guidance in the selection of functions by identifying a suite of functions that “important” wetlands perform. The functions listed in Table 2 are based on this guidance as well as other literature sources (Adamus et al. 1987; Conservation Foundation 1988).

A general list of wetland functions provides a convenient starting point for identifying which functions a wetland is most likely to perform. However, it is often inappropriate to assess a wetland for all the functions in a standard suite because not all wetlands perform all functions to the same degree or magnitude, if at all. For example, it makes little sense to assess the capacity of a wetland in an isolated depression to store floodwater or export carbon to downstream areas. The functions selected for assessment should reflect the characteristics of the wetland ecosystem and landscape under consideration and the assessment objectives. By narrowing the focus to a regional subclass, it is possible to identify the functions that are most likely to be performed and of greatest benefit to the public interest (Brinson et al. 1994). This is different from the approach taken by many of the existing assessment methods that assess a standard suite of functions for all wetlands, regardless of whether a function is likely to be performed or not (Adamus et al. 1987; Adamus et al. 1991; Ammann et al. 1987; and Hollands and Magee 1986).

Key to Hydrogeomorphic Wetland Classes and Regional Subclasses *

1.	Wetland is under the influence of tides	2
1.	Wetland is not under the influence of tides	4
2.	Salinity greater than 30 ppt	Tidal Fringe (Euhaline)
2.	Salinity less than 30 ppt	3
3.	Salinity 5-30 ppt	Tidal Fringe (Mixohaline)
3.	Salinity less than 5 ppt	Riverine (Tidal)
4.	Wetland is topographically flat and has precipitation as a dominant source of water	5
4.	Wetland is not topographically flat and does not have precipitation as a dominant source of water	6
5.	Wetland has a mineral soil	Mineral Soil Flats
5.	Wetland has an organic soil	Organic Soil Flats
6.	Wetland is associated with a stream channel, floodplain, or terrace	7
6.	Wetland is associated with a topographic depression or on a topographic slope or flat	9
7.	Stream is intermittent or ephemeral	Riverine (Nonperennial)
7.	Stream is perennial	8
8.	Stream is 1st or 2nd order	Riverine (Upper perennial)
8.	Stream is 3rd order or higher	Riverine (Lower perennial)
9.	Wetland located in a natural or artificial (dammed) topographic depression	10
9.	Wetland located on a topographic slope	13
10.	Topographic depression has permanent water >2 meters deep, and wetland is restricted to the margin of the depression	Lacustrine Fringe
10.	Topographic depression does not contain permanent water >2 meters deep	11
11.	Topgraphic depression closed without discernable surface water inlets, outlets, or other connections	Depression (Closed)
11.	Topographic depression open with discernable surface water inlets, outlets, or other connections	12
12.	Primary source of water is ground water	Depression (Open, Ground Water)
12.	Primary source of water is precipitation, overland flow, or interflow	Depression (Open, Surface Water)
13.	Primary source of water is ground water	Slope
13.	Primary source of water is precipitation	Organic Soil Flats

* Hydrogeomorphic classes are followed by regional subclass in parenthesis

Figure 8. Key to hydrogeomorphic wetland classes and regional subclasses

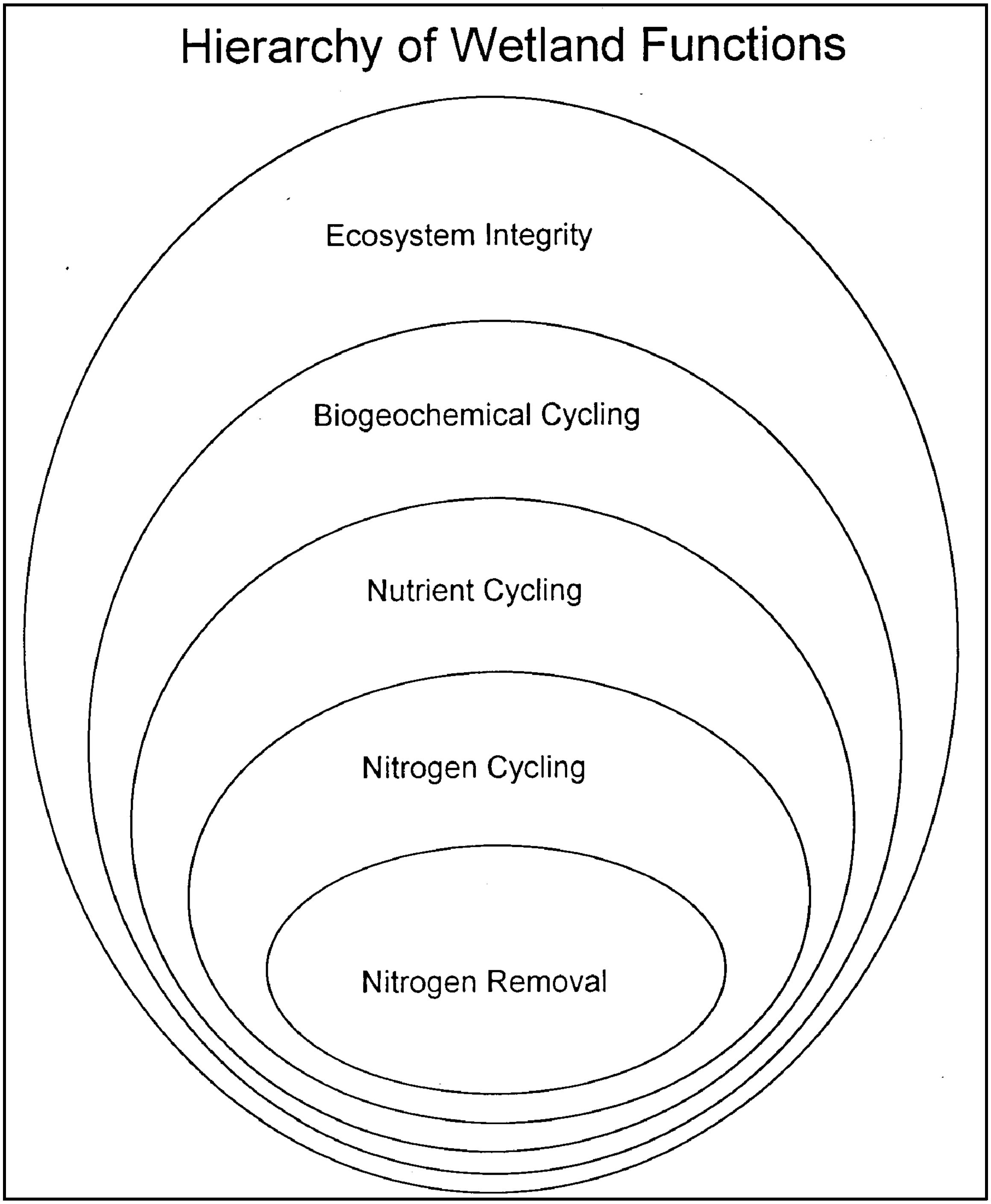

Figure 9. Hierarchy of wetland functions

Table 2
Wetland Functions and Their Value

Functions Related to Hydrologic Processes	**Benefits, Products, and Services Resulting from the Wetland Function**
Short-Term Storage of Surface Water: the temporary storage of surface water for short periods.	Onsite: Replenish soil moisture, import/export materials, conduit for organisms. Offsite: Reduce downstream peak discharge and volume and help maintain and improve water quality.
Long-Term Storage of Surface Water: the temporary storage of surface water for long periods.	Onsite: Provide habitat and maintain physical and biogeochemical processes. Offsite: Reduce dissolved and particulate loading and help maintain and improve surface water quality.
Storage of Subsurface Water: the storage of subsurface water.	Onsite: Maintain biogeochemical processes. Offsite: Recharge surficial aquifers and maintain baseflow and seasonal flow in streams.
Moderation of Groundwater Flow or Discharge: the moderation of groundwater flow or groundwater discharge.	Onsite: Maintain habitat. Offsite: Maintain groundwater storage, baseflow, seasonal flows, and surface water temperatures.
Dissipation of Energy: the reduction of energy in moving water at the land/water interface.	Onsite: Contribute to nutrient capital of ecosystem Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality
Functions Related to Biogeochemical Processes	**Benefits, Products, and Services Resulting from the Wetland Function**
Cycling of Nutrients: the conversion of elements from one form to another through abiotic and biotic processes.	Onsite: Contributes to nutrient capital of ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Removal of Elements and Compounds: the removal of nutrients, contaminants, or other elements and compounds on a short-term or long-term basis through burial, incorporation into biomass, or biochemical reactions.	Onsite: Contributes to nutrients capital of ecosystem. Contaminants are removed, or rendered innocuous. Offsite: Reduced downstream loading helps to maintain or improve surface water quality.
Retention of Particulates: the retention of organic and inorganic particulates on a short-term or long-term basis through physical processes.	Onsite: Contributes to nutrient capital of ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Export of Organic Carbon: the export of dissolved or particulate organic carbon.	Onsite: Enhances decomposition and mobilization of metals. Offsite: Supports aquatic food webs and downstream biogeochemical processes.
Functions Related to Habitat	**Benefits, Goods and Services Resulting from the Wetland Function**
Maintenance of Plant and Animal Communities: the maintenance of plant and animal community that is characteristic with respect to species composition, abundance, and age structure.	Onsite: Maintain habitat for plants and animals (e.g., endangered species and critical habitats), for rest and agriculture products, and aesthetic, recreational, and educational opportunities. Offsite: Maintain corridors between habitat islands and landscape/regional biodiversity.

Value of Wetland Functions

In 404, it is necessary to make a clear distinction between wetland functions and the value of wetland functions. This is because the public interest review process requires not only that the loss of wetland function be quantified, but that a value be assigned to those functions that are lost. The 404 permit decision is based on a "balancing" process that compares the value assigned to the benefits, goods, and services resulting from a proposed project to the value assigned to the wetland functions that are lost as a result of the proposed project. This assessment approach is designed to estimate the loss, or gain, of wetland function as a result of a proposed project. It was not designed to assign a value to that loss or gain of wetland function. Assigning value requires the consideration of a variety of subjective factors beyond the ecosystem and landscape characteristics that are considered in assessing wetland functions.

Value is a term that can be defined or interpreted in several ways. For example, Brown (1984) considered value to be either "held" or "assigned." He characterized a held value as a precept, belief, or ideal of an individual or group, and an assigned value is the relative importance of something to an individual or group. Throughout this assessment approach, the term value will be used in the latter sense of assigned value or a measure of the relative importance of a wetland function to an individual or group. Implicit in the concept of assigned value is the recognition that different individuals or groups may assign a different value to wetland functions.

In the wetland literature, the term value has been used in association with wetland functions in at least two ways. Taylor, Cardamone, and Mitch (1990) use the term values to refer to the benefits, goods, and services that result from the functions performed by wetlands. This use is unnecessarily confusing. The benefits, goods, and services resulting from wetland functions should simply be called benefits, goods, and services, not wetland values. Similarly, Ammann, Franzen, and Johnson (1986) and Ammann and Lindley-Stone (1991) use the term functional values to identify the functions performed by wetlands that are considered to be valuable to society. Again, this is unnecessarily confusing. The subset of wetland functions that are valuable to the public should be called valuable wetland functions, not functional values.

A number of methods are available for assigning economic value to the functions performed by wetlands. The simplest method is to assign economic value to the benefits, goods, and services resulting from wetland functions in terms of dollars or other economic value units. This method works well for the benefits, goods, and services that are exchanged on the open market and can be assigned a market price that establishes value by integrating all the factors that enter into the willingness of people to pay for benefits, goods, and services. For example, the timber products harvested from forested wetlands are exchanged on the open market and can be assigned an economic value based on market price.

Many of the benefits, goods, and services resulting from wetlands cannot be assigned an economic value because they are not exchanged on the open market and consequently have no market price. For example, consider the benefits and services that result from the floodwater storage function performed by some wetlands. In a number of cases, the presence of flood storage areas in the upper and middle portions of a watershed has been found to be important in reducing the level of flooding in downstream areas (Ogawa and Male 1983; Doyle 1986; Demissie and Khan 1993). Reduced levels of flooding are beneficial to farmers and homeowners that work and live in flood prone areas. However, since flood reduction is not a service exchanged on the open market, it cannot be assigned a value based on market price. As a consequence, this service resulting from the wetland function of flood storage has traditionally been ignored when determining cost-benefit ratios of projects that impact wetlands.

There are methods available for assigning an economic value to benefits, goods, and services resulting from wetland functions that are not exchanged on the open market. They include replacement cost analysis, travel cost analysis, contingent valuation, and conjoint analysis (Shabman and Batie 1988; Luzar and Gan 1991). There are also methods available for assigning noneconomic measures of value (Siden and Worrell 1979). For example, in the United States and other countries, the public often assigns value to the benefits, products, and services resulting from wetland functions by passing laws that are designed to protect wetlands as well as water quality, air quality, natural lands, cultural and historic sites, and endangered species for the public good. Guidelines and recommendations for assigning economic and noneconomic value to the benefits, goods, and services that result from wetland functions in the 404 public interest review are discussed by Henderson (1993).

Functional Capacity

In this assessment approach, the change in the ability of a wetland to perform a function is measured in terms of functional capacity. Functional capacity is defined as the degree to which an area of wetland performs a specific function. Throughout this document all discussions of functional capacity refer to the ability of a wetland area to perform a single function and not the capacity of a wetland to perform across multiple functions (i.e., functional capacity is not an aggregate or summed measure of the capacity of a wetland area to perform multiple functions).

Functional capacity can be quantitatively measured (i.e., interval or ratio scale data), or qualitatively estimated (i.e., nominal or ordinal scale data). For example, the functional capacity of a wetland area to store floodwater on an annual basis can be measured in terms of cubic or acre feet per year or estimated to be high or low. Similarly, the functional capacity of a wetland area to remove nitrogen or accumulate sediments on an annual basis can be measured in terms of grams per meter squared per year or estimated to be normal, above normal, or below normal.

The functional capacity of a wetland is determined by characteristics of the wetland ecosystem such as hydrologic regime, plant species composition, and soil type, and the larger systems that surround it. The larger system surrounding a wetland ecosystem is the landscape or the "...heterogeneous land area composed of a cluster of interacting ecosystems that is repeated in a similar form throughout" (Forman and Godron 1986). Depending on the function under consideration, the role of the landscape may be more or less important. Numerous examples of how the landscape surrounding a wetland ecosystem influences wetland function are available. For example, the landscape surrounding a wetland can influence the hydrologic regime (Beaumont 1975; Hill and Keddy 1992), water quality (Ehrenfeld and Schneider 1993; Zampella 1994), the rate at which sediment is accumulated (Kleiss, In Preparation), biomass and organic matter (Holt, Blum, and Hill 1995), plant community composition (Dolores-Holt 1995), or the ability of a wetland to provide habitat (Szaro and Jakle 1985; Knopf and Samson 1994). At a larger regional scale, climate, geology, and other factors can influence the functional capacity of a wetlands (Hajic and Smith, In Preparation).

A simple analogy can be used to illustrate how a wetland ecosystem and the surrounding landscape interact to determine the functional capacity of the wetland. Consider a water pump as a system and the movement of water a function it performs. The functional capacity of the water pump is the rate (e.g., gallons/minute) at which the pump moves water. The rate is determined by the characteristics of the system (i.e., the water pump) and the environment in which it occurs (i.e., sources of water and power). The highest, sustainable functional capacity of the water pump is 100 gallons/minute. This is achieved when the water pump is mechanically sound and connected to an abundant source of water and power. However, it is possible for the functional capacity of a water pump to fall below this highest, sustainable level of functional capacity as characteristics of the water pump or the environment change. For example, if the water pump develops mechanical problems or if the source of water or power become unreliable, the functional capacity of the pump could be reduced to a rate that is less than 100 gal/min. Therefore, depending on conditions in the system and surrounding environment, the functional capacity of the water pump could range from 0.0 gal/min (i.e., the pump was broken or disconnected from a source of water or power) to 100 gal/min (i.e., highest, sustainable functional capacity under optimal conditions).

Now, consider how the characteristics of a riverine wetland and surrounding watershed interact to determine functional capacity of the riverine wetland with respect to the flood storage function. The capacity of a riverine wetland to store floodwater depends on ecosystem characteristics such as elevation relative to an adjacent stream, microtopographic relief, slope, vegetation density, and other factors that influence the volume available for storing floodwater and the degree of roughness in the wetland. It also depends on characteristics of the surrounding watershed such as size, runoff coefficients, the location of control points, and other factors that determine the frequency, duration, magnitude, and seasonality of overbank flood events. As the characteristics of the wetland ecosystem or the surrounding landscape change, the functional capacity of the riverine wetland to store floodwater may increase or decrease.

Reference Standards

In the 404 public interest review, the objective for assessing wetland functions is to determine the impact of a proposed project on wetland functions. In the larger context, this supports the objective of the Clean Water Act (33 U.S.C.1344) which is, "... to restore and maintain the chemical, physical, and biological integrity of the waters of the United States." However, in order to support this objective in assessing impacts to wetland functions, standards of comparison must be defined for what constitutes chemical, physical, and biological integrity in the context of wetland.

This assessment approach defines the standards of comparison, or reference standards, to be the conditions under which the highest, sustainable functional capacity occurs across the suite of functions that are naturally performed by a wetland ecosystem. The approach assumes that highest, sustainable functional capacity is achieved in wetland ecosystems and landscapes that have not been subject to long-term anthropogenic disturbance. Under these conditions, the structural components and physical, chemical, and biological processes in the wetland and surrounding landscape reach the dynamic equilibrium necessary to achieve highest, sustainable function capacity.

In theory, it should be possible to simply characterize the conditions found in undisturbed wetland ecosystems and landscapes to establish reference standards. In practice, several complications arise. First, wetland ecosystems and their surrounding landscapes are dynamic and constantly changing. As the characteristics that influence function change, functional capacity may increase or decrease. These changes are the result of natural short-term processes such as seasonal cycles of precipitation and temperature and long-term processes that include population dynamics, erosion and depositional processes, succession, drought/wet cycles, or sea level rise. For example, the volume available for storing floodwater in a riverine wetland could be reduced over a period of years as sediments gradually accumulate in a wetland or as a river channel migrates. In many types of wetland ecosystems (i.e., regional subclasses) including coastal marshes (Oviatt, Nixon, and Garber 1977), riverine forests (Brinson 1990), cypress swamps (Ewel and Odum 1984), red maple swamps (Golet 1993), and prairie potholes (Kantrud, Krapu, and Swanson 1989), intrasystem variability is the rule rather than the exception. In establishing reference standards, the variability that occurs as a result of natural processes must be taken into account.

The second factor that complicates the establishment of reference standards is that much of the variability exhibited by wetland ecosystems and landscapes is in response to anthropogenic disturbance. Disturbance has occurred widely in the form of land-use changes and hydrologic alteration of streams and rivers through impoundment and channelization. In many cases, several hundred years of continuing disturbance has fundamentally changed the way wetland ecosystems function in the context of the disturbed surrounding landscape. Sometimes it is possible to reconstruct undisturbed conditions using historical descriptions, aerial photographs, or other data; but in most cases, the necessary information is unavailable. The lack of undisturbed wetland ecosystems and landscapes makes it difficult to establish reference standards that reflect the functional capacity of a regional subclass under undisturbed conditions.

The changes resulting from anthropogenic disturbance often occur more quickly than the changes resulting from natural processes. For example, flood storage capacity in a riverine wetland could be lost in a matter of hours or days as fill material is placed in the wetland. Similarly, a wetland ecosystem could quickly lose its functional capacity to store floodwater as a result of being permanently flooded or cut off from the source of floodwater by a levee. In addition, anthropogenic disturbance can also affect the capacity of a wetland to perform functions differentially. For example, it is not uncommon for a wetland ecosystem that exists under disturbed conditions to achieve a level of functional capacity, for one or two functions, that exceeds the highest, sustainable functional capacity achieved in undisturbed wetlands and landscapes. In some situations, the increase is the direct result of intentional management and is often referred to as “enhancement” of wetland functions. Regardless of whether the increase is intentional or not, it is usually not sustainable over the long term or occurs at the expense of reduced capacity for other functions. For example, managing forested wetlands on floodplains to enhance certain habitat functions has been found to have long-term effects on the sustainability of the habitat function as well as other functions performed by riverine wetlands (King 1995; Karr et al. 1990). Similarly, a wetland that retains large amounts of sediment from a recently cleared watershed will often fill rapidly and then cease to perform functions related to sediment retention.

Reference Wetlands and Reference Domain

Because wetland ecosystems exhibit a wide range of conditions as a result of natural processes and anthropogenic disturbance, and few undisturbed wetland ecosystems or landscapes exist, this assessment approach establishes reference standards based on reference wetlands. Reference wetlands are actual wetland sites that represent the range of variability exhibited by a regional wetland subclass as a result of natural processes and anthropogenic disturbance. In establishing reference standards, the geographic area from which reference wetlands are selected is the reference domain. The reference domain may include all, or part, of the geographic area in which the regional subclass actually occurs. The size and location of the reference domain can significantly affect the reference standards established for a regional wetland subclass. For example, if the reference domain selected is a relatively large geographic area, it is more likely to include the full range of conditions that exist across the entire geographic area in which the regional subclass occurs. However, if the reference domain is small (e.g., a subwatershed), it is more likely that it will encompass a narrower range of conditions than will occur across the entire geographic area in which a regional subclass occurs. Similarly, if the reference domain is in close proximity to developed areas, it is more likely to include more disturbed conditions in the wetlands.

The selection of a reference domain should reflect assessment objectives. For example, if the objective of a project is to compare wetlands within a subwatershed, an argument could be made for defining the reference domain to be all the wetlands from a regional subclass within the subwatershed under consideration. The advantage of defining a reference domain of small geographic area is the potential to reduce variability and therefore be able to develop functional indices with greater resolution. The disadvantage of a geographically small reference domain is the loss of the "big picture" in terms of how a specific wetland compares with all other wetlands in the regional subclass throughout the geographic area in which the subclass occurs. In the case of 404, it is arguably more important to understand the functional capacity of wetlands from a regional subclass relative to the variability exhibited by the regional subclass throughout the geographic region in which it occurs. Thus, a relatively large reference domain should be selected for using the approach in 404.

Once the reference domain has been defined, there are a variety of approaches for selecting reference sites, establishing the variability of a regional subclass in a reference domain, and defining reference standards. Guidelines are provided in a later section.

Site Potential

Theoretically, any wetland can achieve the highest, sustainable functional capacity that corresponds to reference standards established for a reference domain. However, it may take hundreds of years for the ecosystem and landscape to recover from the affects of disturbance and achieve the conditions represented by reference standards. For practical reasons, therefore, it is useful to define the concept of site potential to indicate the highest sustainable functional capacity that can be achieved in a reasonable period of time by a wetland, given disturbance history, land use, or other ecosystem and landscape scale factors that influence function. In many cases, disturbance in the surrounding landscape will be the factor that limits the site potential of a wetland ecosystem. For example, it can reasonably be assumed that a riverine wetland downstream from a dam has permanently lost its capacity to perform functions that rely on overbank flood events if, under normal circumstances, the dam operation prevents overbank flooding. In this example, both functional capacity and site potential are reduced. The same riverine wetland may temporarily lose its capacity to provide the habitat function for certain species, but retain site potential as a result of a hurricane, land clearing, or logging. In other cases, hydrologic modifications may result in a slow process of functional degradation that is not fully manifested for decades or even centuries (Klimas 1987).

The distinction between functional capacity and site potential is essentially one of existing versus potential functional capacity of a wetland. Depending on the degree and extent of disturbance and the time required for recovery, the site potential of a wetland may be equivalent to, or far less than, the highest sustainable functional capacity achieved under reference standards in the reference domain. In the cases where an irreversible disturbance has occurred, the wetland may undergo a "change of state" and be transformed into another type of wetland or nonwetland ecosystem (e.g., upland, parking lot, or residential development).

Functional Indices and Assessment Models

The single most important factor distinguishing one model from another is the degree of accuracy with which it represents the system being modeled (Chorley and Haggett 1967). This assessment approach uses functional indices based on multiple criteria assessment models (Smith and Theberge 1987) to estimate the functional capacity of a wetland. The accuracy of these models depends on at least three factors including the level of knowledge about a regional subclass, the skill of the individuals that develop the assessment model, and the ability of users to acquire the information necessary to use the model. In 404, all three factors constrain the degree of accuracy that can be built into assessment models. Classifying wetlands into regional subclasses based on hydrogeomorphic factors offsets these constraints to some degree by reducing variability, thereby facilitating the development of simpler assessment models.

Assessment models are simple representations of the relationship between attributes of the wetland ecosystem and the surrounding landscape, and the functional capacity of the wetland. Variables in the assessment model, such as plant species composition, overbank flow, and soil type, represent the attributes. Variables are assigned a subindex ranging from 0.0 to 1.0 based on the relationship between the variable and functional capacity. If the condition of a variable is similar to the reference standards defined for a reference domain, it is assigned a subindex of 1.0. As the condition of a variable deviates from the reference standard, it is assigned a progressively lower subindex that reflects the decrease in functional capacity.

Variables in the assessment model are assigned a subindex based on a quantitative (i.e., interval or ratio) or qualitative (i.e., nominal or ordinal) scale data. For example, the "frequency of overbank flow" variable could be assigned a subindex based on the continuous curve in Graph A in Figure 10, which is based on stream gauge records, daily observational records, or a hydrologic flow model (Hydrologic Engineering Center 1990). Alternatively, if frequency of flooding is based on more qualitative data, it would be more appropriate to assign a subindex based on categories. For example, in Graph B, Figure 10, a subindex of 1.0 is assigned to the variable when the frequency of overbank flooding is similar to the reference standard; a subindex of 0.5 is assigned when conditions in the wetland deviate somewhat from the reference standard; and a subindex of 0.1 when conditions in the wetland deviate greatly from the reference standard.

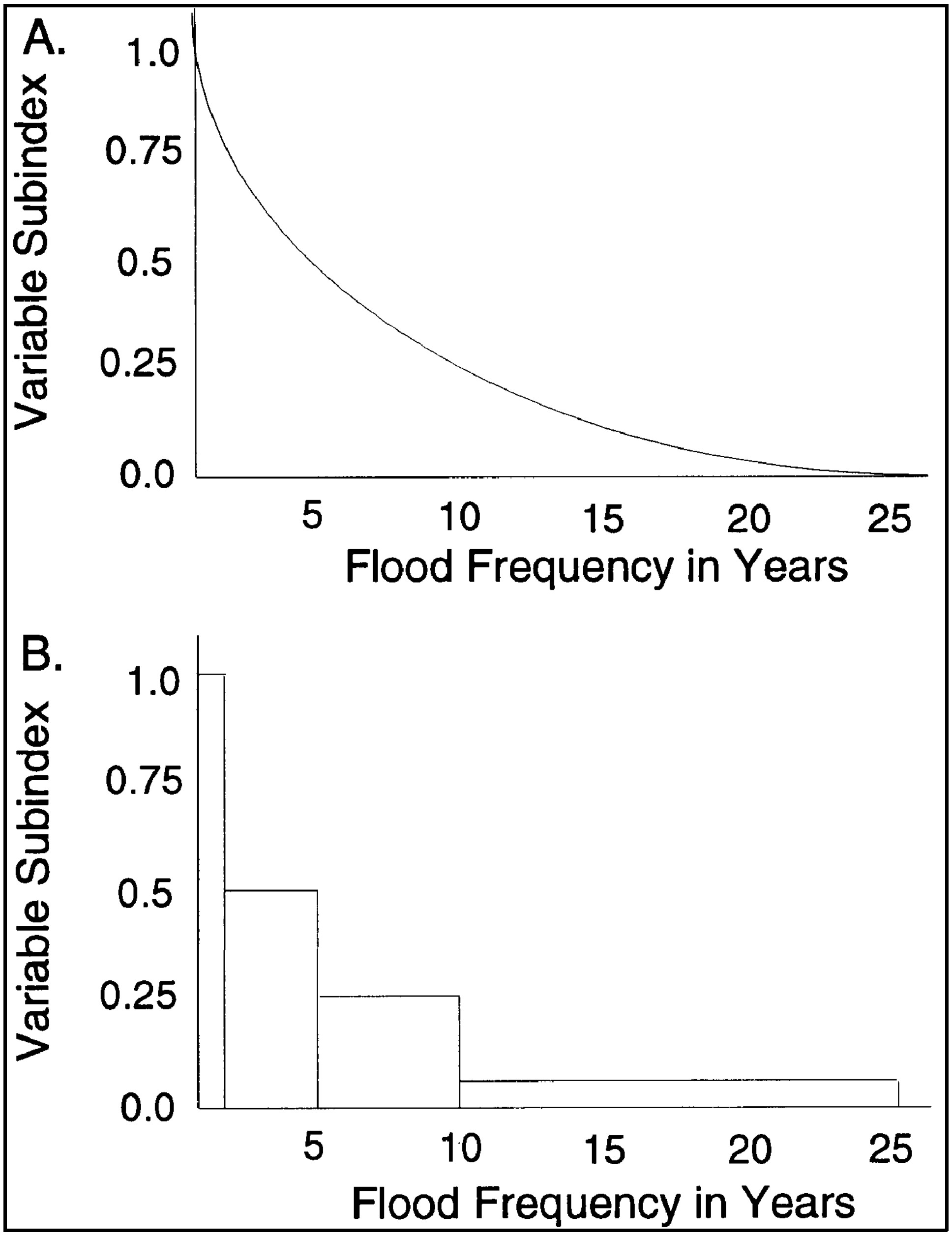

Figure 10. Flood frequency variable subindex based on quantitative and qualitative data

When it is impossible or impractical to assign a subindex based on a direct, quantitative or qualitative data, it may be possible to assign a subindex based on an indicator. Indicators are easily observed or measured characteristics that are correlated with a quantitative measure of a variable. For example, a subindex could be assigned to the frequency of overbank flow variable based on indicators such as the presence of certain vascular or nonvascular plant species or evidence of recent flooding such as water marks or wrack (Table 3).

Table 3
Assigning a Variable Subindex Based on Direct Measure or Indicators

Variable	Direct Measures and Indicators	Subindex
V1: Frequency of Overbank Flooding	Direct Measure 1. Stage data or hydrologic model output or observation by local resident indicates return interval <2 years. Indicators 1. Bryophyte-lichen pattern indicative of annual flooding present on tree trunks. OR 2. Evidence of recent flooding in nondrought year such as (a) undecomposed leaf litter, (b) fresh piles of wrack, or (c) silt on litterfall of the current year.	1.0
	Direct Measure 1. Stage data or hydrologic model output or observation by local resident indicates return interval >2 and <5 years. Indicators None	0.5
	Direct Measures 1. Stage data or hydrologic model output or observation by local resident indicates return interval >5 years. AND 2. No obvious long-term alteration of hydrology exists. Indicators 1. Bryophyte-lichen pattern indicative of annual flooding absent on tree trunks. OR 2. Lack of recent evidence of flooding in nondrought year such as (a) undecomposed leaf litter, (b) fresh piles of wrack, or (c) silt on litterfall of the current year. AND 3. No obvious long-term alteration of hydrology exists.	0.1
	Direct Measures 1. Stage data or hydrologic model output or observation by local resident indicates return interval >5 years. 2. Obvious long-term alteration of hydrology exists. Indicators 1. Bryophyte-lichen pattern indicative of annual flooding absent on tree trunks. OR 2. Lack of recent evidence of flooding in nondrought year such as (a) undecomposed leaf litter, (b) fresh piles of wrack, or (c) silt on litterfall of the current year. AND 3. Obvious long-term alteration of hydrology exists.	0.0

In addition to defining the relationship between variables and functional capacity, the assessment model defines how variables interact to influence functional capacity. The interaction between variables is defined using an

aggregation function (Ott 1978) or logical rules (Starfield 1990). The result is a functional capacity
index (FCI), which is the ratio of the functional capacity of a wetland under existing conditions, and the functional capacity of a wetland exhibiting reference standards for the regional subclass in the reference domain (Equation 1).

$$\text{FCI} = \frac{\text{Functional Capacity under Existing Conditions}}{\text{Functional Capacity under Reference Standards}}$$

Wetlands with a functional capacity index of 1.0 exhibit conditions similar to reference standards. The index decreases as conditions in the wetland deviate from reference standards. Wetlands with a functional capacity of 0.1 perform functions at a minimal, essentially unmeasurable level, but retain the potential for recovery. A wetland with a functional capacity of 0.0 does not perform the function and has lost the potential for recovery because, for all practical purposes, the change is permanent.

One of the strengths of this assessment approach is the flexibility that is possible in developing and calibrating assessment models. While the ultimate long-range goal is to develop assessment models with the relationship between variables and functional capacity based on empirical data from the reference wetlands, a realistic and practical short-term goal is to initiate model development and calibration using the best information and resources available, regardless of whether it represents the opinions of scientific experts, published literature, empirical data, or a combination of the above. The development of assessment models can begin with a simple formalization of a conceptual model that forces the concise articulation of the variables being used and relationships assumed in the conceptual model. It also provides documentation that serves as a hard target for criticism and testing and provides a foundation on which to develop improved models over time.

Good sources of information for developing or refining assessment models are existing models of wetland ecosystem processes and functions. For example, models of wetland function have been developed by Ammann, Franzen, and Johnson (1986), Ammann and Lindley-Stone (1991), Bartoldus, Garbisch, and Kraus (1994), and Hollands and Magee (1986); interpretation keys by Adamus (1983) and Adamus et al. (1987); rule-based models by Starfield (1990) and Starfield and Bleloch (1986); mechanistic models by the U.S. Fish and Wildlife Service (1980); indices of biological integrity by Karr et al. (1986); spatial models by Poiani and Johnson (1993); numerical models by Costanza and Sklar (1985); and simulation models by authors in Mitsch, Straskraba, and Jorgensen (1988) to name a few.

Finally, it should be noted that functional indices and assessment models used in this approach are in many ways similar to the indices and assessment models used in the Habitat Evaluation Procedure developed by the U.S. Fish and Wildlife Service (USFWS) (1980), the Index of Biological Integrity developed by Karr et al. (1986), as well as other biological and ecological indices. Because of these similarities, much of the background and rationale used in the development of these methods are relevant to this assessment approach particularly with respect to the selection of model variables, calibration of assessment models, and the aggregation of variables into an index. The U.S. Fish and Wildlife Services Ecological Services Manuals 101, 102, and 103 are particularly helpful (USFWS 1981a,b,c).

4 Development Phase

Assessment Team

Before the assessment procedure outlined in Chapter 5 can be applied to a specific regional wetland subclass, the development phase of the assessment approach must be completed. The objective of development phase is to develop a guidebook for assessing the functions of the regional subclass. The development phase should be conducted by an interdisciplinary assessment team, or A-team, composed of five to eight individuals with broad expertise in the areas of wetland ecology, geomorphology, biogeochemistry, hydrology, soil science, plant ecology, and animal ecology. Smaller groups lack the necessary breadth of expertise, and larger groups become unwieldy. The A-team should consist of individuals with expertise in a specific discipline as well as experience in the region under consideration. In addition, whenever possible, the A-team should include individuals representing national, State, and local agencies, as well as the private sector. Groups lacking necessary expertise or experience should contract for the services of appropriate experts.

The major technical and administrative responsibilities of the A-team are identified below and discussed in the following sections.

- Identify regional wetland subclasses.
- Prioritize regional subclasses for the purpose of allocating resources.
- Develop profile for selected regional subclass.
- Define reference domain.
- Identify reference wetlands and reference standards.
- Develop assessment models.
- Calibrate assessment models based on reference wetlands.
- Field test assessment models.

- Coordinate with other implementation efforts ongoing in the region (i.e., other A-teams).

- Provide quality assurance and control for assessment models and reference wetlands developed by independent parties.

- Maintain database for regional subclasses to include relevant literature, data, and reference wetland locations.

Identify and Characterize Regional Wetland Subclasses

The first task of the A-team is to classify the wetlands in a region based on hydrogeomorphic and other factors that influence how wetlands function in the region. The number of regional subclasses defined will depend on the diversity of wetlands within a region and assessment objectives. The team should begin by considering regional wetland classifications and other information available for wetlands in the region. For example, wetlands in Georgia have been classified by Wharton (1978); Sharitz and Gibbons (1982) synthesized information for Carolina bays in North and South Carolina; and Harris (1988) and Rosgen (1994) have conducted geomorphic studies on riparian ecosystems in the western United States. This type of information provides important clues concerning the factors responsible for much of the geomorphic, hydrologic, and biotic variation in these regions.

Once regional subclasses have been defined, and their geographic extent identified, a functional profile is developed to characterize the regional subclasses in terms of geomorphic setting, water source, hydrology, soils, vegetation, and other factors that influence function. The functional profile should also define the functions that the regional subclass is most likely to perform (Brinson 1993; Brinson et al. 1994) and discuss the ecosystem and landscape scale characteristics that influence each function. The U.S. Fish and Wildlife Service has developed community profiles for many regional wetland subclasses (Wharton et al. 1982; Golet 1993).

Define Reference Domain and Identify Reference Wetlands

The next task of the A-team is to define the reference domain and select reference wetlands that represent the range of variability across its geographic extent. Reference wetlands should represent the range of variation that results from both natural processes (e.g., succession, channel migration, erosion, and sedimentation) and anthropogenic disturbance in the reference domain. The number of reference wetlands required will depend on the geographic extent and variability within the regional subclass. Generally, the minimum number of reference wetlands that will be required is in the range of 15 to 25 sites. As reference wetlands are selected and characterized across the geographic range of the regional subclass sites, it will become apparent at some point that the variability that exists in the regional subclass is represented by the reference wetlands already identified, and that additional sites will not contribute substantive new variation. This is similar to the diminishing amount of new information that is gained after a certain number of samples are collected in the development of a species area curve in vegetation analysis (Cox 1980, pg. 175). The selection of reference wetlands is more complex however, because a variety of physical, chemical, and biological characteristics of the wetland ecosystem and landscape are being considered in addition to species diversity. Brinson and Rheinhardt (In Press) discuss the importance of reference wetlands in functional assessment and mitigation.

Develop Assessment Models

Following the identification of reference wetlands, the A-team will direct the development assessment models for the regional subclass using the literature (see Chapter 3), their expertise and experience, and information from reference wetlands. These assessment models may be adaptations of generic assessment models from national guidebooks developed for hydrogeomorphic classes such as riverine (Brinson et al., In Preparation) and tidal fringe (Lasalle and Hackney, In Preparation), or regional guidebooks for hydrogeomorphic classes such as riverine, depressional, slope, and fringe (Hollands and Magee, In Preparation). National or regional guidebooks for hydrogeomorphic classes characterize the hydrogeomorphic class, identify which functions are most likely to be performed by wetlands in the class, discuss the ecosystem and landscape characteristics that influence the capacity of wetlands to perform functions, and provide generic assessment models for assessing these functions. The national and regional guidebooks for hydrogeomorphic classes are intended to serve as a template for A-teams developing assessment models for regional subclasses based on reference wetlands.

Calibrate Assessment Models

Once the assessment models for a regional subclass have been developed, the A-team will use information from reference wetlands to establish reference standards, and calibrate assessment models. Several approaches to calibration are possible ranging from best professional judgment (Hollands and Magee, In Preparation) to multivariate analysis techniques (Brinson and Rheinhardt, In Press). A number of efforts are currently underway that will provide further examples of how to collect and use data from reference wetlands to calibrate assessment models. Figure 11 shows the location of these efforts which include the development of reference wetlands and assessment models in riverine wetlands in western Kentucky, western Tennessee, the Flathead River watershed in Montana, the Puget Sound area in Washington, the Santa Margarita River watershed in California, and the Upper Pearl River watershed in Mississippi. Work is also being done in depressional wetlands in the prairie pothole region, in California vernal pools, and in tidal fringe

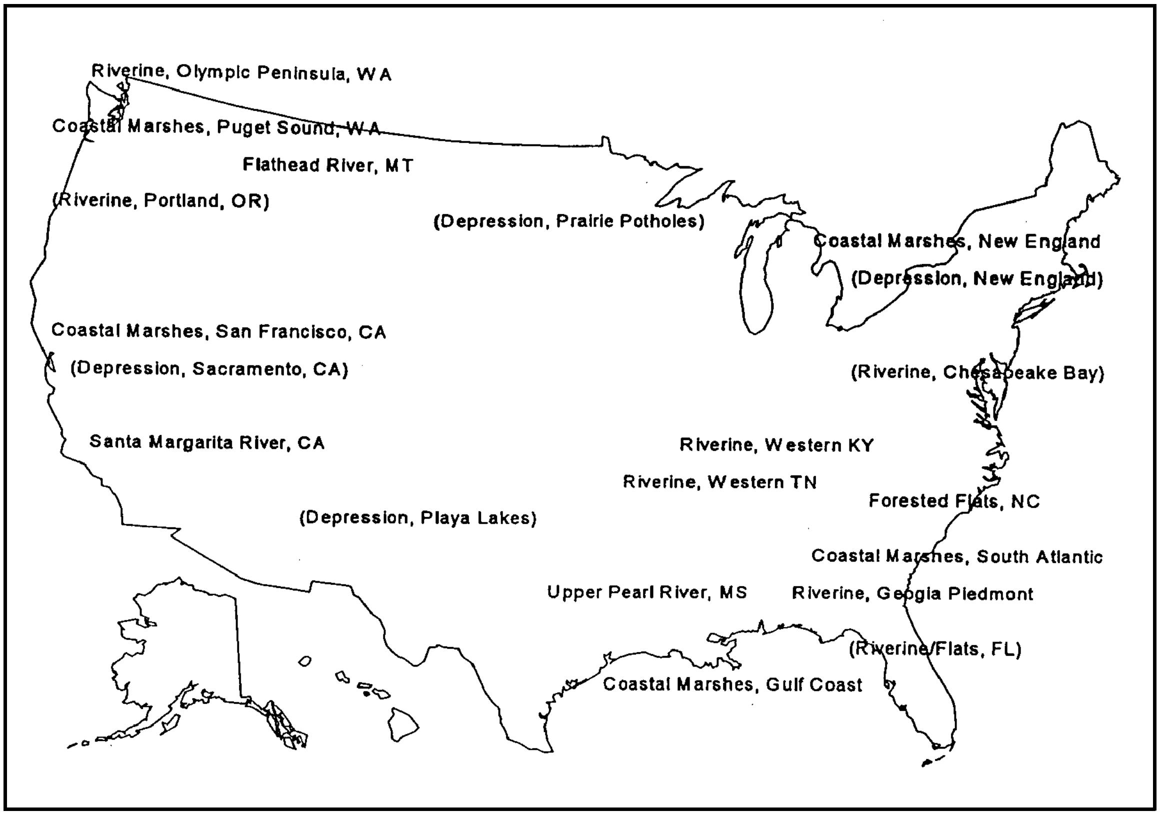

Figure 11. Locations of ongoing and planned efforts to identify reference wetlands and develop assessment models for regional subclasses

wetlands in the Puget Sound in Washington, San Francisco Bay in California, the Gulf Coast in Mississippi and Texas, several locations along the South Atlantic Coast and the New England Coast (Lasalle and Hackney, In Preparation). Similar efforts are underway in mineral soil flats in North Carolina and Florida.

5 Application Phase: The Assessment Procedure

The application phase of the approach, or assessment procedure, consists of a sequence of steps for applying functional indices in a regulatory, management, or planning context. The procedure includes a characterization, assessment, and analysis phase. The sequence of steps in each phase is illustrated in Figure 12 and discussed later.

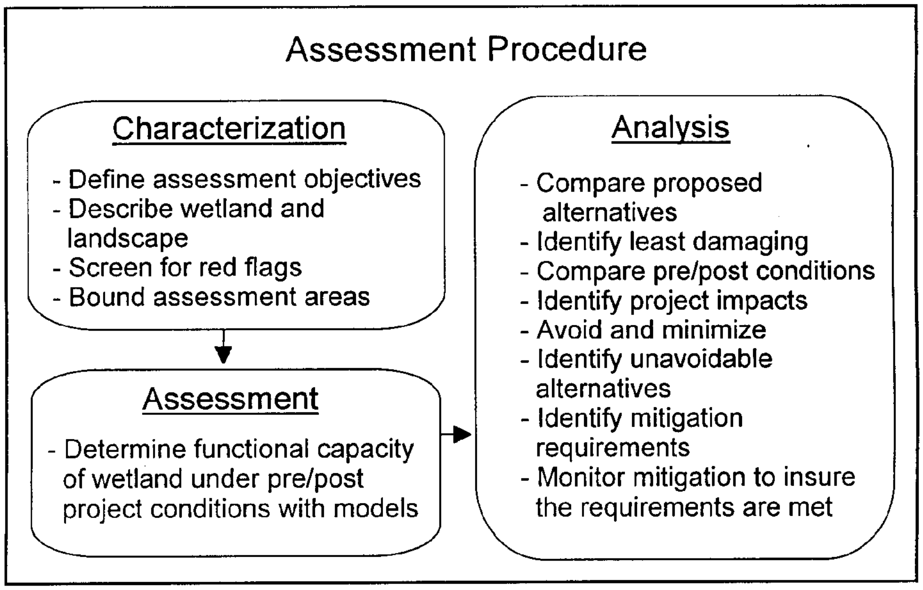

Figure 12. Overview of the assessment procedure

Assumptions and Potential Limitations

a. Prior to applying this assessment procedure, users should be aware of the following assumptions that may limit the applicability of the procedure under certain circumstances:

b. It is assumed that wetlands being assessed belong to a regional wetland subclass for which functional indices have been developed based on reference wetlands by an A-team.

c. It is assumed that persons conducting the procedure have personal knowledge and field experience with the regional wetland subclass under consideration.

d. In applying the procedure, a field visit to the site being assessed is required in order to become familiar with the characteristics of the wetland and the surrounding landscape. At a minimum, the field visit should include walking the perimeter and interior of a wetland to determine sources of water, surface water connections, the composition, structure, extent, and variability of plant and animal communities, soil types, disturbance, and other factors that influence how a wetland functions. The procedure cannot be done without a field visit.

e. The procedure was not designed to compare wetlands from different regional wetland subclasses. Assessment models are calibrated using reference wetlands from a reference domain. Functional indices estimate the capacity of a wetland to perform a function relative to other wetlands in the regional subclass from the defined reference domain. Consequently, using the indices to compare wetlands from different regional wetland subclasses is generally inappropriate. It is theoretically possible to compare wetlands from different regional wetland classes using absolute, empirical standards (e.g., number of cubic feet of water stored annually or the grams of carbon produced per year). This requires the quantitative type of measurements that are feasible only in the context of an intensive research project, and not the public interest review in 404.

f. The procedure was designed to assess functions that occur at the wetland ecosystem scale, and not functions occurring at larger scales (e.g., landscapes or watersheds). As a result, the procedure cannot, in and of itself, be used to assess cumulative impacts of multiple projects on landscape scale functions. However, the information gathered while applying the procedure may be useful in meeting this objective when used in conjunction with other information or procedures (Preston and Bedford 1988; Lee and Gosselink 1988; Leibowitz et al. 1992; Gosselink et al. 1990; and Gosselink and Lee 1989).

g. The procedure is not designed to assign value to wetland functions in terms of economic (e.g., dollars) or other value units. However, the information that is gathered while applying the procedure may be useful in meeting this objective when used in conjunction with other information or procedures (Luzar and Gan 1991; Shabman and Batie 1988; Henderson 1993).

Characterization Phase

Define assessment objectives

The first step in the assessment procedure is to define the objectives of the assessment. In 404, assessment objectives usually fall into one of three that include the following:

a. Documentation of existing conditions.

b. Comparison of several different wetlands at the same point in time.

c. Comparison of a single wetland at different points in time.

In documenting existing conditions, the objective is usually to provide a reference point for comparing future conditions. For example, a resource manager might decide to assess the functional capacity of a wetland under existing conditions in order to provide a reference point to compare the results of a particular management strategy. In documenting existing conditions, no comparisons are made, and no project impacts occur.

In comparing several different wetlands at the same point in time, the objective is usually to determine which of several project locations or design alternative will have the least impact on a wetland (Figure 13). Comparisons among wetlands also occur in other types of applications such as advanced identification (ADID) to determine the "suitability" of wetlands within a regional wetland subclass for the placement of dredged or fill material or establishing priorities for wetland acquisition. When comparing several different wetlands, assessments take place under existing conditions, and the number of assessments conducted will depend on the number of alternative wetland sites under consideration.

In comparing a single wetland at different points in time (Figure 13), the objective is usually to determine how a proposed project will impact the functional capacity of the wetland. Alternatively, the objective might be to determine how a completed project has impacted functional capacity, how a wetland recovers from project impacts with or without restoration efforts, or how a wetland responds to chronic degredation. To achieve any of these objectives, two or more assessments must be completed at different times. The initial assessment normally considers preproject conditions, and the second assesses postproject conditions that are expected to exist after the project is completed. The assessment of postproject conditions is based on predictions of how the proposed project will alter the wetland. In some situations (e.g., "after the fact" permit), this scenario is reversed. The initial assessment is conducted after a project is completed or in progress, and the second assessment is done on the preproject wetland based on hindcasting preproject conditions.

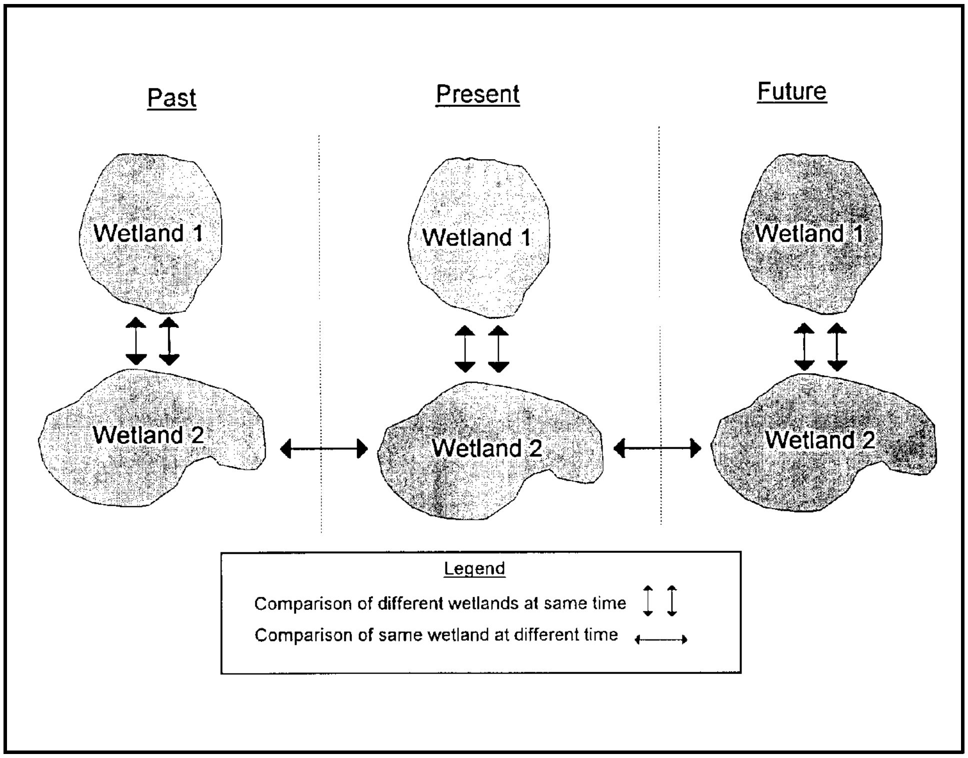

Figure 13. Assessment objectives

Describe project area

The next step in the characterization phase is to describe the project area and surrounding landscape with narrative, maps, and figures. The project area includes jurisdictional wetlands that are subject to direct and indirect impacts, as well as the areas where activities necessary to support the proposed project occur. Project areas will vary considerably in size depending upon the nature of the project. For example, the project area for a road crossing or small building project would typically be small and include the areas necessary to accommodate the structural footprints, access, material storage, and equipment movement. For larger projects such as highway construction or large buildings or developments, the project area will be more extensive and potentially encompass multiple wetland areas. In this case of larger projects, it may be useful to subdivide the project area into smaller, multiple project areas based on the location of wetlands, or other relevant criteria.

Once identified, the project area and the surrounding landscape should be described in a narrative (Figure 14). The narrative should include the following:

a. Project name and location.

b. Nature of the proposed project.

c. Assessment objectives.

Project Area Description

Project Name:

Cache River access road bridge crossing.

Location:

Three miles west on blacktop road from Gregory, Woodruff County Arkansas (R-34W, T-16S, Section 15).

Nature of Project:

The project will replace and improve a road damaged during recent flooding. The road provides year round access to the local boat launch.

Assessment objective:

The objective is to determine the impact of the proposed discharge of dredged or fill material on the functions performed by the jurisdictional wetlands in the project area.

Hydrogeomorphic classification:

Riverine, no subclass

National Wetland Inventory classification:

Palustrine forested, seasonally flooded (PFO1a)

Description of Project Area and Surrounding Landscape:

This project is located on the alluvial floodplain of a fourth order reach of the Cache River in Woodruff County, Arkansas. The active, annual floodplain in this reach ranges from one to two miles wide. The main channel of the Cache River is presently near the center of the annual floodplain. The project area is located approximately one quarter mile west of the Cache River main channel in an area that normally floods to a depth of 2-3 feet several times during the winter and spring of each year.

Most of the floodplain is forested with the Cypress-Tupelo (Type 102), Overcup Oak-Bitter Pecan (Type 96), and Sweetgum-Willow Oak (Type 92) cover types dominating (U.S. Forest Service 1982). Terraces (i.e., historical floodplains) adjacent to the active floodplain are mostly cleared, and dedicated to the cultivation of cotton, soybeans, and rice. Soils on the active floodplain are hydric, and belong to the Amagon-Foley association (U.S. Soil Conservation Service 1984).

All of the annual floodplain in this reach is part of the Cache River National Wildlife Refuge, or other set aside lands, under the control of the US Fish and Wildlife Service and the State of Arkansas.

Figure 14. Project area description

d. Classification of wetlands in the project area using the Hydrogeomorphic and National.

e. Wetland Inventory classifications (Cowardin et al. 1979).

f. Description of the climate, landform and geomorphic setting, hydrology, vegetation, soils, land use, groundwater features, surficial geology, urban areas, potential impacts, red flag features (see later section), and other relevant characteristics.

In addition to the narrative description, a base map of the project area and surrounding landscape should be prepared using a U.S. Geological Survey 7.5-min topographic quadrangle map or suitable alternative (Figure 15). Multiple maps or overlays, keyed to the basemap, can be used to show features of interest. Project area map(s) should display the following information at a minimum:

a. Project area boundaries, property lines, and other relevant political boundaries.

b. Topographic contour lines in the project area and surrounding landscape.

c. lnfrastructure (e.g., roads, fences, buildings, railroad grades, and bridges).

d. Surface water features (e.g., streams, rivers, lakes, ponds, and springs).

e. Soil types.

f. Plant communities.

g. Jurisdictional wetlands.

h. Location of potential wetland impacts.

i. Wetland assessment area(s) (see later section).

j. North arrow (true north), legend or key, and distance scale.

k. Title block with the project name, investigators, dates, and information sources.

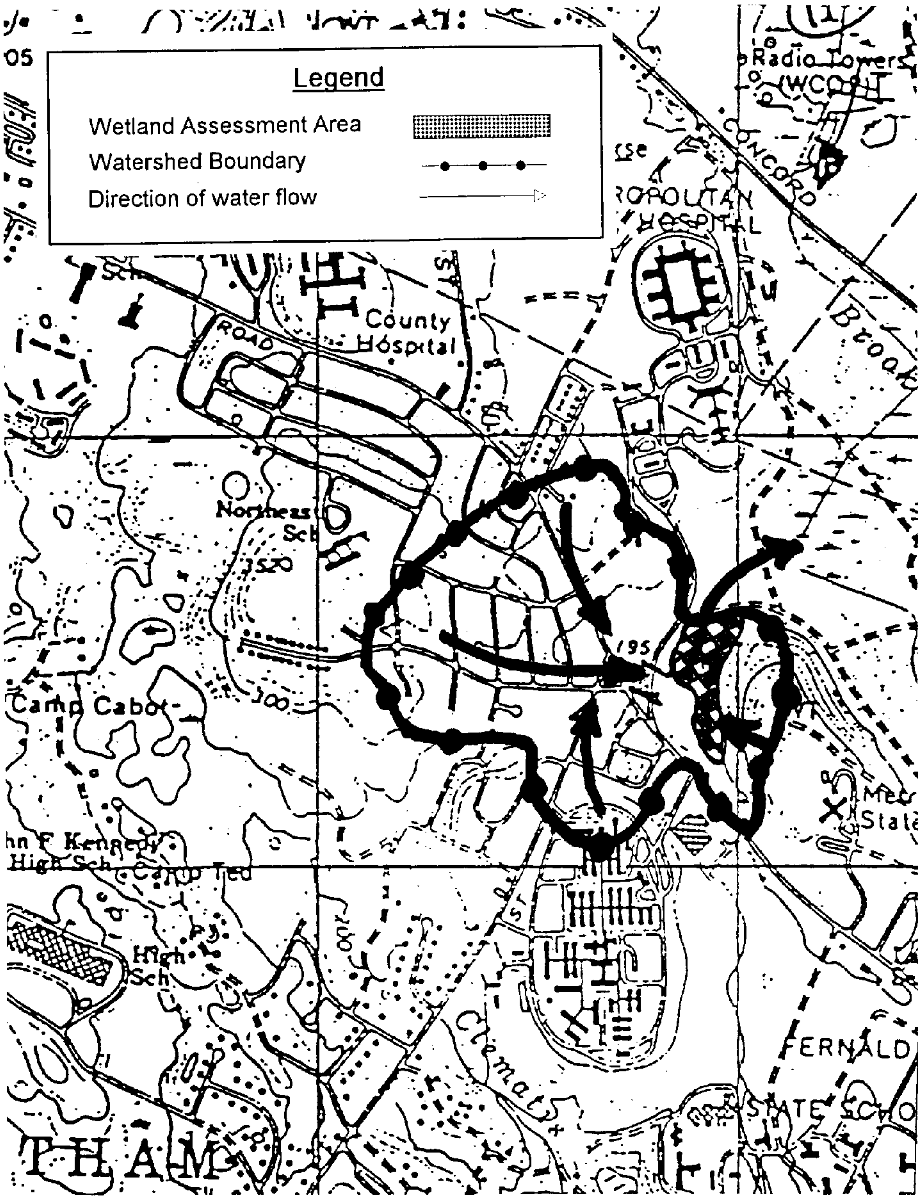

Figure 15. U.S. Geological Survey 7.5-min Quadrangle, Lexington, MA, showing wetland assessment area, watershed boundaries, and direction of water flow

Screen for red flags

Red flags are features of a wetland or the surrounding landscape to which special recognition or protection has been assigned on the basis of objective criteria. The recognition or protection may be at a national, State, regional, or local level and may be official or unofficial. Screening for red flags is not directly related to the assessment of wetland functions. Rather, it is a proactive attempt to determine if a wetland will require special consideration or attention that will preempt the assessment of functions. The public interest review process in 404 already includes some form of red flag screening. However, it is often narrow in scope and limited to a few of the more common, nationally recognized red flag features such as threatened or endangered species.

The initial screen for red flags is made by determining whether the project area falls under the jurisdiction of one of the programs or laws listed in the Figure 16. Information can be obtained by contacting the program authority or responsible agency indicated by the letter following each item. For example, the State Historical Preservation Officer (SHPO) can provide information concerning sites of archaeological and historical importance. Red flag features vary considerably from region to region; therefore, reasonable attempts should be made to expand the national list in Figure 16 to include red flag features that are important at the regional or local level.

Identifying wetland assessment areas

The general definitions of wetland ecosystems given in Chapter 3 provide the criteria necessary to locate wetlands in the landscape, and distinguish them from adjacent upland and aquatic ecosystems. However, in 404, in order to establish the legal extent of regulatory jurisdiction, it is necessary to identify the exact location of the wetland boundary within a proposed project area. The criteria used to define wetlands in Chapter 3 are too general and subjective to locate an exact position of a jurisdiction wetland boundary. Consequently, a detailed set of soil, hydrology, and vegetation criteria has been developed to identify wetland ecosystem boundaries in a precise and objective manner (U.S. Army Corps of Engineers 1987). Considerable effort has gone into determining the most appropriate delineation criteria, but full consensus has yet to be reached (Thompson and Yocum 1993). This is not surprising given the dynamic nature and regional variability of wetlands.

An implicit assumption that underlies the delineation of wetland ecosystem boundaries is that a boundary actually exists at the scale it is being mapped. This assumption is contrary to a considerable body of ecological evidence that suggests the interface between ecosystems rarely occurs as a line on the ground, but more often, as a poorly defined transition zone that can extend over a considerable distance. The changes in species composition or dominance in the vegetation community often provide an observable reflection of the underlying physical and chemical changes taking place in the transition

Red Flag Features

Areas protected under American Indian Religious Freedom Act
(A)
Hazardous waste sites identified under CERCLA or RCRA
(H)
Areas protected by a Coastal Zone Management Plan
(D)
Areas providing Critical Habitat for Species of Special Concern
(I)
Areas covered under the Farmland Protection Act
(L)
Floodplains, floodways, or floodprone areas
(K)
Areas of high public use
(M)
Areas with structures/artifacts of historic or archeological significance
(F)
Areas protected under the Land and Water Conservation Fund Act
(L)
Areas protected by the Marine Protection Research and Sanctuaries Act
(D)
National Wildlife Refuges
(I)
Native Lands
(A)
Areas identified in the North American Waterfowl Management Plan
(I)
Areas identified as significant under the RAMSAR Treaty

Areas supporting rare or unique plant communities

Figure 16. Red flag features and program authorities and responsible agencies

zones (Whittaker 1975, page 112; van der Valk 1981). While ecologists have the luxury of accepting a transition zone between ecosystems of considerable width, regulators do not. For legal reasons, they must decide whether an area is jurisdictional wetland or nonjurisdictional wetland and identify the exact location where the change occurs. They cannot decide that an area is a “somewhat jurisdictional” transition zone between ecosystems.

Up to this point in the discussion, the wetland ecosystem, regardless of how it is defined and delineated, has served as the spatial context for the assessment of functions. However, in 404 and other regulatory situations, there is often little spatial coincidence between the wetland ecosystem and the area of wetland within a project area that must be assessed. For example, in a typical 404 scenario, the wetland area within a project area often turns out to be a small fragment at the edge of, or along a corridor through, a larger wetland ecosystem as shown in Figure 17. This spatial discrepancy reflects the fact that project area boundaries are determined by property lines, land use, or other political criteria that are unrelated to the ecological criteria that dictate ecosystem boundaries.

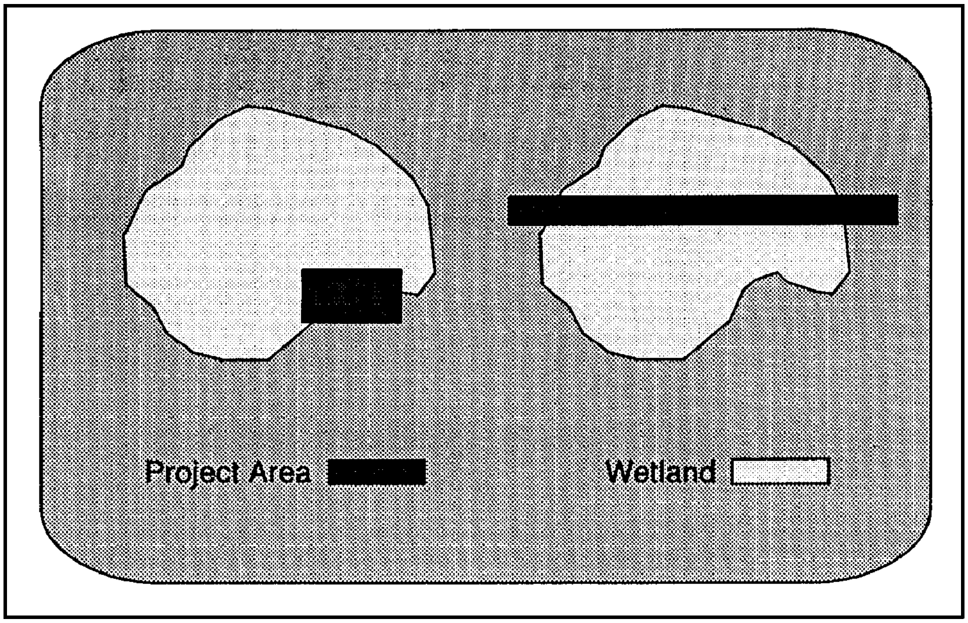

Figure 17. Project areas in relation to the wetland

Narrowing the focus of attention to jurisdictional wetlands in a project area does not change the fact that the capacity of a wetland area to perform functions reflects not only the characteristics of the wetland area itself, but also the characteristics of aquatic, wetland, and uplands in the surrounding landscape. The characteristics that influence how a wetland area functions and the spatial scale at which they operate vary depending on the function under consideration. In assessing the capacity of a wetland area to function, each characteristic that influences a function must be considered at the spatial scale appropriate to that characteristic. The models used to assess wetland functions must capture this relationship by using variables that reflect the influence of size, adjacency, and other spatial factors on function when appropriate.

For example, the nutrient cycling function in riverine wetlands is influenced by the quantity of aboveground biomass and detrital standing stocks (Brinson et al., In Preparation). In assessing the function of nutrient cycling, these characteristics need to be measured at a relatively small scale, because they can vary considerably over a relatively short distance as a result of natural processes or disturbance. Other functions performed by wetlands are influenced by characteristics that occur at larger spatial scales. For example, the ability of a wetland area to provide habitat for a certain animal species may depend on the presence of habitats in the surrounding landscape such as open water or large trees for roosting. These characteristics need to be measured at larger scales.

Once the wetlands in a proposed project area have been delineated, wetland assessment area(s) WAAs can be identified. A wetland assessment area is a wetland area within the proposed project area that is physically continuous and homogeneous in terms of the hydrogeomorphic criteria used to define regional wetland subclasses. Based on these two criteria it is possible to define one or more wetland assessment areas within a project area. For example, in Figure 18, a physically continuous wetland representing a single regional subclass exists in the proposed project area. Thus, in this situation, a single WAA would be identified. In Figure 19, a road grade divides a wetland area representing a single regional subclass into two physically separate areas. Wetland areas that are physically separated may function differently even when they belong to the same regional subclass. This is of potential differences in water sources, hydrologic regimes, soil types, plant communities, or other characteristics that influence function. In situations like this the number of WAAs defined must be decided on a case by case basis after considering the nature of the physical separation and the likelihood that functional differences do exist.

As the size and heterogeneity of a project area increases, so does the likelihood that more than one WAA will occur in the project area. This is because there is a greater likelihood that more than one regional subclass will be represented, or that physically separated wetlands will occur. For example, in Figure 20, three

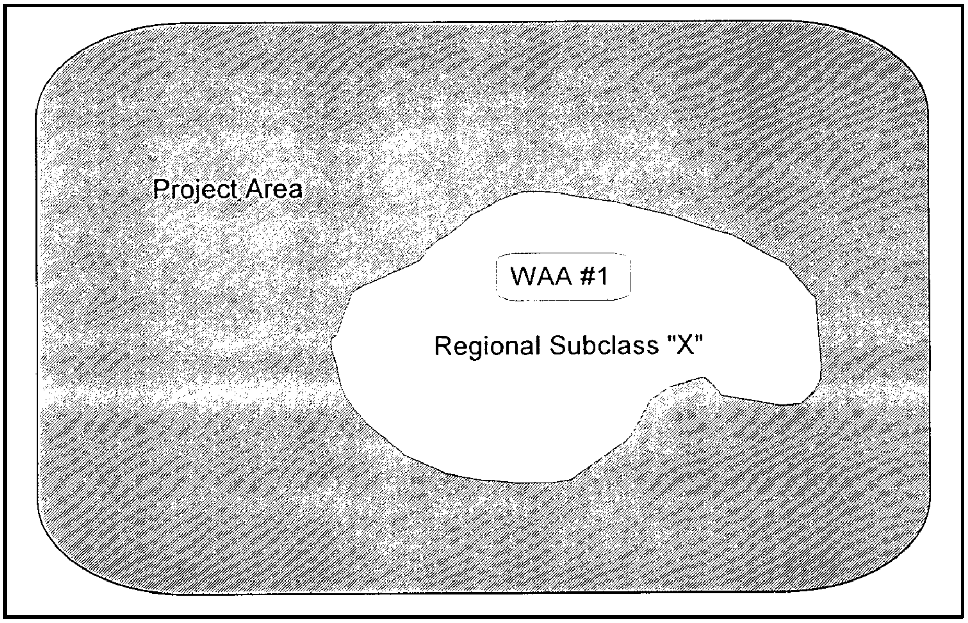

Figure 18. Single wetland assessment area (WAA) within the project area

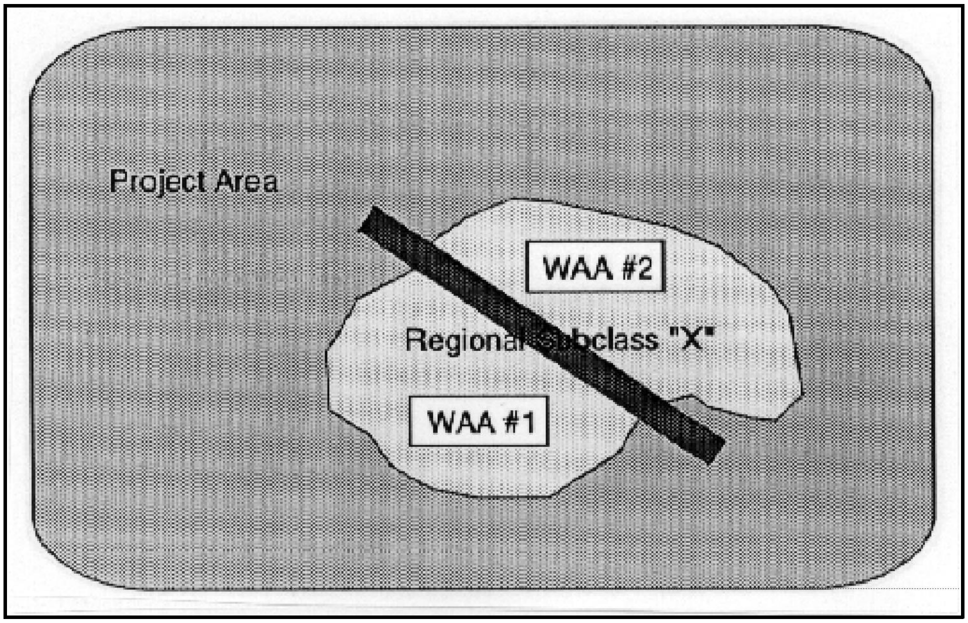

Figure 19. Physically separated wetland assessment areas (WAAs) within a project area

physically separate wetlands from the same regional subclass occur in the project area, and therefore three WAAs would be identified. In Figure 21, two wetland areas that are physically continuous occur; but since they represent different regional subclasses, two WAAs would be identified.

Identifying partial wetland assessment areas

As the size of a wetland assessment area increases, so does the likelihood that it will encompass areas that exhibit different levels of functional capacity as a result of natural processes such as succession, or anthropogenic disturbance such as logging or ditching. To account for these differences, partial wetland assessment areas may be identified. A partial wetland assessment area is a portion of a WAA that is distinctly different from the rest of the WAA in terms of microtopography, soil type, vegetative communities, or other characteristics that influence the capacity of wetlands in the regional subclass to perform function. The number of PWAAs identified is based on the variability within the WAA, assessment objectives, and the ability to actually measure functional differences based on assessment models.

An example of a situation where it may be appropriate to identify PWAAs is shown in Figure 22. In this example, a single WAA has been identified in the project area. However, due to different ownership and management practices, half of the WAA has been clearcut, while the other half remains a mature forest. These two areas exhibit distinct differences in terms of forest structure and composition, two characteristics that influence the capacity of a wetland to perform habitat functions. Applying an assessment model to each of these areas will result in a significantly

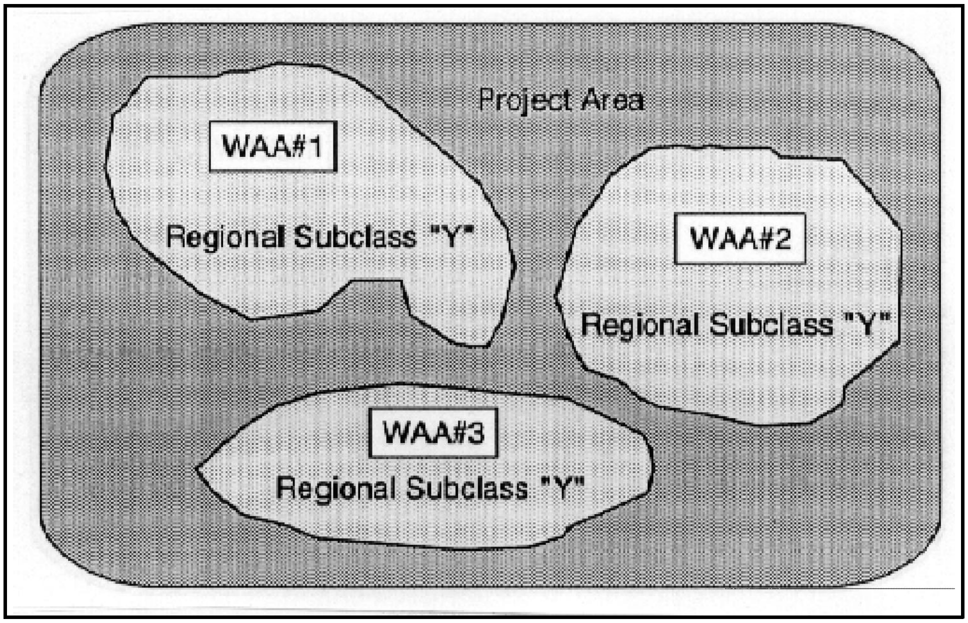

Figure 20. Three physically separated wetland assessment areas (WAAs) within a project area

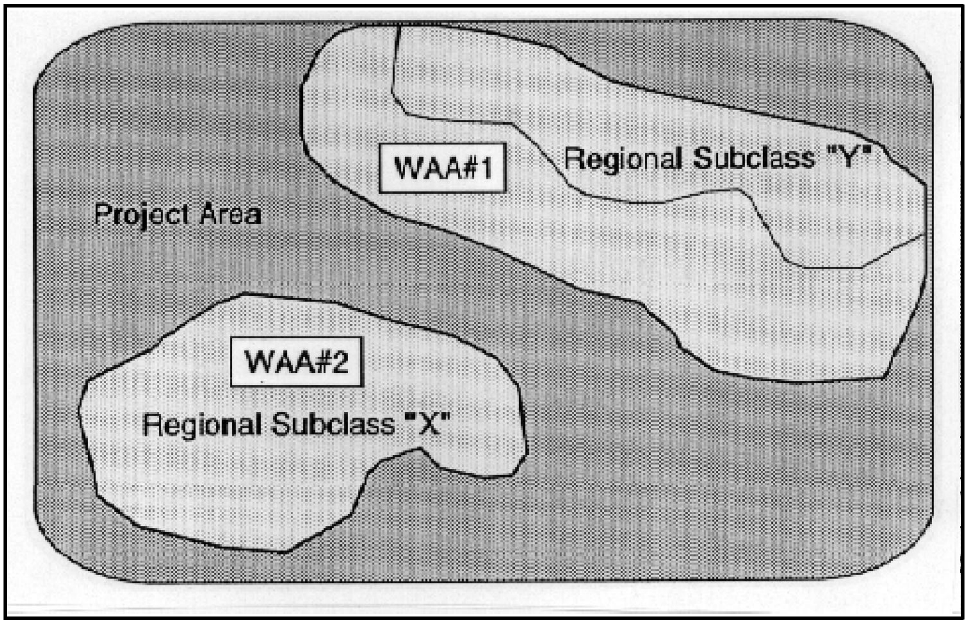

Figure 21. Two different regional wetland subclasses as wetland assessment areas (WAAs) within a project area

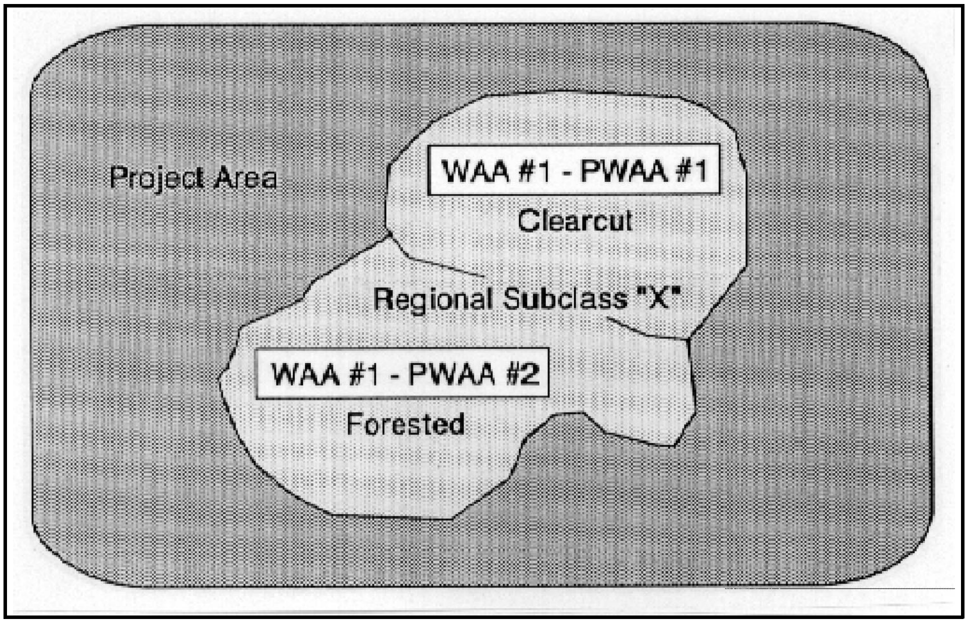

Figure 22. Two partial wetland assessment areas (PWAAs) within a wetland assessment area (WAA) within a project area

different functional capacity index for the two areas; thus it is appropriate to identify them as different PWAAs.

Another example occurs on large river floodplains with areas of wetland that exhibit distinct differences in hydrologic characteristics. Near channel "backswamps" in these systems are normally flooded or saturated for most of the year, while old floodplain terrace areas further away from the channel are flooded at a lower frequency and duration. The dominant source of water in these areas may actually be precipitation. Similarly, at the upland edge of some larger floodplains, there are often areas that are infrequently influenced by overbank flow, but kept constantly saturated by groundwater discharge. All of these areas are to some degree functionally different from each other and may be designated as separate PWAAs. In situations like this, it may be appropriate to distinguish these areas as different regional wetland subclasses. Alternatively, it is also possible to define multiple reference standards to reflect the fact that within a regional subclass certain wetland areas consistently exhibit different characteristics as riverine wetlands across a floodplain moisture gradient. Similarly, it may be appropriate to designate multiple reference standards for a regional subclass to reflect differences in functional capacity in successional stages.

Another situation where it may be appropriate to identify PWAAs is when a proposed project is expected to have differential impacts in the same WAA. For example, the portions of a WAA designated for the direct placement of fill material will likely experience a permanent and total loss of function. Adjacent areas of the WAA might be impacted by minor sedimentation that result in a temporary and partial loss of function. In this situation, it would be appropriate to designate these to areas of the WAA as different PWAAS. Similarly, if a proposed project includes a dredged channel in one location in the WAA and a fill pad in another portion of the WAA, the impact on wetland functions would be different in each area. In this situation it would also be appropriate to designate these to areas of the WAA as different PWAAS.

Assessment Phase

The second phase of the assessment procedure consists of assessing the functional capacity of each of the WAAs identified during the characterization phase. Embarking on this phase of the procedure assumes that assessment models have been developed for the regional wetland subclasses that will be assessed (Chapter 4). In most cases, the first assessment is completed under existing conditions, which normally correspond to preproject conditions. The exception is when the initial assessment is done on a WAA after a project has been completed, in which case existing conditions would correspond to postproject conditions. Depending on the assessment objectives, the initial assessment will be used to establish a reference point to compare with postproject conditions, conditions in other WAAs, or conditions resulting from management activities at some time in the future. Results from the assessment should be recorded on a standardized data sheet such as the one shown in Table 4.

Depending on assessment objectives, a second assessment of postproject conditions may or may not be required. The assessment of postproject conditions provides an estimate of the functional capacity under a set of conditions expected to exist in the future or believed to have existed in the past (i.e., after the fact permit action). The assessment of functional capacity under predicted past or future conditions is done in the same manner as the assessment of existing conditions with one important exception. The data used to assess functional capacity under existing conditions is collected at the wetland site in “real-time,” while the data used under postproject conditions is based on a prediction of the conditions that are expected to exist. The validity of assessments based on predicted conditions depends strictly on the ability to accurately predict what conditions existed in the past or will exist in the future.

Knowledge and experience are the most important factors governing the ability to accurately predict past or future conditions. It requires an understanding of how a proposed project will impact the characteristics and processes influencing how the wetland performs functions. For example, if the proposed project is to construct a road crossing through a wetland, in order to accurately assess functional capacity, the effects of the road on the hydrology of the wetland must be conceptualized and used to predict postproject conditions. Predicting conditions may require the help of a specialist in hydrology or other discipline. A rich literature exists for assisting in predicting what conditions will exist subsequent to a proposed impact and how the conditions will affect the functional capacity of the wetland. All of the following

Table 4
Sample Data Sheet for Recording Assessment Results

Functional Capacity Indices Under Preproject or Postproject Conditions

Date: ______________________________

Project: ______________________________

Wetland Assessment Area: ______________________________

Assessors: ______________________________

Project Status: ____ Preproject ____ Postproject

Functions[1]	**FCI**	**Size of WAA in acres**	**FC**
Dynamic Surface Water Storage	0.5	10	5
Long-Term Surface Water Storage	1.0	10	10
Energy Dissipation	1.0	10	10
Subsurface Storage of Water	1.0	10	10
Modification of Groundwater Flow or Discharge	1.0	10	10
Nutrient Cycling	0.5	10	5
Removal of Elements and Compounds	0.5	10	5
Retention of Particulates	0.5	10	5
Export of Organic Carbon	0.1	10	1
Maintain Characteristic Plant Community	1.0	10	10
Maintain Characteristic Detrital Biomass	1.0	10	10
Maintain Spatial Structure of Habitat	1.0	10	10
Maintain Interspersion and Connectivity	1.0	10	10
Maintain Distribution and Abundance of Invertebrates	0.5	10	5
Maintain Distribution and Abundance of Vertebrates	1.0	10	10

[1] From Brinson et al. (In Preparation).

sources should be utilized to ensure the most accurate predictions possible including the following:

a. Knowledge and experience.

b. Extrapolation based on conditions in similar wetlands in the vicinity that have been subjected to impacts similar to those proposed.

c. 404 (b) (1) guidelines (Subparts C-H).

d. Review of the literature.

Analysis Phase

Calculating functional capacity

The final phase of the procedure is the application of the assessment results. In 404, assessment results are used primarily to determine which of several alternatives is least damaging, or how a proposed project will impact wetland functions. When the wetlands being compared are not the same size, a comparison based on functional indices alone can lead to erroneous conclusions. For example, consider the following scenario. A new highway is being planned, and two alternative routes are under consideration. The first route will result in the total loss of a 5-acre wetland because of filling. Under preproject conditions, this wetland area was determined to have an functional capacity index (FCI) of 0.8 for a particular function. The second proposed route will result in the total loss of a similar type of wetland of 10 acres because of filling. Under preproject conditions, this wetland also has an FCI of 0.8 for the same function. Comparing these two alternatives based on functional capacity index of a single function leads to the conclusion that there is no difference between the alternatives. All else being equal, this conclusion is erroneous since the second alternative will result in the loss of a wetland that is of the same quality, yet twice the size of the first.

Functional capacity indices estimate the capacity of a wetland to perform a function relative to other wetlands in a regional subclass from a defined reference domain. However, in comparing wetlands, the size of the wetland areas being compared must be explicitly incorporated into the calculation of functional capacity. This procedure incorporates size into the calculation of functional capacity (FC) by multiplying the functional capacity index of a WAA by the size of the WAA in acres, hectares, or other units of area for each function. For example:

$$\text{FC} = \text{FCI of WAA} * \text{size of WAA} \tag{2}$$

where

FC = functional capacity for WAA

FCI = functional capacity index for WAA

When a WAA has been divided into PWAAs, FCI and FC are simply calculated separately for each PWAA, then summed to determine FC for the entire WAA for each function. An example of calculating FC for a WAA with PWAAs is shown below:

$$FC = \sum_{n,\ i=1} (FCI_i * PWAA_i) \tag{3}$$

where

FC = functional capacity for WAA

FCI = functional capacity index for FCI

PWAA = size of PWAA

n = number of PWAAs

Once the functional capacity of a WAA is expressed in terms of FC, a number of the assessment situations that occur in the 404 public interest review can be addressed by comparing the FC for different WAAs. The three types of comparison that are usually required are as follows:

a. Comparison of a single WAA at two different points in time.

b. Comparison of WAAs in the same regional subclass at the same point in time.

c. Comparison of WAAs in different regional subclasses at the same point in time.

Comparing same wetland assessment area at different points in time

The most common type of comparison made in 404 is between the same wetland area at different points in time. The time difference typically reflects the preproject and postproject scenario that commonly occurs in 404. For example, conditions before and after the discharge of dredged or fill material or before and after a mitigation project. A comparison between preproject and postproject conditions can be made by using a form similar to the one in Table 5.

Table 5
Sample Data Sheet for Comparing Functional Capacity Indices (FCIs) and Functional Capacities (FCs) for Wetland Assessment Area Under Preproject and Postproject Conditions

FCIs and FCs for WAA Under Preproject and Postproject Conditions

Date: ____________________

Project: ____________________

Wetland Assessment Area: ____________________

Assessors: ____________________

	Preproject			**Postproject**		
Functions[1]	**FCI**	**Size of WAA in acres**	**FC**	**FCI**	**Size of WAA in acres**	**FC**
Dynamic Surface Water Storage	1.0	10	10	0.5	10	5
Long-Term Surface Water Storage	1.0	10	10	1.0	10	10
Energy Dissipation	1.0	10	10	1.0	10	10
Subsurface Storage of Water	1.0	10	10	1.0	10	10
Modification of Groundwater Flow or Discharge	1.0	10	10	1.0	10	10
Nutrient Cycling	1.0	10	10	0.5	10	5
Removal of Elements and Compounds	1.0	10	10	0.5	10	5
Retention of Particulates	1.0	10	10	0.5	10	5
Export of Organic Carbon	1.0	10	10	0.1	10	1
Maintain Characteristic Plant Community	1.0	10	10	1.0	10	10
Maintain Characteristic Detrital Biomass	1.0	10	10	1.0	10	10
Maintain Spatial Structure of Habitat	1.0	10	10	1.0	10	10
Maintain Interspersion and Connectivity	1.0	10	10	1.0	10	10
Maintain Distribution and Abundance of Invertebrates	1.0	10	10	0.5	10	5
Maintain Distribution and Abundance of Vertebrates	1.0	10	10	1.0	10	10

[1] From Brinson et al. (In Preparation).

Another situation in 404 that may require the comparison of the same wetland area at different points in time occurs when there is a possibility of a cumulative loss of functional capacity as a result of time lag or delays. For example, in developing a mitigation wetland, it may take several years to achieve the desired level of functional capacity (Figure 23). If the loss of functional capacity during the time lag is significant, compensation may be required (King 1994). The basic steps in making this type of comparison include the following:

Step 1	Select target years for future prediction.
Step 2	Predict area of WAA that will perform the function in future years.
Step 3	Predict FCI and FC for future years.
Step 4	Calculate cumulative FC.
Step 5	Calculate difference between cumulative FC for WAAs being compared.

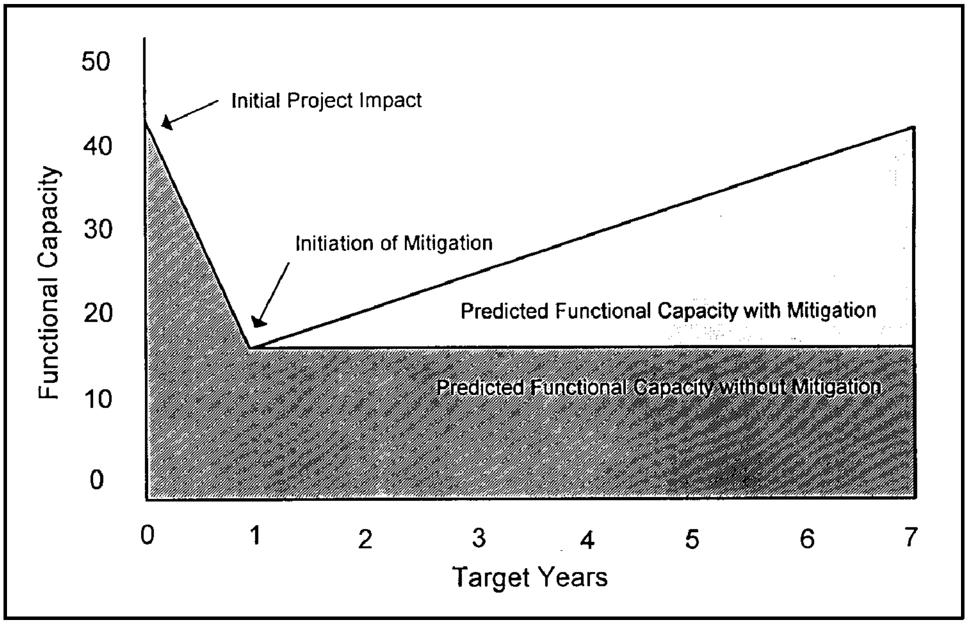

Figure 23. Loss or gain of functional capacity over time with and without proposed mitigation project

Several methods can be used to calculate cumulative FCs. The easiest is to graph the assumed linear relationship between widely spaced target years, estimate the area under the curve, and then calculate the difference between FC loss in the preproject WAA and FC gain in the postproject WAA (Figure 23). Better estimates of FC loss can be made by using more narrowly spaced target years or known nonlinear relationships in calculating differences in FC.

Comparing different wetland assessment areas at same point in time

Comparing WAAs in the same hydrogeomorphic wetland classes at the same point in time is another type of comparison that may be necessary in 404, particularly in conjunction with alternatives analysis. This comparison can also be made using FCIs, in which case the WAA with the higher FCI has a greater capacity to perform a function on a unit area basis. However, it is important to remember that the size of the WAA is not considered in determining an FCI, and that FCI is an estimate of the functional capacity of a unit area of wetland, not an estimate of the functional capacity of the WAA as a whole.

In the context of 404, a comparison of two WAAs using FCs is more useful, because they represent the functional capacity of the WAA as a whole based on its FCI and area. When conducting an analysis to determine which alternative is least damaging, the estimate of functional capacities for the WAA as a whole is a more useful piece of information (for example, consider the following alternatives analysis scenario). Alternative one involves the complete loss of a 5-acre WAA with an FCI of 0.9 and FC of 4.5. The second alternative involves the complete loss of a 25-acre WAA with an FCI of 0.5 and FC of 12.5. If the decision on least damaging alternative is based strictly on FCI (i.e., which WAA has a greater capacity to perform a function on a unit area basis), the first alternative appears to be the least damaging. However, if size is factored into the decision and FCs are used as the basis for the decision, the second alternative turns out to be the least damaging. This simple example points out the distinction between FCIs and FC, but overlooks the many other factors that may need to be considered in the selection of project alternative locations.

Comparing WAAs from different regional subclasses at the same point in time is a third type of comparison that may be necessary in the 404 permit review process, particularly in conjunction with alternatives analysis. When two wetlands are from different regional subclasses, they cannot be compared directly because their functional indices are calibrated based on different reference wetlands. A functional index of 1.0 for the wildlife habitat function in the ombrotrophic peatland is meaningful only in the context of the regional subclass and reference domain for which the index was developed. It is meaningless to compare it with a functional capacity index for wildlife habitat from a fringe tidal mixohaline wetland (salt marsh). The exception is when FCIs for both regional subclasses are calibrated to an absolute empirical standard.

If FCIs and FCs cannot be used to compare wetlands in different hydrogeomorphic classes, how can this type of comparison be made? The answer is to use the information gathered during the assessment to make a decision between project alternatives or mitigation requirements. For example, if the choice is between impacting 3 acres of a depressional wetland or 3 acres of a riverine wetland, the specifics of various functions must be considered. Suppose that the FCI for wildlife habitat is 0.3 for the depressional wetland and 0.9 for the riverine wetland. This means that the riverine wetland is closer to the reference condition for the wildlife habitat than the depressional method. Suppose further that the wildlife habitat assessment model for the forested wetland uses neotropical migrant birds as the target species.

Since neotropical migrants are currently considered to be in decline, in part because of a loss of suitable nesting habitat, it may be reasonable to conclude that the wildlife habitat function provided by the forested wetland is more valuable than the wildlife habitat provided by the marsh. This decision would clearly be based on a subjective value judgment and would need to be thoroughly justified and documented remembering that assigned value is specific to individuals, or groups, and their situation. When different project alternatives will result in the loss of different functions, the choice between alternatives often comes down to a choice between which function is considered to be of less value in the specific context. Regional resource priorities and the results of cumulative impact assessments should be considered when making choices between alternatives.

Other criteria for consideration in comparing wetland assessment areas

The comparison of functional capacity in terms of FCIs or FCs are not necessarily the only criteria that should be considered in comparing alternative project locations. The presence of red flag or other significant features is another potential criteria. The occurrence of a red flag feature may provide the necessary justification to remove a potential project site from the list of alternatives. For example, wetlands that are rare in a locality or region may be considered more valuable. Another potential criteria is the vulnerability of particular wetland ecosystems. Some regional subclasses are inherently more vulnerable to certain project impacts than others. For example, a given length of fill, if it has the effect of blocking tidal flow, will have a profound impact on a tidal fringe wetland. The same length of fill however might only have a minimal impact on a depressional closed surface water wetland (red maple swamp). Another example might be a project that would increase the nutrient inputs, such as a golf course. A depressional closed groundwater wetland (fen) would be much more vulnerable to increased nutrient input than a depressional open surface water wetland (marsh). Vulnerability in this context means that small increases in nutrient input could have the effect of significantly altering the fen ecosystem, but might have very little effect on the marsh. Another potential criterion is the feasibility of mitigation. In this case, several questions must be asked. Does one project alternative impact a wetland that is more easily replaced than another wetland? Are the impacts of a project alternative on a wetland more easily mitigated than the effects of another alternative? It is presently not possible to replicate some hydrogeomorphic wetland classes, such as depressional peatlands (kettle hole bogs) in southern New England. Given a choice between a wetland that can be successfully created and one which cannot, it is probably wise to impact the former rather than the latter. Regional resource prorities and the results of cumulative impact assessments should be considered when making choices between alterations.

Avoiding and minimizing project impacts

The information collected during the assessment of wetland functions is useful throughout the permit review to ensure that a proposed project avoids and minimizes impacts to wetlands to the greatest extent possible. Functional capacity indices and FC are useful in comparing overall impacts, but they lack the detailed descriptive information needed to make specific recommendations about avoidance and minimization. However, the detailed information is available by looking at the assessment models and the specific variables and indicators used in the model. Summarizing the differences in model variables serves as a starting point for making recommendations concerning avoidance and minimization. Table 6 shows a form that can be used to record how the condition of specific variables in the assessment models differs for each WAA and how those differences influence FCI. A brief narrative should be included to explain the nature and significance of the differences.

Compensating for unavoidable project impacts

The information collected during the assessment of wetland functions is also useful for determining design criteria for wetlands serving as mitigation for unavoidable project impacts. FCs are of particular value in determining the level of functional capacity that should be compensation for as a result of unavoidable impacts. Functional capacity indices on the other hand are more valuable in the context of design criteria. FCIs alone lack the detailed descriptive information needed to make specific recommendations about design criteria; however, when used in conjunction with the specific variables, indicator, and conditions in the assessment models, the design criteria necessary to achieve a certain FCI can be determined.

Table 6
Sample Data Sheet for Comparing Assessment Model Variables for Preproject and Postproject

Comparison of Assessment Model Variables for Preproject or Postproject

Date: ____

Project: ____

Wetland Assessment Area: ______________________________

Assessors: ____

Functions[1]	**FCI Preproject**	**FCI Postproject**	**Explanation for Differences**
Dynamic Surface Water Storage	1.0	0.5	
Long-Term Surface Water Storage	1.0	1.0	
Energy Dissipation	1.0	1.0	
Subsurface Storage of Water	1.0	1.0	
Modification of Groundwater Flow or Discharge	1.0	1.0	
Nutrient Cycling	1.0	0.5	
Removal of Elements and Compounds	1.0	0.5	
Retention of Particulates	1.0	0.5	
Export of Organic Carbon	1.0	0.1	
Maintain Characteristic Plant Commuity	1.0	1.0	
Maintain Characteristic Detrital Biomass	1.0	1.0	
Maintain Spatial Structure of Habitat	1.0	1.0	
Maintain Interspersion and Connectivity	1.0	1.0	
Maintain Distribution and Abundance of Invertebrates	1.0	0.5	
Maintain Distribution and Abundance of Vertebrates	1.0	1.0	

[1] From Brinson et al. (In Preparation).

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Appendix A: Glossary

Assessment Model: A simple model that defines the relationship between ecosystem and landscape scale variables and functional capacity of a wetland. The model is developed and calibrated using reference wetlands from a reference domain.

Assessment Objective: The reason why an assessment of wetland functions is being conducted. Assessment objectives normally fall into one of three categories. These include documenting existing conditions, comparing different wetlands at the same point in time (e.g., alternatives analysis) and comparing the same wetland at different points in time (e.g., impact analysis or mitigation success).

Assessment Team (A-Team): An interdisciplinary group of regional and local scientists responsible for classification of wetlands within a region, identification of reference wetlands, construction of assessment models, definition of reference standards, and calibration of assessment models.

Channel: A natural stream or river or an artificial feature such as a ditch or canal that exhibits features of bed and bank and conveys water primarily unidirectional and downgradient.

Direct Impacts: Project impacts that result from direct physical alteration of a wetland such as the placement of dredge or fill.

Direct Measure: A quantitative measure of an assessment model variable.

Functional Assessment: The process by which the capacity of a wetland to perform a function is measured. This approach measures capacity using an assessment model to determine a functional capacity index.

Functional Capacity: The magnitude to which an area of wetland performs a function. Functional capacity is dictated by attributes of the wetland ecosystem and the surrounding landscape and interaction between the two.

Functional Capacity Index (FCI): An index of the capacity of wetland to perform a function relative to other wetlands from a regional wetland subclass in a reference domain. Functional capacity indices are by definition scaled from 0.0 to 1.0. An index of 1.0 indicates that a wetland performs a function at the highest sustainable functional capacity, the level equivalent to a wetland under reference standard conditions in a reference domain. An index of 0.0 indicates the wetland does not perform the function at a measurable level and will not recover the capacity to perform the function through natural processes.

Functional Profile: A narrative description of the physical, chemical, and biological characteristics of a regional wetland subclass that includes a discussion of which functions are most likely to be performed and discusses different ecosystem and landscape characteristics and processes that influence each function.

Highest Sustainable Functional Capacity: The level of functional capacity achieved across the suite of functions by a wetland under reference standard conditions in a reference domain. This approach assumes that the highest sustainable functional capacity is achieved when a wetland ecosystem and the surrounding landscape are undisturbed.

Hydrogeomorphic Wetland Class: The highest level in the hydrogeomorphic wetland classification. This document identifies seven hydrogeomorphic wetland classes, including depression, lacustrine fringe, tidal fringe, slope, riverine, mineral soil flats, and organic soil flats.

Indicator: Indicators are observable characteristics that correspond to identifiable variable conditions in a wetland or the surrounding landscape.

Indirect Measure: A qualitative measure of an assessment model variable that corresponds to an identifiable variable condition.

Indirect Impacts: Impacts resulting from a project that occur concurrently, or at some time in the future, away from the point of direct impact. For example, indirect impacts of a project on wildlife can result from an increase in the level of activity in adjacent, newly developed areas, even though the wetland is not physically altered by direct impacts.

In-kind Mitigation: Mitigation in which lost functional capacity is replaced in a wetland of the same regional wetland subclass.

Interflow: The lateral movement of water in the unsaturated zone during and immediately after a precipitation event. The water moving as interflow discharges directly into a stream or lake.

Jurisdictional Wetland: Areas that meet the soil, vegetation, and hydrologic criteria described in the “Corps of Engineers Wetlands Delineation Manual,” or its successor.

Mitigation: Restoration or creation of a wetland to replace functional capacity that is lost as a result of project impacts.

Mitigation Plan: A plan for replacing lost functional capacity resulting from project impacts.

Mitigation Ratio: The ratio of the FC lost in a Wetland Assessment Area (WAA) to the FC gained in a mitigation wetland.

Mitigation Wetland: A restored or created wetland that serves to replace functional capacity lost as a result of project impacts.

Model Variable: see **Assessment Model Variable.**

Offsite Mitigation: Mitigation that is done at a location physically separated from the site at which the original impacts occurred, possibly in another watershed.

Out-of-kind Mitigation: Mitigation in which lost function capacity is replaced in a wetland of a different regional wetland subclass.

Partial Wetland Assessment Area (PWWA): A portion of a WAA that is identified a priori or while applying the assessment procedure, because it is relatively homogeneous, and different from the rest of the WAA with respect to one or more model variables. The difference may occur naturally or as a result of anthropogenic disturbance. .

Project Alternative(s): Different ways in which a given project can be done. Alternatives may vary in terms of project location, design, method of construction, amount of fill required, and other ways.

Project Area: The area that encompasses all activities related to an ongoing or proposed project.

Project Target: The level of functioning identified for a restoration or creation project. Conditions specified for the functioning are used to judge whether a project reaches the target and is developing toward site capacity.

Red Flag Features: Features of a wetland or the surrounding landscape to which special recognition or protection is assigned on the basis of objective criteria. The recognition or protection may occur at a Federal, State, regional, or local level and may be official or unofficial.

Reference Domain: The geographic area from which reference wetlands are selected. A reference domain may or may not include the entire geographic area in which a regional wetland subclass occurs.

Reference Standards: Conditions exhibited by a group of reference wetlands that correspond to the highest level of functional capacity (highest, sustainable level of functioning) across the suite of functions performed by the regional wetland subclass. The highest level of functional capacity is assigned an index value of 1.0 by definition.

Reference Wetlands: Wetland sites that encompass the variability of a regional wetland subclass in a reference domain. Reference wetlands are used to establish the range of conditions for construction and calibration of functional indices and establish reference standards.

Region: A geographic areas that is relatively homogenous with respect to large-scale factors such as climate and geology that may influence how wetlands function.

Regional Wetland Subclass: Wetlands within a region that are similar based on hydrogeomorphic classification factors. There may be more than one regional wetland subclass identified within each hydrogeomorphic wetland class, depending on the diversity of wetlands in a region and assessment objectives.

Site Potential: The highest level of functioning possible given local constraints of disturbance history, land use, or other factors. Site capacity may be equal to or less than levels of functioning established by reference standards for the reference domain, and it may be equal to or less than the functional capacity of a wetland ecosystem.

Throughflow: The lateral movement of water in an unsaturated zone during and immediately after a precipitation event. The water from throughflow seeps out at the base of slopes and then flows across the ground surface as return flow, ultimately reaching a stream or lake.

Value of Wetland Function(s): The relative importance of wetland function or functions to an individual or group.

Variable: An attribute or characteristic of a wetland ecosystem or the surrounding landscape that influences the capacity of wetland to perform a function.

Variable Condition: The condition of a variable as determined through quantitative or qualitative measure.

Variable Subindex: A measure of how an assessment model variable in a wetland compares to the reference standards of a regional wetland subclass in a reference domain.

Wetland: See wetland ecosystem.

Wetlands: Plural of wetland.

Wetland Ecosystem: In 404: ".......areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Corps Regulation 33 CFR 328.3 and EPA Regulations 40 CFR 230.3). In a more general sense, wetland ecosystems are three-dimensional segments of the natural world where the presence of water, at or near the surface, creates conditions leading to the development of redoxomorphic soil conditions and the presence of a flora and fauna adapted to the permanently or periodically flooded or saturated conditions.

Wetland Assessment Area (WAA): The wetland area to which results of an assessment are applied.

Wetland Banking: The process of creating a "bank" of created, enhanced, or restored wetland to serve at a future date as mitigation for project impacts.

Wetland Functions: The normal activities or actions that occur in wetland ecosystems, or simply, the things that wetlands do. Wetland functions result directly from the characteristics of a wetland ecosystem and the surrounding landscape and their interaction.

Wetland Creation: The process of creating a wetland in a location where a wetland did not previously exist. Wetland creation is typically done for mitigation.

Wetland Enhancement: The process of increasing the capacity of a wetland to perform one or more functions. Wetland enhancement can increase functional capacity to levels greater than the highest sustainable functional capacity achieved under reference standard conditions, but usually at the expense of sustainability or a reduction of functional capacity of other functions. Wetland enhancement is typically done for mitigation.

Wetland Restoration: The process of restoring wetland function in a degraded wetland. Restoration is typically done as mitigation.

Wetland Values: See value of wetland functions.

Wrack: Branches, leaves, and other debris that are carried by floodwater and accumulate on the upstream side of trees and other obstacles on the floodplain or at the highest elevation of floodwater.

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13. ABSTRACT *(Maximum 200 words)*

This report outlines an approach for assessing wetland functions in the 404 Regulatory Program as well as other regulatory, planning, and management situations. The approach includes a development and application phase. In the development phase, wetlands are classified into regional subclasses based on hydrogeomorphic factors. A functional profile is developed to describe the characteristics of the regional subclass, identify the functions that are most likely to be performed, and discuss the characteristics that influence how those functions are performed. Reference wetlands are selected to represent the range of variability exhibited by the regional subclass in a reference domain, and assessment models are constructed and calibrated by an interdisciplinary team based on reference standards and data from these reference wetlands. Reference standards are the conditions exhibited by the undisturbed, or least disturbed, wetlands and landscapes in the reference domain. The functional indices resulting from the assessment models provide a measure of the capacity of a wetland to perform functions relative to other wetlands in the regional subclass. The application phase of the approach, or assessment procedure, includes the characterization of the wetland, assessing its functions, analyzing the results of the assessment, and applying them to a specific project. The assessment procedure can be used to compare project alternatives, determine the impacts of a proposed project, avoid and minimize impacts, determine mitigation requirements or success, as well as other applications requiring the assessment of wetland functions.

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14. (Concluded).

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