U.S. Fish & Wildlife Service

Data Collection Requirements and Procedures for Mapping Wetland, Deepwater and Related Habitats of the United States

U.S. Fish and Wildlife Service
Division of Habitat and Resource Conservation
Branch of Resource and Mapping Support
Arlington, VA 22203

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Data Collection Requirements and Procedures for Mapping Wetland, Deepwater and Related Habitats of the United States[1]

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This document can be found at: http://www.fws.gov/wetlands/

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DATA COLLECTION REQUIREMENTS AND PROCEDURES FOR MAPPING WETLAND, DEEPWATER AND RELATED HABITATS OF THE UNITED STATES

PREFACE

These technical procedures serve as a reference for conducting the image analysis work normally associated with mapping wetlands and deepwater habitats. This document is intended to be comprehensive, however situations may develop that require modifications or additions. It is impractical to include all of the technical aspects of data handling and analysis within this document or anticipate all resource inventory needs. Users are advised that other written conventions or formal training may be useful in recognizing and describing wetland habitats, image interpretation and/or mapping protocols. More detailed field guides, regional information, wetland plant lists and soils descriptions are also available.

This information is intended to provide general guidelines for work performance, but should not be substituted for direct communication with the appropriate Program, Project or Technical Specialist(s) regarding procedural questions. For additional information contact:

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General Disclaimer

The use of trade, product, industry or firm names or products in this report is for informative purposes only and does not constitute an endorsement by the U.S. Government or the Fish and Wildlife Service.

1. Introduction

The mission of the U. S. Fish and Wildlife Service (Service) is to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people. The Service supports programs relating to migratory birds, endangered species, certain marine mammals, inland sport fisheries and wildlife refuges. The Service communicates information essential for public awareness and understanding of the importance of fish and wildlife resources and changes reflecting environmental conditions that ultimately will affect the welfare of people. To this end, the Service maintains an active role in the inventory, monitoring, and assessment of wetland habitats of the Nation.

The Service established the National Wetlands Inventory (NWI) to provide resource managers with information on the location, extent, and types of wetlands and deepwater habitats. Congress recognized that wetlands are nationally significant resources and that they have been affected by human activities. Direction was given to the Inventory with enactment of the Emergency Wetlands Resources Act (Public Law 99-645). The Act and its subsequent amendments gave the Inventory specific goals and deadlines for producing wetland maps for the conterminous United States, Alaska, Hawaii, and the Trust Territories.

The objective of mapping wetlands and deepwater habitats remains to produce medium resolution information[2] on the location, type, size of these habitats such that they are accurate at the product scale of 1:12,000 (1:63,360 in Alaska). The Service continues to recognize the limitations of using remotely sensed information as the primary data source for mapping, and additionally, by policy, excluded some wetland types from its inventory (see Section 6 - Limitations). The Service did not design or intend these procedures to yield legal or regulatory products.

The Service provides habitat information to a diverse clientele including local planning commissions, regional governments, multinational corporations, and foreign governments. However, the Service must continue to develop contemporary applications of its data that will facilitate broader use and relevancy for integrated natural resource management and decision making in the future. Advances in information technology and geographic information systems have influenced public expectations for greater utility and functionality from Government data sources.

There is an ever growing importance and sensitivity placed on data quality and integrity. The Service strives to present information on wetlands, deepwater and related habitats in an accurate, clear, complete and unbiased manner. To ensure the effectiveness and reliability of wetland map data, the Service has established quality standards and instituted quality assurance and quality control protocols. The goal of these protocols is to ensure that the data collection, analysis,

[2] Medium resolution mapping at 1:12,000 scale is constrained by remote sensing methods employed, time and cost of data collection. It usually does not produce data to the species level.

verification and reporting methods used to produce uniform information. The information collected using these requirements and procedures are intended to support the decision-making process. Unintended use of the information or products is discouraged.

The technical procedures described here have been developed by the Service to provide the quality assurance measures and protocols needed to produce accurate wetland map products. Because of recent technological innovations and the changing realm of computerized mapping, this document has been expanded over previous quality control guidelines that were referred to as "Mapping Conventions"[3]. Although revisions to existing operating conventions have taken place periodically since 1981, these documents provided "...specific instructions to the photo interpreter when applying the" Service's classification system "...to aid photo interpreters to correctly identify, classify and delineate wetlands on high altitude aerial photography." This document applies to modern processes that use digital imagery and take a more comprehensive approach in describing quality control procedures by directly linking to Service and National Standards; Information Quality Guidelines; and product quality requirements; while providing flexibility to accommodate different technologies.

2. Standardized Classification and Terminology

In providing wetland habitat information, the Service uses the Federal Geographic Data Committee (FGDC) Standard, Classification of Wetlands and Deepwater Habitats (Cowardin *et al*. 1979) which is the approved Federal Standard for mapping, monitoring and reporting wetlands data. This provides a standardized system of nomenclature and terms for habitat mapping only. The Cowardin system defines wetlands in a biological framework. (See Appendix A)

- Cowardin *et al*. (1979), was developed to meet four long-range objectives:
- Describe ecological units that have certain homogeneous natural attributes.
- Arrange these units in a system to aid resource management decisions
- Furnish units for inventory and mapping
- Provide uniformity in concepts and terminology throughout the nation

2.1. Wetland Classification - Adaptations for Mapping Purposes

One of the uses of the Cowardin *et al*. classification system is inventory and mapping of wetlands and deepwater habitats. A classification used in the mapping is scale-specific both for the minimum size of units mapped and for the degree of detail attained. It is

[3] Historically, the National Wetlands Inventory produced "mapping conventions" that were project documents to guide wetlands mapping. Several iterations of these conventions were produced from 1978 through 2000.

necessary to develop a specific set of data collection procedures to accommodate map making using remotely sensed imagery as the primary data source.

For example, some water chemistry, halinity, water depth, substrate size and types and even some differences in vegetative species cannot be reliably ascertained from air photos or digital imagery used by the Service. Image analysts must primarily rely on physical or spectral characteristics evident on high altitude imagery to make decisions regarding wetland classification and deepwater determinations[4].

Other considerations regarding wetland classification and mapping constraints involve the potentially huge number of classification combinations that are possible using the Cowardin system. Currently, the wetlands mapping database contains over 7,500 unique classification codes. Some diversity in classification coding and nomenclature is desirable as it provides descriptors of unique habitat types or wetland conditions. However, the proliferation of mapping codes is neither useful nor desirable and the need to provide uniformity in the terminology is essential to describe ecological characterization. For this reason, conventions have been developed to try and limit the number and types of classification code descriptors to those that will be most informative about wetland and deepwater habitats.

Adaptations to the Cowardin classification system have been made to conform to operational and practical constraints in the data collection and mapping processes. These are reflected in the map legend information developed by the Service and included as Appendix B and a glossary of terminology in Appendix C.

3. Data Collection Guidelines

Mapping involves a number of functions including feature identification, classification, field verification, methods for data capture and storage, generation of map products in digital formats, procedural documentation, and application of technology. Each function requires a level of standardization to produce consistent products (USFWS 2004). Coordination of data collection and product availability is the responsibility the Service's Regional Wetlands Coordinators (http://www.fws.gov/wetlands/Organization/RWC.html). Mapping entities are well advised to consult with these Coordinators prior to any wetlands mapping effort.

Existing wetland maps have been produced using a multi-step process (see Appendix D). Most, if not all, existing maps have been through extensive quality control reviews at the image interpretation stage, draft and final map stages of production. When they were produced, the

[4] Analysis of imagery is often supplemented with limited field work and ground observations.

maps reflected the type and extent of wetland habitats that the Service was able to portray given technical and logistical constraints.

By 2002, the Service's National Wetlands Inventory had mapped a large percentage of wetlands of the conterminous United States. In reassessing its priorities, the Service concluded that existing digital wetland map data would regularly need to be updated to meet the needs of resource managers and decision makers in order to address increasingly complex environmental issues. The Service implemented a strategic plan (USFWS 2002) that shifted focus to updating wetland maps in priority areas, in and adjacent to high-growth areas of the country. In December 2007, the Service provided additional direction based on priorities, existing budgets and personnel. The overall direction is to (1) address habitat changes resulting from climatic shifts including sea-level rise, and energy development, and (2) support Strategic Habitat Conservation activities of the Bureau.

The existing wetland map library would be used as a basis for updating and the assumption that the base wetland map information was essentially correct at the time it was produced forms the underlying premise for this updating process.

The goals of editing are to produce maps that match existing wetland and deepwater conditions (on-the-ground) as closely as possible, and to use resources efficiently and cost effectively. Editing shall conform to the principles listed below:

- The resulting map or data set must support clear, unambiguous interpretation and readability of the wetland features represented.
- The position and classification accuracy of the mapped features must meet current standards, and the map as a whole must represent the scientific precision that underlies the Service's habitat mapping objectives.

Wetland and deepwater feature delineation and attribution distinguish features by class, subclass, water regime or special modifier. The decision to retain or change the existing map features or attributes is based on several factors considered to be revision guidelines.

3.1. Basic Revision Guidelines:

Make qualitative determination(s) about the usefulness of the original wetland data (map) (i.e. should it be updated or re-done). The following guidelines generally apply to map updates or revisions. In some cases wetland map data may be so outdated or inaccurate that the map should be replaced in its entirety. Some basic revision guidelines include:

Retain all lakes, ponds, rivers, bays, sounds, estuaries, perennial streams and other water bodies regardless of size, unless a feature has obviously changed or no longer exists.

Revise coastal shorelines only if there are obvious manmade changes or substantial natural changes.

Revise wetland or deepwater boundaries by using ancillary data sources and the geographical features that define location and configuration.

Revise existing wetland and deepwater habitat delineations and attributes only where reliable ancillary data indicates a change or there is positive visual evidence of a change.

On quadrangles shifted from NAD 27 to NAD 83, fill any voids (gaps) created by the datum shift by extracting the missing line work from the adjoining map, or close polygons based on logic or visual evidence.

Revise data where data transfer procedures or older data formats have created improper alignment with base maps or imagery.

On revised or updated maps there will be a temporal difference between the update and older edition map. Seasonal or climatic variations in the source imagery should be considered when making update changes or revisions.

Change obsolete attribute codes to meet current standards.

Replace unknown water regime with the appropriate water regime modifier.

Add the diked/impounded special modifier (especially important in coastal areas).

Revise bathymetric information (i.e. lacustrine sub-system delineations) only if pertinent new information is available or where shorelines have obviously not been modified.

Revise classification of vegetative surface cover only in one of the following minimum change criteria is met:

- The total area of the feature to be re-delineated or re-classified is greater than 0.25 acre.
- The hierarchy of the re-classification is Cowardin class level or higher (subclass for forested or shrub areas).

Do not label upland(s) as part of a standard product. The Wetlands Geodatabase is a seamless dataset that does not contain upland labels (http://www.fws.gov/wetlands/Data/)

Do not delineate features as points in digital data files. Points delineated on photo overlays and digitally captured in a later process will be buffered to 11.36 m.

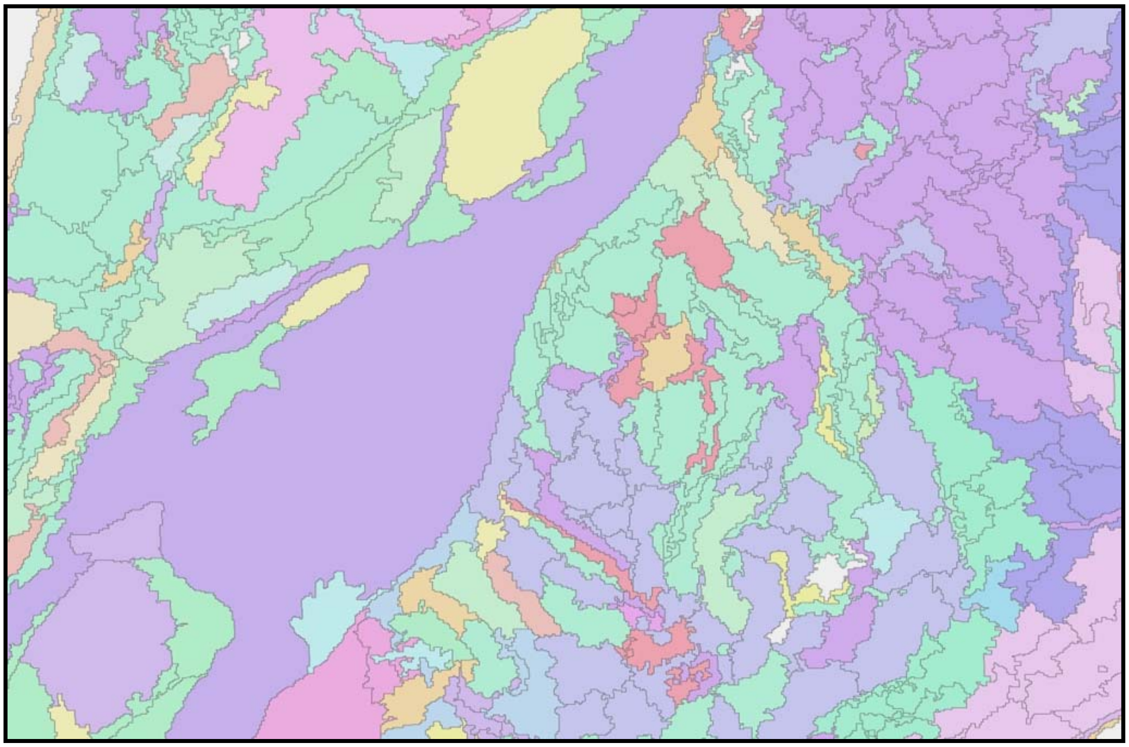
3.2. Avoiding Extraneous Detail and Misrepresentation of Data

Technological advances in the acquisition of remotely sensed imagery and computerized mapping techniques often provide the ability to capture more detailed information about earth objects. The use of such technologies can be advantageous in terms of producing better quality natural resource information in a more timely fashion and often at a reduced cost. However, appropriate use of these capabilities requires specific knowledge of project objectives, limitations, and the proper application of the end products.

In the context of conducting a medium resolution national mapping effort[5], updated wetlands maps should reflect ecological characterization or land use condition that influence the size, distribution or classification of wetland habitats. Enhancements to refine cartographic precision should be undertaken only to the extent they bring products into conformance with the Service's standards and quality requirements (Figure 1).

[5] Local project area mapping may be more detailed and contain project specific objectives.

A



B

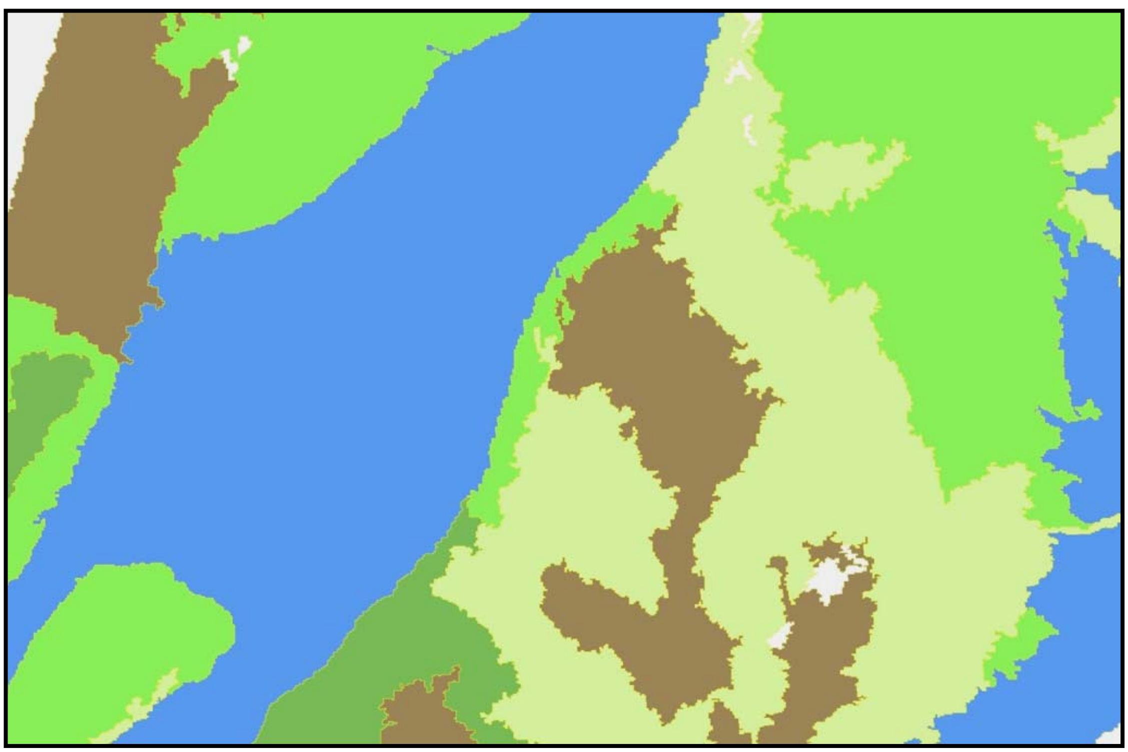


Figure 1. Comparison of (A) high resolution (original scale approximately 1:6,500) detailed vegetative cover data and (B) more generalized ecological characterization of wetland classification types.

When mapping wetlands, deepwater and riparian habitats, image analysts will address the following criteria in priority order:

1. Delineation of wetland and deepwater habitats to resemble size and shape;
2. Appropriate classification to the Cowardin class level[6];
3. The horizontal accuracy[7] minimum requirement is commensurate with the base imagery/map scale available for the area consistent with the FGDC Wetlands Mapping Standard (2009)[8];
4. Classification of Cowardin water regime;
5. More detailed classification of Cowardin modifying terms within specific specialized project objectives and as can be determined by the imagery;
6. More precise geographical location or boundary determination within specific specialized project objectives and as can be determined by the imagery.

Unrealistic attempts to characterize habitats in greater detail should be avoided unless specifically required by special project specifications or instructions from Service Project Manager(s). Detail is often confused with quality. The goal of the Service is to produce high quality resource maps. Steps that are implemented to add additional detail (delineation or classification of extremely small features or components) lends a sense of false precision and can misrepresent the data in way that it was not intended to be used.

Excessive detail of mapped features will be avoided. Within a wetland boundary, the delineation of ecologically unsubstantiated internal breaks should be avoided. Intricate sub-delineation of wetland types (less than 1.0 ac.) within a wetland is often not warranted. In areas of undulating terrain (i.e. ridge and swale) or complexes of wetland classes (i.e. small shrub islands within emergent meadow), it is best to identify and characterize the wetland by a single classification rather than attempt to delineate and classify internal features. Highly detailed resource information can be provided by the Service through various special projects. The Service's Regional Wetlands Coordinator has knowledge of where these projects have been completed and the products available.

4. Technical Procedures for Data Collection and Image Analysis

The delineation of wetlands, deepwater habitats and riparian features through image analysis forms the foundation for deriving all subsequent products and data results. Consequently, the Service places a great deal of emphasis on the quality of the image interpretation. The Service

[6] The Service has recommended that the minimum standard for wetland classification is: ecological system, subsystem (with the exception of Palustrine), class, subclass for forested and scrub-shrub classes, water regime, and (where applicable) special modifiers. Farmed wetlands need only include system and farmed modifier.
[7] Horizontal accuracy refers to a feature's spatial relationship to the base imagery.
[8] Local project area mapping may be more detailed and contain project specific objectives.

makes no attempt to adapt or apply the products of these techniques to regulatory or legal authorities regarding wetland boundary determinations, jurisdiction or land ownership, but rather uses the information to assist in resource mapping and habitat characterization. Coordination and consultation with the Service's Regional Wetlands Coordinator is very important to understand classification application concepts, wetland delineations, and national project objectives.

4.1. Image Interpretation of Wetlands - General Concepts

This document is not a primer on wetland ecology, interpretation or resource analysis using remotely sensed imagery. Wetland image analysts need to be fully trained before attempting to apply these data collection procedures (see section 4.2.3.a Personnel Qualifications).

There are "basic elements" that can aid in identification of wetland habitats from aerial photographs or digital imagery. The image analyst uses these to make decisions about ecological habitat boundaries to map wetlands. These same elements are used in the quality control review of delineated information to check for accuracy and completeness.

Tone (also called Hue or Color) -- Tone refers to the relative brightness or color of elements on an image. It is, perhaps, the most basic of the interpretive elements because without tonal differences none of the other elements could be discerned.

Size -- The size of objects must be considered in the context of the scale of an image. The scale will help you determine if an object is a stock pond or large lake or reservoir.

Shape -- Refers to the general outline of objects. Regular geometric shapes are usually indicators of human presence and use.

Texture -- The impression of "smoothness" or "roughness" of image features is caused by the frequency of change of tone in images. It is produced by a set of features too small to identify individually. Grass, cement, and water generally appear "smooth", while a forest canopy may appear "rough".

Pattern (spatial arrangement) -- The patterns formed by objects in an image can be diagnostic. Consider the difference between (1) the random pattern formed by a natural grove of trees and (2) the evenly spaced rows formed by an orchard or planted forest.

Shadow -- Shadows may aid interpreters in determining the height of objects on aerial imagery. However, they can also obscure objects within them.

Geographic Location -- This characteristic of imagery is especially important in identifying vegetation types and land forms. For example, large oval depressions in the ground are readily identified as Carolina Bays in the coastal regions of southeast.

Association -- Some objects are always found in association with other objects. The context of an object can provide insight into what it is. For instance, a nuclear power plant is not (generally) going to be found in the midst of single-family housing.

For general information on photo interpretation and photo interpretation techniques, users are referred to the following publications:

Avery, T.E. 1970. Interpretation of Aerial Photographs 4th edition. Burgess Publishing Co., Minneapolis, MN. 324 p.

Lillesand, T.M. and R.W. Kiefer. 1987. Remote Sensing and Image Interpretation 2nd edition. John Wiley and Sons, Inc., New York, NY. 721 p.

W. Philipson (editor) 1996. Manual of Photographic Interpretation (Second edition). American Society for Photogrammetry and Remote Sensing. Bethesda, MD

Ustin, S. 2004. Manual of Remote Sensing, Volume 4, Remote Sensing for Natural Resource Management and Environmental Monitoring, (3rd Edition). Wiley Publishing, Inc., Indianapolis, IN. 768 p.

Also see: http://www.asprs.org/ for additional information on remote sensing techniques.

4.2. Technical Methodologies

Currently there are various accepted techniques used to interpret, delineate and map wetlands. The technologies change with time and this section does not contain a comprehensive discussion of all possible data capture methods. One of the predominant approaches currently being employed by the Service is presented below. Information on other wetland interpretation techniques is included in Appendix D.

4.2.1. On-Screen (Heads-up) Method

The Heads-up process is the current method most feasible for identifying and delineating wetlands using digital imagery and supporting tools.

The on-screen or heads-up method involves viewing digital map data that overlays digital imagery on a personal computer screen (monitor). Changes to the map data to make it current with the digital imagery can be made on-screen and the digital data file checked and saved or exported.

The heads-up method was primarily developed for updating existing wetland maps, although it can be used to do original habitat mapping. Three-dimensional viewing which can be incorporated into a heads-up process provides a useful method to delineate wetland and deepwater habitats. Stereoscopic views can be helpful in locating and classifying wetlands (See Appendix D). ArcMap (latest version) employs geodatabase formats for viewing, editing and storing map data. This greatly improved the administration, access, management and integration of spatial data. The ArcMap system also provided access to a suite of editing tools available in ArcGIS, it created smaller more efficient files and it permitted map editors to "drag and drop" polygons which proved to be a very important capability in updating wetland map files.

The heads-up method has several distinct advantages:

- Uses digital imagery (DOQs or other digital data)
- Eliminates manual cartographic transfer work
- Provides seamless coverage of work areas
- Easily transportable to ArcSDE or other platforms
- Digital Raster Graphics (DRGs), or other digital data layers provide a direct backdrop for image interpretation and checking
- Hydric soils can be imported and viewed as ancillary information
- Linear feature files can be eliminated
- Automated verification routines can incorporate GIS capability

There are also several limitations associated with this method:

- The process is machine/cursor driven. This requires an Arc-literate operator
- On-screen viewing generally does not include stereo capabilities (although these capabilities can be incorporated through heads-up stereoscopic analysis or by viewing imagery through a manual stereoscopic process.) USGS digital raster graphics help compensate for this by providing hydrographic, topographic, cultural and contour information to assist.
- Electronic media requires different preparation, storage, distribution and archiving skills

The heads-up process developed for updating wetland maps relies on the image interpreter's ability to recognize, accurately delineate and classify wetlands, perform data edits, and verify the digital file. It eliminates all of the manual transfer and rectification stages of the traditional (older) photo interpretation method. Customized ARC tools were created to allow quicker attribution of map features using wetland and deepwater codes as well as other descriptive codes or information. A custom verification tool was also developed to provide quality control or logic checks of the digital data. This tool can be accessed at: http://www.fws.gov/wetlands/Data/Tools.html.

Editing and updating wetland digital map data using the heads - up process implies the following:

- Digital imagery will be used as the base imagery to update the wetlands information
- The existing wetland map digital data will overlay and register to a USGS DRG topographic base map or rectified imagery where available
- ArcGIS software will be used in a Windows environment to edit existing digital data
- The Service's customized software tools will be used to assist the updating and editing and data verification processes

4.2.2. Minimum Hardware and Software Requirements

Desktop Work Stations: The customized Attribution and Verification Tools are extensions to Environmental Systems Research, Incorporated's (ESRI) ArcMap desktop geographic information system (GIS) product. To run these tools, any workstation must be capable of running the ArcGIS suite, including Arc Desktop and Arc Workstation. ESRI has published system requirements for ArcGIS on their web site: www.esri.com.

Hardware specifications change with technological developments. Recommended high end GIS work station and computer hardware should be used.

Software - ArcGIS (latest version) was best suited to performing map edits in a heads-up environment. ArcMap provides a suite of efficient editing tools, interactive editing capability and integrated version control of data. Customized attribution and verification processes are integrated into the ArcGIS on-screen display.

4.2.3. a. Personnel Qualifications

Personnel using the on-screen method need the experience in the identification and classification of wetlands. Using the on-screen method, image analysts are responsible for insuring the ecological integrity of the mapping process as well as most of the cartographic accuracy. The identification, delineation and attribution of features is done within the digital data file requiring analysts to understand the ecological aspects of wetlands as well as be able to operate in a computerized mapping environment. For this reason, image analysts using this method should be experienced with ArcDesktop (latest version) software, and have some familiarity with geodatabases and editing spatial data. Inefficient or inadequately trained interpreters will greatly increase work time and potentially create numerous technical difficulties.

It is suggested that individual data analysts seek certification or advanced training as provided in the example below:

Certified Mapping Scientist, Remote Sensing (ASPRS) - A professional that specializes in analysis of images acquired from aircraft, satellites or ground bases, or platforms using visual or computer-assisted technology. Analysis is used by various specialized disciplines in the study of natural resources, temporal changes, and for land use planning. They develop analytical techniques and sensor systems.

Three years of experience in photogrammetric or cartographic applications, all of which have been in a position of responsibility that demonstrated knowledge and competence in planning and application. Three years of specialized experience at a professional level in remote sensing and interpretation of data from various imaging systems.

4.3.2.b. Defining the project area

Using the heads - up method no longer constrains analysts to quadrangle based work areas. Work areas may be river corridors, watersheds, counties, etc. However, defining the project area in geographical terms is important for the purposes of selecting the appropriate digital data from the Service's wetlands geodatabase, acquiring and registering digital ancillary data, versioning of the data, metadata tracking, and edge matching. Regions may request digital wetlands data by defining a project area by 1:24,000 quadrangle(s) or by providing a shape file or personal geodatabase of the project area boundary, and forwarding a request for digital wetland data covering that project area to the Service's Wetlands Geodatabase Manager. Digital wetlands data will be provided in personal geodatabase format that is 'checked-out' from the master SDE geodatabase. Data from the Service's wetlands geodatabase is clipped to match the project study area boundaries and provided to analysts in personal geodatabase format. Data are provided in a uniform projection (Albers Equal-Area Conic Projection). The horizontal planar units are meters. The horizontal planar datum is the North American Datum of 1983, also called NAD83. Analysts must delineate all wetland and deepwater features (or other target habitats) within the project boundary.

Data must be returned to the Service's Wetlands Geodatabase Manager and only data in geodatabase format will be accepted. In order to 'check-in' revisions to the Master SDE geodatabase, the personal geodatabase returned must be the ‘checked-out’ geodatabase (with revisions) initially provided. Data must have passed verification and quality control review(s).

4.3.2.c. Acquiring digital raster graphics

A digital raster graphic (DRG) is a scanned image of a USGS standard series topographic map. The image inside the map neatline is georeferenced to the surface of the earth and fit to the UTM projection. The horizontal positional accuracy and datum of the DRG matches the accuracy and datum of the source map. These form the standard base for mapping using the heads-up method.

Optimum transparency for DRG backdrops - DRG images should be visible as a backdrop to the imagery being used for mapping. The recommended transparency setting for viewing DRG backdrops is 75%. Transparency settings within an ArcMap session should not exceed 80% or be less than 60%. The DRG image may be toggled on and off as needed when conducting active editing or feature delineations on the digital image.

4.3.2.d. Acquiring and using digital imagery

Digital orthophotos are rectified digital imagery that combines the image characteristics of a photograph with the geometric qualities of a map. Digital orthophotos are geo-referenced. This means that any point on the orthophoto is referenced to its actual latitude/longitude (its actual location on the earth). Ortho-rectification removes distortion in the photo and provides uniform scale throughout the image.

Many digital orthophoto quarter quads (DOQQs) are produced by the USGS and represent a quarter of a standard USGS 1:24,000 quadrangle. DOQQs are either gray scale (black and white) or color infrared and have a 1.0. meter ground resolution. The DOQQ's have 50 to 300 meters of overlap between images so if two or more adjacent DOQQ's are open in a GIS no seam will show. DOQQ's are projected in UTM meters in NAD83 Datum. USGS DOQQ's meet National Map Accuracy Standards at 1:12,000 scale for 3.75-minute quarter quadrangles and at 1:24,000 scale for 7.5-minute quadrangles (corresponding to standard, 7.5-minute USGS topographic maps).

Not all digital imagery has been collected by USGS and may not meet these specifications. For this reason, checking the accuracy and registration of the digital imagery is an important first step. This can be done by aligning the digital imagery with the matching portion of the DRG. Since USGS products will continue to be the base data for the wetlands mapping effort, all digital data are aligned or compared to the USGS standard or rectified orthophoto products or maps. If imagery is scanned and rectified, acquired from non-conventional sources or if digital imagery is used, it must match the standards established for the base. This can be accomplished by checking alignment of known features on the image and map for correlation, checking datum corner points, or by establishing ground sample points at known location and distance. Digital imagery, when used as a base, will be considered acceptable if at a scale of 1:10,000 known features or points appear not more than 5 meters from their location on the base.

4.3.2.e. Incorporating and using National Wetlands Inventory (NWI) digital data.

The existing NWI dataset is an invaluable tool for updating wetland maps or re-mapping. In most cases the existing NWI data have been collected using high altitude aerial photography. The map information has been quality control reviewed by Service Regional personnel, qualitatively inspected by national team member(s), incorporated and distributed to review as draft products, finalized and digitized. NWI digital data are currently available for the majority of the nation and should be evaluated and used as a starting point for any heads-up project[9]. (See: http://www.fws.gov/wetlands/Data/)

Several issues were discovered when working with older NWI digital data. 1) The digital files contained artifacts or errors from older software or data capture processes. 2) There were alignment and systemic zoom transfer scope offsets to the digital data. 3) The NWI maps contained older map codes (attributes) that are no longer used. This is especially true for raster scanned images of older NWI maps available on-line. 4) Ties or edge matching between quadrangles were often "forced" at the digital map stage with no resolution of feature delineations. Existing digital data coming from the Service's wetlands geodatabase may retain some issues that have carried over from the older NWI dataset. These include: data gaps between quadrangles, conflicts in edge matching, and data holes where original source materials were not available to complete the mapping. In addition, some obsolete attribute codes need revision.

Of primary concern is the alignment of the wetlands digital data with the digital imagery and standardized base. During the manual transfer process of registering the interpreted photographic information to a stable base map, offsets of the data were created. These offsets are not uniform in direction, frequency of occurrence, or magnitude. Analysts will need to determine if this problem is tolerable, adjustments can be made or an area will need to be re-mapped in order to have the

[9] Contact the appropriate Regional Wetlands Coordinator for information and status.

wetlands data align with the base information as required by the data quality requirements.

4.3.2.f. Acquiring and Incorporating Ancillary Digital Data

Imagery, DRGs, hardcopy topographic maps, soil survey data or other ancillary data are currently not available through the Service's wetlands geodatabase. These ancillary data should be acquired as available from other sources.

Minimal data requirements for mapping wetlands using the heads-up method are digital imagery, DRG(s) and if conducting map updates existing NWI map data. Optional ancillary data may include, digital soils data, hydrology, coastal navigation chart data, etc. (see Section 7.2 below).

Alignment and registration of ancillary data should be checked against the DRG or orthorectified imagery. Analysts should be aware of the data limitations for any the digital datasets used. Some of these issues are discussed in Section 7.2 below.

4.3.2.g. Minimum Wetland Classification

The minimum standard for wetland classification is; Ecological system, subsystem (with the exception of Palustrine), class, subclass for forested and shrub, water regime and (where applicable) special modifiers. Reference to the Federal Geographic Data Committee Wetland Map Standards (2009) should be made to help ensure consistent, compliant data classification (http://www.fws.gov/wetlands/_documents/gNSDI/FGDCWetlandsMappingStandard.pdf).

4.3.2.h. Arc Map Editing - Image analysis

The Wetlands Geodatabase is the foundation for the Service's digital wetlands data holdings that make up the wetland geospatial data layer for the nation. The geodatabase is composed of five geographical units (conterminous U.S., Alaska, Puerto Rico and the Virgin Islands, Hawaii, and the Pacific Trust). The geodatabase is designed to provide feature class information for wetlands polygons, riparian and other related data. Each feature class is structured to include definitions and purpose, product description and use, metadata and limitations (Figure 2).

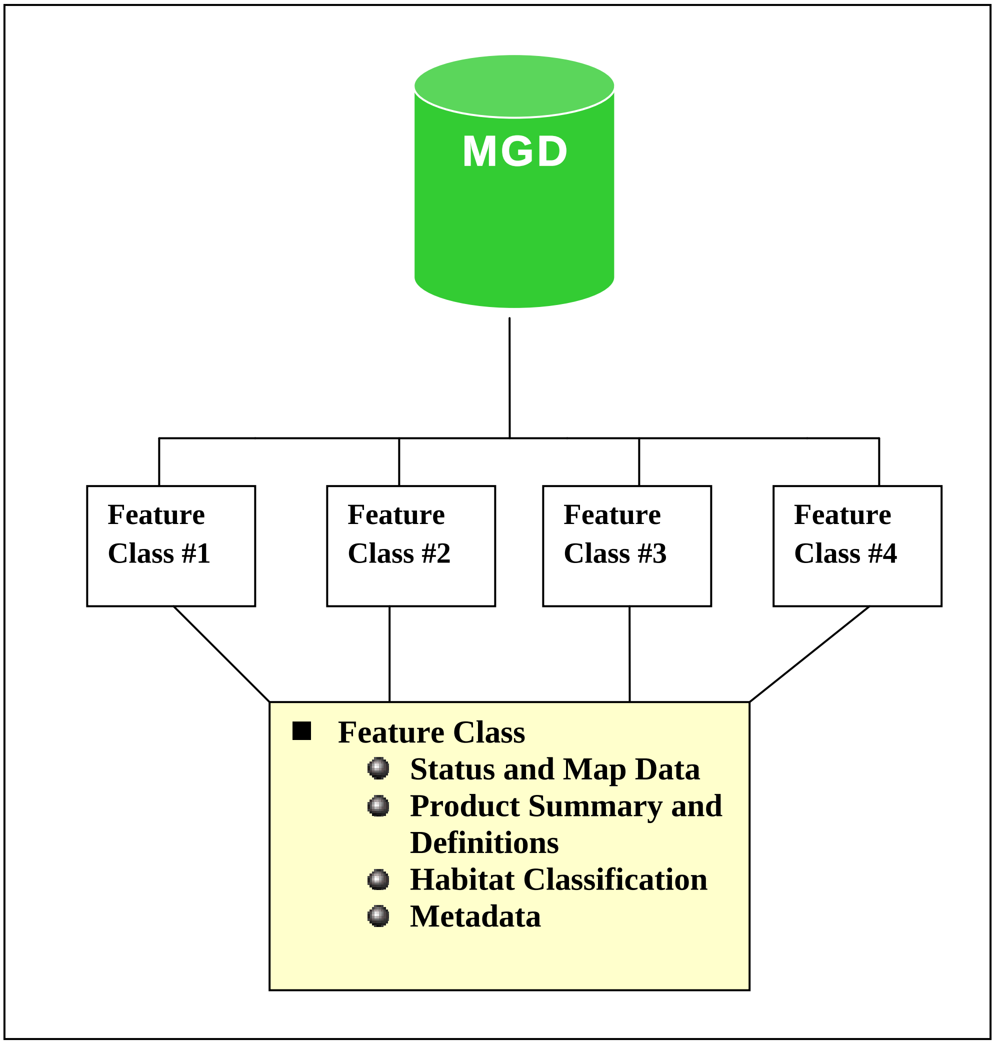


Figure 2. The geodatabase geographical unit for the conterminous U.S. (Conus) is designed to contain various feature classes (i.e. wetland polygons, riparian, etc.) each with status and supporting information.

In an open ArcMap session, there are several digital map parameters that need to be set prior to editing. These include:

Optimal polygon color, fill and line width - It is necessary to set optimal parameters for working with existing digital wetland map data in an ArcMap edit session. Optimum polygon outline color shall provide the image analyst good contrast between the line work and source imagery. Thus, polygon color is based on imagery type. Bright yellow or red display well against the gray scales of black and white imagery. Other colors may be more appropriate if the imagery is color or color infrared, or if the line work is displayed directly on the DRG backdrop. Black, white and low contrast colors should not be used. A solid polygon fill color should not be used during the wetland interpretation process.

This prevents the image analyst from clearly viewing the underlying image and may adversely influence wetland covertype classification or water regime assignment. Color fills may be useful in searching and identifying particular polygons or habitat types form the attribute table or for other quality control measures. In these instances, fill color is determined by the analyst.

Polygon outline width (line weight) in ArcMap should not be so heavy as to mask the boundaries of wetlands on the imagery or so thin that they are difficult to detect or give a false sense of boundary precision. Settings for polygon outline width shall not be less than 0.50 or exceed 2.5[10]. Line widths of 0.75 to 1.25 are considered optimum.

Polygon labels – These should be displayed for most of the edit session. This enables the image analyst to determine the accuracy of existing feature classifications. Labels may be toggled on and off to better view landscape features or details during an edit session. Label color and font size are determined by the image analyst, but should provide high contrast for easy viewing without masking important image characteristics.

DRG and other ancillary layers – These may be toggled on and off to facilitate viewing the imagery and delineating features. Ancillary data layers may be viewed separately or in various combinations at the discretion of the image analyst.

Analyst corrections – These are made to the existing digital data to fix past mistakes. Corrections include such things as missed wetlands, areas incorrectly delineated as wetland, repositioning or rectification of old line work and corrections to the wetland classification or labeling.

Analyst updates or changes – These are made to the wetland delineations based on actual change over time. Updates included the deletion of lost wetlands, additions of new wetlands, the reshaping of wetland boundaries based on changes that have occurred over time, and re-classification of wetlands that have changed cover-type. Changes to the digital wetlands data are tracked in the Service's database by retaining temporal versions of the dataset.

Working scales - The project scale for the Service's wetland map products is 1:12,000 (1:63,360 scale in Alaska). Over-delineation of features is possible given the quality of some of the digital imagery being used. This should be avoided to realize project efficiencies and has led to establishing specific project scale thresholds.

[10] Default unit(s) in ArcMap symbology

The source imagery used to interpret wetlands should be a minimum of 1m resolution or as specified in Table 1. Spatial resolution refers to the detail with which a map depicts the location and shape of geographic features. The larger the map scale, the higher the possible resolution. Base imagery is the ortho-rectified imagery (aerial photography/satellite imagery) that is used as the base image to overlay wetlands data. The base imagery must be rectified to a national standard dataset. Digital Ortho-photo Quarter Quads (DOQQs) would be the most ubiquitous base imagery used (1:12,000 scale). The purpose of specifying base imagery requirements is to produce a high detail and consistent wetland data layer.

Table 1. Spatial Resolution Requirements of Source Imagery. (Source: FGDC 2008)

	Lower 48 States and Hawaii*	Alaska	In-Shore Deepwater
Resolution	1m	5m	3m

***Includes the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. In-shore deepwater habitats are excluded. Alaska is also excluded.**

The Target Mapping Unit (TMU) is an estimate of the size class of the smallest wetlands that can be consistently mapped and classified at a particular scale of imagery, and that the image-interpreter attempts to map consistently. The size of a TMU is based on a simple square or a circle shape (a polygon with significant interior area relative to its perimeter) and not a long, narrow rectangle (i.e., a linear feature with little or no discernable interior area at the scale of interest). Therefore, wetlands which appear long and narrow (less than 15 feet wide at a scale of 1:12,000), such as those following drainage-ways and stream corridors, are excluded from consideration when establishing the TMU, and such wetlands may or may not be mapped, depending on project objectives. TMU requirements are shown in Table 2.

Table 2. Targeted Mapping Unit(s) and Requirements

	Lower 48 States, Hawaii, & Territories *	Estuarine & Lacustrine Deepwater **	Alaska (Including Deepwater)
TMU	0.5 acres (0.2 ha)	1.0 acres (0.4 ha)	5.0 acres (2.0 ha)
Feature Accuracy (Wetland Identification)	98%	98%	98%
Attribute Accuracy (FGDC Wetlands Classification)	85%	85%	85%

†PA across each DOQQ (or the project area if the project area is smaller than a DOQQ), as documented through external quality assessment of samples.
***Includes the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. Estuarine and lacustrine deepwater habitats are excluded. Alaska is also excluded.**
****Includes the Estuarine and Lacustrine deepwater of the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. Alaska is excluded.**

Universal scale - The universal working scale is the scale where review or edits are done in ArcMap and the delineations are quality controlled. The universal scale should range between 1:7,000 and 1:12,000 in an ArcMap session. This exceeds the requirements to ensure accuracy and sufficient detail.

Maximum zoom - This is the maximum magnification an analyst should use for wetland delineation and classification purposes. This scale is established at 1:5,000. Delineations performed below this maximum zoom threshold greatly exceed the requirements, and may misrepresent the data as being more precise than can be supported by the techniques and objectives as established by the Service[11]. Delineations performed at scales larger than this threshold lead to project inefficiencies.

Linear and point data - There are no point data in a personal geodatabase. Features too small to be mapped as small polygons far exceed the minimum mapping unit and will not be included. Linear segments are not included in the geodatabase.

Existing linear features from older wetland maps will be converted to polygon features and included in the wetlands feature class. Narrow wetland features shall be mapped as polygons. Other entities such as the USGS - National Hydrography

[11] Special project may exceed these scale recommendations.

Data (NHD) map linear stream and riverine features and duplication is not warranted.

4.3.2.i. Quality Assurance

All data collectors are required to coordinate to the extent possible with Regional Wetlands Coordinators and project personnel for data reviews and quality assurance steps prior to submission to the Service's Wetlands Geodatabase.

Internal reviews and checking - Quality control of interpreted map products will be performed on 100 % of the project area by a qualified image analyst other than the person performing the original work. To accomplish this, the review analyst will perform an incremental screen by screen (working west to east or north to south) qualitative review of the project area at no less than 1:12,000 scale. Following completion of row or column of screen views edits should be saved in the personal geodatabase.

Internal quality control review of interpreted images should include a comparison of contours, hydrographic symbols or cultural features from the DRG to wetland delineations and vegetation signatures. There is considerable latitude allowed in conducting qualitative reviews. However, a complete review of the project area with the backdrop of the standardized base visible at a scale not smaller than 1:12,000 must be completed. All work shall adhere to all National Standards and Quality Requirements and these Data Collection Requirements.

Attribute table review - During this quality control review the analyst will access the Arc attribute table and review for errors. Sorting various data fields in ascending order can easily isolate null attributes, empty attributes, improper attributes and very small, or "sliver" polygons.

Draft product review - The production of draft map products is optional. Plots of the ArcMap data may be made to review in the field or to provide visual inspection of mapped features at various smaller scales than is practical to view on-screen. There are no specifications for draft products since they are considered interim work products - not for distribution.

Data Verification - There are tremendous advantages in using newer technologies to store and analyze geographic data. The Geodatabase is a mechanism for spatial and attribute data that contains specific storage structures for features, collections of features, attributes, relationships between attributes and relationships between features. Many of the geopositional data checks are now inherent in the creation of a geodatabase in ArcMap. Topological checks such as defined projections are no longer necessary in a geodatabase since the geodatabase itself cannot be created without defining the coordinate system.

Customized data verification tools have been constructed to automate (to the extent possible) the quality control functions necessary to ensure the geodatabase is accurate. This suite of functions has been designed to address geopositional errors, digital anomalies, and some logic checks that make use of the power of the geographic information system. These tools are extensions to Environmental Systems Research, Incorporated's (ESRI) ArcMap desktop geographic information system (GIS) product. The latest version of the verification tools and accompanying user documentation can be found at; http://www.fws.gov/wetlands/Data/Tools.html

Cartographic accuracy - For digital data to be accepted into the Service's Wetland Geodatabase, they must first pass verification. A number of geospatial quality control checks are mandatory for the digital data to pass verification. The pass/fail function on the customized tool will automatically execute those verification tools. Other functions the verification tools perform will flag potential problems but provide the image analyst the option of editing or ignoring the feature.

Logic checking - The geodatabase verification process also uses the analytical ability of the Geographic Information System to build in enhancements to the quality control process. Things like wetland classification accuracy can be checked along with cartographic precision.

Edge matching - Edge-matching of wetland interpretation is required for a seamless wetland database. There are two types of edge-matching: 1) internal ties along the borders of source images and 2) external ties to pre-existing wetland data immediately adjacent to the project area.

The Service requires that in all cases, internal edge-matching shall be performed. Wetland mapping units lying along the outer borders of source images within a project area, whenever practical shall be edge-matched with interpretations on all adjacent images within the project area. All polygon features shall be edited to ensure an identical or coincident transition across images in the entire project area. At a minimum, features located on the outer edge of the project area will be closed exactly at the border of the project area. Because some maps have been updated, there may be some temporal differences in the data.

Edge matching of data adjacent to the project area can be facilitated by referencing on-line data available at:

http://www.fws.gov/wetlands/Data/Mapper.html or by establishing a web mapping service (WMS) connection to the existing wetland data.

4.3.2.j. Metadata

Metadata are stored in the Wetlands Geodatabase in FGDC compliant format. Metadata at the National level are provided to comply with the Service's Metadata Documentation and Record form. These data address the informational content of each of the five map areas contained in the Wetlands Geodatabase. Additional supplemental information which serves as project level metadata is included as well. Metadata layers contained in the Services Geodatabase are shown in Figure 3.

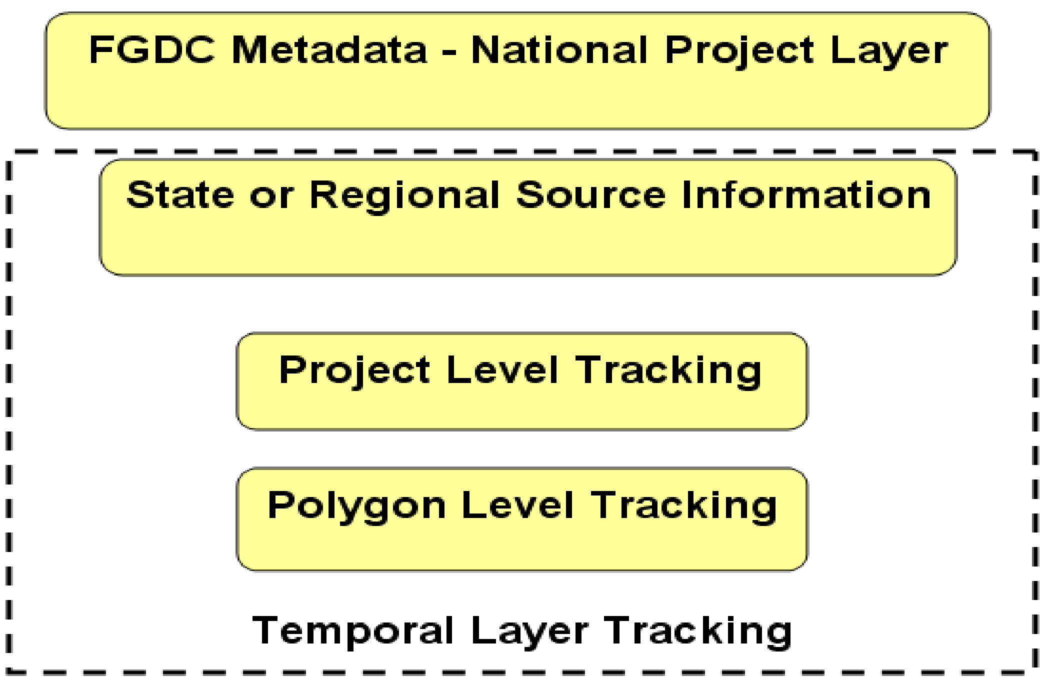


Figure 3. Metadata layers contained within the Wetlands Geodatabase

Project Level Metadata - Project level metadata are assembled for each project area checked-out from the Service's Wetlands Master Geodatabase and modified/updated. This will provide the needed tracking and reference information to the geodatabase users.

Mandatory Submissions - A completed Supplemental Map Information Report (supplemental metadata) must be included and an electronic copy is to accompany the digital data when submitted. This information becomes the "project level metadata" or intra-data specific to the updated version of the geodatabase. An electronic copy of a completed Wetland Digital Data Submission Form must also be included. These forms can be accessed at; http://www.fws.gov/wetlands/WetlandsLayer/ContributorForm.html

Optional Submissions - Submission of completed field data forms and/or field photographs are optional. These are supplemental information to the data and should be clearly labeled if included. Each photograph submitted must be linked to subject matter discussed on the field data form and be provided at 72 dpi in j-peg or tiff format.

The Supplemental Map Report, Field Data Form and Region Transmittal Form are standardized report forms designed specifically for the Service's geodatabase and are included as Appendices F, G and H.

3.2. K. Digital Data Requirements and Delivery

The digital data must conform to the following criteria:

- Digital data must be submitted and pass FWS Regional reviews prior to submission to the wetlands geodatabase
- Digital wetlands data must be provided in personal geodatabase format
- Data will be in a uniform projection (Albers Equal-Area Conic Projection). The horizontal planar datum is the North American Datum of 1983, also called NAD83
- Data must have passed verification and all quality control review(s). All polygons must have a valid attribute code to depict wetland habitat type. To avoid attribute errors, all data submissions must be run through attribute verification checks prior to submission. Implementation recommendations for ensuring attribute validity reside in Appendix E.
- No point data are to be submitted.
- Internal to the project area, data should be seamless.

5. Scalable Map Options

Scalable map products may be generated in certain parts of the country as initial or interim information. The goal is to develop maps that can be expanded or upgraded on demand. These products still must meet the Service's geospatial data requirements for wetlands mapping although they will differ in the source materials used to create the data and will not meet resolution and scale requirements. For example:

- Digital data must be submitted and pass FWS Regional reviews prior to submission to the wetlands geodatabase
- Cowardin coding may be truncated at higher levels of classification (example; PFO instead of PFO1A)
- Digital wetlands data must be provided in personal geodatabase format
- Data will be in a uniform projection (Albers Equal-Area Conic Projection). The horizontal planar datum is the North American Datum of 1983, also called NAD83
- Data must have passed verification (topology only) and all quality control review(s).
- No point data.

For any wetland mapping activity that will not comply with the existing FGDC Wetlands Mapping Standards, a waiver is required from the Service's Data Steward for Water Resources and Wetlands. A waiver is an authorized exemption from a specific minimum requirement(s) in the FGDC standard and will only be considered for non-conformance to technical specifications of spatial resolution, source imagery, geospatial accuracy requirements, or level of classification. A waiver is not required for projects not directly or indirectly funded with the use of federal funds.

The intent of these products is to fill an immediate data gap and should be replaced with standardized wetland map information as funding and priorities will allow. For example, areas of the arid west (UT, AZ and NM) remote mountains, interior Alaska, and interior of Puerto Rico may fall into this category (Figure 4). Consulting the Regional Wetlands Coordinators prior to initiating this type of data collection is recommended.

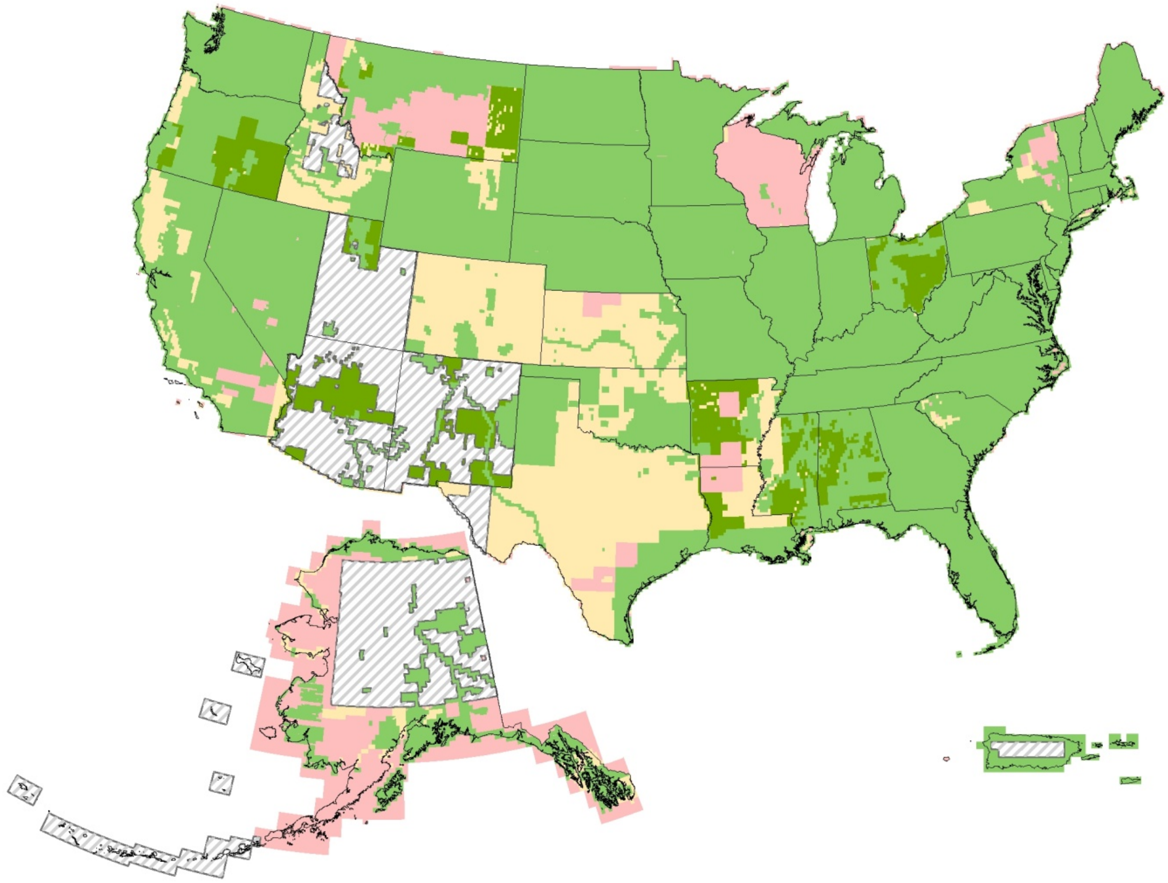


Figure 4. Preliminary candidate areas for scalable map products to assist in providing initial wetland map data for the nation have been identified by blue cross hatch on this map.

6. Limitations

The Service's wetland and deepwater habitat maps were prepared from the analysis of high altitude imagery. Wetlands were identified based on vegetation, visible hydrology and geography. There is a margin error inherent in the use of imagery, thus detailed on-the-ground inspection of any particular site, may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the ancillary data, and the amount of ground truth verification work conducted. Wetlands or other mapped features may have changed since the date of the imagery and/or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site. Most data discrepancies will occur in the application of the different subclasses and water regime modifiers assigned to particular wetlands. Aerial imagery typically reflects conditions during the specific year or season when it was captured. Precise description of hydrologic characteristics requires detailed knowledge of the duration and timing of surface inundation, both yearly and long-term as well as an understanding of groundwater fluctuations. Because such information is seldom available, the water regimes are described in general terms. The analysts' goal is to assign the average condition. Assigning water regime based on a single point-in-time image can lead to misrepresentations, especially in times of drought or extreme high water conditions. Ancillary data sources should be consulted to determine the date of the source imagery used and any mapping problems.

Certain wetland habitats may not be consistently mapped because of the limitations of aerial imagery as the primary data source used to detect wetlands (USFWS 2004). These habitats include sea grasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and near shore coastal waters.

Reefs include tropical reef communities (coral or tuberficid worm reefs) and oyster (*Crassostrea virginica*) reefs. Reef communities form a vital component of coastal ecosystems. Tropical coral and worm reefs can be found in the Florida Keys extending south from Miami and Soldier Key to the Dry Tortugas, Puerto Rico, the U.S. Virgin Islands, Hawaii and the islands of the Pacific Trust Territories. Oyster reefs can be found in several states along the south Atlantic and Gulf coasts. Reefs are found offshore in water depths from less than 1 m to over 40 m. Because of their depth, most reefs go undetected by aerial imagery used to map wetlands (Dahl 2005).

Cowardin *et al.* (1979) does not recognize ephemeral water areas as a wetland type. Therefore, ephemeral waters are not included as part of this mapping effort. Different agencies describe "ephemeral wetlands" in different ways. Ephemeral waters are areas that are flooded or ponded with surface runoff for less than seven days. Wetlands such as seasonal ponds, temporary ponds or vernal pools (U.S. EPA – www.epa.gov) are included as wetland types in the Service's mapping efforts.

Historically, the Service excluded certain types of "farmed wetlands" by policy[12]. Other farmed wetlands cannot be determined from aerial imagery and may not be included. Contact the Service's Regional Wetlands Coordinator for additional information on what types of farmed wetlands are included on wetland maps.

Federal, state and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than is described here. There is no attempt, in either the design or products of the Service's inventory, to define the limits of proprietary jurisdiction of any Federal, state or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving

[12] The policy originating in 1978, allowed the Service to map farmed prairie pothole depressions, cranberry bogs, California tidelands and playa lakes.

modifications within or adjacent to wetland areas should seek the advice of appropriate Federal, state or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

7. Universal Technical Processes

7.1. Suitable Imagery

In general, the most recent era imagery available should be used to update resource maps[13] . Only good quality imagery is acquired and used. The preferred type is digital color infrared with a resolution of 1.0 meter. Experienced wetland interpreters have found color infrared to be superior to other imagery types for recognition and classification of wetland vegetation types. There are multiple sources of imagery available including products from the National Agricultural Imaging Program, USGS digital ortho-imagery products, state acquired imagery, and others.

Wherever possible, leaf-off (early spring or late fall) imagery will be used. A number of studies have found that imagery obtained when vegetation is dormant allows for better identification of wetland boundaries, areas covered by water, drainage patterns, separation of coniferous from deciduous forest, and classification of some understory vegetation. (U.S. Environmental Protection Agency 1991) There are distinct advantages to using leaf-off imagery to detect the extent of forested wetland. Visual evidence of hydrologic conditions such as saturation, flooding, or ponding combined with ancillary data sources including soil surveys, topographic maps, and wetland maps are used to identify and delineate the aerial extent of forested wetlands. Leaf-off imagery is an important tool in this process.

7.2. Ancillary Data as an Aid to Image Analysis

All data sources can vary in quality, resolution, availability and age. Data sources should be scrutinized for applicability to meet project objectives. The analyst is required to use all available and approved photographic imagery, topographic maps, soils information or any other sources of ancillary data that can be reasonably obtained during image interpretation. Review of these materials is helpful in interpreting digital imagery. It is suggested to use technically sound, reliable data sources to aid in the determination of wetland habitats. Some recognized sources of ancillary data may include the following:

U.S. Geological Survey (USGS) Topographic Maps or Digital Raster Graphic (DRG): Areas indicated on USGS 1:24,000 scale (1:63,250 scale in AK) topographic maps by swamp symbology should be closely inspected on the source

[13] Older imagery may be used in extenuating circumstances.

imagery. These features are often excellent indicators of wetland and unless strong evidence indicates otherwise, should be included on the map (Figure 5). Due to the nature of USGS topographic mapping, wetlands marked on USGS quadrangles tend to be at least seasonally flooded (U.S. Geological Survey 2001). All permanent water bodies are also mapped by USGS. USGS DRG's can be acquired at: http://topomaps.usgs.gov/drg.

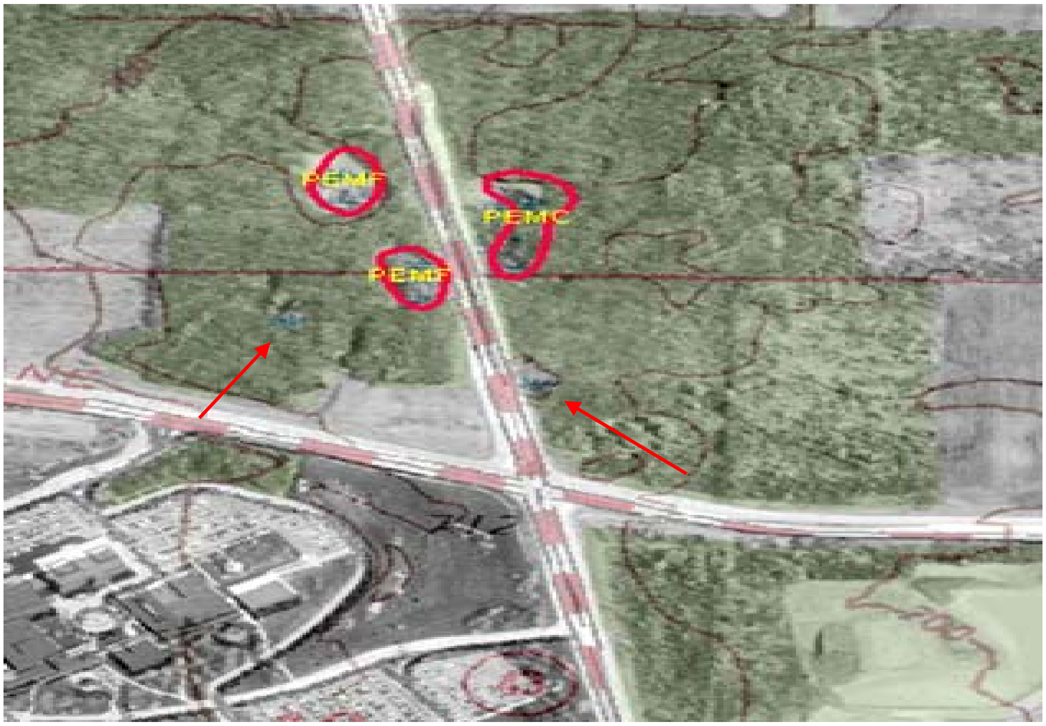


Figure 5. The DRG backdrop can assist in locating some wetland areas. In this example, swamp symbols from the DRG indicate two small wetlands (red arrows) that might have been missed using imagery alone.

USGS maps also provide hydrographic, topographic, cultural and contour information. Close attention should be paid to the topographic contour lines on the USGS maps. Many interpretation errors can be avoided if the degree of slope is taken into consideration. The location, shape, drainage pattern, and surrounding physical and cultural features are all important clues when mapping wetlands. Analysts should also take into consideration the potential for the existence of slope wetlands, particularly in high-relief or geologically complex landscapes, and that the existence of seepage driven, perched, and other saturated wetlands can occur on topographic slopes. Geologic maps and data may be helpful in identifying areas where slope wetlands may be encountered. The date of the DRG should always be considered when using this information.

U.S. Geological Survey – National Hydrographic Data (NHD) and other Hydrologic Data Sets: NHD data are maps of surface water bodies including lakes, rivers, ponds and streams. The high resolution dataset is most desirable for use in conjunction with wetlands mapping projects. USGS NHD data can be acquired at: http://nhd.usgs.gov

The USGS quadrangles or USGS Water Resources Data (stream gauge data) should be used as the primary data source in determining if the river channel is perennial or intermittent. Perennial streams are indicated by a continuous line on topographic maps whereas, intermittent streams are shown as a broken line. The exceptions to this are provisional maps produced by the USGS.

Natural Resource Conservation Service County Soil Surveys or Digital Soils Information: Soil survey maps are useful ancillary data providing the description, classification, and mapping of soils within a county. These maps are a representation of various soil patterns and types on the landscape. The complexity of the soil patterns, scale of the base imagery, field techniques employed, date compiled, and the minimum mapping unit for soil classification all play a role in how the soils information was produced and the utility as ancillary data for mapping wetlands. When used by an experienced image analyst as ancillary data, soils maps are useful in assisting in separating upland from wetland (hydric) soils. Hydric soils information can be found at: http://soils.usda.gov/use/hydric

The soil survey geographic (SSURGO) data base duplicates the original soil survey maps and presents it in digital form. The SSURGO data represents the most detailed level of digital soil information.

National Oceanic and Atmospheric Administration Navigational Charts: A NOAA navigational, or nautical chart, is a graphic representation of the estuarine, marine and near shore environment. They are primarily used to plot routes for sea-going vessels. All nautical charts depict coastline features, configuration of the sea bottom, tidal ranges, location of man-made and natural hazards to navigation, and the properties of the earth's magnetism. Nautical charts are especially useful in determining the subtidal and intertidal subsystem breaks in the Marine and Estuarine wetland classification systems. They are also useful in determining the location and extent of mangrove vegetation, coastal shoals, flats or bars. NOAA Navigation Charts can be found at: http://www.nauticalcharts.noaa.gov/

Previous Edition NWI Maps and Ancillary Project Information: Whenever a previous edition of an NWI map exists, the analyst will use the map as ancillary information to determine the location and extent of wetlands based on an earlier time period. Using previous edition Service wetland maps will provide important information on the presence or absence of wetlands. This information is useful to the analyst using more current imagery or imagery at a different scale. Different techniques to update maps will require different formats for the best use of the NWI data. For example, the heads-up technique is designed to use digital data draped on more recent imagery, whereas, traditional stereoscopic techniques have used hard copy maps as ancillary work materials. Existing digital wetland map information can be found at: http://www.fws.gov/wetlands/Data/Mapper.html

Local or Regional Studies or Maps and Other Data Sources: The analyst is also encouraged to consult appropriate internal and external resources (regional experts, on-site resource managers, etc.) to assist in the interpretation process. Examples of this type of information include: water management or district maps, vegetation maps or surveys, digital elevation data and local habitat studies or characterizations. The Service's Regional Wetlands Coordinators, state agencies, or regional authorities are often good sources for such information. The interpretation and delineation of wetlands and deepwater habitats is expected to meet the Service's standards for accuracy and consistency. Communication and problem resolution procedures to ensure product acceptance should be maintained throughout the project.

7.3. Field Reconnaissance

Field reconnaissance can address questions regarding image interpretation, land use practices, and classification of wetlands. Field work is also done as a quality control measure to verify that map information is correct. Viewing digital data on laptop or other portable devices can facilitate the review of wetlands map data in the field.

Initial field reconnaissance provides an opportunity for image analysts to become familiar with wetland communities and land use patterns. Information gained from field studies in combination with the analyst's skills and experience in image interpretation and use of ancillary data should result in successful wetland delineation and classification. In these instances, field work should involve visits to a cross section of wetland types and geographical settings, as well as to sites that may be mapped using different image types, scales, and dates.

Timing of field work inevitably influences results, particularly regarding vegetation data and water regime classification. Work conducted in early spring will highlight different components of an ecosystem than work conducted late in fall when different water conditions and plant species may predominate on the same site.

7.3.1. Preparation for Field Reconnaissance

To ensure accurate and consistent interpretation of imagery and to resolve various problems, analysts need to conduct field reconnaissance to correlate image signatures with observed wetland and upland types. The actual number of person-days required in the field is often determined by access to field sites, weather, travel logistics, etc. Preplanning of the field trip should include identification of hydric soils or hydric soil characteristics likely to be encountered, information about common wetland plants and their distribution, dominant land use, drainage practices, agricultural crops and some preliminary image analysis of sites to be field inspected.

Field sites should be chosen based on such things as commonly occurring image signatures or habitats characterizing an area; unusual but important imagery signatures (some which may be difficult to identify); borderline signatures (those features that might be wetland or upland) and; specific signature problems based on the date of imagery (recent burning, extreme high or low water conditions). All sites should be accessible. Analysts will want to select field sites near roads or public lands if access is limited.

7.3.2. Field Sites and Data Collection

While in the field, representative photographs (slides or digital) of land use and wetland types should be obtained. Field data sheets for selected sites should be completed. The exact location of the field photographs, site location referred to in notes and other information must be provided. Wherever possible, digital cameras, data recorders, image display laptops, and ground positioning satellite (GPS) should be used to provide more accurate information.

Any handwritten field notes regarding changes observed should be clear and understandable. Notations might include: ‘extend or add this wetland’; ‘delete wetland’; or ‘refine delineation’.

Time spent in the field is invaluable. To realize maximum results, it is often necessary to reassess some potential field sites based on work already completed versus time, access to sites and priorities.

7.3.3. Field Work as Verification

Image interpreters may conduct field verification exercises to ensure accurate and consistent interpretation of imagery. Field trip reports and Field Data Sheets (see Appendix F) provide documentation of the field verification efforts including, general descriptions of wetlands and uplands in an area, descriptions of surface water conditions both on the imagery and at the time of field work, and details about the quality of the source materials used.

7.4. Aids to Field Determinations

Plant Species That Occur in Wetlands

The presence of wetland plant species often provide important ancillary information to help biologists determine if a site is a wetland or to gain insight to length and periodicity of flooding. Many plant species, however, seemingly grow equally well in wetlands and upland conditions. To clarify what plants may be found in wetlands a list of wetland plant species, *"National List of Plant Species That Occur in Wetlands"* (Reed 1988). In the listing, wetland plants are divided into four indicator categories based on a frequency of occurrence in wetland. These categories include:

- *Obligate wetland* - almost always found in wetlands (estimated probability >99%)
- *Facultative wet* - usually found in wetlands (estimated probability 67-99%)
- *Facultative* - sometimes found in wetlands (estimated probability 34-66%)
- *Facultative upland* - seldom found in wetlands (estimated probability 1<33%) [14]

A list of plant species with the wetland indicator status found at a particular site can provide useful information about the site. This information, taken from the field data form, will be entered into a database for future reference and use. Wetland plant information can be accessed at: http://plants.usda.gov/wetland.html

Hydric Soil Lists and Indicators

Hydric soils are defined as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, July 13, 1994).

A list of the Nation's soils with actual or high potential for hydric conditions has been prepared by Natural Resources Conservation Service. "Hydric Soils of the United States" includes at least one phase in the listing that meets the hydric soil criteria. The list does not include soils that are classified at categories higher than

[14] The wetlands indicator categories should not be equated to degrees of wetness.

the series level in Soil Taxonomy (USDA - NRCS 1999) nor does it include map units that may contain these series. The list is useful in identifying map units that may contain hydric soils. There is a national list of hydric soils as well as state and county lists. While the state and county lists may provide more regionally specific information, analysts should be aware that they may not be comprehensive in their presentation of all soil series with hydric characteristics.

Hydric soils lists and maps reflect only the soil series or map unit considered hydric. Soil map units may contain inclusions of smaller features with hydric characteristics (wetland). Soils that are artificially drained or protected (for instance, by levees) may be listed as hydric even though it will no longer meet the Cowardin definition of wetland.

Experienced analysts should rely on field indicators as a more reliable way to help identify existing wetlands. Nearly all hydric soils exhibit characteristic morphologies that result from repeated periods of saturation and/or inundation for more than a few days. Saturation or inundation when combined with anaerobic microbiological activity in the soil causes a depletion of oxygen. This anaerobiosis promotes biogeochemical processes such as the accumulation of organic matter and the reduction, translocation, and/or accumulation of iron and other reducible elements. These processes result in characteristic morphologies which persist in the soil during both wet and dry periods, making them particularly useful for identifying hydric soils (USDA - NRCS, Wetland Science Institute and Soils Division 1996). *Field Indicators of Hydric Soils in the United States* (2006) is a guide to help identify and delineate hydric soils in the field. The most recent version of the field indicators document can be found at: http://soils.usda.gov/use/hydric/

7.5. Field Forms and Reporting Requirements

A field trip report may be completed for data collection projects. Map update projects may also require a field trip report subject to the requirements established by the Regional Wetlands Coordinator.

Field trip reports shall discuss the details of the field reconnaissance efforts (including participants, dates, and location), ancillary data sources and uses, general descriptions of wetlands and uplands in the area, description of water conditions, details about the quality and interpretation of the imagery and any special problems, findings or conventions.

During each field trip, participants are encouraged to complete Field Data Forms at a variety of different check sites which are well distributed throughout the trip area. The exact number of check sites may be determined by specific project specifications, weather conditions, access to sites, trip objectives, etc. Good quality digital photographs should be provided for field sites for which a Field Data Form is completed (Field Data Form is included in Appendix F). Protocols for submitting digital Field Data Forms and digital photographs to become part of the Wetlands Master Geodatabase are discussed below.

7.6. Private Land Access Protocol

The Service respects private property and land owner rights. Personnel should contact landowners in advance to obtain permission to access private lands to conduct field verification or evaluations. Site visits will not be made where this is not possible, or landowners cannot be contacted. At no time should Service personnel cross fences, gates, and barriers or traverse posted property without permission of the landowner. Analysts should select alternative field sites near roads or public lands if access is limited.

8. Achieving Quality Requirements for Wetland and Deepwater Data

Quality requirements for wetland data are defined as "level of accuracy" benchmarks in the National Standards and Quality Requirements. This information can be found at; http://www.fws.gov/stand/standards/dl_wetlands_WWW.html. They include quality goals for wetland identification, delineation and classification accuracy[15]. Additional requirements for digital data accuracy and metadata ensure data are complete and accurate.

The Service has produced step-down Information Quality Guidelines for information disseminated by the agency. These guidelines are applicable to all Service offices that disseminate information to the public to ensure the information complies with the basic standards of ***quality*** to ensure and maximize its ***objectivity***, ***utility*** and ***integrity***.

The quality and integrity of the Service's wetland map products is based on a process involving various levels of quality oversight (Figure 6).

[15] Currently, the Service is working with the Federal Geographic Data Committee Work Group to complete revised wetland map standards to be applied to all federally funded wetlands mapping projects.

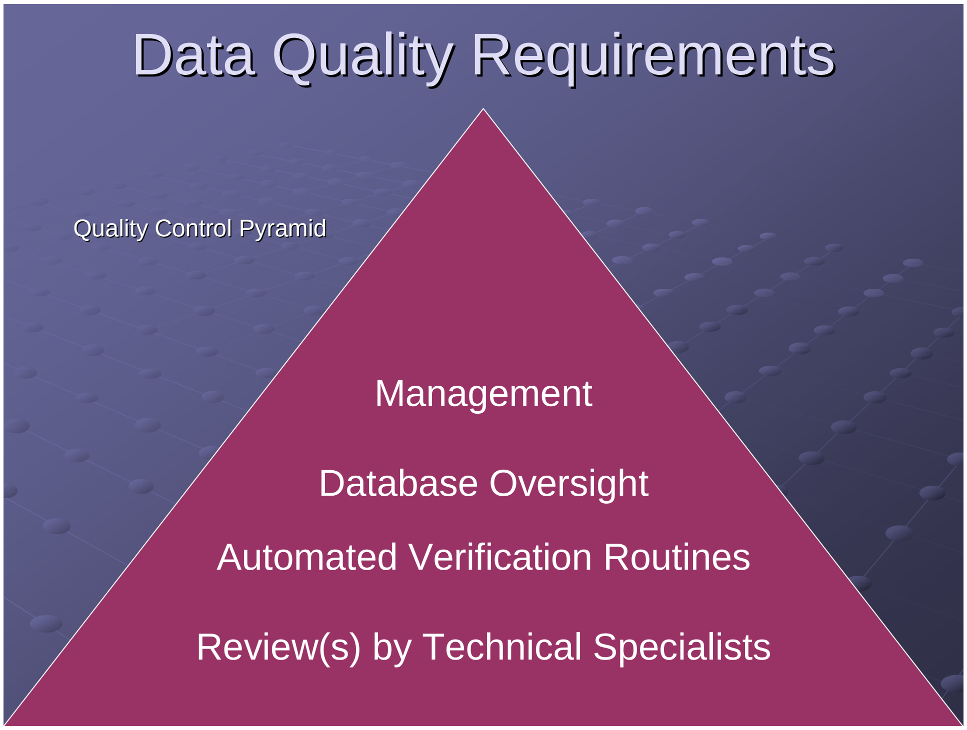


Figure 6. The Service's quality control schema provides various levels of quality oversight and data review.

As part of this process, wetland map data must pass these quality control procedures to ensure the information is accurate. The steps include: 1) review by technical specialist(s) 2) pass automated verification routines, and 3) pass final verification and data integrity inspection as provided by a database manager. Each step and components are described below:

A) **Review by Technical Specialist(s)** - This quality assurance step defines the responsibilities of the image analyst(s) for data quality and completeness. There are two mandatory sub-steps:

- **Internal Inspections of Data Quality** - Quality control of interpreted map products will be performed by a qualified image analyst other than the person performing the original work. The reviewing analyst will adhere to all National Standards, Quality Requirements and Data Collection Requirements and will perform a 100% review of the work. This internal inspection may be completed by non-Service personnel under the specific technical direction and performance monitoring by a Government official through an extramural agreement.

  Internal quality control review of interpreted images (regardless of methodology used) should include a comparison of contours, hydrographic symbols or cultural features from the USGS base map to wetland delineations and vegetation signatures. All available ancillary data should be used during this quality control review. The responsible reviewer must record the pertinent information regarding the review process to accompany the appropriate metadata for the project area.

If internal review is conducted by the Service Region it does not substitute for a Regional quality control review as described below.

- **Regional Quality Control** - This is considered to be exclusively a Service function that must be performed by responsible Service personnel. Regional quality control of map products entails spot checking of not less than 20% of the project area by qualified personnel. The Region has the discretion of how these quality controls are completed (i.e. using different technical means, field verification, etc.) Upon completion of the Regional quality control review, the Region should be prepared to certify that work products meet all applicable standards, quality requirements and technical specifications. If the products do not meet these standards, the Region has two options: Correct the work to bring it into compliance with quality standards, or return the work to the originating entity citing deficiencies and requesting additional work be completed to meet the standard(s).[16]

  Regions may choose to use other qualified Service personnel to perform quality control reviews. Work backlogs, level of expertise and experience in mapping particular wetland types may be factors in soliciting quality control review from other qualified Service personnel to ensure the work is accurate and completed in a timely fashion. Not less than 20% of the project area must be reviewed to ensure the work is complete and meets the quality requirements and specifications.

- **Final Quality Control Review** - This is considered to be exclusively a Service function that must be performed by responsible Service personnel. Final quality control of map products entails spot checking of not less than 10% of the project area by qualified personnel. Any qualified Service personnel may conduct final quality control reviews. These reviews may entail using various technical means or field verification to check the work. Final quality control reviewers must coordinate closely with Regional quality control personnel regarding revisions or modification to the work products. Ultimately, the Regional certification of data integrity and quality to the Service's Geodatabase Manager will conclude the data collection phase of the project.

B) **Scalable Products** - Scalable map products may be generated in certain parts of the country as initial or interim information. These interim products may include map

[16] There may be contractual considerations regarding review time lines and obligations under any extramural agreement.

information at different scales, classification level(s), or resolution. The goal is to develop maps that can be expanded or upgraded on demand. The production of interim products is at the discretion of the Region with an approved waiver provided by the Service's Data Steward for Water Resources and Wetlands. They do need to conform to the specifications established for standard map products or data. Regional specifications will dictate the procedures used to produce and distribute any interim map information.

C) **Data Verification** - All digital data files will be subjected to rigorous quality control inspections.

Data verification includes quality control checks that address the geospatial correctness, digital integrity and some cartographic aspects of the digital data. This step takes place after the ecological data collection phase of the project has been completed, reviewed and approved as qualitatively acceptable. Implementation of quality checks ensures that the data conform to the specified criteria, thus achieving the project objectives.

The Service, in conjunction with USGS has developed customized Attribution and Verification Tools for performing data checks on wetland map data. These tools can be found at; http://www.fws.gov/wetlands/Data/Tools.html. This suite of tools is extensions to Environmental Systems Research, Incorporated's (ESRI) ArcMap desktop geographic information system product. The latest version of the verification tools has been constructed to automate (to the extent possible) the quality control functions necessary to ensure the geodatabase is accurate. Various functions have been designed to address geopositional errors, digital anomalies, and some logic checks that make use of the power of the geographic information system. Additional quality assurance issues not readily apparent on the verification tools may be handled by the geodatabase architecture itself.

Some quality control functions of the verification tools will flag potential problems but provide the image analyst the option of editing or ignoring the feature. This is to accommodate the image analyst's ability to ultimately determine the best ecological portrayal of the data. For example, a small lake that is only 18 acres has been identified during the data verification process as a potential problem based on its size (18 acres) and classification (lacustrine) because the minimum size for a lacustrine lake is 20 acres. The analyst has information that the lake depth exceeds 90 feet (greater than the 6.6 foot required depth for lacustrine) and thus determines that lacustrine is the proper classification.

There are nine functions executed by the automated verification checking process (see Description of the Verification Tests within Appendix E). At a minimum, digital data must pass the critical tests for topology and attribution of the quality control procedure to be considered qualitatively acceptable. Critical verification tests include "Unattributed or Null Attributed Wetlands," "Adjacent Wetlands with the Same Attribute," "Wetlands less than 0.01 Acres," "Improper Island Polygons," and "Overlapping Polygons."

D) **Attribute Validity -** This standard requires that all polygons have a valid attribute code to depict wetland habitat type. To avoid attribute errors, all data submissions must be run through the attribute verification checks prior to submission to the Service for inclusion in the wetlands geospatial data layer.

The Service's Attribution Tools have been constructed to attribute map features that may depict wetlands, riparian areas, uplands or other natural features. These tools can also serve as a reference for uncommon or rarely used codes or to assist users who are not familiar with the alphanumeric wetland mapping codes. The main Attribution Tool contains the entire hierarchical scheme for classifying wetlands and deepwater habitats (Cowardin *et al*, 1979).

E) **Oversight, Data Integrity and Database Management** - The National Standards and Support Team has primary responsibility for the Service's wetlands geodatabase configuration and systems. This includes responsibility for the integrity and distribution of the digital geo-spatial data developed by the Service as part of the wetland and deepwater habitat mapping effort. Geodatabase Management is an important part to successful application of the processes used to verify, assimilate, distribute and archive geo-spatial wetland data. The Geodatabase Manager plays a substantial role in the quality assurance of the digital data files. This includes the following responsibilities:

- **Final Data Verification** - The Geodatabase Manager performs the final verification checks of the digital data before it is approved and entered into the wetlands geodatabase. This final check involves some geospatial analysis, logic checking, and ensuring the necessary supporting documentation has been provided in proper format.

- **Records and Documentation** - Additional reporting requirements applicable to all mapping projects include submission of a Supplemental Map Report (User Report) included as Appendix G. This will be used as project specific metadata information.

  Submission of completed field data forms and/or field photographs are optional. These are supplemental information to the data and should be clearly labeled if included (format(s) provided). Information on where to store these images and how to send them will be provided by the Service's Geodatabase Manager (Wetlands_Team@fws.gov). A completed Wetlands Digital Data Submission Form

(Appendix H) must be included and is the responsibility of the Regional Wetlands Coordinator.

New or updated digital map data must be returned to the Service's Geodatabase Manager on a CD or DVD with the contents and date marked. Only data in geodatabase format will be accepted. For work produced by Service Regions the 'check-in' revisions or updates to the Master SDE geodatabase, must be returned to conform with the 'checked-out' geodatabase (with revisions) initially provided by the National Standards and Support Team (NSST). Data must have passed verification and Regional review(s). For data contributed to the Service's geodatabase, information should follow the flow and quality control processes shown in Figure 7.

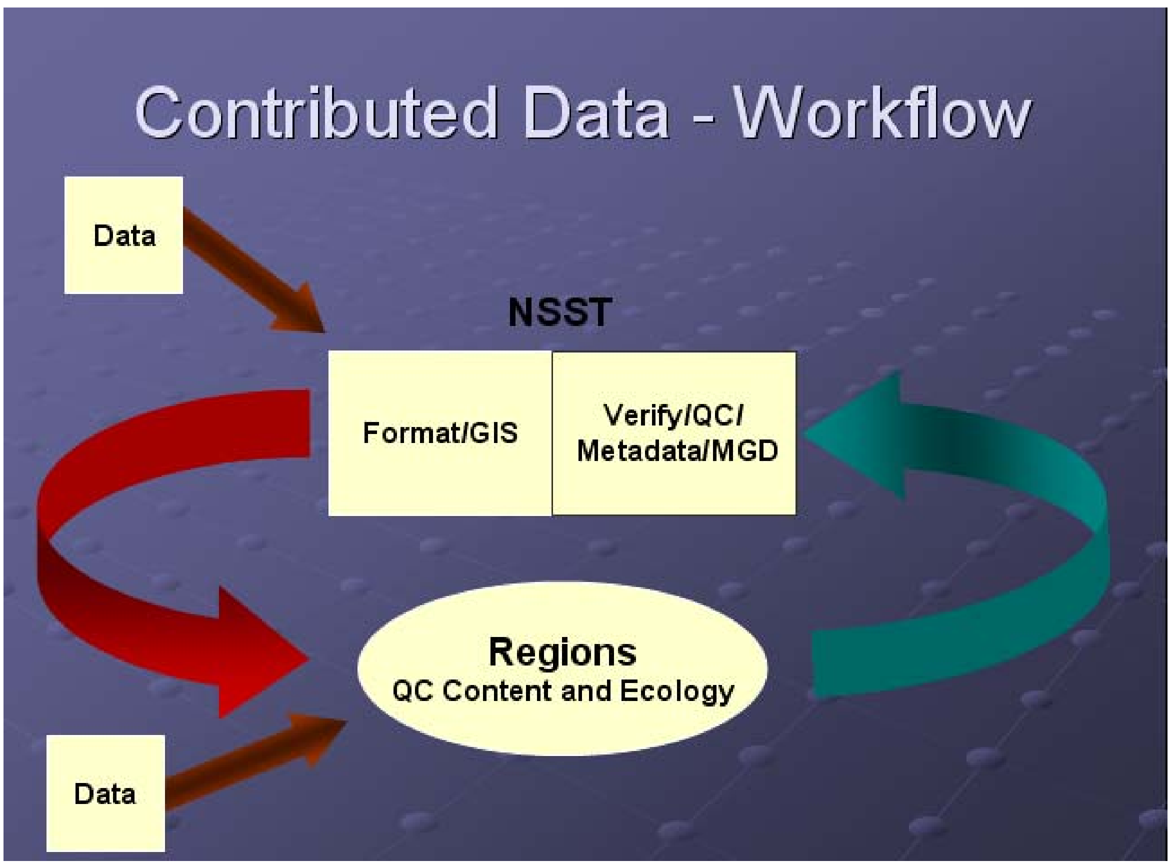


Figure 7. Workflow for incoming data submitted to the Service's geodatabase. Information passes through Regional and national quality control and verification steps.

Finally, when the data pass these quality assurance steps, all information disseminated to the public is approved prior to its dissemination by authorized representative(s) of Branch of Resource and Mapping Support or the Division of Habitat and Resource Conservation.

9. References

Avery, T.E. 1968. Interpretation of Aerial Photographs 2nd edition. Burgess Publishing Co., Minneapolis, MN. 324 p.

Cowardin, L.M, V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. Department of the Interior. U.S. Fish and Wildlife Service, Washington, D.C. 131 p.

Dahl, T.E. 2005. Florida's Wetlands - An Update on Status and Trends 1985 to 1996. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C. 80 p.

Federal Geographic Data Committee. 2008. Federal Geographic Data Committee Wetlands Inventory Mapping Standard. FGDC Wetland Subcommittee and Wetland Mapping Standard Workgroup. 50 p. (http://www.fgdc.gov/participation/working-groups-subcommittees/wsc/)

Federal Register. 1994. Changes in Hydric Soils of the United States. Washington, DC. (Hydric Soil Definition).

Lillesand, T.M. and R.W. Kiefer. 1987. Remote Sensing and Image Interpretation 2nd edition. John Wiley and Sons, Inc., New York, NY. 721 p.

Philipson, W. (editor) 1996. Manual of Photographic Interpretation (Second edition). American Society for Photogrammetry and Remote Sensing. Bethesda, MD

Reed, P.B. 1988. National list of plant species that occur in wetlands: 1988 National Summary. Biol. Rept. 88 (24). U.S. Fish and Wildlife Service, Washington, D.C. 244 p.

U.S.D.A., Natural Resources Conservation Service. 2006. Field Indicators of Hydric Soils in the United States, Version 6.0. G.W. Hurt and L.M. Vasilas (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils. 38 p.

U.S.D.A., Natural Resource Conservation Service. 1999. Soil Taxonomy: A basic system of soil classification for making and interpreting soil surveys. Agriculture Handbook No. 436, 2nd edition. U.S. Department of Agriculture, Natural Resource Conservation Service, Washington, D.C. 869 p.

U.S.D.A., Natural Resource Conservation Service. 1996. Field indicators of hydric soils in the United States, Version 3.3. G.W. Hurt, P.M. Whited, and R.F. Pringle (eds.). USDA, NRCS in cooperation with the National Technical Committee for Hydric Soils, Fort Worth, TX. 34 p.

U.S. Environmental Protection Agency. 1991. Wetlands detection methods investigation. Report No. 600/4-91/014. Systems Laboratory, Environmental Monitoring, Las Vegas, NV. 73 p.

U.S. Environmental Protection Agency. 1995. Wetland identification and delineation. Medea Wetlands Study Group- Technical Report 1. Environmental Protection Agency, Washington, D.C.

U.S. Fish and Wildlife Service. 1995. Photointerpretation Conventions for the National Wetlands Inventory. St. Petersburg, FL. 60 p.

U.S. Fish and Wildlife Service. 2002. National Wetlands Inventory: A Strategy for the 21st Century. U. S. Fish and Wildlife Service, Washington, D.C. 12 p.

U.S. Fish and Wildlife Service. 2004. National Standards and Quality Components for Wetlands, Deepwater and Related Habitat Mapping (http://www.fws.gov/stand/standards/dl_wetlands_WWW.html) U.S. Fish and Wildlife Service, Arlington, VA. 19 p.

Appendix A: Wetland and Deepwater Classification for Mapping Purposes

The Cowardin *et al*. (1979) classification system is hierarchical, with wetlands and deepwater habitats divided among five major systems at the broadest level.

Systems are further subdivided into subsystems which reflect hydrologic conditions; e.g. Lower Perennial, Upper Perennial, and Intermittent in the Riverine System. Below the subsystem is the class which describes the appearance of the wetland in terms of vegetation or substrate. Each class is further subdivided into subclasses; vegetated subclasses are described in terms of life form and substrate subclasses in terms of composition.

The classification system also includes modifiers to describe hydrology (water regime), soils, water chemistry (pH, salinity) and special modifiers relating to man's activities (e.g. impounded, partly drained).

The Service uses this classification system to classify and delineate wetlands and deepwater habitats. To do so, requires some adaptations as described below:

SYSTEM

Marine System

The marine system describes open ocean or high energy coast lines with salinities exceeding 30 parts per thousand (ppt) and little or no dilution except outside the mouths of estuaries. Shallow coastal indentations or bays without appreciable freshwater inflow, and coasts with exposed rocky islands, that provide the mainland with little or no shelter from wind and waves, are also considered part of the marine system because they generally support typical marine biota.

> **Limits**: The marine system extends from the outer edge of the continental shelf shoreward to one of three lines: (1) the landward limit of tidal inundation (extreme high water of spring tides), including the splash zone from breaking waves; (2) the seaward limit of wetland emergents, trees, or shrubs; or (3) the seaward limit of the estuarine system, where this limit has been determined by factors other than vegetation. Deepwater habitats lying beyond the seaward limit of the marine system are not mapped.

Estuarine System

The estuarine system include habitats with low energy and variable salinity, influenced and often semi-enclosed by land. Near shore areas with typical estuarine plants and animals, such as red mangroves (Rhizophora mangle) and eastern oysters (Crassostrea virginica), are also included in the estuarine system. In the absence of salinity data, the marine - estuarine break should be indicated by a straight line drawn across the mouth of a bay, tidal river or sound. This line should not split other delineations (such as unconsolidated shores or aquatic beds) that may be found at the mouth of bays, inlets or estuaries. Rock shorelines, unconsolidated shores, and other classes that are contiguous with upland and stretch from marine areas to estuarine areas may be divided into separate systems.

The estuarine system is defined in terms of halinity and tidal influence. If tidal influence is only partially obstructed by weirs or tide (flap) gates or if tidal flux is accomplished by an underground connection (as in the Hawaiian Islands), the area should be classified as estuarine. However, if an area has been completely cut off from tidal action (totally obstructed by a dike), the area regardless of its location or salinity, would then fall in the lacustrine or palustrine systems.

In most cases, the image analyst will not be able to tell if the obstruction is complete. These areas should, by convention, be classified as estuarine. Only when ancillary data or field site information is available should a system other than estuarine be used for obstructed coastal waters.

> **Limits**: The estuarine system extends (1) upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow; (2) to an imaginary line closing the mouth of a tidal river, bay, or sound; and (3) to the seaward limit of wetland emergents, shrubs, or trees. The estuarine system also includes off-shore areas of continuously diluted sea water.
>
> The primary data to be used in identifying estuarine systems is tidal influence, salinity and plant communities. Lagoons that are hyperhaline (salinity greater than 40 ppt due to ocean-derived salts) are also included in the estuarine system. If the mouth of an estuarine river has been extended into the marine system by parallel breakwater, the seaward limit of breakwaters forms the estuarine - marine break. The limit of the estuarine system is further identified by the seaward limit of wetland emergents, shrubs, or trees where these plants grow seaward of the line closing the mouth of a river, bay, or sound. The seaward limit of mollusk reefs occurring outside of the line closing the mouth of a river, bay, or sound is also used to describe the estuarine - marine break. The location of the break separating the estuarine system from the tidal rivers can often be judged by identifying the upstream limit of salt tolerant vegetation that is observable on aerial imagery in coastal areas.

Riverine System

The riverine system includes all wetlands and deepwater habitats contained in natural or artificial channels periodically or continuously containing flowing water or which form a connecting link between the two bodies of standing water. Upland islands or palustrine wetlands may occur in the channel, but they are not part of the riverine system.

> **Limits**: The riverine system is bounded on the landward side by upland, by the channel bank (including natural and man-made levees), or by wetland dominated by trees, shrubs,

persistent emergents, mosses, or lichens. In braided streams, the system is bounded by the banks forming the outer limits of the channel where the braiding occurs.

The riverine system terminates at the downstream end where the concentration of ocean-derived salts in the water exceeds 0.5 ppt during the period of annual average low flow, or where the channel enters a lake. It terminates at the upstream end where tributary streams originate, or where the channel leaves a lake. Springs discharging into a channel are considered part of the riverine system.

Where a river enters a lake, the extension of the lacustrine shoreline across the mouth of the river forms the riverine - lacustrine break. Oxbow lakes are placed in the palustrine or lacustrine systems unless they are connected to a river by an open channel at both ends where water flows either on a permanent or intermittent basis. Run-of-the-river dams should be handled in the same manner as described above, with the lacustrine system extending upstream to the contour approximating the normal spillway or pool elevation.

Lacustrine System

The lacustrine system includes wetlands and deepwater habitats with all of the following characteristics:

- deepwater situated in a topographic depression or a dammed river channel
- lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% aerial coverage;
- total area exceeds 8 hectares (20 acres).

Basins or catchments less than 8 hectares in size are included if they have at least one of the following characteristics:

- a wave formed or bedrock feature forms all or part of the shoreline boundary
- at low water the water depth is greater than 2 meters (6.6 feet) in the deepest part of the basin

Lacustrine habitats formed by damming a river channel are confined by the contour approximating normal spillway elevation or summer pool elevation. Rivers with dams and associated locks that impound water to the extent that the ecological character of the river is significantly impacted, are considered lacustrine to the upstream point that approximates spillway or normal pool elevation, or to the upstream point where riverine characteristics return.

Limits: The lacustrine system is bounded by upland or by wetland dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens. Lacustrine systems formed by damming a river channel are bounded by a contour approximating the normal spillway elevation or normal pool elevation, except where palustrine wetlands extend into the lake system. Where a river enters a lake, the extension of the lacustrine shoreline forms the riverine - lacustrine boundary.

Palustrine System

The palustrine system includes all nontidal wetlands dominated by trees, shrubs, emergents, mosses or lichens, and all wetlands that occur in tidal areas where salinity due to ocean-derived salt is below 0.5 ppt. Wetlands lacking such vegetation are also included if they exhibit all of the following characteristics:

- are less than 8 hectares (20 acres)
- do not have an active wave-formed or bedrock shoreline feature
- at low water the depth is less than 2 meters (6.6 ft.) at the deepest part
- have salinity due to ocean-derived salts of less than 0.5 ppt.

All water bodies visible on the aerial imagery that are less than 8 hectares (20 acres) in size are considered to be in the Palustrine System unless depth information is available, or unless an active wave-formed or bedrock shoreline feature is visible.

Limits: The palustrine system is bounded by upland or by any of the other four systems described above.

SUBSYSTEM

Marine and Estuarine

Subtidal - These habitats are continuously submerged substrate, (i.e. below extreme low water).The division between intertidal and subtidal should be made by reference to National Ocean Survey charts and USGS topographic maps or, as a last resort, the tide stage at the instant of imagery.

Intertidal -This is defined as the area from extreme low water to extreme high water and associated splash zone. Substrates that are exposed by mean low water are indicated on most topographic maps by a dot pattern. Areas that are irregularly exposed at extreme low water are also included in the intertidal subsystem.

Riverine

Tidal - This Subsystem of Riverine extends from the upper boundary of the Estuarine System to the extreme upper limit of tidal fluctuations. The tidal reach terminates downstream where the concentration of ocean-derived salts in water exceeds 0.5 ppt during period of annual average low flow. The gradient is low and water velocity fluctuates under tidal influence.

Lower Perennial - This Subsystem is characterized by a low gradient and slow water velocity. There is no tidal influence, and some water flows throughout the year. The substrate consists mainly of sand and mud. The flood plain is well developed. Oxygen deficits may sometimes occur.

Upper Perennial - This Subsystem is characterized by a high gradient and fast water velocity. There is no tidal influence, and some water flows throughout the year. This substrate consists of rock, cobbles, or gravel with occasional patches of sand. There is very little flood plain development.

Intermittent - This Subsystem includes channels that contain flowing water only part of the year, but may contain isolated pools when the flow stops.

Unknown Perennial - This Subsystem designation was created specifically for use when the distinction between lower perennial, upper perennial, and tidal cannot be made from aerial imagery and no data is available.

Lacustrine

Limnetic - Extends outward from Littoral boundary and includes all deep-water habitats within the lacustrine System.

Littoral - Extends from shoreward boundary to 2 meters (6.6 feet) below annual low water or to the maximum extent of nonpersistent emergents, if these grow at depths greater than 2 meters.

CLASS and Subclass

Class describes the general appearance of the habitat in terms of either the dominant vegetation cover type or composition of the non-vegetated substrate. Vegetation (e.g. trees, shrubs, emergents) is used to define classes because it is easily recognizable, are less susceptible to seasonal cover-type changes, and has traditionally been used to classify wetlands. Other forms of vegetation such as submerged or floating-leaved vascular plants are more difficult to detect. Substrates reflect regional and local variations in geology and the influence of wind, waves, and currents on erosion and deposition of substrate materials.

Some differences in life forms are recognized at the Subclass level. For example, Forested Wetland is divided into the Subclasses Broad-leaved Deciduous, Needle-leaved Deciduous, Broad-leaved Evergreen, Needle-leaved Evergreen, and Dead. Subclasses and may be identified on the basis of the predominant life form.

Definitions of wetland classes and their subclasses:

Unconsolidated Bottom: Unconsolidated bottom includes all wetlands with at least 25 percent cover of particles smaller than stones, and a vegetative cover less than 30 percent. **Subclasses** include: cobble gravel, sand, mud, and organic.

Cobble-Gravel -- The unconsolidated particles smaller than stones are predominantly cobble and gravel, although finer sediments may be intermixed.

Sand -- The unconsolidated particles smaller than stones are predominantly sand, although finer or coarser sediments may be intermixed.

Mud -- The unconsolidated particles smaller than stones are predominantly silt and clay, although coarser sediments or organic material may be intermixed. Organisms living in mud must be able to adapt to low oxygen concentrations.

Organic -- The unconsolidated material smaller than a stone is predominantly organic matter.

Rock Bottom: Rock bottom wetlands and deepwater habitats are characterized by substrates predominantly made up of stones, boulders or bedrock (75 percent or greater by area). Subclasses include: bedrock and rubble.

Bedrock -- Bottoms in which bedrock covers 75% or more of the surface.

Rubble -- Bottoms with less than 75% areal cover of bedrock, but stones and boulders alone, or in combination with bedrock, cover 75% or more of the surface.

Aquatic Bed: Aquatic beds are dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. Examples include seagrass beds, pondweeds (Potamogeton spp.), wild celery (Vallisneria americana), waterweed (Elodea spp.), and duckweed (Lemna spp.). Subclasses include:

Algal -- Algal Beds are widespread and diverse in the marine and estuarine systems, where they occupy substrates characterized by a wide range of sediment depths and textures. They occur in both the subtidal and intertidal subsystems and may grow to depths of 30 m (98 feet). Coastal algal beds are most luxuriant along the rocky shores of the northeast and west. Kelp beds are especially well developed on the rocky substrates of the Pacific Coast.

Aquatic Moss -- Aquatic mosses are far less abundant than algae or vascular plants. They occur primarily in the riverine system and in permanently flooded and intermittently exposed parts of some lacustrine systems.

Rooted Vascular -- Rooted vascular beds include a large array of vascular species in the all major systems (fresh and salt water) within the photic zone.

Floating Vascular. -- Beds of floating vascular plants occur mainly in the lacustrine, palustrine, and riverine systems and in the less saline waters of the estuarine system. These plants float freely either in the water or on its surface.

Reef: Reefs are often ridge-like or mound-like structures generally at or below the surface of the water. They may be formed by the colonization and growth of sedentary invertebrates, mollusks or other shellfish or they may be natural rock outcrops or structures. Reefs are characterized by their elevation above the surrounding substrate and as an obstruction to normal water movement. Subclasses include: coral, mollusk, and worm.

Coral -- Coral Reefs are widely distributed in shallow waters of warm seas, in Hawaii, Puerto Rico, the Virgin Islands, and southern Florida. They are characterized as stable, well-adapted, highly diverse, and highly productive ecosystems with a great degree of internal symbiosis. Coral Reefs lie almost entirely within the subtidal subsystem of the marine system, although the upper part of certain reefs may be exposed.

Mollusk -- This Subclass occurs in both the intertidal and subtidal subsystems of the estuarine system. These reefs are found on the Pacific, Atlantic, and Gulf of Mexico Coasts and in Hawaii and the Caribbean. Mollusk reefs may become extensive, affording a substrate for sedentary and boring organisms and a shelter for many others. Reef mollusks are adapted to great variations in water level, salinity, temperature, and these same factors control their distribution.

Worm -- Worm Reefs are constructed by large colonies of Sabellariid worms living in individual tubes constructed from cemented sand grains. Although they do not support as diverse a biota as do coral and mollusk reefs, they provide a distinct habitat which may cover large areas. Worm reefs are generally confined to tropical waters, and are most common along the coasts of Florida, Puerto Rico, and the Virgin Islands. They occur in both the Intertidal and subtidal systems of the marine and estuarine systems where the salinity approximates that of sea water.

Streambed: Streambed wetlands are contained within the intermittent subsystem of riverine habitats as well as all channels that are completely dewatered at low tide in estuarine habitats. Subclasses include: bedrock, rubble, cobble-gravel, sand, mud, organic, and vegetated.

Bedrock -- This subclass is characterized by a bedrock substrate covering 75% or more of the stream channel.

Rubble -- This subclass is characterized by stones, boulders, and bedrock that in combination cover more than 75% of the channel.

Cobble-Gravel -- In this subclass at least 25% of the substrate is covered by unconsolidated particles smaller than stones; cobbles or gravel predominate. The Subclass occurs in riffle areas or in the channels of braided streams.

Sand -- Sand-sized particles predominate among the particles smaller than stones. Sand streambeds often contain bars and beaches interspersed with mud or interspersed with cobble-gravel in areas of fast flow or heavy sediment load.

Mud -- Mud particles are chiefly silt or clay. Mud streambeds are common in arid areas where intermittent flow is characteristic of streams of low gradient. Mud streambeds are also common in the estuaries and tidal subsystem of the some rivers.

Organic -- This subclass is characterized by channels formed in peat or muck. Organic streambeds are common in the small creeks draining organic soils.

Vegetated -- These streambeds are exposed long enough to be colonized by herbaceous annuals or seedling herbaceous perennials (pioneer plants). This vegetation, unlike that of emergent wetlands, is usually killed by rising water levels or sudden flooding.

Rocky Shore: Rocky shore include high energy shoreline environments characterized by bedrock, stones, or boulders which singly or in combination have an areal extent of 75 percent or more and less than 30 percent vegetative cover by area. Subclasses include: bedrock and rubble.

Bedrock -- These wetlands have bedrock covering 75% or more of the surface.

Rubble -- These wetlands have less than 75% areal cover of bedrock, but stones and boulders alone or in combination with bedrock cover 75% or more of the area.

Unconsolidated Shore: Unconsolidated shore includes all wetland habitats having two characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders or bedrock and; (2) less than 30 percent areal cover of vegetation. Subclasses include: cobble-gravel, sand, mud, organic and vegetated.

Cobble-Gravel -- The unconsolidated particles smaller than stones are predominantly cobble and gravel. Shell fragments, sand, and silt often fill the spaces between the larger particles. Stones and boulders may be found scattered on some cobble-gravel shores. In areas of strong wave and current action these shores take the form of beaches or bars, but occasionally they form extensive flats.

Sand -- The unconsolidated particles smaller than stones are predominantly sand which may be either calcareous or terrigenous in origin. They are prominent features of the marine, estuarine, riverine, and lacustrine systems where the substrate material is exposed to the sorting and washing action of waves.

Mud -- The unconsolidated particles are predominantly silt and clay. Anaerobic conditions often exist below the surface. Mud shores have a higher organic content than cobble-gravel or sand shores. They are typically found in areas of minor wave action. They tend to have little slope and are frequently called flats. Irregularly flooded mud shores in the estuarine system have been called salt flats, pans, or pannes. In many arid areas, palustrine and lacustrine mud shores are encrusted or saturated with salt. They are called inland saline flats, alkali flats, salt flats, and salt pans. Mud shores may also result from removal of vegetation by man, animals, or fire, or from the discharge of thermal waters or pollutants.

Organic -- The unconsolidated material is predominantly organic soil of formerly vegetated wetlands.

Vegetated -- Some nontidal shores are exposed for a sufficient period to be colonized by herbaceous annuals or seedling herbaceous perennials (pioneer plants). This vegetation, unlike that of Emergent Wetlands, is usually killed by rising water levels and may be gone before the beginning of the next growing season. Many of the pioneer species are not hydrophytes but are weedy mesophytes that cannot tolerate wet soil or flooding.

Moss/lichen: These wetlands are dominated by the mosses or lichens covering substrates other than rock. This class is found in the northern regions of the conterminous U.S. and Alaska. Subclasses include: moss and lichen.

Moss -- Moss dominated wetlands are most abundant in the far northern boreal forest and Arctic tundra environments. These areas are dominated by peat mosses (Sphagnum spp., e.g., S. fuscum, S. warnstorfii). In Alaska, Drepanocladus revolvans, D. lycodiodes and liverworts may dominate shallow pools with semi permanent water; other water mosses (e.g., Campylium stellatum, Aulacomnium palustre, A. turgidum and Oncophorus wahlenbergii) are typical of wet, saturated soils in these regions.

Lichen -- Lichen wetlands dominated by reindeer lichens (Cladonia spp., Cladina spp.) are also a northern subclass occurring primarily in northern boreal and Arctic tundra environments. Lichen cover is elevated above moss, sedge/moss, or dwarf-shrub/sedge/moss types.

Emergent Wetland: Emergent wetlands are characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. Subclasses include: persistent and nonpersistent.

Persistent -- Persistent emergent wetlands are dominated by species that normally remain standing at least until the beginning of the next growing season. This subclass is found only in the estuarine and palustrine systems. Persistent emergent wetlands dominated by saltmarsh cordgrass, saltmeadow cordgrass, big cordgrass, needlerush, narrow-leaved cattail and southern wild rice are major components of the estuarine systems of the Atlantic and Gulf of Mexico Coasts. On the Pacific Coast, common pickleweed, sea blite, arrow grass, and California cordgrass, are common dominants. Palustrine persistent emergent wetlands contain a vast array of grasslike plants such as cattails, bulrushes, saw grass, sedges; and true grasses such as reed, manna grasses, slough grass, and whitetop. There is also a variety of broad-leaved persistent emergents such as purple loosestrife, dock, and many species of smartweeds.

Nonpersistent -- Wetlands in this subclass are dominated by plants which fall to the surface of the substrate or below the surface of the water at the end of the growing season so that, at certain seasons of the year, there is no obvious sign of emergent vegetation. For example, wild rice does not become apparent in the North Central States until midsummer and fall, when it may form dense emergent stands. Nonpersistant emergents also include species such as arrow arum, pickerelweed, and arrowheads. Movement of ice in estuarine, riverine, or lacustrine systems often removes all traces of emergent vegetation during the winter.

Phragmites -- Wetlands in this subclass are dominated by common reed (*Phragmites australis*).

Scrub/shrub Wetland: Shrub wetlands include areas dominated by woody vegetation less than 20 feet (6 meters) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions. Subclasses include: broad-leaved deciduous, needle-leaved deciduous, broad-leaved evergreen, needle-leaved evergreen, and dead.

Broad-leaved Deciduous -- This subclass is made up of broad-leaved deciduous woody plants less than 6 m tall. In estuarine system the predominant deciduous and broad-leaved trees or shrubs are plants such as sea-myrtle, and marsh elder. In the palustrine system they are alders, willows, buttonbush, red osier dogwood, honeycup, spirea, bog birch, and young trees of species such as red maple or black spruce.

Needle-leaved Deciduous -- This Subclass, consisting of wetlands where trees or shrubs are predominantly deciduous and needleleaved, is represented by young or stunted trees such as tamarack or bald cypress.

Broad-leaved Evergreen -- In the estuarine system, vast wetland acreages are dominated by mangroves that are less than 6 m tall. In the palustrine system, the broad-leaved evergreen species are typically found on organic soils. Northern representatives are Labrador tea, bog rosemary, bog laurel, and the semi-evergreen leatherleaf. In the south, fetterbush, coastal sweetbells, inkberry, and the semi-evergreen black ti-ti, are characteristic broad-leaved evergreen species.

Needle-leaved Evergreen -- This subclass is made up of needle-leaved evergreen woody plants less than 6 m tall. The dominant species in needle-leaved evergreen wetlands are young or stunted needle-leaved evergreen trees.

Dead -- This subclass is made up of dead woody plants less than 6 m tall. These wetlands are usually characterized by prolonged rise in the water table resulting from impoundment of water. Such wetlands may also result from various other factors such as fire, salt spray, insect infestation, air pollution, and herbicides.

Evergreen -- A wetland plant community where evergreen shrubs or woody vegetation less than 6 meters (20 feet) tall represent the dominant spatial coverage.

Deciduous -- A wetland plant community where deciduous shrubs or woody vegetation less than 6 meters (20 feet) tall represent dominant spatial coverage.

Forested Wetland: Forested wetlands are characterized by woody tree species that are 6 meters (20 feet) tall or taller. Subclasses include: broad-leaved deciduous, needle-leaved deciduous, broad-leaved evergreen, needle-leaved evergreen, and dead.

Broad-leaved Deciduous -- These forested wetlands are dominated by woody vegetation taller than 6 meters (20 feet). Dominant trees typical of broadleaved deciduous wetlands include species such as red maple, American elm, ashes, black gum, tupelo gum, swamp white oak, overcup oak, and basket oak. Wetlands in this subclass generally occur on mineral soils or highly decomposed organic soils.

Needle-leaved Deciduous -- These forested wetlands are dominated by woody vegetation taller than 6 meters (20 feet). The southern representative of the needle-leaved deciduous subclass is bald cypress, which is noted for its ability to tolerate long periods of surface inundation. Tamarack is characteristic of the Boreal Forest Region, where it occurs as a dominant on organic soils. Relatively few other species are included in this subclass.

Broad-Leaved Evergreen -- These forested wetlands are dominated by the broad-leaved evergreen woody vegetation taller than 6 meters (20 feet). In the Southeast, broad-leaved evergreens include red bay, loblolly bay, and sweet bay are prevalent on organic soils. This subclass also includes taller red mangrove, black mangrove, and white mangrove, which are adapted to varying levels of salinity.

Needle-leaved Evergreen -- Black spruce, growing on organic soils, represents a major dominant of the needle-leaved evergreen subclass in the north. Though black spruce is common on nutrient-poor soils, Northern white cedar dominates northern wetlands on more nutrient-rich sites. Along the Atlantic Coast, Atlantic white cedar is one of the most common dominants on organic soils. Pond pine is a common needle-leaved evergreen found in the Southeast in association with dense stands of broad-leaved evergreen and deciduous shrubs.

Dead -- Dead forested wetlands are dominated by dead woody vegetation taller than 6 meters (20 feet).

Evergreen -- A wetland, woody plant community where evergreen tree species 6 meters (20 feet) tall or taller represent the dominant spatial coverage.

Deciduous -- A wetland, woody plant community with dominant spatial coverage of deciduous tree species 6 meters (20 feet) tall or taller.

Not all classes are applicable or occur in all subsystems. For example, reefs are not found in the palustrine system for the purposes described here. Table 3 provides the appropriate class/sub-system possibilities.

Mixed Classes: Mixed classes are limited to the attribute combinations and their reciprocals as shown in Table 4.

In some cases a mixed class description provides the best characterization of a wetland.

In Alaska, wetlands may be represented by numerous mixed class designations due to mapping scale as well as unique ecological features. These account for the extreme variability of wetland habitats found within the Arctic tundra, boreal forest, Aleutian Islands, and Pacific Gulf Coastal ecoregions of the State. In particular, permafrost underlying treeless and tree lined Arctic and boreal environments, may be described by unique wetland classifications not found elsewhere in the U.S. Some of these designations may have specific research and management applications.

Table 3. Class application matrix.

Class/Subclass	Map Code	Marine: Subtidal M1	Marine: Intertidal M2	Estuarine: Subtidal E1	Estuarine: Intertidal E2	Riverine[1]: Tidal R1	Riverine[1]: Lower Perennial R2	Riverine[1]: Upper Perennial R3	Riverine[1]: Intermittent R4	Lacustrine: Limnetic L1	Lacustrine: Littoral L2	Palustrine: NA P	Water Regimes *Tidally influenced freshwater systems.
Rock Bottom	**RB**	■		■		■		■		■	■	■	Nontidal F, G, H, K Tidal L, T*, V*
Bedrock	RB1	■		■		■		■		■	■	■	
Rubble	RB2	■		■		■		■		■	■	■	
Unconsolidated Bottom	**UB**	■		■		■	■	■		■	■	■	Nontidal F, G, H, K Tidal L, T*, V*
Cobble-Gravel	UB1	■		■		■	■	■		■	■	■	
Sand	UB2	■		■		■	■	■		■	■	■	
Mud	UB3	■		■		■	■	■		■	■	■	
Organic	UB4			■		■	■			■	■	■	
Aquatic Bed	**AB**	■	■	■	■	■	■	■		■	■	■	Nontidal C, E, F, G, H, K Tidal L, M, N, R*, T*, V*
Algal	AB1	■	■	■	■	■	■	■		■	■	■	
Aquatic Moss	AB2					■	■	■		■	■	■	
Rooted Vascular	AB3	■	■	■	■	■	■	■		■	■	■	
Floating Vascular	AB4			■	■	■	■	■		■	■	■	
Reef	**RF**	■	■	■	■								Tidal L, M, N, P
Coral	RF1	■	■										
Mollusk	RF2			■	■								
Worm	RF3	■	■	■	■								
Streambed	**SB**				■	■			■				Nontidal A, C, J, K Tidal M, N, P, R*, S*
Bedrock	SB1				■	■			■				
Rubble	SB2				■	■			■				
Cobble-Gravel	SB3				■	■			■				
Sand	SB4				■	■			■				
Mud	SB5				■	■			■				
Organic	SB6				■	■			■				
Vegetated (pioneer plants)	SB7								■				
Rocky Shore	**RS**		■		■	■	■	■			■		Nontidal A, C, J, K Tidal M, N, P, R*, S*
Bedrock	RS1		■		■	■	■	■			■		
Rubble	RS2		■		■	■	■	■			■		
Unconsolidated Shore	**US**		■		■	■	■	■			■	■	Nontidal A, C, J, K Tidal M, N, P, R*, S*
Cobble-Gravel	US1		■		■	■	■	■			■	■	
Sand	US2		■		■	■	■	■			■	■	
Mud	US3		■		■	■	■	■			■	■	
Organic	US4		■		■	■	■	■			■	■	
Vegetated (pioneer plants)	US5					■	■	■			■	■	

[1] **Unknown Perennial R5** - This Subsystem designation was created specifically for use when the distinction between Lower Perennial, Upper Perennial and Tidal subsystems cannot be made through remote sensing and no supplementary data are available. Use is limited to the Unconsolidated Bottom class. The only valid code is **R5UB**.

Table 3. Continued …

Class/Subclass	Map Code	Marine: Subtidal M1	Marine: Intertidal M2	Estuarine: Subtidal E1	Estuarine: Intertidal E2	Riverine: Tidal R1	Riverine: Lower Perennial R2	Riverine: Upper Perennial R3	Riverine: Intermittent R4	Lacustrine: Limmetic L1	Lacustrine: Littoral L2	Palustrine: P NA	Water Regimes *Tidally influenced freshwater systems.
Moss-Lichen	**ML**												Nontidal B
Moss	ML1												
Lichen	ML2												
Emergent	**EM**												Nontidal A, B, C, E, F, G, H, J, K Tidal M, N, P, R*, S*, T*
Persistent	EM1												
Phragmites	EM5												
Nonpersistent	EM2												Nontidal E, F, G, H, K Tidal N and T*
Scrub-Shrub	**SS**												Nontidal A, B, C, E, F, G, H, J, K Tidal L, M, N, P, R*, S*, T*
Broad-leaved Deciduous	SS1												
Needle-leaved Deciduous	SS2												
Broad-leaved Evergreen	SS3												
Needle-leaved Evergreen	SS4												
Dead	SS5												
Deciduous	SS6												
Evergreen	SS7												
Forested	**FO**												Nontidal A, B, C, E, F, G, H, J, K Tidal L, M, N, P, R*, S*, T*
Broad-leaved Deciduous	FO1												
Needle-leaved Deciduous	FO2												
Broad-leaved Evergreen	FO3												
Needle-leaved Evergreen	FO4												
Dead	FO5												
Deciduous	FO6												
Evergreen	FO7												

MODIFIERS

In order to more adequately describe wetlands and deepwater habitats, one or more of the special, water chemistry, or soil modifiers may be applied to classes or subclasses. The farmed modifier may also be applied to the Palustrine System level.

Water Regime Modifiers

Nontidal		Saltwater tidal	
A	Temporarily Flooded	L	Subtidal
B	Saturated	M	Irregularly Exposed
C	Seasonally Flooded	N	Regularly Flooded
E	Seasonally Flooded / Saturated	P	Irregularly Flooded
		Freshwater Tidal	
F	Semipermanently Flooded		
G	Intermittently Exposed	S	Temporarily Flooded -Tidal
H	Permanently Flooded	R	Seasonally Flooded-Tidal
J	Intermittently Flooded	T	Semipermanently Flooded-Tidal
K	Artificially Flooded	V	Permanently Flooded-Tidal

Special Modifiers

These Codes are used to indicate habitats modified or created by man or beaver. The use of only one special modifier is permitted, (e.g. PUBHx).

b	Beaver
d	Partly Drained/Ditched
f**	Farmed
h***	Diked/Impounded
r	Artificial
s	Spoil
x	Excavated

Other Modifiers

Other modifiers are not widely used during image analyses but can be applied where additional information or field work provides sufficient information.

Water Chemistry: Coastal Halinity		Water Chemistry: Inland Salinity		Water Chemistry: pH Modifiers for all Freshwater		Soil	
1	Hyperhaline	7	Hypersaline	a	Acid	g	Organic
2	Euhaline	8	Eusaline	t	Circumneutral	n	Mineral
3	Mixohaline (Brackish)	9	Mixosaline	I	Alkaline		
4	Polyhaline	0	Fresh				
5	Mesohaline						
6	Oligohaline						
0	Fresh						

** Farmed wetlands are normally Pf (Palustrine farmed) but cultivated cranberry bogs may be classified as PSSf.

*** Because the diked/impounded modifier is crucial for sea-level models, it is given priority over any other modifiers. Example, diked/impounded - spoil areas will be coded h for diked/impounded.

Table 4. Cowardin *et al*. (1979) mixed classes (and reciprocals) that are allowable for mapping purposes.

Cowardin Mixed Classes (or reciprocal)	Mapping Attributes (and reciprocals)	Attribute Example
Forested/Aquatic bed	FO/AB	PFO1/ABF
Scrub shrub/Aquatic bed	SS/AB	PSS1/ABF
Emergent/Aquatic bed	EM/AB	PEM/ABF
Aquatic bed/ Reef	AB/RF	M1AB3/RF1L
Aquatic bed/Rocky shore	AB/RS	E2AB/RSN
Aquatic bed/Unconsolidated bottom	AB/UB	E1AB/UB4L
Aquatic bed/Unconsolidated shore	AB/US	E2AB/US2M
Forested/Emergent	FO/EM	PFO1/EM1A
Scrub shrub/Emergent	SS/EM	PSS1/EM1C
Emergent/Moss lichen	EM/ML	PEM1/ML1B
Emergent/Rocky shore	EM/RS	E2EM1/RSN
Emergent/Unconsolidated shore	EM/US	E2EM/USM
Emergent/Unconsolidated bottom	EM/UB	PEM/UBG
Emergent/Steam bed	EM/SB	R1EM2/SBN
Forested/Scrub shrub	FO/SS	PFO4/SS4B
Scrub shrub/Moss lichen	SS/ML	PSS3/MLB
Scrub shrub/Unconsolidated shore	SS/US	PSS1/USC
Scrub shrub/Unconsolidated bottom	SS/UB	PSS1/UBFb
Forested/Moss lichen	FO/ML	PFO2/MLB
Forested/ Unconsolidated bottom	FO/UB	PFO2/UBF
Forested/Unconsolidated shore	FO/US	PFO1/USA
Unconsolidated shore/Reef	US/RF	E2US/RF2N

CLASS and SUBCLASSES - Mixing of Classes and Subclasses: Attributing Non-homogeneous Habitats Using the Cowardin Wetland Classification System

The use of mixed classes is not recommended. However, there are times when mapping non-homogeneous habitats require mixed class descriptors. As an example, a wetland with a mixture of shrub and emergent habitats that are inseparable given the limitations of scale, the use of mixed class cover types best describe the wetland community. Mixed classes should not be used unless the following conditions are met: (1) the wetland contains two distinct wetland types each encompassing at least 30 percent coverage by area, but is too small to allow delineation of each type separately. In this case the class with the greater areal extent will be listed first, (2) The wetland contains two classes or subclasses comprising at least 30 percent coverage by area that are so evenly interspersed that separate delineation is not possible.

Mixed Subclasses: The mixed subclasses are limited to the combinations and their reciprocals as shown in Table 5.

Table 5. Forested and/or scrub shrub classes with subclass designation(s).

Cowardin Mixed Subclasses (or reciprocal)	Mapping Attributes (and reciprocals)	Attribute Example
Broad leaved deciduous/Needle leaved deciduous	1/2 - 2/1	PFO1/2B PSS2/1B
Broad leaved deciduous/Broad leaved evergreen	1/3 - 3/1	PFO1/3A PSS1/3A
Broad leaved deciduous/Needle leaved evergreen	1/4 -4/1	PFO1/4A PSS4/1B
Needle leaved deciduous/Needle leaved evergreen	2/4 - 4/2	PFO2/4B PSS4/2B
Needle leaved deciduous/Broad leaved evergreen	2/3 - 3/2	PFO2/3A PSS2/3C
Broad leaved evergreen/Needle leaved evergreen	3/4 - 4/3	PFO3/4C PSS3/4C
Dead/Any forested or scrub shrub subclass	5/* - */5	
Deciduous/Any forested or scrub shrub subclass	6/* - */6	
Evergreen/Any forested or scrub shrub subclass	7/* - */7	

***Denotes wildcard character compatible with any other subclass type in this Table.**

Water Regime Applications

Water regimes or modifiers are added to the ecological description of the wetland cover type and indicate the periodicity of flooding or saturation. There are three categories of Water Regimes that include: Nontidal, Tidal (salt and brackish water areas) and Tidal freshwater areas. All Water Regimes are not applicable to all wetland types. Table 3 indicates the appropriate use of Water Regime modifiers for mapping purposes.

General descriptions of the Water Regime modifiers follow:

Nontidal

A - Temporarily Flooded - Surface water is present for brief periods during growing season, but the water table usually lies well below the soil surface. Plants that grow both in uplands and wetlands may be characteristic of this water regime.

B - Saturated - The substrate is saturated to surface for extended periods during the growing season, but surface water is seldom present.

C - Seasonally Flooded - Surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.

E - Seasonally flooded/saturated – The wetland has surface water present at some time during the growing season exhibiting flooded conditions (especially early in the growing season). When surface water is absent the substrate remains saturated near the surface for much of the growing season.

F - Semi-permanently Flooded - Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land's surface.

G - Intermittently Exposed - Surface water is present throughout the year except in years of extreme drought.

H - Permanently Flooded - Water covers the land surface throughout the year in all years.

J - Intermittently Flooded - This water regime is limited to describing habitats in the arid western portions of the United States. Substrate is usually exposed, but surface water present for variable periods without detectable seasonal periodicity. These habitats are very climate-dependent. Weeks or months or even years may intervene between periods of inundation. Flooding or inundation may come from spring snowmelt or sporadic summer thunderstorms. The dominant plant communities under this regime may change as soil moisture conditions change. Some areas exhibiting this regime do not fall within the Cowardin *et al*. definition of wetland because they do not have hydric soils or support hydrophytes. This water regime has been used extensively in vegetated and non-vegetated situations including identifying some shallow depressions (playa lakes), intermittent streams, and dry washes in the arid west.

K - Artificially Flooded - The amount and duration of flooding is controlled by means of pumps or siphons in combination with dikes or dams. The vegetation growing on these areas cannot be considered a reliable indicator of water regime. The Artificially Flooded modifier should be used with water and waste-water treatment facilities. Neither wetlands within nor resulting from leakage from man-made impoundments, nor irrigated pasture lands supplied by diversion ditches or artesian wells are included under this modifier. The K water regime should not be used in the Riverine System as more applicable special modifiers such as impounded, excavated or artificial better describe artificial flooding conditions in riverine channels.

U - Unknown - The use of the unknown water regime should be restricted as much as possible especially in the estuarine system where it adversely affects predictive sea level rise models.

Tidal Water Regimes - Tidal Salt and Brackish Areas

L - Subtidal - The substrate is permanently flooded with tidal water.

M - Irregularly Exposed - Land surface is exposed by tides less often than daily.

N - Regularly Flooded - Tidal water alternately floods and exposes the land at least once daily.

P - Irregularly Flooded - Tidal water floods land surface less often than daily.

Tidal Freshwater Areas - Freshwater systems, inundated by tide are further described by the water regime modifiers:

S - Temporarily Flooded-Tidal

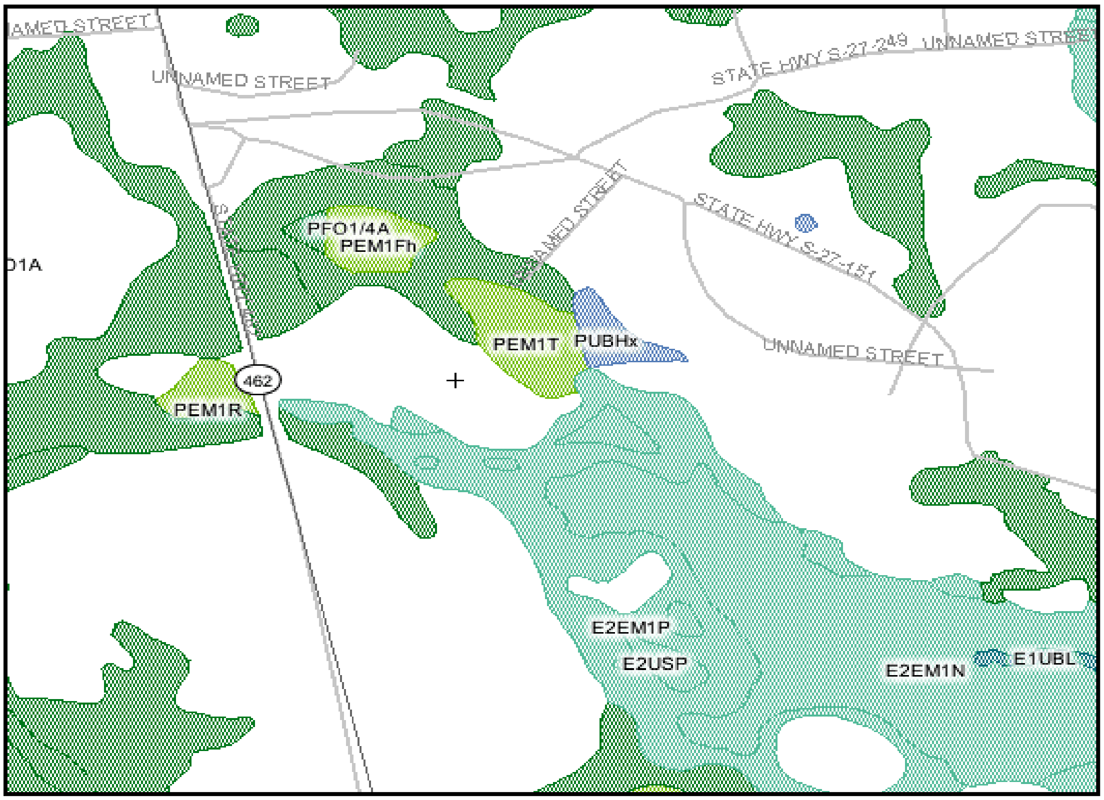
R - Seasonally Flooded-Tidal

T - Semi permanently Flooded-Tidal

V - Permanently Flooded-Tidal

Examples of freshwater tidal wetlands are found along tidal rivers and upstream of estuarine habitats (Figure 8). These areas are influenced by tidal fluctuations but support freshwater plant species.

Figure 8. Irregularly flooded estuarine tidal wetlands (E2EM1P and E2USP) transition into semi permanently flooded freshwater tidal (PEM1T) and seasonally flooded freshwater tidal (PEM1R) wetlands along South Carolina's coast.



Special Modifying Terms and Their Use on Wetland Maps

Special Modifiers – These code descriptors are used to indicate wetlands and deepwater habitats modified or created by man or beaver. The use of more than a single special modifier is not permitted, (e.g. PUBHh). Special modifiers are all represented by lower case letters. With the exception of "beaver", all of the special modifiers describe human alterations to wetlands. It may be difficult in some instances, to choose the single special modifier that best describes the landscape modification. Because the diked/impounded modifier is crucial for use in coastal watersheds as denoting wetland modifications for sea level rise models, it will be given priority over any other modifiers (e.g. diked/impounded – spoil areas will be classified using the diked/impounded modifier.)

b - Beaver - These wetlands have been created or modified by the action of beaver (Castor canadenis). Beaver activity (such as dam building) may flood vegetation or create small impoundments that are easily identified on aerial imagery. Small impoundments, adjacent meadows or other influenced habitats created by beaver should use this modifier.

d - Partly Drained/Ditched - A partially drained wetland has been hydrologically altered but soil moisture is sufficient to support some hydrophytes. Totally drained areas are not considered wetland if they can no longer support hydrophytes. This modifier has also been used to indicate wetlands connected by extensive ditch networks. The "d" modifier can be applied to wetlands with ditch or drain networks or wetlands adjacent to the ditches even if the ditch is too small to be included in the delineations. Large ditches that may be delineated as separate features should have the "x" modifier applied to the ditch itself and the "d" modifier applied to the wetland area.

f - Farmed - Farmed wetlands occur where the soil surface has been mechanically or physically altered for production of crops, but hydrophytes will become reestablished if farming is discontinued. Farmed wetlands will be identified by using the attributes Pf (palustrine farmed). Cultivated cranberry bogs may be classified as palustrine farmed wetland or as palustrine scrub/shrub - farmed.

h - Diked/Impounded - These wetlands have been created or modified by a man-made barrier or dam which obstructs the inflow or outflow of water. The descriptors 'diked' and 'impounded' have been combined into a single modifier since the observed effect on wetlands is similar.

r - Artificial Substrate - This modifier has been used to describe rock bottom, unconsolidated bottom, rocky shore and unconsolidated shore where rock or unconsolidated materials have been placed by man. Jetties and breakwaters are examples of artificial rocky shores.

s - Spoil - The spoil modifier has been used to describe wetlands where deposition of spoil materials forms the primary substrate type. By definition spoil has been artificially excavated by man. To accurately apply the spoil modifier, image interpretation alone may not be sufficient as some reclaimed strip mines or dredge spoil areas may have been completely re-vegetated or developed. Ancillary data sources may aid in the proper application of the "s" modifier in these instances.

x - Excavated - Excavated wetlands have been dug, gouged, blasted or suctioned through artificial means (man-made)..

Other Modifiers

Water Chemistry Modifiers - Water chemistry modifiers of coastal halinity and inland salinity are generally not used because of the limitations of using remote sensing data for image analysis. These modifiers should be applied only where detailed ancillary data is available. (There is often interest in identifying slightly brackish marshes and the "oligohaline" water chemistry modifier has been used for this purpose.)

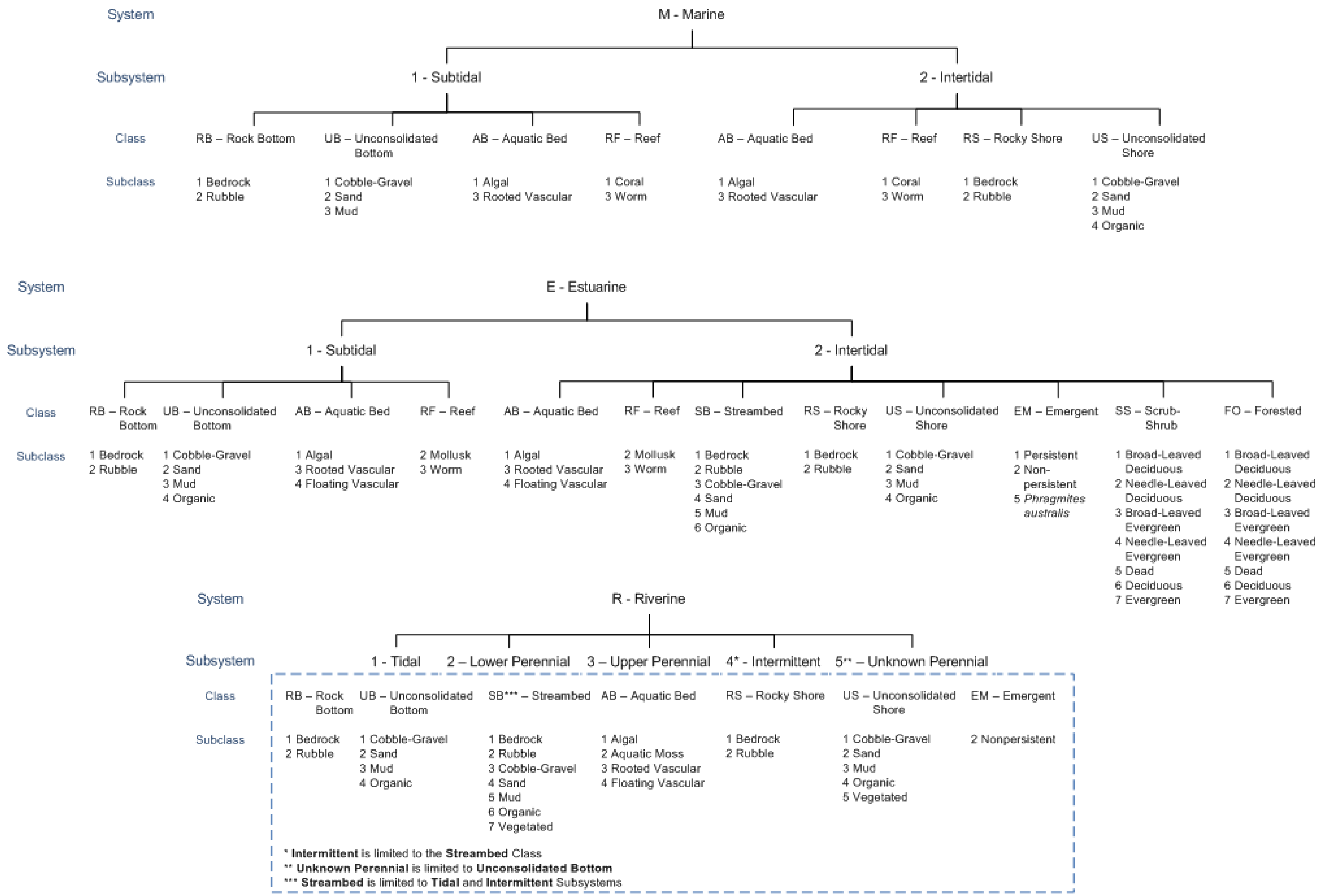
pH Modifiers - Although the pH modifiers are generally not used, the acid modifier (a) has been used to indicate bog wetlands with characteristic low pH. Similarly the alkaline modifier (i) has been used to describe desert salt (alkali) flats, or alkaline playas and fens.

Soil Modifiers - The organic soil modifier (g) has been used to describe peatland, poor fens, bogs or Atlantic white cedar swamps. Other soil modifiers have not been widely used during image analysis but can be applied where additional information or field work provides sufficient information for further soil descriptors.

Appendix B. Map Legend and Coding

For the purposes of applying the wetland classification system for mapping, a series of letter and number codes has been developed by the Service. The following map code diagram shows codes and relationships of wetland systems (e.g. estuarine), subsystems (e.g. intertidal), and classes (e.g. emergent).

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION



Classification of Wetlands and Deepwater Habitats of the United States, Cowardin *et al.* 1979

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

System: L - Lacustrine

Subsystem: 1 - Limnetic

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular

Subsystem: 2 - Littoral

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	RS – Rocky Shore	US – Unconsolidated Shore	EM – Emergent
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	2 Nonpersistent

System: P - Palustrine

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	US – Unconsolidated Shore	ML – Moss-Lichen	EM – Emergent	SS – Scrub-Shrub	FO – Forested
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	1 Moss 2 Lichen	1 Persistent 2 Nonpersistent 5 *Phragmites australis*	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen

MODIFIERS

In order to more adequately describe the wetland and deepwater habitats, one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

Water Regime			Special Modifiers	Water Chemistry			Soil
Nontidal	Saltwater Tidal	Freshwater Tidal		Coastal Halinity	Inland Salinity	pH Modifiers for all Fresh Water	
A Temporarily Flooded	L Subtidal	S Temporarily Flooded-Tidal	b Beaver	1 Hyperhaline	7 Hypersaline	a Acid	g Organic
B Saturated	M Irregularly Exposed	R Seasonally Flooded-Tidal	d Partly Drained/Ditched	2 Euhaline	8 Eusaline	t Circumneutral	n Mineral
C Seasonally Flooded	N Regularly Flooded	T Semipermanently Flooded-Tidal	f Farmed	3 Mixohaline (Brackish)	9 Mixosaline	I Alkaline	
E Seasonally Flooded/ Saturated	P Irregularly Flooded	V Permanently Flooded-Tidal	h Diked/Impounded	4 Polyhaline	0 Fresh		
F Semipermanently Flooded			r Artificial	5 Mesohaline			
G Intermittently Exposed			s Spoil	6 Oligohaline			
H Permanently Flooded			x Excavated	0 Fresh			
J Intermittently Flooded							
K Artificially Flooded							

Appendix C: Glossary of terms for Appendix A and B.

Acid: Term applied to water or soil with a pH less than 5.5.

Aeration: The exchange of air in soils with air from the atmosphere

Alkaline: Term applied to water or soil with a pH greater than 7.4.

Bar: An elongated landform formed by waves, currents or deposition of unconsolidated sediments such as sand, gravel, stones, cobbles, or rubble and with water on two sides.

Beach: A sloping landform on the shore of larger water bodies, generated by waves, currents or deposition of sediments and extending from the water to a distinct break in landform or substrate type.

Brackish: Marine and Estuarine waters with Mixohaline salinity. The term should not be applied to inland waters.

Boulder: Rock fragments larger than 60.4 cm (24 inches) in diameter.

Broad-leaved deciduous: Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season.

Broad-leaved evergreen: Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that generally remain green and are usually persistent for a year or more.

Calcareous: Formed of calcium carbonate or magnesium carbonate by biological deposition or inorganic precipitation. Calcareous sands are usually formed of a mixture of fragments of mollusk shell, echinoderm spines and skeletal material, coral, foraminifera, and algal platelets.

Channel: An open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water.

Circumneutral: Term applied to water with a pH of 5.5 to 7.4.

Cobbles: Rock fragments 7.6 cm (3 inches) to 25.4 cm (10 inches) in diameter.

Deciduous stand: A plant community where deciduous trees or shrubs represent the dominant spatial coverage of woody vegetation.

Dominant: The species making up the majority of spatial cover.

Dormant season: The non-growing portion of the year for vegetation.

Effectively drained: A condition where ground or surface water has been removed by artificial means to the point that an area no longer meets the definition of wetland.

Emergent hydrophytes: Erect, rooted, herbaceous angiosperms that may be temporarily to permanently flooded at the base but do not tolerate prolonged inundation of the entire plant.

Emergent mosses: Mosses occurring in wetlands, but generally not covered by water.

Estuary: Estuaries are found at the mouth of a river(s) entering the sea where the current of the river meets the tide and salt water and freshwater mix.

Evergreen stand: A plant community where evergreen trees or shrubs represent the dominant spatial coverage of woody vegetation.

Extreme high water of spring tides: The highest tide occurring during a lunar month, usually near the new or full moon. This is equivalent to extreme higher high water of mixed semidiurnal tides.

Extreme low water of spring tides: The lowest tide occurring during a lunar month, usually near the new or full moon. This is equivalent to extreme lower low water of mixed semidiurnal tides.

Euhaline: Marine water with excessive or supersaturated with sea salt at a level of 30 to 35 ppt.

Euslaine: Inland water with excessive or supersaturated with inland salts.

Flat: Flats are unconsolidated sediments found along lakes, rivers, estuarine or marine near shore areas that may be irregularly shaped or elongate and continuous with the shore.

Floating plant: A non-anchored plant that floats freely in the water or on the surface.

Floating-leaved plant: A rooted, herbaceous hydrophyte with some leaves floating on the water surface; e.g., white water lily, floating-leaved pondweed. Plants such as yellow water lily sometimes have leaves raised above the surface are considered floating-leaved plants or emergents, depending on their growth habit at a particular site.

Freshwater: Term applied to water with salinity less than 0.5 ppt dissolved salts.

Gravel: A mixture composed primarily of rock fragments 2 mm (0.08 inch) to 7.6 cm (3 inches) in diameter.

Ground Water: Water filling all the unblocked pores of an underlying material below the water table.

Growing season: The frost-free period or non-growing portion of the year.

Haline: Term used to indicate presence of ocean salt.

Herbaceous: Vegetation with the characteristics of an herb; a plant with no persistent woody stem above ground.

Hydric soil: Soil that is wet long enough to periodically produce anaerobic conditions, thereby influencing the growth of plants.

Hydrophyte, hydrophytic: Any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content.

Hyperhaline: Term to characterize waters with salinity greater than 40 ppt due to ocean-derived salts.

Mesohaline: Term to characterize waters with salinity of 5 to 18 ppt due to ocean-derived salts.

Mesophyte, mesophytic: Any plant growing where moisture and aeration conditions lie between extremes. (Plants typically found in habitats with average moisture conditions, not usually dry or wet.)

Mesosaline: Term to characterize waters with salinity of 5 to 18 ppt land-derived salts.

Mineral soil: Soil composed of predominantly mineral rather than organic materials.

Mixohaline: Term to characterize water with salinity of 0.5 to 30 ppt ocean salts.

Mixosaline: Term to characterize waters with salinity of 0.5 to 30 ppt land-derived salts.

Mud: Wet soft earth composed predominantly of clay and silt--fine mineral sediments less than 0.074 mm in diameter.

Muck: A dark colored, well decomposed organic soil.

Needle-leaved deciduous: Woody gymnosperms (trees or shrubs) with needle-shaped or scale-like leaves that are shed during the cold or dry season.

Needle-leaved evergreen: Woody gymnosperms with green, needle-shaped, or scale-like leaves that are retained by plants throughout the year.

Nonpersistent emergents: Emergent hydrophytes whose leaves and stems break down at the end of the growing season so that most above-ground portions of the plants are easily transported by currents, waves, or ice. The breakdown may result from normal decay or the physical force of strong waves or ice. At certain seasons of the year there are no visible traces of the plants above the surface of the water.

Oligohaline: Term to characterize water with salinity of 0.5 to 5.0 ppt ocean-derived salts.

Oligosaline: Term to characterize water with salinity of 0.5 to 5.0 ppt land-derived salts.

Organic soil: Soil composed of predominantly organic rather than mineral material. The organic material is made up of plant and animal residue in the soil in various stages of decomposition.

Peat: Soil that is largely undercomposed organic matter that has accumulated under excess moisture.

Persistent emergent: Emergent hydrophytes that normally remain standing at least until the beginning of the next growing season.

pH value: PH is a numerical designation of acidity or alkalinity in water or soil.

Pioneer plants: Herbaceous annual and seedling perennial plants that colonize areas as a first stage in secondary succession.

Photic zone: The extent (depth) that sunlight penetrates a water column.

Polyhaline: Term to characterize water with salinity of 18 to 30 ppt due to ocean salts.

Polysaline: Term to characterize water with salinity of 18 to 30 ppt due to land-derived salts.

Saline: General term for waters containing various dissolved salts. Restricted to description of inland waters where the ratios of the salts often vary; the term haline is applied to estuarine and marine waters where the salts are roughly in the same proportion as found in undiluted sea water.

Salinity: Salinity is the total amount of dissolved material in grams in one kilogram of sea water.

Sand: Composed predominantly of coarse-grained mineral sediments with diameters larger than 0.074 mm and smaller than 2 mm.

Shrub: A woody plant which at maturity is usually less than 6 meters (20 feet) tall and generally exhibits several erect, spreading, or prostrate stems.

Sound: A body of water that is usually broad, elongate, and parallel to the shore between the mainland and one or more islands.

Spring tide: The highest high and lowest low tides during the lunar month.

Rubble Stone: Rock fragments larger than 25 cm (10 inches) but less than 60 cm (24 inches).

Submergent plant: A vascular or nonvascular hydrophyte, either rooted or nonrooted, which lies entirely beneath the water surface, except for flowering parts in some species; e.g., wild celery or the stoneworts.

Terrigenous: Derived from or originating on the land (usually referring to sediments) as opposed to material or sediments produced in the ocean (marine) or as a result of biologic activity (biogenous).

Tree: A woody plant which at maturity is usually 6 meters (20 feet) or more in height and generally has a single trunk, unbranched for 1 m or more above the ground, and a more or less definite crown.

Water table: The upper surface of a zone of saturation.

Woody plant: A seed plant (gymnosperm or angiosperm) that develops persistent, hard, fibrous tissues and includes species of trees and shrubs.

Appendix D: Other Methods of Data Capture

(Provided for Informational Purposes)

Manual Stereoscopic Interpretation Methods

Manual Stereoscopic Interpretation Methods (excerpted from Photointerpretation Conventions National Wetlands Inventory U.S. Fish and Wildlife Service, 1995)

Air photo interpretation involving three-dimensional viewing of successive air photos that overlap the same geographic area (between flight lines) provides a useful method to delineate wetland and deepwater habitats. In stereo view, topographic relief features become recognizable. Photos are examined stereoscopically by experienced ecologists who delineated (or "classify") habitat boundaries in ink on photo overlays. Supporting information from topographic maps, soil surveys, and other land cover maps can assist in this process. This, combined with the visual appearance of discrete vegetation communities based on color, texture and relative height, permits an experienced wetlands interpreter to accurately identify and delineate wetland habitats. This process has been employed successfully by Service biologists to map wetlands since the mid 1970s. Other Federal agencies including National Aeronautics and Space Administration, U.S. Geological Survey, Environmental Protection Agency, Army Corps of Engineers, Natural Resources Conservation Service, and the National Oceanographic and Atmospheric Administration have all successfully employed stereoscopic air photo interpretation techniques to identify wetlands and related habitats.

Interpretation Equipment Requirements

All stereo photo interpretation should be done using equipment equal to or better than four-power (4X) mirror stereoscopes. Before beginning actual delineation, photointerpreters shall ensure that the work photo overlays (with work areas identified) are correctly aligned to the fiducial or other registration marks on the photograph. The photo overlays shall be properly secured to the photographs.

Personnel Qualifications

Photo interpreters must be able to see in stereo and have an understanding of surface water hydrology and wetland ecology. The interpreter observes the amount of standing water, if any, visible on the photograph and relates it to the date of photography, type of wetland vegetation, local or regional precipitation patterns, length of growing season, soil types, physiographic position, and knowledge of the area gained from supplemental data sources. The examination of aerial photos stereoscopically enables the interpreter to observe the vertical as well as the horizontal spatial relationships of the ground features. These variables are synthesized and applied by the photo interpreter in making delineation and classification determinations. Due to the complexity of the interpretative process and the wealth of data within aerial photos, accurate photo interpretation requires considerable expertise (U. S. EPA 1991).

Delineating Photo Overlays

Photo overlays are made from clear stabilene mylar and are fastened on photos with drafting tape. The fiducial (registration) marks on the photos are precisely transferred to the overlay. The photo interpreters shall ensure that the overlays are correctly aligned to the fiducial before beginning the photo interpretation. Wetlands, deepwater habitats and all other mapped features shall be labeled using the letter and number codes (alpha-numeric) that coincide with map legend. All labels shall be printed neatly and legibly. All photo interpretation delineations shall be made on the photo overlays in waterproof black ink with pen points no larger than a Castell 000 or a Keuffel and Esser 0000 or 000000 point, depending on wetland complexity and the level of detail deemed necessary by specific project area guidelines. All map feature labels and line work must be drawn neatly on the aerial photography overlays. All labels must be consistent and legible. Labels for polygons should be placed within the polygon, if space permits. If the label is placed outside the polygon, a lead line shall be drawn from the label extending inside the polygon. To complete interpretation and facilitate edge matching of features, photo interpretation will be performed beyond the work area boundary by approximately one-quarter inch on the acetate overlay.

Wetlands and deepwater habitats are identified and classified according to Cowardin *et al*. (1979). Classification of each mapped unit shall include the appropriate system, subsystem, class and water regime. The use of subclasses and special modifiers will be determined by project specifications originating from the Region or Project Officer. The use of split-classes is discouraged. If a wetland is too small in area based on the minimum mapping unit to allow separate delineation of each cover type, the polygon should be classified to represent the cover type encompassing the greatest acreage. Polygons that may contain a mosaic of cover types or ecosystem components and cannot be delineated separately will be classified using the predominant component.

Additionally, wetland delineation line work will follow the border of the wetland boundary. No upland features should be included as part of a wetland feature (i.e. adjacent roads, railroads, etc.).

The aerial photos in combination with field reconnaissance will prevail as the principal data source for mapping. Changes which have taken place since the time of the photography (wetland gains or losses) should not be included as part of the mapping effort. Maximum vegetative summer growth in an average year and at the average water level shall be basis for classification.

Wetlands will be labeled using the letter and number code (alphanumeric) that correspond to classification descriptors and presented as wetland map legend information.

Feature Edge-matching

To ensure accurate delineation, wetland and deepwater delineations lying along the outer borders of each work area must be edge-matched in stereo with the all adjacent work areas. Where edge ties have been checked, the photo interpreter shall label the photo work overlay to indicate edge-matching is complete. The necessary steps must be taken to ensure accurate feature edge-matching of all delineated work.

Stereoscopic Quality Control Review

The photo interpreter will review the work area for any problems such as missed wetlands, upland included as wetland, miss-classifications, missing labels, incomplete work and agreement with ancillary data sources.

Cartographic Transfer Specifications

The use of manual stereoscopic interpretation methods requires a separate cartographic transfer process to align the photographic delineations to a USGS 7.5' topographic quadrangle (rectified base map). The Service developed cartographic conventions (January 1995) that are applicable to this process. Some elements of the transfer process have particular relevance to quality control of map products. These include the following technical steps:

- Photo overlay review and alignment
- Scaling the photographic image on the zoom transfer scope(ZTS)
- Cartographic alignment
- Use of the topographic quadrangle
- ZTS overlay alignment
- Transfer of delineated polygons and classification labels

Digital Data Capture Specifications

The use of manual stereoscopic interpretation methods also requires a separate digital capture step following manual transfer to a rectified base map. The Service developed digitizing conventions (January 1995) that are applicable to this process. Although the Service provides considerable latitude on the method(s) of digital data capture used (i.e. scanning. board digitizing, etc.), there are specific requirements for data delivery formats. These include the following:

- Digital map data must be provided in geodatabase format
- Data should be provided in a uniform Albers Equal-Area Conic Projection
- The horizontal planar datum should be the North American Datum of 1983, also called NAD83
- Point features (if delineated) must be buffered to 11.28 m (0.1 ac.)
- Data must pass the Service's automated verification
- There may be metadata requirements required by the Region or Project manager
- All digital data produced by cooperators, collaborators, or contractors must be delivered to the appropriate Regional Wetlands Coordinator

Digital Transfer Scope (DTS) Method (Transitional ArcView based method or application that is no longer supported by Arc technology.)

The DTS application is an ArcView 3.x Extension. By interfacing a digital transfer scope with Arc View polygonal Shapefiles can be georeferenced to a base data source (i.e. DRGs, etc). Wetland polygons are created using digitizing tools and editing functions in ArcView 3.x. A recommended technical reference of the digital transfer scope operation is: Getting Started with the Digital Transfer Scope (DTS) Software Tutorial Accompaniment to the Digital Transfer Scope Reference Manual.

Interpretation Equipment Requirements

System and hardware information may be found in the Digital Transfer Scope Reference Manual, which is provided in hard copy form with the DTS instrument.

Personnel Qualifications

Personnel using the on-screen method need the same experience in the identification and classification of wetlands as cited in the manual stereoscope method. Photo interpreters must be able to see in stereo. Using the DTS, image analysts are responsible for ecological integrity of the mapping process as well as most of the cartographic accuracy. The identification, delineation and attribution of features are done within the digital data file requiring analysts to be able to operate in a computerized mapping environment. For this reason, image analysts using this method should be experienced with ArcView (3.x or later versions) software, and have some familiarity with Shapefiles and editing spatial data.

Operational Techniques

File Structure / Shapefile Creation – Create a folder for Shapefile/base maps on a local or network drive. For creating a new NWI map coverage, begin with a Hydrology DLG or the DRG for the quadrangle and trace the major water bodies. This creates the most accurate data set to match further interpretation work. Append the existing wetland polygons. Alignment of themes to the basemap is done by adjusting the scale in the ArcView view.

Add a digital soils layer, if available. Query out all hydric soils. Use this to append the DLG.

Create a new polygon theme. Set general snap tolerance to 0.001 miles name the new theme (based on the quadrangle, etc.) and direct ArcView to store the new theme in a designated folder.

Create a new line theme. Set snap tolerance for 1.01 miles. Name the new theme and direct ArcView to store the new theme in a designated folder. Modify the data table for new themes, in ArcView and add an “Attribute” field, any other fields needed, and a “comments” field for quickly selecting areas for future field review.

Use the topographic map or contour lines (if available) to gather the best data. Check obvious drainage’s and large flat areas in particular. Wetland areas are mapped to the extent of the source imagery.

For editing an existing NWI coverage, or updating an old coverage, the DLG or DRG is still the starting point. Work towards refining the coverage and re-labeling by using the newest photography available.

Attributing Polygons – Reduce the size of the view in ArcView, open the data table and resize so that both fit on the screen. In edit mode, select polygon(s) in the view activate table, and type in the attribute.

Edge Matching – To accurately tie adjacent Shapefiles, match vertices of the new theme with the previous theme. Use the “Snap-to-It” tool.

Backup Shapefiles – It is recommended that at the end of every edit session Shapefiles be copied to a backup folder. It is also advisable to create a CD with all Shapefiles completed and in progress at weekly intervals.

Quality Control Review - To ensure accuracy, the analyst will review the work area for any problems such as missed wetlands, upland included as wetland, mis-classifications, missing labels, incomplete work and agreement with ancillary data sources.

After a work has been complete, open the data table along with the “query builder” window. Activate the “Attribute” field to show a list of all attribute labels used. This can be used to find missing labels as well as correct attribution errors.

Once work on the DTS is complete. Convert the Shapefile to a personal geodatabase using ArcGIS. Run the Service’s verification routine to ensure the digital data meet the requirements.

Advantages of the DTS Method

- Utilizes existing digital NWI layer during photo interpretation
- Utilizes other digital sources as ancillary information (i.e. SSURGO, state digital wetland data, DLG, and DRGs)
- Can create NWI data from scratch
- Allows stereoscopic views of imagery and digital layers simultaneously
- Ability to work on ArcGIS
- Eliminates need for acetate paper, ZTS and digitizing steps
- The DTS Extension also provides a freehand drawing tool for tracing features without having to click the mouse for each individual node. This is functionally equivalent to stream mode digitizing on a regular tablet. To bring up the Freehand Drawing Dialog, choose **Freehand Drawing Tools** from the **DTS** menu
- Shapefiles are easily converted to personal geodatabase files

Appendix E: Using the Verification Tools (Version 2.5.1)

The Verification Tools Version 2.5.1, have been constructed to automate (to the extent possible) some of the quality control functions necessary to ensure the geodatabase is accurate. This suite of functions has been designed to address geopositional errors, digital anomalies, and some logic checks that make use of the power of the geographic information system.

Some functions the verification tools perform will flag potential classification coding and geospatial problems and provide the image analyst the option of editing or ignoring the feature. This is to accommodate the image analyst's ability to ultimately determine the best ecological portrayal of the data. For example, a small lake that is only 18 acres has been identified during the data verification process as a potential problem based on its size (18 acres) and classification (lacustrine). The analyst has information that the lake depth exceeds 90 feet and determines that lacustrine is the best ecological descriptor for this feature.

The verification tools allow the user to easily find attribute problems with the NWI wetlands polygons. There are two types of procedures involved. The first procedure is a non-interactive, intensive process that checks all the wetland attribute codes, repairs some of them and flags others for subsequent checks. The second type of procedure is an interactive process where the analyst uses the interactive mapping capabilities of ArcMap to visually identify specific topological and attribute features that may need adjustment.

The tool incorporates the following:

- Allows the image analyst to perform a series of verification tests and optionally visualize the results of those tests through the use of 'graphic elements'.
- Results of the tests are stored and managed by the Tool in a special field added to the layer's attribute table.
- Provides the image analyst with a count of the number of errors found by a particular test.
- A "progress bar" provides the image analyst with an estimate of the processing time remaining until completion of a verification test.
- Provides a function that runs the most critical tests and produces either a 'pass' or 'fail' assessment of the QA/QC procedure.

Note: The Verification tool has been updated to Version 2.5.1. On the surface the tool and user interface has not changed. The verification program has been modified to improve speed and to better process large geodatabases. In particular, Version 2.5.1 significantly increases the speed of finding invalid wetlands attributes. Additionally, this version better supports editing large geodatabases by periodically saving the pending edits stored in the ArcMap edit cache.

Description and Organization of the Tool

The Verification Tool is organized as a table (Figure 9). The rows of the table correspond to particular verification test, while the columns of the table refer to properties of a particular verification test.

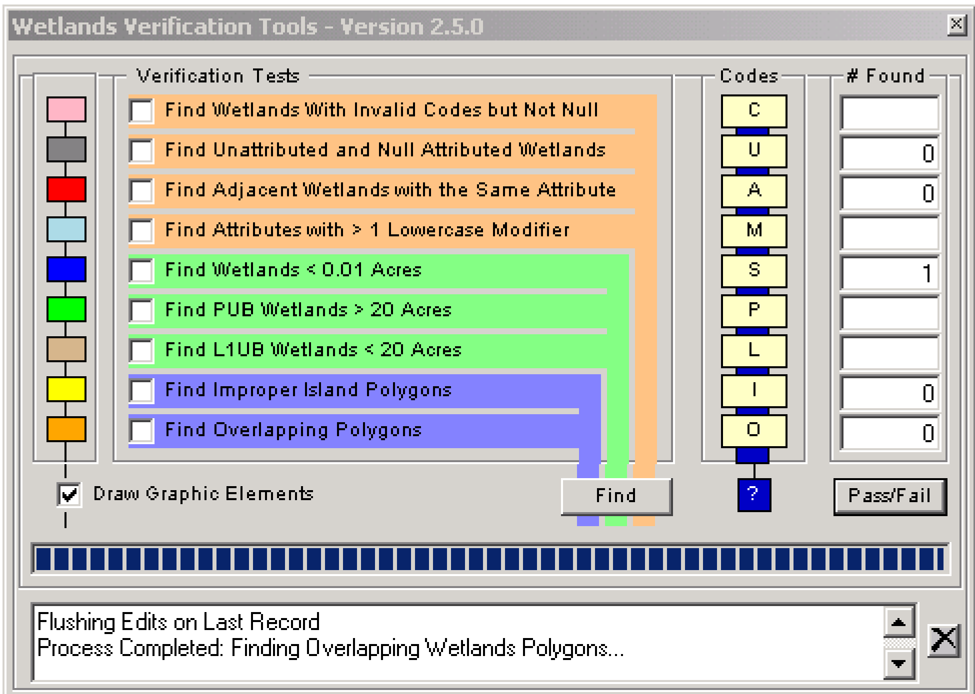


Figure 9. Wetlands Verification Tool

Graphic Element Legend

The first column is a series of colored boxes linked by a vertical line to a checkbox titled "Draw Graphic Elements". When a particular test is run the user has the option of adding graphic elements to the map to indicate wetlands that fail a particular test. A graphic element is a visual flag that assists the image analysts in locating wetlands with problems. Graphic elements are removed using tools on the "Draw" toolbar. They are visual pointers and problems in the underlying wetlands data are fixed using ArcMap "Edit" tools and/or the Attribution Tools. The color of the box corresponds with the color of the added graphic elements. Un-checking the "Draw Graphic Elements" checkbox omits the graphic elements if the image analyst does not wish to add them to the map.

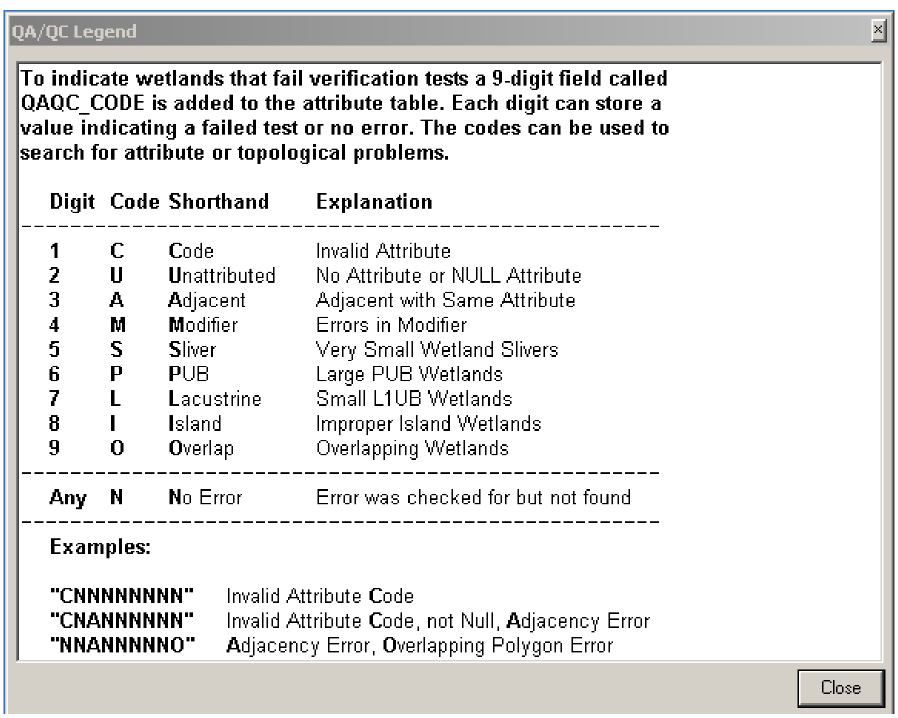
Verification Tests

The second column labeled "Verification Tests" organizes both checkboxes and descriptions of each verification test. The verification tests are grouped by function and by color. The orange group includes tests for verifying wetland attributes. The green group includes tests for verifying the size of wetlands, specifically very small wetlands that may be slivers, and those with PUB or

L1UB attributes that are unusual in size. The blue group includes tests for topological problems, which should not exist in a properly organized geodatabase. Each of the groups is graphically and functionally linked to a button labeled “Find”. The procedure for running a verification test is to check off a particular test using its checkbox and then click the “Find” button to start the procedure.

QA/QC Codes

The third column, labeled “Codes” is an alternative identification tool designed into the verification process to identify ‘failed’ wetlands. Only those experienced with ArcMap attribute tables and selection tools should use this technique! The column labeled “Codes” is a legend of the error codes associated with a particular test. As previously described, the verification tools record the results of the verification procedures using a special field added to the layer’s attribute table. The field is a 9-digit field named QAQC_CODE and each of the nine positions corresponds to each of the nine verification tests. If a particular test is run the results of that test are stored in the corresponding digit using the codes in the third column. For example, if the first test is run for finding wetlands with invalid codes, the character “C” is stored in the first digit of the QAQC_CODE for those wetlands that fail the test. Those wetlands which “pass” the test have valid codes and are given a value of “N” in the first digit which is a mnemonic for “No error”. A more complete explanation of the code is provided by pressing the button labeled “?” at the bottom of the list of codes (Figure 10.).


QA/QC Legend

To indicate wetlands that fail verification tests a 9-digit field called QAQC_CODE is added to the attribute table. Each digit can store a value indicating a failed test or no error. The codes can be used to search for attribute or topological problems.

Digit	Code	Shorthand	Explanation
1	C	Code	Invalid Attribute
2	U	Unattributed	No Attribute or NULL Attribute
3	A	Adjacent	Adjacent with Same Attribute
4	M	Modifier	Errors in Modifier
5	S	Sliver	Very Small Wetland Slivers
6	P	PUB	Large PUB Wetlands
7	L	Lacustrine	Small L1UB Wetlands
8	I	Island	Improper Island Wetlands
9	O	Overlap	Overlapping Wetlands
Any	N	No Error	Error was checked for but not found

Examples:

"CNNNNNNNN" Invalid Attribute Code
"CNANNNNNN" Invalid Attribute Code, not Null, Adjacency Error
"NNANNNNNO" Adjacency Error, Overlapping Polygon Error

Close

Figure 10. Quality assurance - quality control legend

Number of Problem Wetlands Found

The fourth column, labeled "# Found", indicates to the image analyst the number of wetlands that failed a particular test. Ideally, the image analyst would run a particular test and the results would be zero.

Pass/Fail Check

At the bottom of the "# Found" column is a button labeled "Pass/Fail". The "Pass/Fail" button automates the checking of the most critical verification tests. The most critical verification tests are "Unattributed or Null Attributed Wetlands," "Adjacent Wetlands with the Same Attribute," "Wetlands less than 0.01 Acres," "Improper Island Polygons," and "Overlapping Polygons." If any of the tests indicate that any wetlands in the layer have any or all of these errors, the procedure is evaluated as having 'failed' the QA/QC procedures and the image analyst is notified with the message window shown in Figure 11.

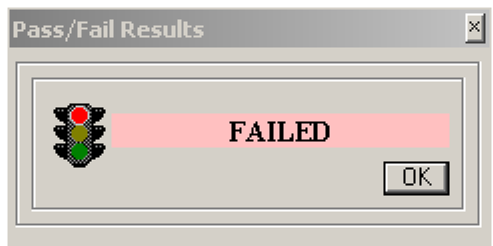


Figure 11. Pass/Fail Results window

The last two areas of the Verification Tool are informational. The gray horizontal band below the "Pass/Fail" "Find", and "?" buttons is a progress bar. The bar fills with a dark blue color to indicate the progress of a particular verification test. The white horizontal band at the bottom of the Verification Tool is a message box, which provides textual feedback to the analyst, describing the various tasks performed as part of the verification tests. The message box also displays various error messages. The message box holds 1000 characters and can be scrolled using the up/down arrows on the right side of the box and cleared using the 'X' button on the right side of the box.

Using the Graphic Elements

When the "Draw Graphic Elements" checkbox is checked all verification tests add a graphic element to the map indicating wetlands that fail the test. The graphic element is a visual flag that assists the image analysts in locating wetlands with problems. The graphic element is drawn in a hatched fill pattern in the color indicated by colored box in the first column. For example, wetlands polygons that overlap are indicated by an orange-hatched graphic element labeled "<OVERLAP>" drawn on top of the wetland (Figure 8.)

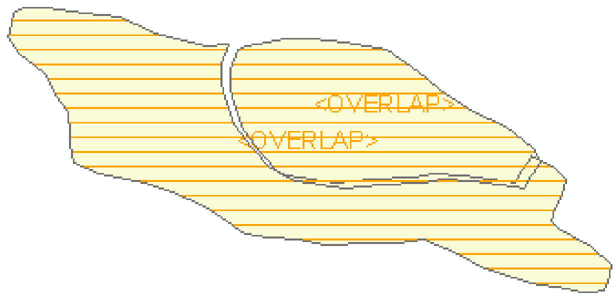


Figure 12. Example of overlapping wetland polygons

Graphic elements are used instead of either adding new features to the layer or creating a new feature class populated with the problem wetlands, because of the potential problem of inadvertently modified the copied features and not the original. Graphic elements are copies of the wetlands but since they require completely different tools to edit them, there is no chance that an image analyst would inadvertently modify any feature except the original.

Using the QAQC Code field

Only those experienced with ArcMap attribute tables and selection tools should use this technique! The previously described QAQC field, 'QAQC_CODE", can be used by any of the ArcMap attribution selection tools. Moreover, wetlands can be symbolized using the values in the QAQC_CODE field. Since each of the codes is unique simple queries can be used to select those polygons with specific errors. For example "QAQC_CODE" Like "*A*" could be used in the 'Select by Attributes' window to find all wetlands that failed the "Adjacent with Same Attribute" verification test.

Description of the Verification Tests

A brief description of each of the verification functions is provided below. Additional quality assurance issues not readily apparent on the verification tools may be handled by the geodatabase architecture itself.

Find Wetlands with Invalid Codes but Not Null

The first process this test conducts is to convert the old mapping code of "OW" to the known Cowardin type of "UB". It also converts modifying terms that are uppercase to lower case, which is the current accepted convention (Many of the NWI wetlands quads tested had both of the described conditions). The second process this test conducts is to identify invalid codes. This process runs an exhaustive error checking procedure that checks every attribute for valid Cowardin System alphanumerics (codes), Subsystem codes, Class and Subclass codes, water regimes modifiers, and special modifiers. An additional check compares any of the illegal

Cowardin attribute codes against a list of known map codes from existing digital files (6,400 possibilities). The polygons found with invalid codes are identified in the attribute table QAQC_CODE field with a "C" and on screen with a pink graphic drawing.

Find Unattributed and Null Attributed Wetlands

This test finds polygons that have a blank attribute field or contain "<Null>" in the attribute field. The polygons found with unattributed or Null codes are identified in the attribute table QAQC_CODE field with a "U" and on screen with a gray graphic drawing.

Find Adjacent Wetlands with the Same Attribute

This test searches for polygons that share a common border, but have the same value for the NWI attribute. This condition indicates that something is wrong with the attribute or the delineation since there should only be a single polygon. The polygons found that are adjacent with the same attribute are identified in the attribute table QAQC_CODE field with an "A" and on screen with a red graphic drawing.

Find attributes with > 1 Lowercase Modifier

This test searches for those polygons that have been given more than one lower case modifier. Although it is legitimate to have wetland features with more than one lower case modifier, these are usually rare. Identifying these attribute codes can help find miss-coded errors or force re-evaluation of labeling conventions. The polygons found that have more than 1 lowercase modifier are identified in the attribute table QAQC_CODE field with an "M" and on screen with a light-blue graphic drawing.

Find Wetlands < 0.01 Acres

This test searches for polygons that are on the cusp of being slivers, digital artifacts or very small polygonal features. Experience has shown that polygons smaller than this size (about 55 square meters) are slivers indicating a spatial processing problem. The polygons found that are smaller than 0.01 acres are identified in the attribute table QAQC_CODE field with an "S" and on screen with a dark-blue graphic drawing.

Find PUB Wetlands > 20 Acres

This test finds palustrine unconsolidated bottom polygons larger than 20 acres. By convention these size cutoffs determine system classification breaks in the absence of other information. The image analyst is given the discretion to make these classification changes or not. The PUB polygons found that are larger than 20 acres are identified in the attribute table QAQC_CODE field with a "P" and on screen with a green graphic drawing.

Find L1UB Wetlands < 20 Acres

This test finds lacustrine limnetic unconsolidated bottom polygons smaller than 20 acres. By convention these size cutoffs determine system classification breaks in the absence of other information. The image analyst is given the discretion to make these classification changes or not. The L1UB polygons found that are smaller than 20 acres are identified in the attribute table QAQC_CODE field with an "L" and on screen with a brown graphic drawing.

Find Improper Island Polygons

This test finds "improper island" polygons. An "improper island" polygon is a polygon that is nested completely inside another larger polygon, but the larger polygon does not have a "hole" corresponding to the nested polygon. When this problem is encountered, the larger polygon should be "repaired" by clipping a hole in it with the smaller island polygon with the Editor toolbar's Clip menu command. The island polygons found are identified in the attribute table QAQC_CODE field with an "I" and on screen with a yellow graphic drawing.

Find Overlapping Polygons Function

This test is a more general case of the "improper island" polygon problem. It finds any polygons that overlap, which is an error in the geodatabase. The overlapping polygons found are identified in the attribute table QAQC_CODE field with an "O" and on screen with an orange graphic drawn

Appendix F. Field Data Sheet (Example)

Field Data Form

Field Form ID: ____________________

Site Code: ________________________

State: _______ County:_______________ USGS Quad:________________________

TWP/R: _____________ Lat/Long (dms):_______________________ Datum: __________

Reported by: __________________________________ Date: ________________________
(Name and affiliation) (dd/mm/yyyy)

Other Participants: ____

Accessed Via: ____
(Boat /road /helicopter /air boat/etc.)

Wetland type: ______________________ Cowardin Classification: _____________________
(Lake, fen, pothole, etc.)

Video: _____________________ Photograph(s): quantity: ________
(Direction and view angle)

Direction and view angle: ____________________

Source Imagery

Type of Imagery Used: Photograph: ____ DOQQ: ___ Sat. Image: ___ Other: ___________

Date of Imagery: __________________

Imagery source: ___________________ Type: ____________ Scale: __________________

Discussion of Imagery: ____

____

____

____

Wildlife

Wildlife Observations:____

____

____

____

____

____

____

Hydrology

Tide Stage: High: ___ Low: ___ Slack: ___

Water Depth at the time of field visit: ________________
(Feet or inches)

Indicators Standing water___ Water Marks ___

Buttressed Trunks ___ Water Stained Leaves___

Water Carried Debris ___ Saturated Soils ___

Floating Mat ___ Shallow Roots ___

Bare Areas ___ Oxidized Rhizospheres ___

Other Indicators of Hydrology____

Surrounding Land Use: ____
(Farmland, residential, mining, etc.)

Hydrogeomorphic Classification:____

Plant Community

Dominance Type: ___________________________________

Abundance -	Cover Dense (high)	70 - 100%	_________
	Common (medium)	30 - 69%	_________
	Occasional	< 30%	_________

Common Plant Spp.: ____

____

Less Common Plant Spp.: ____

____

Rare or Unique Plant Spp.: ____

____

Soils/Substrate

Substrate type: Silt______ Sand______ Clay ______ Loam _____ Peat ______

Rubble ___ Rock _____ Other ____________________________________

Soil Map Unit Name: ____

Taxonomy: ____

Drainage Class: ___________________________ Hydric List (National)_____ Other_____

Soil Survey Publication Date: _______________

Munsell: hue value chroma

_________________________depth________(inches)

_________________________depth________(inches)

_________________________depth________(inches)

_________________________depth________(inches)

Hydric Soil Indicators

Histosol_____	Concretions_______	Histic Epipedon _______
High Organic Content____	Sulfidic Odor_____	Organic Streaking______
Aquic Moisture Regime___	Reducing Conditions___	Gleyed_____

Other Remarks____

Disturbance

Fill ___	Waste ___	Dredging ___	Fire ___
Channels/ditches ___	Farming ___	Industrial ___	Residential__
Commercial ___	Timber Harvesting ___	Roads ___	Drainage ___
Impoundment ___	Other ____		

Land Ownership

Federal ___ State ____ County ___ Private ___

Appendix G. Supplemental Map Information (User Report)

Outline

1. Project Area:
2. Source Imagery: (type, scale and date)
3. Ancillary Data: (include any digital data used as ancillary information)
4. Inventory Method: (original mapping, map update, techniques used)
5. Classification: (Cowardin wetlands, riparian, uplands, hydrogeomorphic, etc.)
6. Data Limitations:
7. General description of the Project Area
    - Geography
    - Vegetation, soils, land use
    - Natural history or important cultural features
8. Description of wetland habitats
    - Organize by Cowardin classification type
    - Wetland classification codes and corresponding community type(s)
9. Description of other habitats
    - Riparian
    - Uplands
10. List of wetland plant species with indicator status
11. Regional specialized conventions
12. Other discussion of mapping issues (image quality, water conditions, etc.)
13. References

Appendix H: Wetlands Digital Data Submission Form

* Indicates Required Field

Contributing Organization: Name of the organization and the contact information for the individual contributing data.

Organization Representative:

* First Name

* Last Name

* Street Address

* City

* State

* Zip Code

* Telephone

Extension

* E-mail address

Date of Submission: Date project was submitted to the Wetlands Database Administrator (preferably, month/day/year). Most likely will be today's date.

* **Project Name:** Name given to the project, may be place name, restoration name, etc...

* **Data Date:** This is the date (preferably, month/day/year) of data collection. May be date of imagery used or data collection date.

* **Data Type:** Explanation of data type or collection method (i.e. new data, updated data, digitized data, GPS survey data, field

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