FGDC *Draft* Wetlands Mapping Standard

FGDC Wetland Subcommittee and

Wetland Mapping Standard Workgroup

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1 INTRODUCTION

1.1 Background

Historically, the U.S. Fish and Wildlife Service (FWS) has had the responsibility for mapping wetlands in the United States. Those map products are currently held in the National Wetlands Inventory (NWI). As time has passed, more local, state and non-governmental organizations have become interested in mapping wetlands, and at a more refined scale than has been available from NWI. It has become increasingly important to have consistency and to develop a wetlands mapping standard that everyone can use to map and share wetlands data in a digital format. It is highly desirable to be able to reprocess data from the NWI to support multiple mapping applications and digital products. It is also important for wetlands map data to be "compatible/complimentary" with other water data, such as the features represented in the National Hydrography Dataset (NHD), so that wetlands can be considered in a more holistic environmental context, whether at the watershed, ecosystem, or regional level.

In early wetlands inventory mapping, the intended end-products were primarily paper-based maps, and small wetland features were represented as points. These points were an artifact of the scale limitations of the cartographic technology used at the time. As technology progressed, such geographic data were stored as polygons and lines. The use of modern digital technology and on-screen mapping of wetlands allows interpretation to be done in much finer detail. Features previously represented as points and lines can now be delineated as polygons. Increasingly, such finer-detail digital wetlands map products are needed (instead of the traditional paper-based maps), to allow for comparison with other maps and data, execution of spatial analyses, and other data processing.

The NWI digital wetlands data now serves as the foundation for the wetlands data layer of the National Spatial Data Infrastructure (NSDI). A national standard is needed to facilitate inclusion of new wetlands inventory data into the NSDI, as mandated by OMB Circular A-16 (revised). This will support a consistent transition from traditional paper-based map products to technology-based mapping products, and increase sharing and multiple uses of the wetlands data.

1.2 Objectives

The objective of the standard is to support the accurate mapping and classification of wetlands while ensuring mechanisms for their revision and update as directed under OMB Circular A-16 (revised). The Wetlands Mapping Standard is designed to direct the current and future digital mapping of wetlands.

The current structure of the National Wetlands Inventory U.S. Fish and Wildlife Service geodatabase is a mosaic of best available wetland data. The goal of the Federal Geographic Data Committees (FGDC) Wetlands Mapping Standard is to improve the overall quality and consistency of new wetland data added to the NWI data layer. While this standard cannot change the NWI data produced prior to its implementation, the standard specifies a core set of data quality components necessary to add to the National Wetlands Inventory data layer in a way that is consistent and supports multiple uses of the data, while meeting the requirements of the National Spatial Data Infrastructure. The standard is based largely on the existing draft standard used by U.S. Fish and Wildlife Service in support of the NWI: National Standards and Quality Components for Wetlands, Deepwater and Related Habitat Mapping.

The standard provides specification of the minimum data quality components for wetlands inventory mapping needed to support inclusion of the data into the NSDI, particularly when these activities are funded or conducted by the Federal government. The standard balances the burden on the end-user community with the need for consistency and documented quality of digital mapping products. Additionally, this standard is created to coordinate wetlands mapping with the NHD, a national geospatial framework recognized by the FGDC. Although this standard is structured to be extensible over time, it is deliberately developed with a forward-looking perspective to accommodate technology and map-scale enhancements that assure its long-term usability, and minimize the need for revisions and updates.

1.3 Scope

The Wetlands Mapping Standard directs the incorporation of federally-funded wetlands mapping data into the national wetlands geospatial database (under direction of the Fish and Wildlife Service) and the NSDI. This standard provides minimum requirements and guidelines for wetlands inventory mapping. Specific cartographic, photogrammetric, and classification conventions where applicable, have been identified and are represented by other Federal standards. Nothing in the standard precludes the use of ancillary or collateral data (such as soil data, DEMs, LIDAR,

radar, topographic maps, etc.) to enhance wetland mapping. In fact, these ancillary or collateral sources are often important in wetland mapping.

For activities which include wetlands inventory mapping as a subset, any new, updated or revised wetland mapping shall conform to this standard. More general mapping activities may use wetlands data from NSDI to incorporate the wetland subset rather than conducting new wetland mapping. Mapping activities of which wetlands may be a subset include, but are not limited to:

- *Land Use Land Cover (LULC) classifications*
- *Forest cover maps*
- *Floodplains*

Exemptions to the standard

Circumstances for which this standard does not apply, or for which portions of the technical requirements of the standard may be waived, include the following:

1. Wetlands inventory mapping activities that are not federally-funded are strongly encouraged but not required. The NSDI will not incorporate non-compliant wetlands inventory data from any source except NWI maps created prior to the implementation of this standard (these pre-standard NWI maps may be provided as scanned images only).
2. NWI mapping and other federally-funded projects that began prior to the standard's effective date. Also exempt are federally-funded projects for which contract execution occurred prior to the standard's effective date, even if the actual work had not begun prior to that date.
3. The standard is designed to support polygonal wetland datasets and does not apply to plot/point transects, and linear datasets. While nothing in this standard precludes the capture of point or line data for referencing wetlands below the target mapping unit (TMU, see section 2.3.1), only polygon features will be included in the NWI geodatabase.
4. The standard is neither designed, nor intended, to support legal, regulatory, or jurisdictional analyses of wetland mapping products, nor does it attempt to differentiate between regulatory and non-regulatory wetlands.
5. Change detection efforts that seek to extrapolate the amount of change in wetland area, type, functionality, value, integrity or quality, from samples. An intermediate step in these change detection efforts may include mapping individual wetlands in sample plots; this standard does not prevent Federal funding for this intermediate step.
6. Marine and estuarine benthic habitat mapping is exempt because it currently necessitates the use of definitions and classifications which

require different approaches than the FGDC Classification of Wetlands and Deepwater Habitats in the United States standard.

7. Maps and data developed for site-specific wetland studies for scientific research, environmental assessments (EAs) and environmental impact statements (EIS), and wetland determinations for regulatory purposes, when these site-specific activities necessitate the use of definitions and classifications which are incompatible with the FGDC wetland classification standard.
8. Mapping products when they are not developed primarily for wetland inventory mapping and classification. These types of data are useful as ancillary or collateral data for wetlands inventory mapping. For example:

    - *Deepwater substrate types*
    - *Vegetation types*
    - *Soil types (including hydric soil units)*
    - *Topography*
    - *Geology*
    - *Forest cover maps*
    - *Hydrography*
    - *Navigation or bathymetry*
    - *Submerged aquatic vegetation (SAV)*

9. In order to ensure the best available data can always be included in the wetlands layer of the NSDI, it is recognized that there may be certain limited circumstances where no better data are available, so a mechanism is needed to allow the incorporation of these data where appropriate. Allowing extremely limited and well-justified inclusion of non-compliant data where data meeting the standard does not yet exist may allow for comprehensive coverage of "best available" data more quickly, meeting the needs of many end users. An exemption from a specific minimum requirement in the standard may be granted based on data quality, but not on cost. A waiver may be requested to incorporate such data. A waiver is an authorized exemption from a specific minimum requirement in the standard. The U.S. Fish and Wildlife Service data steward for water resources and wetlands is the final authority for the waiver process. The U.S. Fish and Wildlife Service water resources and wetlands data steward should be contacted regarding the waiver process to find out if a waiver may be justified.

1.4 Applicability

This standard is intended for all Federal or federally-funded wetlands inventory mapping including those activities conducted by Federal agencies, states, and federally-recognized tribal entities, non-governmental organizations, universities, and others. Specifically, if Federal funding is

used in support of wetlands inventory mapping activities, then use of this standard is mandatory. The adoption of the standard for all other wetlands inventory mapping efforts (non-federally funded) is strongly encouraged to maintain and expand the wetland layer of the NSDI.

1.5 FGDC Standards and Other Related Practices

The following standards and applications are listed as core components to the Wetlands Mapping Standard effort. Some of these standards are included because the Wetlands Mapping Standard was developed in consideration and conformance with their requirements and intent.

The related FGDC standards include:

- Classification of Wetlands and Deepwater Habitats in the United States, FGDC-STD-004 http://www.fws.gov/stand/standards/cl_wetl.html
- Content Standard for Digital Geospatial Metadata (version 2.0) FGDC-STD-001-1998, http://www.fgdc.gov/metadata/geospatial-metadata-standards
- Geospatial Positioning Accuracy Standards Part 3. National standard for spatial data accuracy. FGDC-STD-007.3-1998
- *National Vegetation Classification Standard*, FGDC-STD-005 (version 2)
- *Soil Geographic Data Standard*, FGDC-STD-006
- Information Technology – Geographic Information Framework Data Content Standard, Part 5: Governmental unit and other geographic area boundaries, http://www.fgdc.gov/standards/projects/incits-l1-standards-projects/framework/documents-2/GU20061024-1509.pdf/view

Other related practices include:

- *Canadian Wetland Inventory* maintained by Agriculture and Agri-Food Canada (AAFC) at http://www.cwi-icth.ca/
- *National Hydrography Database* (NHD) maintained by the USGS at http://nhd.usgs.gov/
- *Fish and Wildlife Service National Standards and Quality Components for Wetlands, Deepwater and Related Habitat Mapping*, http://www.fws.gov/stand/standards/dl_wetlands_National%20Standards.doc
- *Draft FGDC Riparian Standard* maintained by FGDC at http://www.fgdc.gov/standards/projects/FGDC-standards-projects/riparian-mapping/index_html
- *Guidance for Benthic Habitat Mapping: An Aerial Photographic Approach* maintained by the U.S. NOAA Coastal Services Center.

Available for download at http://www.csc.noaa.gov/benthic/mapping/pdf/bhmguide.pdf.

- *Coastal and Marine Ecological Classification Standard (CMECS)* developed for NOAA by NatureServe at http://csc.noaa.gov/benthic/funding/active.htm
- *RAMSAR Classification for Wetland Type* maintained by Convention on Wetlands (Ramsar, Iran, 1971) at http://www.ramsar.org/ris/key_ris_types.htm
- Primary Indicators Method. Tiner, R.W. 1993. *The primary indicators method - a practical approach to wetland recognition and delineation in the United States*. Wetlands 13(1): 50-64. (This method is typically used for verifying NWI wetlands on the ground).
- NatureServe's Terrestrial Ecological System Classification Comer, P., D. Faber-Langendoen, R. Evans, S. Gawler, C. Josse, G. Kittel, S. Menard, M. Pyne, M. Reid, K. Schulz, K. Snow, and J. Teague. 2003. *Ecological Systems of the United States: A Working Classification of U.S. Terrestrial Systems.* NatureServe, Arlington, Virginia. http://www.natureserve.org/library/usEcologicalsystems.pdf

1.6 Standard Development Procedures and Representation

Stakeholder representation from the Federal, State, and local government, non-profit, and private sectors was included in the development of this standard to ensure that the end-user information requirements are reflected in the final product. Technical development of the content of this standard began in June 2006 with a 3-day meeting of the workgroup comprised of members representing multiple Federal agencies and stakeholder groups. It was emphasized again that the standard would benefit from a wide vetting process targeting diverse members of the end-user community. Technical refinement of the standard occurred through the Spring of 2008 based on over 125 comments received through the Federal Register Notice process in late 2007.

The development of this standard generated findings for minor revisions to other existing FGDC standards, including an expansion of the FGDC Wetlands and Deepwater Habitat Classification System; additional tools for handling and tracking wetland unique identifiers; and publishing new FGDC standards for related habitat types.

1.7 Maintenance Authority

The maintenance authority for the *Wetlands Mapping Standard* resides with the Chair of the FGDC Wetland Subcommittee at the Fish and Wildlife Service. This workgroup recommends review of this standard at five-year intervals.

2 FGDC REQUIREMENTS AND QUALITY COMPONENTS

The sections below present the specifications for the technical components of the Wetlands Mapping Standard. To further the Information Quality Act and conform to NWI Quality Review Procedures, a technically skilled person other than the person doing the original image interpretation will perform an initial quality control review of the image interpretation for the entire project area. Producers must provide an opportunity for review by other interested agencies and stakeholders prior to submission to the FWS for inclusion in the NSDI. Names and affiliations of the reviewers of the data must be included in the metadata.

2.1 Imagery

Source imagery is the imagery used to develop signatures and interpret wetlands. The source imagery used should be color infrared at a minimum of 1m resolution[1] or as specified in Table 1, in order to provide the required target mapping unit (TMU) and producer's accuracy (PA) metrics (see section 2.3 Accuracy for more information on TMU and PA). Using a resolution of less than 1m (higher detail) will enhance the capability to meet the minimum requirements. The purpose of specifying source imagery requirements is to ensure meeting the TMU and PA metrics.

Base imagery is the ortho-rectified imagery (aerial photography/satellite imagery) that is used as the base image (map) to overlay wetlands data. The base imagery must be rectified to a national standard dataset. Digital Orthophoto 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.

2.1.1 Source Imagery

Table 1. Spatial Resolution Requirements of Source Imagery

	Lower 48 States, Hawaii, & Territories *	Estuarine & Lacustrine Deepwater **	Alaska (Including Deepwaters)
Resolution	1m	3m	5m

*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 deepwaters of the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. Alaska is excluded.

[1] For example, source imagery scales of 1:40,000 or greater (higher detail) should be sufficient to produce 1m resolution.

Additional incorporation of any of the imagery source(s) from the following list will enhance data quality.

- *Near-infrared wavelength imagery*
- *Stereoscopic imagery*
- *Leaf-off imagery*
- *Source imagery at a scale greater than 1:40,000 (higher detail)*

In some situations, incorporation of some of these imagery sources may be necessary to achieve the completeness and accuracy requirements specified in this standard. To better interpret to the subclass level, multi-seasonal imagery may be desirable.

2.1.2 Base Imagery

The minimum requirement for this standard is that all base imagery must have a true spatial resolution and scale based on the geographic context of the mapping effort (Table 2).

Table 2. Spatial Resolution Requirements of Base Imagery

	Lower 48 States, Hawaii, & Territories *	Estuarine & Lacustrine Deepwater **	Alaska (Including Deepwaters)
Resolution	1m	3m	5m
Scale	1:12,000	1:24,000	1:63,360

*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 deepwaters of the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. Alaska is excluded.

2.2 Classification

This standard is based upon classification using the FGDC Wetlands and Deepwater Habitat Classification System. The minimum standard for the completeness of the wetland classification is: ecological system, subsystem (with the exception of Palustrine), class, subclass (only required for forested, scrub-shrub, and emergent classes), water regime, and special modifiers (only required where applicable). The minimum standard for deepwater habitat classification is: system, subsystem, class, and water regime. Table 3 represents required classifications based on habitat type. Further recommendations for classification are discussed in Appendix A.

Table 3. Classification Levels Required Based on Habitat Type

	System	Sub-system	Class	Subclass†	Water Regime	Special Modifiers (where applicable)
Lower 48 States, Hawaii, & Territories *	Yes	Yes	Yes	Yes	Yes	Yes***
Estuarine & Lacustrine Deepwater **	Yes	Yes	Yes****	Yes*****	Yes	No
Alaska (Including Deepwaters)	Yes	Yes	Yes	Yes	Yes	Yes***

†At minimum users should include Subclass for forested, and scrub-shrub classes.
*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 deepwaters of the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. Alaska is excluded.
***Farmed wetlands need only include system and farmed modifier; cultivated cranberry bogs may be classified as PSSf.
****Classify as unconsolidated bottom unless data indicates otherwise for estuarine and lacustrine deepwater habitats.
*****Users should include Class and Subclass when data are available for estuarine and lacustrine deepwater habitats; for other areas Class will suffice.

2.3 Accuracy

Accuracy is a measure of both errors of omission and commission. For wetland mapping, accuracy may be dependent upon several factors affecting identification including:

- *Scale of imagery*
- *Mapping scale or base map scale*
- *Quality of imagery*
- *Season of imagery (leaf-off or leaf-on)*
- *Type of imagery or emulsion of imagery*
- *Environmental conditions when imagery was captured*
- *Difficulty of identifying particular types of wetlands*
- *Availability and quality of ancillary or collateral data sources*

Accuracy is also a function of data quality and technology as well as proper training of the image interpreter. Classification accuracy of the final map product should be measured by the TMU and PA metrics. This standard presents no requirement for User's Accuracy (UA).

- ***The Target Mapping Unit*** *is an estimate of the size class of the smallest wetland that can be consistently mapped and classified at a*

particular scale of imagery, and that the image-interpreter attempts to map consistently. TMU allows for mapping below a specified threshold, but does not subject that finer detailed mapping to the accuracy requirements of the standard. 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[2]), such as those following drainage-ways and stream corridors, are excluded from consideration when establishing the TMU. Such wetlands may or may not be mapped, depending on project objectives.

- ***Producer's Accuracy*** *measures the percentage of wetland features that are correctly identified and correctly classified on the imagery. PA is measured by both feature and attribute accuracy. Feature accuracy is the correctness of the identification of wetland vs. non-wetland. Attribute accuracy is the correctness of the classification of the wetlands using the FGDC Wetlands Classification Standard.*
- ***User's Accuracy*** *measures the percentage of reference sites on the ground (field-check) sites that are correctly classified on the map. This standard presents no requirement for User's Accuracy.*

Spatial accuracy is a function of two metrics: Horizontal Accuracy (HA) and Vertical Accuracy (VA). This standard presents no requirement for Vertical Accuracy.

- ***Horizontal Accuracy*** *refers a feature's horizontal positional accuracy in relation to the base imagery.*
- ***Vertical Accuracy*** *is a measure of the positional accuracy of a dataset with respect to a specified vertical datum.*

Requirements for these accuracy metrics are presented in the following sub-sections.

2.3.1 Target Mapping Unit and Producers Accuracy

Wetlands data that meet or exceed the minimum TMU and PA requirements will be accepted for submission to the NSDI. Ninety-eight percent of all wetlands visible on an image, at the size of the TMU or larger must be mapped regardless of the origin (natural, farmed, or artificial). For the lower 48 states and Hawaii and the Trust Territories, features that are at least 0.5 acre would be mapped with a demonstrated

[2] The 15 feet wide measurement for linear features is specified because when viewed at a scale of 1:12,000, two lines bounding a polygon will converge if the polygon is less than 15 feet wide.

PA of 98% for feature accuracy and 85% for attribute accuracy, or higher, across each DOQQ (or the project area if the project area is smaller than a DOQQ), as documented through external quality assessment of samples. The minimum technical requirements are specified in Table 4. Habitat changes that have occurred between the date of the base imagery and the date of field observation/groundtruthing are not considered errors because the wetland was correctly classified on the base imagery.

Table 4. TMU and Producer Accuracy† Requirements

	Lower 48 States, Hawaii, & Territories *	Estuarine & Lacustrine Deepwater **	Alaska (Including Deepwaters)
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 deepwaters of the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. Alaska is excluded.

The actual TMU and PA for the project area must be declared in the metadata, along with an associated justification and description of the quality assurance process used.

2.3.2 Horizontal Accuracy

Horizontal accuracy is ensured by conformance with FGDC Digital Orthophoto Quarter Quadrangle requirements used by many Federal agencies. The FGDC standard requires that spatial accuracies are reported at the 90% or 95% confidence interval. This means that when the requirement states that the Horizontal Accuracy must be 5m root mean square error (RMSE) then the features must fall within 5m of the location of the features on the base imagery at least 68% of the time. The horizontal accuracy minimum requirement is commensurate with the base imagery/map scale available for the area (see Table 2). Where horizontal accuracies are mixed within a project area, the actual horizontal accuracies should be reported in the metadata. This standard requires a nominal RMSE commensurate with the context of the mapping as specified in Table 5.

Table 5. Horizontal RMSE Accuracy Requirements

	Lower 48 States, Hawaii, & Territories *	Estuarine & Lacustrine Deepwater **	Alaska (Including Deepwaters)
Horizontal RMSE Accuracy	5m	15m	25m

*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 deepwaters of the lower 48 states, Hawaii, District of Columbia, Trust Territories, Puerto Rico, and the Virgin Islands. Alaska is excluded.

2.4 Data Verification

The overall guiding principle is that the wetlands data generated are added to the wetlands layer of the NSDI. To ensure quality control, the following verification checks outlined in this Section must be followed prior to submission for inclusion in the NSDI. FWS, as steward of the NWI, will conduct data verification, quality control, and quality assurance to meet current Quality Review Procedures before including data in the NWI layer of the NSDI.

2.4.1 Logical Consistency

Logical consistency refers to the internal consistency of the data structure, and particularly applies to topological consistency. This standard's intent is to ensure the ability to generate seamless digital mapping products within a project area. Tests for logical consistency must be performed that verify topology validity prior to submission to the NSDI.

The minimum requirement for topological verification includes:

- *Polygons intersecting the border of a project area must be closed along the border.*
- *Segments making up the outer and inner boundaries of a polygon tie end-to-end to completely enclose the area.*
- *Line segments must be a set of sequentially numbered coordinate pairs.*
- *No duplicate features exist nor duplicate points in a data string.*
- *Intersecting lines are separated into individual line segments at the point of intersection.*
- *All nodes are represented by a single coordinate pair which indicates the beginning or end of a line segment.*

2.4.2 Edge Matching

Edge-matching of wetland interpretation is required for a seamless wetlands 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 standard requires that in all cases, internal edge-matching will be performed. Wetland mapping units lying along the outer borders of source images within a project area, whenever practical will be edge-matched with interpretations on all adjacent images within the project area. All linear and polygon features will 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.

2.4.3 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 attribute verification checks prior to submission to FWS, and then again by FWS before inclusion in the NSDI.

The USFWS Attribution Tools have been constructed to attribute map features that may depict wetlands, riparian areas, uplands or other natural resource 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).

2.5 Datum and Projection

Wetlands data may be created or used in any standard datum and projection. However, in accordance with the NWI and NSDI, the standard requires all data to be re-projected to Albers Equal-Area projection and the datum to be North American Datum 1983 (NAD83) prior to submission for inclusion in NSDI.

2.6 Metadata

Metadata must be provided and conform to the most recent FGDC Content Standard for Digital Geospatial Metadata (CSDGM). Adherence to the standard requires metadata to be produced for all the core accuracy requirements listed in this standard.

All metadata for derived wetland classifications must contain a reference to the FGDC-STD-004 Wetlands and Deepwater Habitat Classification System.

2.7 FWS Coordination and Quality Control

Mapping organizations are advised to consult with FWS to coordinate any federally-funded wetlands mapping effort. The mapping organization should coordinate mapping activities with FWS to assure a logical, technically sound, and comprehensive approach. Mapping organizations must run data through the FWS Attribution Tools (see 2.4) before providing the final finished project data to the FWS. FWS will be responsible for final quality control of all products.

References

Classification of Wetlands and Deepwater Habitats in the United States, FGDC-STD-004 (also referred to as Cowardin Classification System in the standard)
http://www.fws.gov/stand/standards/cl_wetl.html

Content Standard for Digital Geospatial Metadata (version 2.0) FGDC-STD-001-1998, http://www.fgdc.gov/metadata/geospatial-metadata-standards

National Hydrography Database (NHD) maintained by the USGS at http://nhd.usgs.gov/

Draft FGDC Riparian Standard maintained by FGDC at http://www.fgdc.gov/standards/projects/FGDC-standards-projects/riparian-mapping/index_html

Fish and Wildlife Service National Standards and Quality Components for Wetlands, Deepwater and Related Habitat Mapping, http://www.fws.gov/stand/standards/dl_wetlands_National%20Standards.doc

Geospatial Positioning Accuracy Standards Part 3. National standard for spatial data accuracy. FGDC-STD-007.3-1998

Guidance for Benthic Habitat Mapping: An Aerial Photographic Approach maintained by the U.S. NOAA Coastal Services Center. Available for download at
http://www.csc.noaa.gov/benthic/mapping/pdf/bhmguide.pdf

National Vegetation Classification Standard, FGDC-STD-005
http://biology.usgs.gov/npsveg/classification/sect2.html

RAMSAR Classification for Wetland Type maintained by Convention on Wetlands (Ramsar, Iran, 1971) at
http://www.ramsar.org/ris/key_ris_types.htm

U.S. Geological Survey. 2001. Standards for revised primary service quadrangle maps. Part 2 specifications. National Mapping Technical Instructions. U.S. Department of the Interior, U.S. Geological Survey, Reston, VA. 76p. plus appendices.

Primary Indicators Method. Tiner, R.W. 1993. *The primary indicators method - a practical approach to wetland recognition and delineation in the United States*. Wetlands 13(1): 50-64.

Appendix A:
Attributes for Wetland Classification
(Normative)

The following keys in Figures 1a and 1b provide a list of codes for writing alpha-numeric designations for wetlands and deepwater habitats as defined by the wetlands classification system developed by the U.S. Fish and Wildlife Service (Cowardin et al. 1979).

Figure 1a

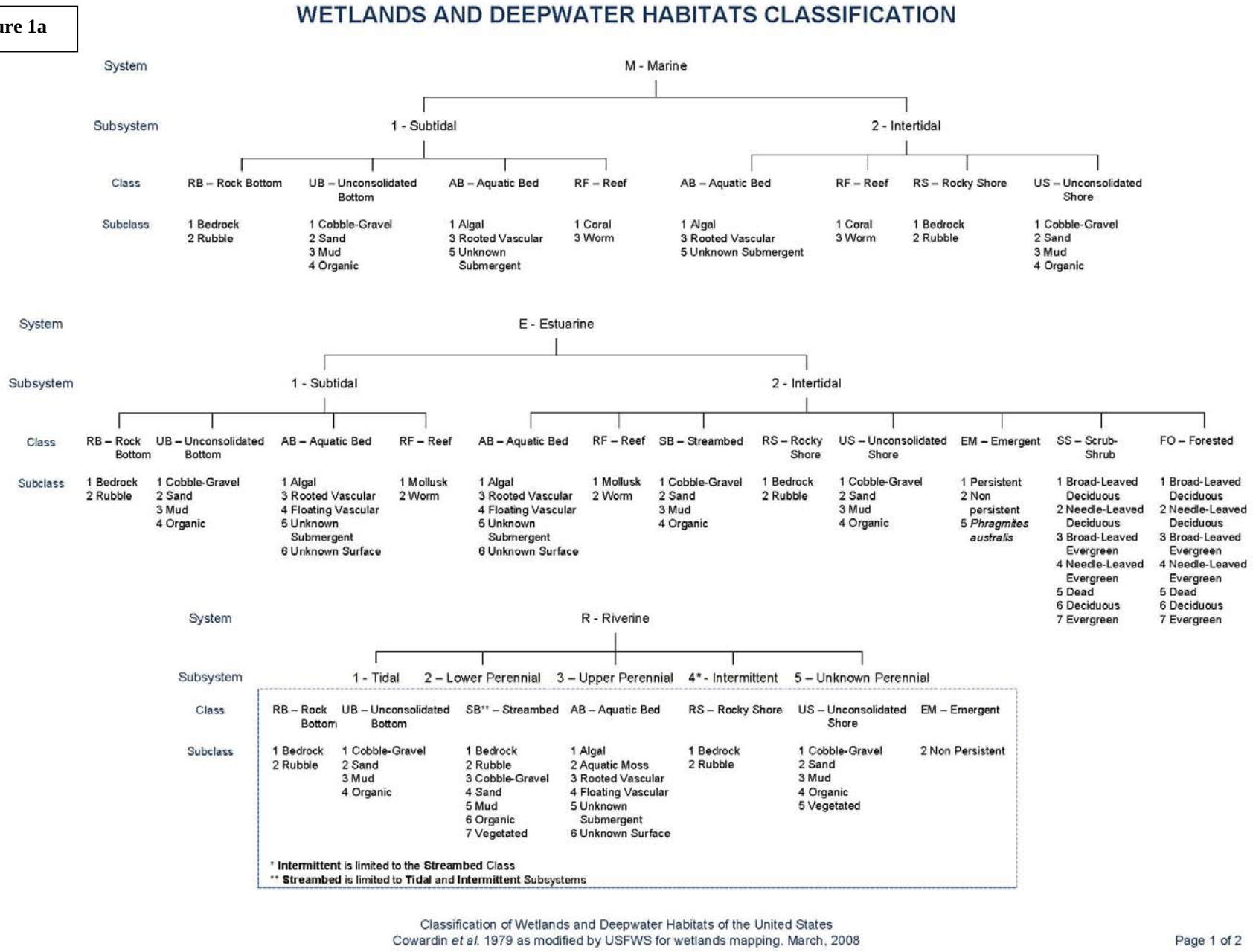
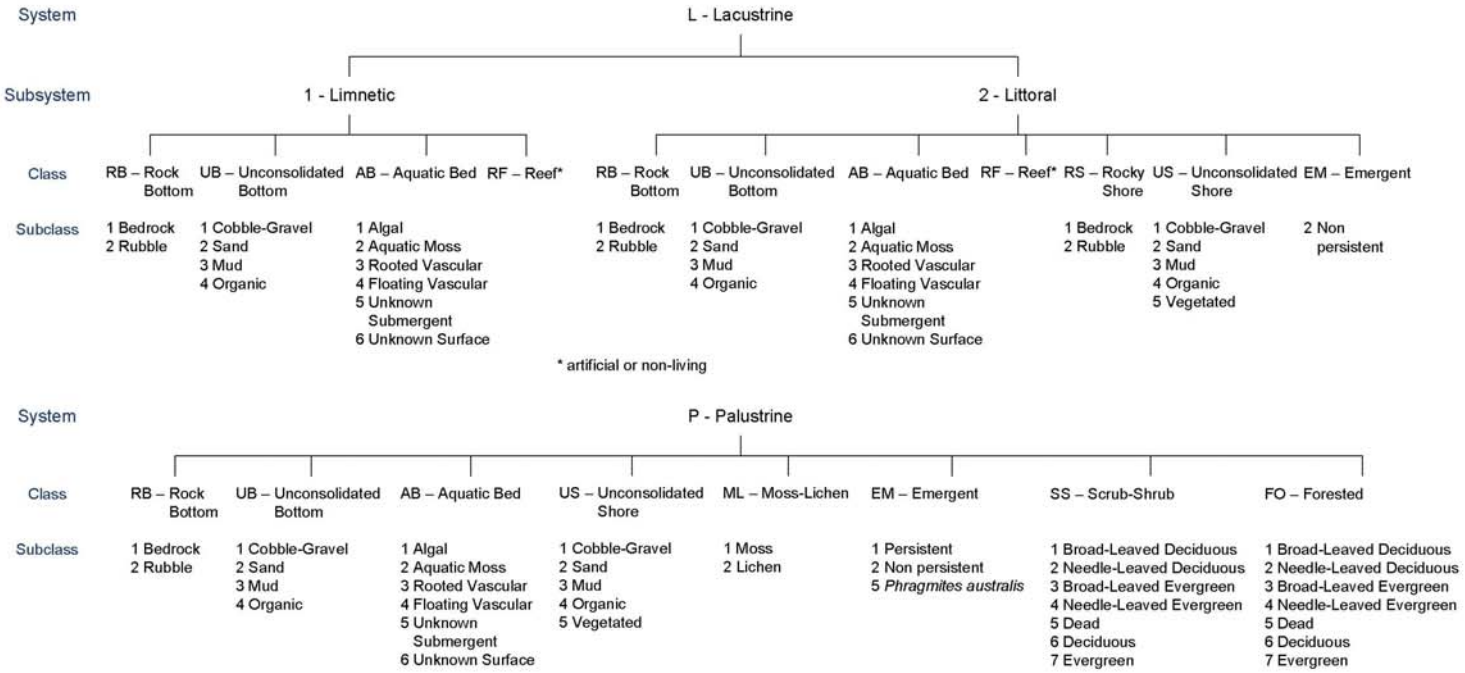


Figure 1b

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION



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
Non Tidal	**Saltwater Tidal**	**Freshwater Tidal**		**Coastal Halinity**	**Inline 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 Euthaline	8 Eusaline	t Circumneutral	n Mineral
C Seasonally Flooded	N Regularly Flooded	T Semipermanently Flooded-Tidal	f Farmed	3 Mixohaline (Brackish)	9 Mixosaline	l Alkaline	
E Seasonally 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		*All: U Unknown					

Appendix B:
Attributes for LLWW (for Landscape, Landform, Water Flow path, and Waterbody Type)
(Informative)

The following keys provide a list of other descriptors that have been developed by the U.S. Fish and Wildlife Service to describe other wetland properties not currently addressed in Cowardin et al. 1979 wetland classification system. When added to existing NWI wetland classifications, the expanded wetland database becomes a more powerful analytical tool, allowing users to predict wetland functions for large geographic areas, better characterize wetlands (e.g., palustrine wetlands associated with lakes, rivers, streams, and ponds), and generate information of interest to policymakers and others (e.g., how many and how much of the wetland resource is isolated or connected to waters of the United States). When the Cowardin et al. classification is reviewed in the future, it is likely that these attributes in whole or part will be added to the classification. This operational draft system is referred to informally as LLWW (for Landscape, Landform, Water Flow path, and Waterbody type).

Simplified Keys for Classifying Tidal and Nontidal Wetlands by Landscape Position, Landform, and Water Flow Path (Adapted from Tiner 2003)

Landscape Position

1. Wetland borders a river, stream, lake, reservoir, in-stream pond, estuary, or ocean……..2
1. Wetland does not border one of these waterbodies; it is surrounded by upland or borders a pond that is surrounded by upland…….Terrene
2. Wetland lies along an ocean shore and is subject to tidal flooding……Marine
2. Wetland does not lie along an ocean shore or if oceanside, it is not subject to tidal flooding.....3
3. Wetland lies along an estuary (salt-brackish waters) and is subject to tidal flooding……Estuarine
3. Wetland does not lie along an estuary or if along the estuary, it is not subject to tidal flooding……..4
4. Wetland lies along a lake or reservoir or within its basin (i.e., the relatively flat plain contiguous to the lake or reservoir)……. ……..Lentic
4. Wetland lies along a river or stream, or in-stream pond, or borders a marine or estuarine wetland or associated waters but is not flooded by tides (except episodically)…….…....5
5. Wetland is associated with a river or stream……..6
5. Wetland is not associated with a river or stream; it is a freshwater nontidal wetland bordering a marine or estuarine wetland or associated waters.……Terrene
6. Wetland is the source of a river or stream and this watercourse does not flow through the wetland……..…….Terrene
6. A river or stream flows through or alongside the wetland ……...7
7. Wetland is periodically flooded by river or stream ……..……Lotic[3]
7. Wetland is not periodically flooded by the river or stream ……..…….……...Terrene

[3] Lotic wetlands are separated into river and stream sections (based on watercourse width: polygon = Lotic River vs. linear = Lotic Stream at a scale of 1:24,000) and then divided into one of five gradients: 1) high (e.g., shallow mountain streams on steep slopes), 2) middle (e.g., streams with moderate slopes), 3) low (e.g., mainstem rivers with considerable floodplain development and slow-moving streams), 4) intermittent (periodic flows), and 5) tidal (hydrology under the influence of the tides).

Landform

1. Wetland occurs on a slope >2%.....Slope
1. Wetland does not occur on a slope>2%.....2
2. Wetland forms an island completely surrounded by water…….……..Island
2. Wetland does not form an island…….…….……3
3. Wetland occurs in the shallow water zone of a permanent nontidal waterbody, the intertidal zone of an estuary with unrestricted tidal flow, or the regularly flooded (daily tidal inundation) zone of freshwater tidal wetlands…….……..Fringe
3. Wetland does not occur in these waters or in estuarine intertidal zones with unrestricted tidal flow……..……..4
4. Wetland occurs in a portion of an estuary with restricted tidal flow due to tide gates, undersized culverts, dikes of similar obstructions……Basin
4. Wetland does not occur in such location……..……5
5. Wetland forms a nonvegetated bank or is within the banks of a river or stream…….….Fringe
5. Wetland is a vegetated river or stream bank or not within the banks……..……..……6
6. Wetland occurs on an active alluvial plain of a river (a polygonal feature)[4]…… Floodplain*
6. Wetland does not occur on an active floodplain……..…..7
7. Wetland occurs on a broad interstream divide (including headwater positions) associated with coastal or glaciolacustrine plains or similar plains……....Interfluve*
7. Wetland does not occur on such a landform...…….….8
8. Wetland occurs in a distinct depression…….…...Basin
8. Wetland occurs on a nearly level landform……..Flat

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*Basin and Flat sub-landforms can be identified within these landforms when desirable.

[4] For practical purposes, floodplain is restricted to rivers (i.e., polygonal watercourses); similar areas along streams (i.e., linear watercourses) are designated as basins or flats.

Water Flow Path[5]

1. Wetland is typically surrounded by upland (nonhydric soil); receives precipitation and runoff from adjacent areas with no apparent outflow[6]…..……..……Isolated**
1. Wetland is not geographically isolated…….……..…….2
2. Water flow is mainly bidirectional from tides or lake/reservoir fluctuations……..….3
2. Water flow is essential one-directional (downstream)……...….4
3. Wetland is subjected to tidal flooding……...……..Bidirectional-Tidal
3. Wetland is located along a lake or reservoir and not along a river or stream entering this type of waterbody; water levels are mainly affected by the rise and fall of lake or reservoir water levels ……..……..Bidirectional-Nontidal***
4. Wetland is a sink, receiving water from a river, stream, or other surface water source and lacking surface-water outflow……..……Inflow
4. Wetland is not a sink; surface water flows through or out of the wetland……...5
5. Water flows out of the wetland, but does not flow into this wetland from another source…….Outflow
5. Water flows through the wetland, often coming from upstream or uphill sources (typically wetlands along rivers and streams)….……..……..Throughflow

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**Wetland is geographically isolated; hydrological relationship to other wetlands and watercourses may be more complex than can be determined by simple visual assessment of surface water conditions. If groundwater relationships are known can apply other water flow paths as appropriate, but add "groundwater" to the term (e.g., outflow-groundwater).

***Bidirectional-Nontidal flow should be expanded to reference the water flow path of the associated waterbody: BH – bidirectional-nontidal/throughflow, BN – Bidirectional-nontidal/inflow, BO – Bidirectional-nontidal/outflow, and BS – Bidirectional-nontidal/isolated.

[5]Surface water connections are emphasized because they are more readily identified than groundwater linkages (see footnote below for paludified landscapes).

[6] Water flow path for some bogs and similar wetlands may be paludified; paludification processes occur in areas of low evapotranspiration and high rainfall, peat moss moves uphill creating wetlands on hillslopes (i.e., wetland develops upslope of primary water source).

Waterbody Types from Dichotomous Key

List of Estuary, Ocean, River, Stream, Lake, and Pond Types (with corresponding map codes assigned)

EY Estuary
- 1 drowned river valley estuary
  - a open bay (fully exposed)
  - b semi-enclosed bay
  - c river channel
- 2 bar-built estuary
  - a coastal pond-open
  - b coastal pond-seasonally closed
  - c coastal pond-intermittently open
  - d hypersaline lagoon
- 3 river-dominated estuary
- 4 rocky headland bay estuary
  - a island protected
- 5 island protected estuary
- 6 shoreline bay estuary
  - a open (fully exposed)
  - b semi-enclosed
- 7 tectonic
  - a fault-formed
  - b volcanic-formed
- 8 fjord
- 9 other

Note: If desired, you can also designate river channel (rc), stream channel (sc),and inlet channel (ic) by modifiers. *Examples*: EY1rc = Drowned River Valley Estuary river channel; EY2ic= Bar-built estuary inlet channel. If not, simply classify all estuarine water as a single type, e.g., EY1 for Drowned River Valley or EY2 for Bar-built Estuary.

OB Ocean or Bay
- 1 open (fully exposed)
- 2 semi-protected oceanic bay
- 3 atoll lagoon
- 4 other reef-protected waters
- 5 fjord

RV River
- 1 low gradient

a connecting channel
b canal
2 middle gradient
a connecting channel
3 high gradient
a waterfall
b riffle
c pool
4 intermittent gradient
5 tidal gradient
6 dammed gradient
a lock and dammed
b run-of-river dammed
c other dammed

ST Stream
1 low gradient
a connecting channel
2 middle gradient
a connecting channel
3 high gradient
a waterfall
b riffle
c pool
4 intermittent gradient
5 tidal gradient
6 dammed
a lock and dammed
b run-of-river dammed
c beaver dammed
d other dammed
7 artificial
a connecting channel
b ditch

LK Lake
1 natural lake (*see also Pond codes for possible specific types*)
a main body
b open embayment
c semi-enclosed embayment
d barrier beach lagoon
2 dammed river valley lake
a reservoir
b hydropower
c other
3 other dammed lake
a former natural

	b		artificial
	4	other artificial lake	
PD	Pond		
	1	natural	
	a		bog
	b		woodland-wetland
	c		woodland-dryland
	d		prairie-wetland (pothole)
	e		prairie-dryland (pothole)
	f		playa
	g		polygonal
	h		sinkhole-woodland
	i		sinkhole-prairie
	j		Carolina bay
	k		pocosin
	l		cypress dome
	m		vernal-woodland
	n		vernal-West Coast
	o		interdunal
	p		grady
	q		floodplain
	r		other
	2	dammed/impounded	
	a		agriculture
	a1		cropland
	a2		livestock
	a3		cranberry
	b		aquaculture
	b1		catfish
	b2		crayfish
	c		commercial
	c1		commercial-stormwater
	d		industrial
	d1		industrial-stormwater
	d2		industrial-wastewater
	e		residential
	e1		residential-stormwater
	f		sewage treatment
	g		golf
	h		wildlife management
	i		other recreational
	o		other
	3	excavated	
	a		agriculture
	a1		cropland
	a2		livestock

a3		cranberry
b		aquaculture
b1		catfish
b2		crayfish
c		commercial
c1		commercial-stormwater
d		industrial
d1		industrial-stormwater
d2		industrial-wastewater
e		residential
e1		residential-stormwater
f		sewage treatment
g		golf
h		wildlife management
i		other recreational
j		mining
j1		sand/gravel
j2		coal
o		other
4	beaver	
5	other artificial	

Source: Tiner, R.W. 2003. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA. 44 pp.

Appendix C:
Definitions
(Informative)

Commission error – commission errors are errors related to misclassification or limits of scale. For wetland mapping, commission errors include: 1) misclassification (e.g., nonwetland areas mapped as wetlands or misidentification of the wetland type), 2) small uplands included within a large wetland mapping unit, and 3) small wetlands of different type included within a larger wetland unit of another type (e.g., a small scrub-shrub wetland within a palustrine forested wetland mapping unit) simply because they are too small to map (below the target mapping unit). The latter two situations are commonly referred to as "inclusions." Habitat changes that have occurred between the date of the base imagery and date of field observation/groundtruthing are not considered errors as the wetland was correctly classified on the base imagery.

Cowardin classification system – the U.S. Fish and Wildlife Service's official wetlands and deepwater habitat classification system written by Cowardin, Carter, Golet, and LaRoe and published in 1979, approved by the FGDC as the National Standard in 1996.

estuarine and lacustrine deepwater – subtidal waters below the extreme spring low tide mark in estuaries and tidal freshwater lakes and nontidal waters of lakes deeper than 2 m at annual low water; "deepwater" excludes the shallow water zone of lakes (lacustrine littoral wetlands).

federally-funded – financial support for the mapping project comes directly or indirectly from one or more federal agencies.

final map product – the final map product directed by this standard is the incorporation of the interpreted and mapped wetlands within a project area into the NWI Geodatabase. Additional final map products may be required by the funding federal agencies.

horizontal accuracy – refers to a feature's spatial relationship to the base imagery.

logical consistency – logical consistency refers to the internal consistency of the data structure, and particularly applies to topological consistency.

non-federally funded – financial support comes from state, local, or private funds with no contribution either directly or indirectly from Federal sources.

National Spatial Data Infrastructure (NSDI) – consistent means to share geographic data among all users could produce significant savings for data collection and use and enhance decision making. Executive Order 12906 calls for the establishment of the National Spatial Data Infrastructure defined as the technologies, policies, and people necessary to promote sharing of geospatial data throughout all levels of

government, the private and non-profit sectors, and the academic community.

> *The goal of this Infrastructure is to reduce duplication of effort among agencies, improve quality and reduce costs related to geographic information, to make geographic data more accessible to the public, to increase the benefits of using available data, and to establish key partnerships with states, counties, cities, tribal nations, academia and the private sector to increase data availability.*
>
> *The NSDI has come to be seen as the technology, policies, criteria, standards and people necessary to promote geospatial data sharing throughout all levels of government, the private and non-profit sectors, and academia. It provides a base or structure of practices and relationships among data producers and users that facilitates data sharing and use. It is a set of actions and new ways of accessing, sharing and using geographic data that enables far more comprehensive analysis of data to help decision-makers chose the best course(s) of action. Much has been accomplished in recent years to further the implementation of the NSDI, but there is still much to be done to achieve the vision of current and accurate geographic data being readily available across the country.*

omission errors – for wetland mapping, omission errors are wetlands that are not identified on the map. Wetlands may be omitted due to several factors that preclude their identification or delineation including scale and emulsion of imagery, mapping scale or base map scale, quality of imagery, environmental conditions when imagery was captured, and difficulty of identifying particular types of wetlands.

Producer's Accuracy (PA) – measures the percentage of features that are correctly classified on the imagery. PA is measured by both feature and attribute accuracy. Feature accuracy is the correctness of the identification of wetland vs. non-wetland. Attribute accuracy is the correctness of the classification of the wetlands using the FGDC Wetlands Classification Standard.

project area – a geographic area where wetland mapping is to be performed through some form of remote sensing (e.g., photointerpretation, satellite or other image processing). It may range in size from a region, state, county, or municipality or to portion thereof. For purposes of this standard, a project area is not a site-specific area where construction, restoration, or similar actions are proposed or where on-the-ground wetland delineations are performed. It would be best for project areas to be indexed and organized by USGS topographic quadrangles or DOQQs. The NWI Geodatabase recognizes only data input based on the USGS 7.5 minute quadrangle and DOQQ grid.

spatial resolution – the detail with which a map depicts the location and shape of geographic features. The larger the map scale, the higher the possible resolution. As scale decreases, resolution diminishes and feature

boundaries must be smoothed, simplified, or not shown at all; for example, small areas may have to be represented as points.

Target Mapping Unit (TMU) – is an estimate of the size class of the smallest wetland that can be consistently mapped and classified at a particular scale of imagery, and that the image-interpreter attempts to map consistently. TMU allows for mapping below a specified threshold, but does not subject that finer detailed mapping to the accuracy requirements of the standard.

upland – **"**Upland" or "U" is the default classification for regions of the map that are not classified as wetlands or other aquatic habitats. As such, the designation "Upland" represents generalized terrestrial areas which have not been further subdivided or categorized by type. While "Upland" primarily includes terrestrial (non-wetland) areas and former wetlands that are effectively drained or filled, it may include unclassified wetlands such as human-modified areas (e.g., farmed wetlands), wetlands that are too small to be differentiated, wetlands that couldn't be detected on the type of imagery used (e.g., small wetlands under forest cover), and other unintentional wetland omissions (errors). According to the FWS Wetlands Classification System (Cowardin *et al*, 1979):

> *The upland limit of wetland is designated as (1) the boundary between land with predominantly hydrophytic cover and land with predominantly mesophytic or xerophytic cover; (2) the boundary between soil that is predominantly hydric and soil that is predominantly nonhydric; or (3) in the case of wetlands without vegetation or soil, the boundary between land that is flooded or saturated at some time during the growing season each year and land that is not.*

User's Accuracy (UA) – measures the percentage of reference sites on the ground that are correctly classified on the map.

vertical accuracy – the measure of the accuracy of the vertical measure of a reference point.

wetland classification – in support of maintaining an ecological perspective, wetlands are defined as below, based upon the FWS Wetlands Classification System (Cowardin *et al*, 1979). This definition is the national standard for wetland mapping, monitoring, and data reporting as recognized by the FGDC on December 17, 1996.

> *Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.*
>
> *For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil*

and is saturated with water or covered by shallow water at some time during the growing season of each year.

wetlands inventory mapping – more detailed mapping and classification of wetlands beyond distinguishing wetland from non-wetland or between simple categories of forested and non-forested or vegetated and non-vegetated.