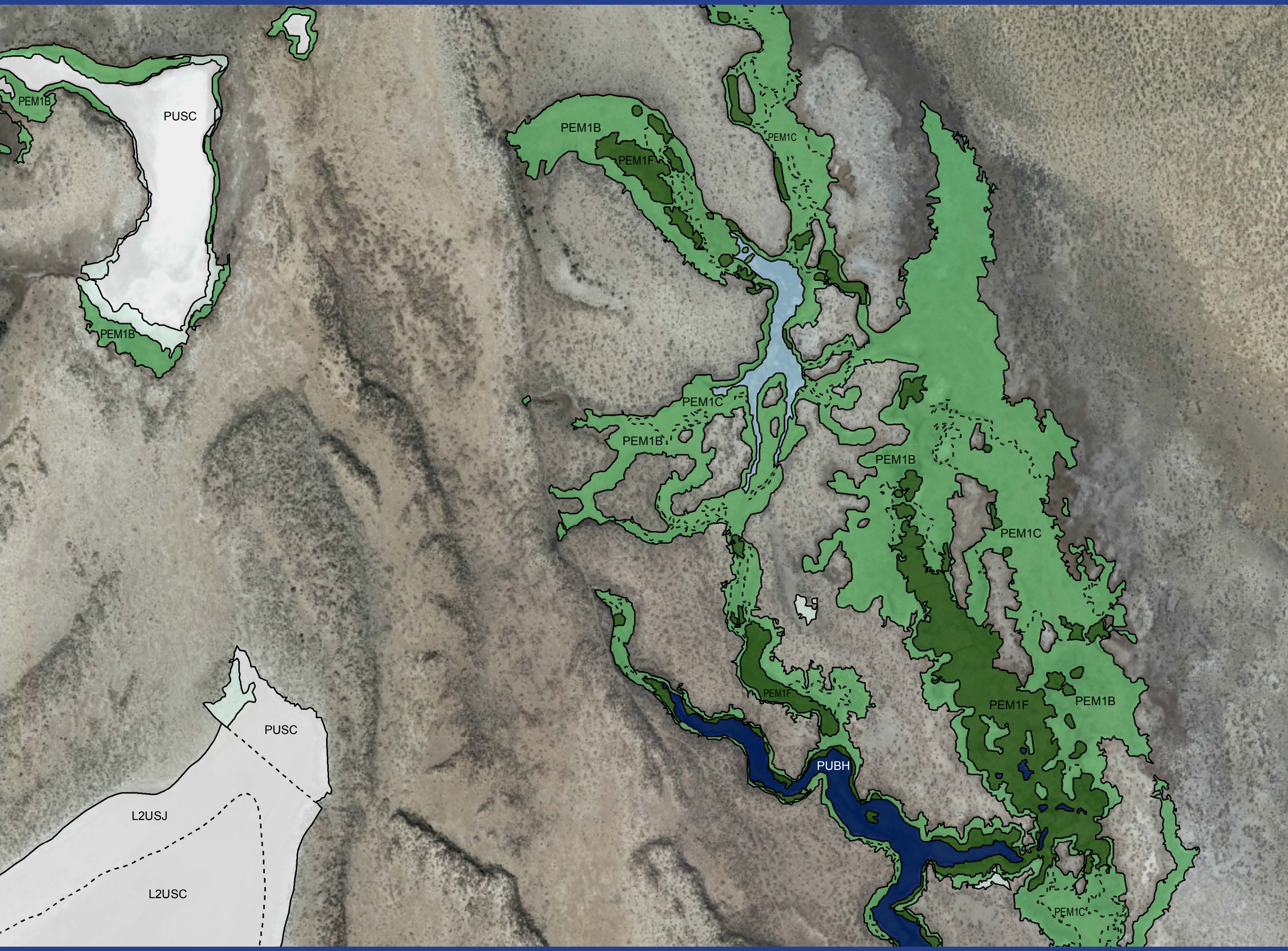
Utah Wetland Functional Classification: Version 1

by Richard Emerson and Ryhan Sempler



OPEN-FILE REPORT 661
UTAH GEOLOGICAL SURVEY
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2017

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Cover photo: *National Wetland Inventory functional subtypes shown in Snake Valley, Millard County, Utah.*

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ABSTRACT

The most comprehensive wetland classification system for the state of Utah is the National Wetland Inventory (NWI). While the NWI is the most complete and accessible classification system, the 366 unique wetland type identifiers in the state are often difficult to interpret and have little relevance to natural resource managers. Consequently, NWI data are often overlooked as a viable wetland spatial data source, which often restricts opportunity for interagency cooperation as agencies develop their own wetland GIS-based datasets and workflows. Agencies benefitted from a simplified functional reclassification of NWI data provided by the Utah Geological Survey (UGS) in 2014 to the Utah Automated Geographic Reference Center for distribution to the public. In the subsequent two years, legacy data was added to the NWI, database schema was revised, and areas were remapped to current conditions and mapping standards. The UGS reclassified the 2016 release of the NWI wetland data in an effort to provide GIS data users with a current and universal data schema across the state. The reclassification scheme was based on the hydrogeomorphic (HGM) approach, modified from the UGS's 2014 reclassification and focused largely on landscape position (geomorphology) and hydrodynamic and ecologic characteristics.

1.0 INTRODUCTION

1.1 National Wetland Inventory

The National Wetland Inventory (NWI) is the data set most relied on by the nation for wetland mapping and has a standardized scale and attribute schema that's used by a variety of disciplines to provide accurate maps and wetland spatial data (Stelk, 2013). The NWI data models were developed by the U.S. Fish and Wildlife Service (USFWS) and U.S. Geological Survey in the 1970s and accepted in 1979 with the publication of *Classification of Wetlands and Deepwater Habitats of the United States* to "impose boundaries on natural ecosystems for the purposes of inventory, evaluation, and management." The document and data models went through numerous revisions throughout the 1980s and 1990s before being accepted as the national standard in 1996 (FGDC-STD-004). Interpretation of wetland classification codes is based on standards outlined by the Federal Geographic Data Wetlands Committee's 2013 revision of original 1979 publication (FGDC-STD-004-2013) and two addendums released in 2015 and 2016 by the USFWS, which are discussed in sections 2.1 and 2.3.1 of this document. The USFWS is the agency responsible for providing national wetland information to the public. The primary mechanisms through which this information is conveyed include the NWI database and the semi-decadal Status and Trends reports (e.g., Dahl, 2006). The NWI is also the most widely available wetland dataset for the nation, including Utah.

Wetland data for the state has steadily improved over the past decade as more historical data has been digitized and added to the NWI database. Wetlands in the state of Utah were primarily mapped in the mid-to-late 1980s but some revisions were released in the mid-to-late 2000s for various study areas including Great Salt Lake and a portion of Bear Lake. By 2014, data for 40% of the state (by area) had been made available through the NWI database; data for parts of the Colorado Plateau and western Utah still needed to be added. In 2016, the final installment of data was made available through the NWI, bringing the first complete coverage of digital wetland maps to the state. This update brought the total number of wetland polygons to over 150,000 with 457 unique codes within the state of Utah. The sheer volume and complexity of the data can be overwhelming to potential data users; as such the data is often underutilized due to improper interpretation or overlooked as a source of wetland spatial information. The objective of this project was to reclassify, or "crosswalk," the current NWI dataset for the state to a more functional system. This was accomplished by methods originally developed by the U.S. Environmental Protection Agency (EPA) (Sumner and others, 2010), adapted by the UGS in Bear River Bay of Great Salt Lake (Emerson and Hooker, 2011), and expanded to the existing statewide dataset in 2014 (Emerson, 2014). This simplified data allows users to target and analyze specific wetland types and symbolize wetlands in an orderly fashion to more clearly communicate wetland information. This reclassification is especially useful to the general public and stakeholders who may be unfamiliar with the NWI data or the Cowardin classification system.

1.2. Landscape

Utah's ecological contrasts, from arid desert valleys and canyons to high alpine mountains, make it a challenge to apply a single classification system to all of the state's wetlands. Terminal basin lakes, like Sevier Lake and Great Salt Lake, can further complicate this effort. Both of these lakes occupy parts of the Bonneville basin and have high-salinity water that fluctuates in response to climatic variations on multi-scale intervals. As water and salinity levels fluctuate, the wetlands around these lakes are in constant flux as they expand or contract in response to these influences. The NWI classification system has a very rigid set of parameters regarding water inundation period, substrate, and vegetation, which does not provide users with an appropriate level of flexibility needed for the rapidly changing wetland conditions associated with terminal basin wetlands. Wetlands in the NWI are mapped based on water levels at the time of mapping, which does not account for large decadal trends that are often observed in places like Great Salt Lake.

Examination of wetland data for Great Salt Lake wetlands highlights the issues associated with the NWI classification scheme for wetlands in a terminal basin. The main period of the NWI mapping (1982–1987) coincided with times of higher than average precipitation in Utah and record water levels in Great Salt Lake. Great Salt Lake remained above the historical average of 4199.4 ft for a decade from 1982 to 1992. In 1986, the highest water level ever recorded at Great Salt Lake was marked at 4211.6 ft above sea level and resulted in heavy damage to levees, dikes, canals, and ditches. The water retreated to below average levels, reaching 4197.5 ft in 1994, and then rose again in the late 1990s to a peak of 4204.2 ft in 1999, 5 ft higher than the historical (1950 to 2013) average. Water levels remained above 4200 ft from 1997–2001. Water levels between 2008 and 2016 have fluctuated between 4192.2 and 4198.9 ft, and represent one of the lowest periods for Great Salt Lake, just above the historic low of 4191.4 ft reached in 1963 (figure 1) (Baskin and Allen, 2005; Baskin and Turner, 2006). As water levels change, a wetland can transition from marsh to playa and may even lose wetland characteristics during extended periods of drought. Knowing a wetland's position on the landscape can help determine the range of classes that a wetland may experience, even if it is only mapped at a single point in time. Since the Cowardin system does not account for wetland function or geomorphology, and identically coded wetlands can occupy very dissimilar positions within the landscape or have dissimilar substrates or water sources, we added basic landscape and geomorphology attributes to the NWI data in our Utah-specific reclassification to better characterize wetland types. These attributes help separate features that are subject to large-scale changes in hydrology versus those that are not. By adding basic landscape position and geomorphologic properties to the NWI data, wetland types can be differentiated and described in a more descriptive manner specific to Utah's unique ecologic regions.

2.0 METHODOLOGY

This work relies heavily on project work accomplished for two previously funded EPA wetland program development grants: Hydrogeomophic Reclassification of Bear River Wetlands (Emerson and Hooker, 2011) and Utah Wetland Functional Classification (Emerson, 2014). The 2011 schema was modified from Sumner and others (2010) to include additional NWI classes and added functional classes and descriptor fields. While Sumner's original work created five classes with no modifiers, the Bear River Bay reclassification system included seven classes and three modifiers. We further developed the Bear River Bay reclassification system to include all of the wetlands of the state and attempted to refine the crosswalk as our knowledge of the state's wetlands increased. The 2014 work included eight wetland classes and added functional modifiers to further describe wetland function and/or use, such as sewage lagoon, position within the riparian zone, and modifications such as ditched, impounded, or excavated. The latest version builds on the methods and classification developed in the 2014 work but adds scalability by adding a hierarchical classification that includes 6 types and 17 subtypes.

2.1. Important Changes

The current release includes some important changes in the wetland classes which are outlined in the following subsections. The most significant change includes condensing the wetland types to 6 (table 1) and the addition of a subtype field that includes 17 wetland subtypes (table 2). The Riparian and Hydrologic Unit fields, which were included in the previous version, were no longer required for the workflow to differentiate wetland types, and were therefore not included in the dataset.

2.2 Value Added Attributes

Additional information was added to the wetlands classification by modelling spatial relationships between the wetland's geomorphology, ecological setting, and elevation. Those spatial and ecological relationships were important to determine wetland types across the state. It would be unreasonable to expect wetlands with identical Cowardin codes from different ecoregions to function identically. In many cases these wetlands will have dramatically different appearance, function, and attributes not captured by the Cowardin code. Consider a seasonally flooded shore in Great Basin of western Utah versus a seasonally flooded shore in the Uinta Mountains. While both are attributed with the Cowardin code, PUSC, the wetland in the Great Basin will be an alkaline playa, while the wetland in the Uinta Mountains would be a seasonal freshwater pond. We used proximity to waterbodies, ecological setting, and elevation to differentiate some wetland Subtypes within Shore, Waterbody, Playa and Riverine.

2.2.1. Geomorphic Position

Unconsolidated Shore Cowardin coded wetlands were attributed as Shore, Playa, or Waterbody (Seasonal Pond subtype), depending on whether they shared boundaries with a Permanent Waterbody, Riverine, or one of the various Shore Subtypes. Since Unconsolidated Shore may or may

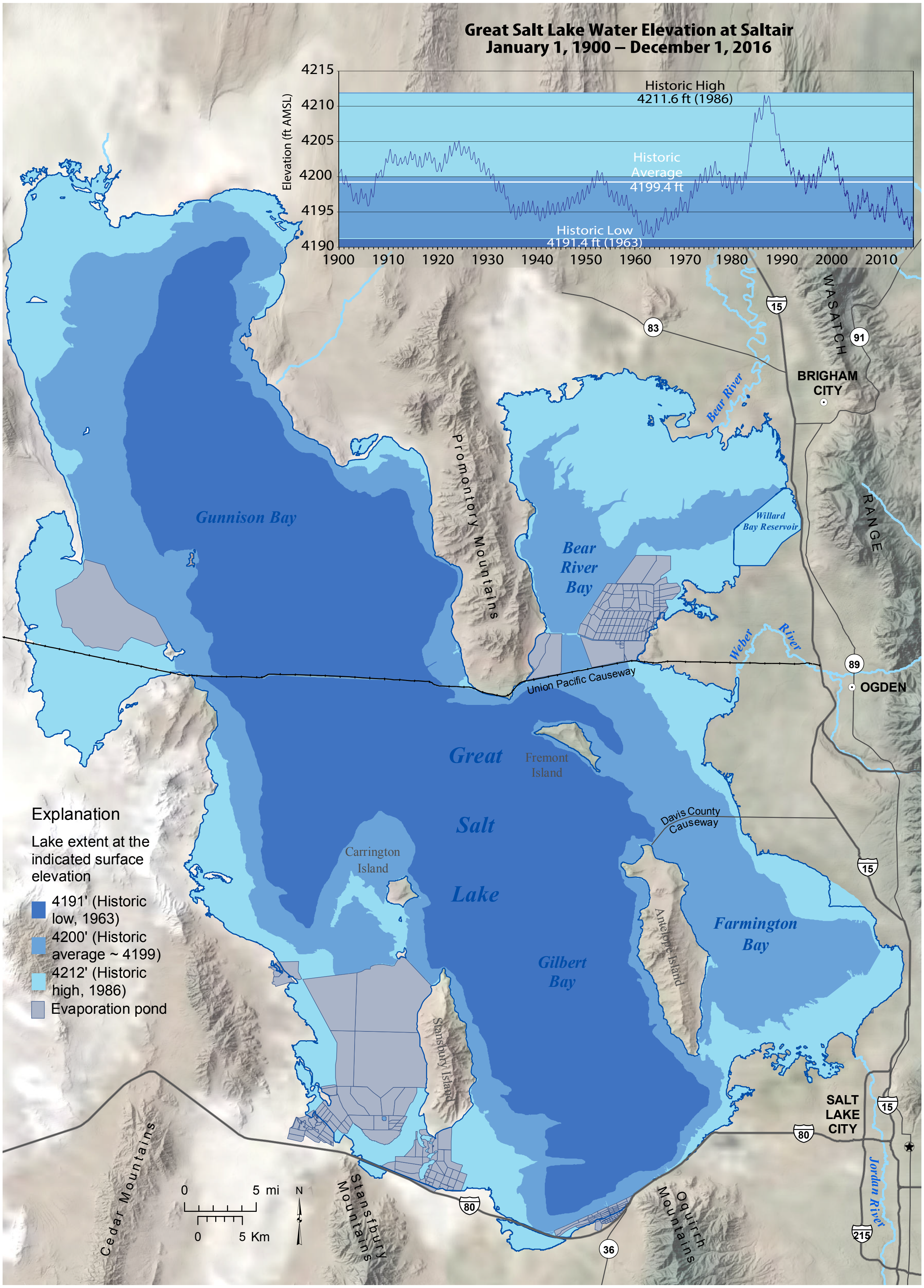

***Figure 1.** Map of Great Salt Lake showing the historical high, low, and average water levels from 1900–2016. (inset) Great Salt Lake water elevation graph recorded at Saltair Marina from 1900–2016.*

Table 1. 2016 UGS designated wetland types, with descriptions, assigned to all NWI wetland codes in the state of Utah.

Utah Type	Description
Waterbody	Perennial and seasonal waterbodies.
Playa	Depressional features or expansive mineral flats where evapotranspiration exceeds water supply or through-flow; a mineral soil must be present. Although similar in appearance and substrate, playas are distinct from shores in that playas function independently from and do not rely on perennial water-bodies for the water supply.
Shore	Unvegetated or less than 30% vegetated wetlands near the shoreline of lakes and reservoirs where water availability is controlled by lake levels and where the primary movement of water is sheet-flow. These are often expansive mudflats or barren ground during low water-level periods around the fringes of reservoirs and endorheic lakes.
Herbaceous	Wetlands with at least 30% areal plant cover dominated by non-woody annual and perennial plants. These wetlands include all water regimes; as such, the vegetation communities in this class will range from drought and salt-tolerant plants to hydrophytic plants.
Wooded	Wetlands with at least 30% areal plant cover dominated by woody plants including shrubs and forested wetlands dominated by trees greater than 6 meters in height.
Riverine	Stream confined within a channel (includes canals and ditches).

not directly share a border with a permanent waterbody, attributing Unconsolidated Shore wetlands was an iterative process. A first-order connection to a waterbody was used to select additional Unconsolidated Shores that were not directly connected to the waterbody resulting in second-order connectivity. This process was repeated until no additional shores were selected. The highest order of connectivity was ninth order. All shores above third order were visually inspected to ensure they were in-fact shores of a waterbody or are an isolated pond or playa. Priority was given to waterbodies when a feature was connected with both a lake and a river for first- and second-order connectivity. Dual connectivity above second order was inspected visually and decisions were made on an individual landscape position based on aerial photo interpretation.

2.2.2. Ecological Setting

Ecological setting was applied to the wetland layer using Omernik Level III and IV Ecoregion data. Originally developed in 1987, Omernik Level III and Level IV Ecoregion data represent the most detailed levels of the hierarchical spatial dataset developed for the conterminous United States. The ecoregions are delineated using local knowledge to classify areas of similar ecological characteristics by identifying patterns in land use, geomorphology, vegetation, soil, and geology (Omernik, 2014). Each wetland was assigned a Level III and a Level IV Omernik Ecoregion and given the attributes of the respective ecoregion. Wetland types not clearly defined by existing Cowardin or spatial attributes were then selected within each ecoregion and assigned an appropriate type or subtype based on patterns and differences between ecoregions. Distinction between playa and seasonal pond was the most obvious and most productive determination made; specifically in the Great Basin where isolated Unconsolidated Shores in the valley bottoms are playa but those on slopes or in the montane regions are seasonal ponds. Streambed subtypes were also attributed by ecoregions; this helped differentiate between intermittent streams, and ephemeral streams and riverine shores. Once the wetland classification was completed, the ecoregion data was dissolved from the dataset and merged by NWI code and Utah wetland types and subtypes to eliminate identically attributed wetlands from sharing a border.

2.2.3. Elevation

Elevation was added to each polygon to further refine landscape position under the assumption that a wetland will have different characteristics within an ecoregion, primarily driven by elevation. Some features were differentiated by using elevation, such as seasonal ponds and playas. This field was maintained in the final dataset.

2.3. Attribute Table Fields

The NWI GIS data from the USFWS includes three data fields: Attribute, Wetland Type, and Acres. The data from these fields is maintained in the final wetland data, however the first two are renamed NWI Code and NWI Type, respectively. In addition to renaming these two fields, seven additional descriptor and metadata fields were added to the attribute table (table 3). A full description of the data and how it was generated for each column is outlined in the following subsections.

2.3.1 NWI Code

The field NWI Code is the Cowardin classification scheme provided directly from the National Wetland Inventory. This code, along with spatial relationships from the value-added attributes discussed above, is used to derive all other attributes in this dataset. While the attributes provided in this field do provide a great amount of detail regarding wetland systems, vegetation, substrate, water regime, and wetland modifications, these details can be extremely difficult to extract from the code without an in-depth understanding of the dataset or

Table 2. 2016 UGS designated wetland sub-types, with descriptions, assigned to all NWI wetlands in the state of Utah.

Utah Type	Utah Type	Utah Type
Herbaceous	Emergent Marsh	Wetlands that when not inundated maintain saturated conditions throughout most of the growing season dominated by hydrophytic and/or aquatic vegetation.
	Emergent Meadow	These wetlands span a wide range of water regimes with some exhibiting saturated conditions throughout the growing season but most have dry conditions during the latter part of the growing season and some are dry throughout drought years. As such, the vegetation communities in this class will range from drought tolerant salt grasses to hydrophytic plants.
Wooded	Forest	Associated with woody vegetation greater than 6 meters in height, typically found around the margins of rivers, montane lakes, or springs.
	Scrub Shrub	Associated with woody vegetation less than 6 meters in height.
Waterbody	Deep Water	Lacustrine systems at a depth greater than 2.5 meters. This is the approximate maximum depth at which emergent plants will grow but if emergents are found past that depth then their edge boundary becomes the new deepwater boundary.
	Shallow Water	Semipermanently to permanently flooded lakes, greater than 20 acres of total coverage with a max depth less than 2.5 meters. Typically adjacent to Deep Water habitat but may include shallow lakes, reservoirs, and impoundments.
	Aquatic Bed	Lakes and ponds with aquatic plants that grow on or below the water surface with at least 30% areal coverage most years.
	Permanent Pond	Semipermanently to permanently flooded ponds, less than 20 acres total coverage having water less than 2.5 meters in depth. Typically isolated waterbodies not adjacent to Deep Water habitat.
	Seasonal Pond	Seasonally flooded ponds, less than 20 acres total coverage.
	Bedrock Pothole	Unique erosional features most commonly found in southern Utah where water collects in exposed bedrock during local precipitation events. Typically little to no soil present.
Shore	Lacustrine Shore	Non-vegetated or less than 30% vegetated wetlands that are often near the shoreline of lakes and reservoirs where water availability is controlled by lake levels or through-flow; primary movement of water is sheet-flow. These are often expansive mudflats or barren ground during low water-level periods around the fringes of reservoirs and endorheic lakes.
	Emergent Shore	Herbaceous wetlands near the shoreline of lakes and reservoirs where water availability is controlled by lake levels. In some cases, vegetation may be pioneering upland species and may persist for multiple years until water-levels increase. Hydrophytic vegetation is typically not lush and may be absent some years due to flooding or drought conditions.
	Riverine Shore	Seasonally flooded stream banks, cutoff channels, point bars, and islands. Vegetation is typically scoured from this zone but may have pioneering species.
Playa	Unvegetated Playa	Depressional features or expansive mineral flats where evapotranspiration exceeds water supply or through-flow; a mineral soil must be present. Although similar in appearance and substrate, playas are distinct from lacustrine shores because playas function independently from perennial water bodies and typically rely on local precipitation or groundwater for their water supply.
	Emergent Playa	Distinct from Emergent Meadow because the substrate is primarily a mineral soil, most often alkaline, and may only be vegetated for short durations during the year. Typical vegetation includes Salicornia spp. (pickleweed) and Distichlis spicata (saltgrass). Hydrophytic vegetation is typically not lush and may be absent some years due to flooding, alkaline, or drought conditions.
Riverine	Permanent Streambed	Permanently flooded areas of streams and rivers confined within the channel at baseflow.
	Intermittent Streambed	Ephemeral, intermittent, and seasonally flooded streams. These are typically buffered linear features from the National Hydrography Network (NHD) but may also include digitized ephemeral washes and floodplain features.

decoding each attribute individually. Appendix A contains the Cowardin classification system schema simplified to only include types that are possible in the state of Utah. Users may also wish to use the decoder provided by the USFWS to learn more about the Cowardin classification system at this URL. https://fwsmapservices.wim.usgs.gov/decoders/SWI.aspx. Appendix B is a table showing the water regime restrictions by the NWI sub-classes.

2.3.2 NWI Type

This is the basic description provided by the USFWS for wetlands of the United States and is a generalized wetland type, standardized across the nation, which typically does not provide the detail necessary to describe wetlands at the state or local level (table 4). For instance, the Lake type includes both permanent waterbodies and shores and playas while the

Table 3. Description of UGS GIS data fields.

Table Field	Description
NWI Code	Original Cowardin classification code
NWI Type	Original Cowardin wetland description
Utah Type	Generalized wetland description specific to Utah
Utah Subtype	Detailed wetland description specific to Utah
Utah Mod	Description of Cowardin modifier
Utah Use	Primary use of wetland if known (non-comprehensive)
Source	Data provider if not provided by NWI
Acres	Wetland polygon acres calculated by GIS in an equal area projection
Elevation	Centroid elevation derived from the National Elevation Dataset 10 meter digital elevation model

Table 4. Description of NWI wetland types designated by the USFWS NWI program.

NWI Type	Description
Freshwater Emergent Wetland	All herbaceous wetlands in Utah fall into this wetland type
Freshwater Forested/Shrub Wetland	All forest and scrub/shrub wetlands in Utah are lumped into a single type
Freshwater Pond	All water bodies and shores less than 20 acres in size
Lake	All water bodies and shores greater than 20 acres in size
Riverine	All riverine wetlands

Freshwater Emergent Wetland type describes both an aquatic habitat and a seasonally flooded wet meadow.

2.3.3 Utah Type

The primary identification field for the NWI data for the state of Utah is called Utah Type. The eight primary types from our 2014 classification were condensed to six types in the current 2016 version by combining Forested and Scrub/Shrub (now subtypes, see below) to Wooded and placing Waterpocket (renamed Bedrock Pothole subtype) under the waterbody type. The majority of the NWI Codes can be used to generate the Utah wetland type by standard queries written using Structured Query Language (SQL). While the translation is mostly a one-to-one relationship between NWI Code and Utah Type, Shore classes with a Temporarily or Seasonally Flooded water regime (L2USA/C and PUSA/C) were put through a GIS spatial exercise to determine if the class belonged to Playa, Waterbody, or Shore. All features that were directly or iteratively connected to a Waterbody Type were classified as Shore through successive spatial selections (see section 2.2.1). The classification was based on the assumption that water will run off these wetlands into the adjacent permanent waterbody, whereas those that did not share a border with one of these two classes were assumed to be isolated and were classified as Playa or Waterbody, depending on ecoregion. All NWI coded wetlands for the state of Utah are assigned to one of the six functional classes by following the crosswalk flow chart in figure 2. Table 1 defines each classification generated by this functional crosswalk.

2.3.4 Utah Subtype

As this work has progressed so has our knowledge and understanding regarding the types of wetlands ecologically important in the state. We determined that the types could be further parsed into discrete units, but doing so could create obscure wetland types not suitable for general use. To capture these additional details, a subtype field was added to the wetland layer and allows the data to be scaled for users that may need more detailed information not provided by the original classification. The assignment of wetlands to subtypes relies heavily on accurate NWI attributes and well defined and delineated ecoregions. The subtypes and their descriptions are shown in table 2. A decision model outlining the method generating each wetland subtype is shown in figure 3.

2.3.5 Utah Mod

An important descriptor within the NWI code are the special modifiers that denote unique attributes such as artificially constructed, impounded, or drained wetlands. These modifiers were retained in the NWI code and also added as a separate column and decoded to a descriptive format to ease users' ability to query, sort, and visualize the data. Descriptions of these special modifiers and the definitions from Cowardin and others (1979) can be found in table 5.

2.3.6 Utah Use

A field was added to allow for special wetland land use designations independent of the NWI code. Additional attribute

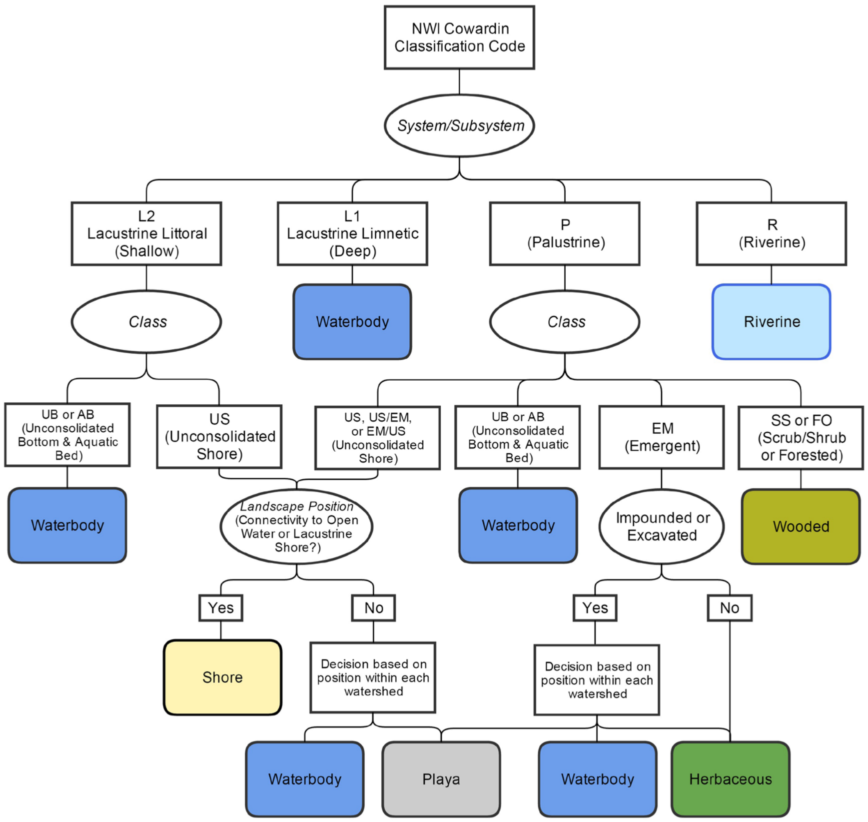

Figure 2. *Flow chart showing how a NWI-coded wetland for the state of Utah is assigned to one of the six functional classes.*

queries were made to determine function of some features, such as canal or impoundments. Land use was added to some features by overlaying the water-related land use layer to extract important land use categories such as evaporation ponds, tailings, fish hatcheries or sewage treatment facilities (table 6). Attribution in this field, though not comprehensive, is an initial step towards identifying features within the NWI that users may wish to query so that they can be easily selected for inclusion or exclusion from analysis or sample frame design. Additional refinement of attributes was made through aerial photograph interpretation. This attribute was labeled as Utah Function in the previous 2014 version of this data, but was considered confusing or misleading since this field does not attempt to define the function of wetlands in the state but rather the particular use of some wetlands that users may wish query within their datasets.

2.3.7 Source

This field denotes the source of the data, if known. While all data we compile will be submitted to the NWI Dataset, the update cycle for data can sometimes exceed six months for the national data. We will occasionally have more current data that will be contributed to the Utah dataset before it is integrated into the NWI. NWI source data, including map reports and metadata regarding mapping methods and imagery dates can be found on the NWI mapping website in the State Downloads section. https://www.fws.gov/wetlands/Data/State-Downloads.html

2.3.8 Acres

The Acres field is recalculated to ensure the correct acreage is reported since we cannot verify what editing, if any, has occurred since it was last calculated. We use an equal area projection (NAD83 State Plane Utah Central) to obtain an accurate calculation. Values within the Acres field may not match the Shape Area field calculated within the GIS, depending on projection.

2.3.9 Elevation

Elevation was extracted from the 10 meter National Elevation Dataset (NED) Digital Elevation Model (DEM) for the centroid of each wetland polygon and is reported in meters above sea level. Position within a watershed can be helpful in determining wetland type. For instance a seasonally flooded montane pond and a playa in the center of the basin will have the same NWI code (PUSC). Elevation thresholds can be applied along with position on the landscape (near lacustrine or riverine) to help automate reclassification of the NWI code to the descriptive codes provided in this dataset.

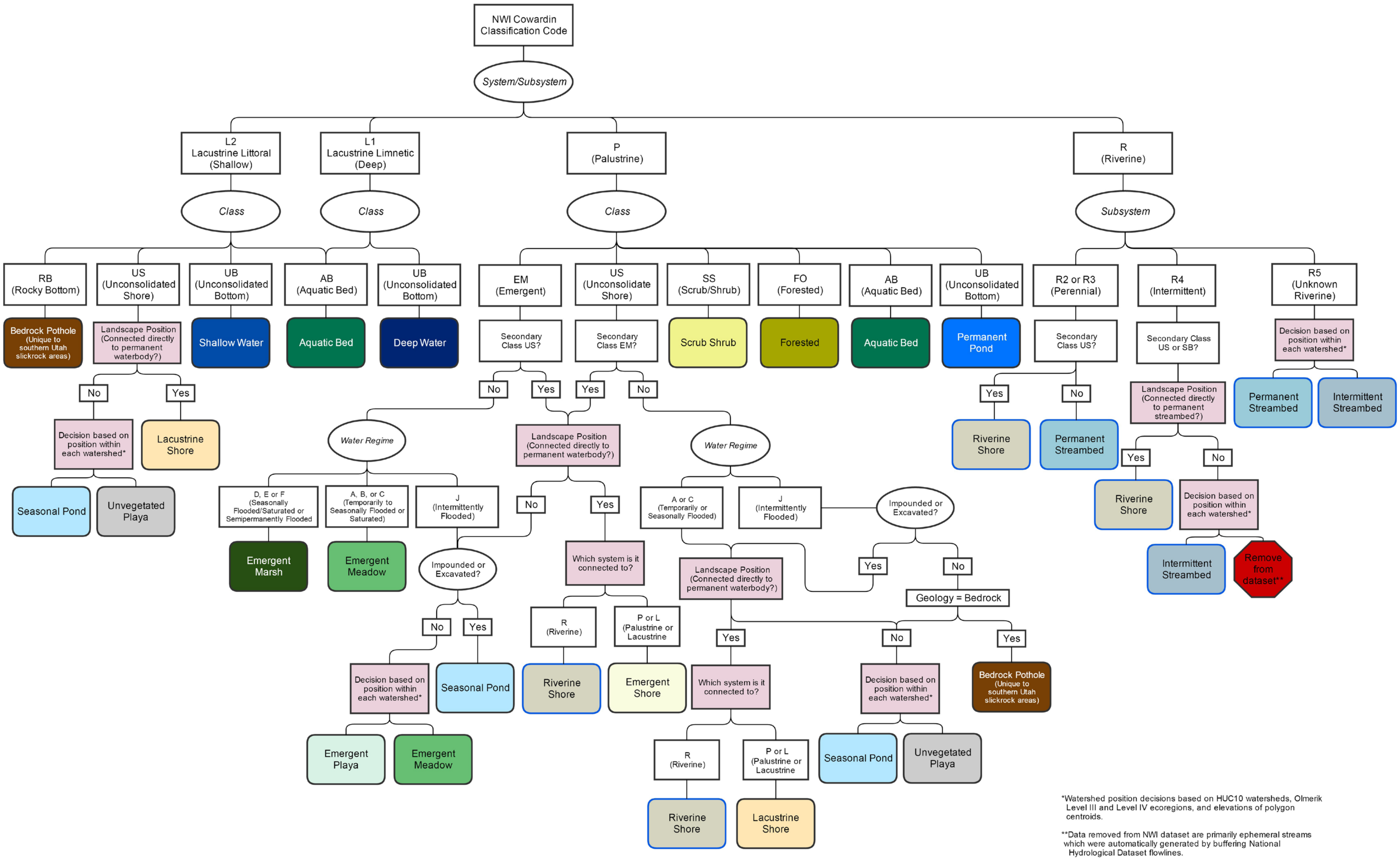

Figure 3. *Flow chart showing how a NWI-coded wetland for the state of Utah is assigned to one of the 17 functional classes.*

Table 5. *List of NWI and Utah special modifiers used to describe human or beaver alterations to a wetland.*

	NWI Modifier Codes	Utah Modifier (hierarchical order)	Description
Special Modifiers	b	Beaver	Wetlands resultant of or influenced by beaver activity.
	d	Ditched or Partially Drained	Water level has been artificially lowered.
	f	Farmed	Wetlands that have been altered for crop production, hydrophytes will establish if farming practices stop.
	m	Managed	Water inputs are controlled to reach a certain habitat types. Typically coincide with impoundments and water control structures although wetlands receiving water input from irrigated farmland is also included.
	h	Impounded	Water is typically retained by dams or dikes for the purpose of modifying or creating a wetland.
	r	Artificial Substrate	Lined drainageways or where substrate material has been emplaced by humans, e.g., jetties.
	s	Spoil	Deposition of spoil material forms the primary wetland substrate.
	x	Excavated	Human-built basin or channel.
pH Modifier	a	Acid	pH < 5.4
	t	Circumneutral	pH 5.5–7.4
	l	Alkaline	pH > 7.5

Table 6. *UGS designated uses that describe special wetland land use independent from the NWI codes.*

Utah Use	Description
Ditch or Canal	Riverine class with an excavated special modifier code.
Evaporation Pond	Excavated or impounded classes spatially coincident with evaporation ponds from the Utah Division of Water Resources' water-related land use GIS layer.
Sewage Treatment	Excavated or impounded classes spatially coincident with sewage lagoons from the Utah Division of Water Resources' water-related land use GIS layer.
Pond	Impounded PUB or PUS systems, built to provide fresh water for stock, recreation, municipal water use, or industrial use. Less than 20 acres.
Mine Tailings	Determined from aerial photograph interpretation or USGS topo maps.
Fish Hatchery	Constructed water body for the artificial breeding, hatching, and rearing of fish.
Reservoir	Impounded Lacustrine waterbodies greater than 20 acres.

3.0. PRODUCTS

3.1. Interactive Map

An interactive wetland map for the state of Utah was produced using the new functional classification layer. In order to provide landowner information directly to personnel in the field, this map is available on any portable device and includes detailed information regarding wildlife management areas, including federal, state, and privately managed parcels such as duck clubs and wildlife cooperative management units. This map can be accessed from the Utah Department of Natural Resources mapping platform at http://utahdnr.maps.arcgis.com, or directly at http://geology.utah.gov/resources/data-databases/utah-wetlands/.

3.2. Data

The wetland GIS data can be downloaded from the Utah Automated Geographic Reference Center (AGRC) in shapefile or geodatabase format at http://gis.utah.gov/data/water-data-services/wetlands.

4.0. CONCLUSION

This project represents the latest effort to categorize wetlands in the state of Utah to improve communication and scientific research. The data generated here represents the first standardized digital vector wetland dataset for the state. While we found the NWI data to be obsolete in some areas and not representative of current on-the-ground conditions, we found that the crosswalk effectively reclassified the data to a functional classification system when the underlying mapping was correct. A long-term goal is to update all wetland data in the state to NWI standards on a watershed-by-watershed basis. High-resolution imagery and lidar will expedite efforts to create wetland maps in these areas. These technologies have the potential to streamline wetland classification and make it possible to generate large amounts of highly accurate wetland classification data (Snyder and Lang, 2012). As technological advances allow for expedited wetland mapping at increased resolution and periodicity, it is important to have a clearly defined yet adaptive classification system to apply to newly mapped wetlands. Our reclassification provides a clear method from which to generate a functional wetland classification from Cowardin classified data in Utah. The rules outlined above are designed to provide guidance to quickly reclassify wetland types in Utah and are designed to be flexible as wetland types in the state are expected to change with technological advances in mapping techniques, definition changes, or data user requirements.

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APPENDICES

APPENDIX A
Cowardin Classification System Schema Simplified to Only Include Types That Are Possible in the State of Utah

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

System: R - Riverine

Subsystem: 1 - Tidal, 2 – Lower Perennial, 3 – Upper Perennial, 4* - Intermittent, 5** – Unknown Perennial

Class	RB*** – Rock Bottom	UB – Unconsolidated Bottom	SB****– Streambed	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 Bedrock 2 Rubble 3 Cobble-Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated	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

* **Intermittent** is limited to the **Streambed** Class;
** **Unknown Perennial** is limited to **Unconsolidated Bottom** Class code **R5UB** only
** **Rock Bottom** is not permitted for the **Lower Perennial** Subsystem;
**** **Streambed** is limited to **Tidal** and **Intermittent** Subsystems

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: Halinity/Salinity	Water Chemistry: pH Modifiers for all Fresh Water	Soil
Nontidal				
A Temporarily Flooded	b Beaver	1 Hyperhaline / Hypersaline	a Acid	g Organic
B Seasonally Saturated	d Partly Drained/Ditched	2 Euhaline / Eusaline	t Circumneutral	n Mineral
C Seasonally Flooded	f Farmed	3 Mixohaline / Mixosaline (Brackish)	i Alkaline	
D Continuously Saturated	m Managed	4 Polyhaline		
E Seasonally Flooded/Saturated	h Diked/Impounded	5 Mesohaline		
F Semipermanently Flooded	r Artificial Substrate	6 Oligohaline		
G Intermittently Exposed	s Spoil	0 Fresh		
H Permanently Flooded	x Excavated			
J Intermittently Flooded				
K Artificially Flooded				

Modified from: Classification of Wetlands and Deepwater Habitats of the United States, Cowardin and others, 1979 (modified to exclude tidal wetland systems and water regimes)

APPENDIX B
Water Regime Restrictions Set by the NWI for Each Wetland Sub-class

NWI Water Regime Restriction Table

		Riverine			Lacustrine				Palustrine	
		Lower Perennial	Upper Perennial	Intermittent	Limnetic		Littoral			
Class/Subclass	Code	R2	R3	R4	L1		L2		P	
ROCK BOTTOM	RB		F G H		V	G H K	T V	F G H K		F G H K
Bedrock	RB1		F G H		V	G H K	T V	F G H K		F G H K
Rubble	RB2		F G H		V	G H K	T V	F G H K		F G H K
UNCONSOLIDATED BOTTOM	UB	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Cobble-Gravel	UB1	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Sand	UB2	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Mud	UB3	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Organic	UB4	F G H			V	G H K	T V	F G H K	T V	F G H K
AQUATIC BED	AB	C F G H	C F G H		V	G H K	Q R T V	C F G H K	R T V	C F G H K
Algal	AB1	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Aquatic Moss	AB2	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Rooted Vascular	AB3	C F G H	C F G H		V	G H K	Q R T V	C F G H K	R T V	C F G H K
Floating Vascular	AB4	C F G H	C F G H		V	G H K	Q R T V	C F G H K	R T V	C F G H K
STREAMBED	SB			A C J						
Bedrock	SB1			A C J						
Rubble	SB2			A C J						
Cobble-Gravel	SB3			A C J						
Sand	SB4			A C J						
Mud	SB5			A C J						
Organic	SB6			C						
Vegetated	SB7			A C J						
ROCKY SHORE	RS	A C	A C				Q	A C J K		
Bedrock	RS1	A C	A C				Q	A C J K		
Rubble	RS2	A C	A C				Q	A C J K		
UNCONSOLIDATED SHORE	US	A C E J	A C E J				Q	A C E J K	R S	A C E J K
Cobble-Gravel	US1	A C J	A C J				Q	A C J K	R S	A C J K
Sand	US2	A C J	A C J				Q	A C J K	R S	A C J K
Mud	US3	A C J	A C J				Q	A C J K	R S	A C J K
Organic	US4	E	E				Q	E		E
Vegetated	US5	A C J	A C J				Q	A C J K		A C J K
MOSS-LICHEN	ML									B C D E
Moss	ML1									B C D E
Lichen	ML2									B C D E

Saltwater Tidal = **BROWN** Water Regimes; Freshwater Tidal = **BLUE** Water Regimes; Nontidal = **RED** Water Regimes.

Class/Subclass	Code	Riverine Lower Perennial R2	Riverine Upper Perennial R3	Riverine Intermittent R4	Lacustrine Limnetic L1	Lacustrine Littoral L2	Palustrine P
EMERGENT							
Persistent	EM1						R S T A B C D E F J K
Non persistent	EM2	F G H				Q T V F G H K	T V F G H K
Phragmites australis	EM5						R S T A B C D E F K
SCRUB-SHRUB							
Broad-Leaved Deciduous	SS1						R S T A B C D E F J K
Needle-Leaved Deciduous	SS2						R S T A B C D E F J K
Broad-Leaved Evergreen	SS3						R S A B C D E K
Needle-Leaved Evergreen	SS4						R S A B C D E K
Dead	SS5						T V F G H K
Deciduous	SS6						R S T A B C D E F J K
Evergreen	SS7						R S A B C D E K
FORESTED							
Broad-Leaved Deciduous	FO1						R S T A B C D E F K
Needle-Leaved Deciduous	FO2						R S T A B C D E F K
Broad-Leaved Evergreen	FO3						R S A B C D E K
Needle-Leaved Evergreen	FO4						R S A B C D E K
Dead	FO5						T V F G H K
Deciduous	FO6						R S T A B C D E F K
Evergreen	FO7						R S A B C D E K

Saltwater Tidal = **BROWN** Water Regimes; Freshwater Tidal = **BLUE** Water Regimes; Nontidal = **RED** Water Regimes.

Modified from: Data Collection Requirements and Procedures for Mapping Wetland, Deepwater, and Related Habitats of the United States (version 2) Table Revised August 31, 2015 (modified to exclude tidal wetland systems and water regimes)