Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region

by U.S. Army Corps of Engineers

Contents

Preface

This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual. It was developed by the U.S. Army Engineer Research and Development Center (ERDC) at the request of Headquarters, U.S. Army Corps of Engineers (USACE), with funding provided through the Wetlands Regulatory Assistance Program (WRAP).

This document was developed in cooperation with the Arid West Regional Working Group, whose members contributed their time and expertise to the project over a period of many months. Working Group meetings were held in Sacramento, CA, on 9-10 December 2003; Salt Lake City, UT, on 26-27 October 2004; and Phoenix, AZ, on 15-16 February 2005. Members of the Regional Working Group and contributors to this document were:

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Technical editors for this Regional Supplement were Dr. James S. Wakeley, Mr. Robert W. Lichvar, and Mr. Chris V. Noble, ERDC. Ms. Katherine Trott was the project proponent and coordinator at Headquarters, USACE. During the conduct of this work, Dr. Morris Mauney was Chief of the Wetlands and Coastal Ecology Branch; Dr. David Tazik was Chief, Ecosystem Evaluation and Engineering Division; and Dr. Edwin Theriot was Director, EL. Dr. James Houston was Director and COL James Rowan was Commander of ERDC.

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1 Introduction

Purpose and Use of this Regional Supplement

This document is one of a series of Regional Supplements to the Corps of Engineers Wetland Delineation Manual (hereafter called the Corps Manual). The Corps Manual provides technical guidance and procedures, from a national perspective, for identifying and delineating wetlands that may be subject to regulatory jurisdiction under Section 404 of the Clean Water Act (33 U.S.C. 1344). According to the Corps Manual, identification of wetlands in most cases is based on a three-factor approach involving indicators of hydrophytic vegetation, hydric soil, and wetland hydrology. This Regional Supplement presents wetland indicators, delineation guidance, and other information that is specific to the Arid West Region.

This Regional Supplement is part of a nationwide effort to address regional wetland characteristics and improve the accuracy and efficiency of wetland-delineation procedures. Regional differences in climate, geology, soils, hydrology, plant and animal communities, and other factors are important to the identification and functioning of wetlands. These differences cannot be considered adequately in a single national manual. The development of this supplement follows National Academy of Sciences recommendations to increase the regional sensitivity of wetland-delineation methods (National Research Council 1995).

This Regional Supplement is designed for use with the current version of the Corps Manual (Environmental Laboratory 1987) and all subsequent versions. Where differences in the two documents occur, this Regional Supplement supersedes the Corps Manual for applications in the Arid West Region. The procedures given in the Corps Manual, in combination with wetland indicators provided in this supplement, can be used to identify wetlands for a number of purposes, including land-use planning, resource inventories, management plans, and regulatory programs. The determination that a wetland is subject to regulatory jurisdiction under Section 404 must be made independently of procedures described in this supplement.

Indicators and procedures given in this Supplement are designed to identify wetlands as defined jointly by the Corps of Engineers (33 CFR 328.3) and Environmental Protection Agency (40 CFR 230.3). Wetlands are a subset of the “waters of the United States” that may be subject to regulation under Section 404. One key feature of the definition of wetlands is that, under normal circumstances, they support “a prevalence of vegetation typically adapted for life in saturated soil conditions.” Many waters of the US are unvegetated and thus are excluded from the Corps/EPA definition of wetlands, although they may still be subject to Clean Water Act regulation. Other potential waters of the US in the Arid West include but are not limited to desert playas, mud and salt flats, and intermittent and ephemeral stream channels. Delineation of these waters in non-tidal areas is based on the “ordinary high water mark” (33 CFR 328.3e) or other criteria and is beyond the scope of this Regional Supplement.

This document is subject to periodic technical review and revision in response to new scientific information and user comments. The Corps of Engineers has established an interagency National Advisory Team for Wetland Delineation whose role is to review new data and make recommendations for changes that may be needed in wetland-delineation procedures to

Headquarters, Regulatory Branch, U.S. Army Corps of Engineers. Items for consideration by the Team, including full documentation and supporting data, should be submitted to:

National Advisory Team for Wetland Delineation
Regulatory Branch (Attn: CECW-CO)
U.S. Army Corps of Engineers
441 G Street, N.W.
Washington, DC 20314-1000

Applicable Region and Subregions

This supplement is applicable to the Arid West Region, which consists of all or significant portions of eleven states: Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Texas, Utah, Washington, and Wyoming (Figure 1-1). The region encompasses a wide variety of landforms and ecosystems, but is differentiated from surrounding areas by its predominantly dry climate and long summer dry season. Annual evapotranspiration generally exceeds precipitation across most of the region (Bailey 1995).

The boundary of the Arid West Region shown in Figure 1-1 is based on a combination of Land Resource Regions (LRR) B, C, and D recognized by the U. S. Department of Agriculture (USDA Soil Conservation Service 1981). The region also corresponds closely to the combined Level I Ecoregions 10, 11, 12, and 13 of the Commission for Environmental Cooperation (CEC 1997), with the exception that the Sierra Nevada Mountains are excluded from the CEC's classification. Lists of wetland indicators presented in this Supplement are intended for use across the entire Arid West Region (Figure 1-1) including the embedded mountain ranges, coastline, and other areas that may have a wetter climate than is found in most of the region. Most of the indicators are applicable throughout the region, although some are restricted to particular subregions.

Region and subregion boundaries are depicted in Figure 1-1 as sharp lines. However, climatic conditions and the physical and biological characteristics of landscapes do not change abruptly at the boundary. In reality, regions and subregions may grade into one another in broad transition zones that may be tens or hundreds of miles wide. In some cases, wetland indicators presented in this Regional Supplement may differ between adjoining regions or subregions. In transition areas, the investigator must use experience and good judgment to select the indicators that are appropriate to the site based on its physical and biological characteristics relative to those described for the adjoining areas. Indicators presented in this Supplement may also be appropriate in arid environments outside of the designated region boundary.

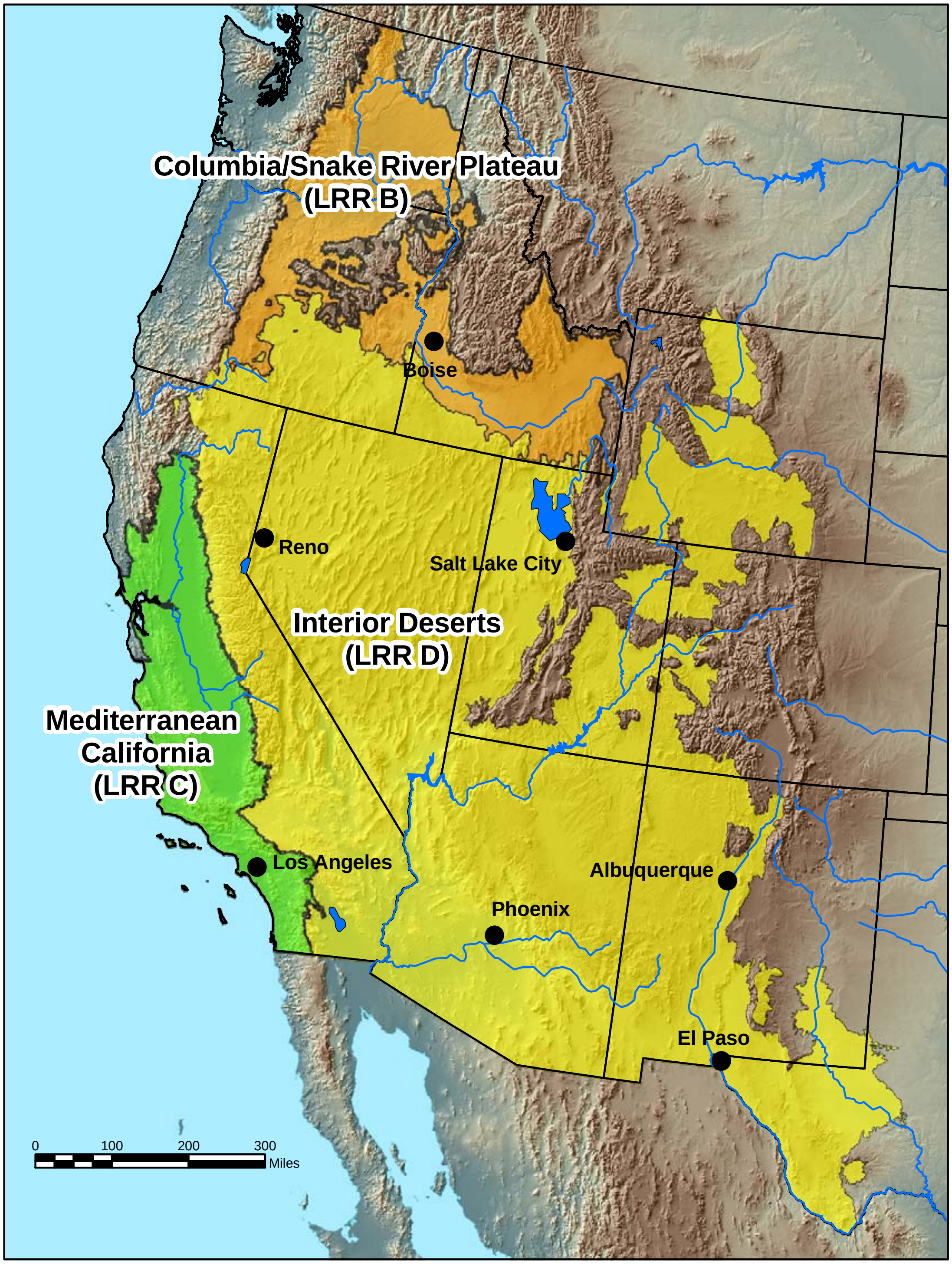

Figure 1-1. Approximate boundaries of the Arid West Region and subregions. Wetland indicators in this Supplement are intended for use throughout the highlighted areas, including embedded mountain ranges, coastal areas, and other areas that receive more abundant precipitation.

Physical and Biological Characteristics of the Region

The Arid West Region consists of desert and shrub-steppe ecosystems in the rain shadow of the Cascade and Sierra Nevada Mountain ranges, plus portions of central and southern California that have a Mediterranean climate with mild winters and dry summers. In general, the region is characterized by relatively high average temperatures, low humidity, and often extreme temporal and spatial variability in precipitation amounts. The Arid West is a vast and topographically diverse region containing enclosed basins, broad valleys, plateaus, canyons, arroyos, mesas, buttes, and numerous mountain ranges. Soils are generally dry, poorly developed, low in percentage of organic matter, and high in carbonates (CEC 1997). Native vegetation across much of the region is dominated mainly by grasses and shrubs with relatively few large trees except in the embedded mountain ranges and riparian zones along perennial streams (Bailey 1995, CEC 1997).

Within the Arid West Region, this supplement recognizes three subregions that differ sufficiently from each other in climate, landforms, biogeography, and/or wetland characteristics to warrant separate consideration of wetland indicators and delineation guidance. These subregions are the Interior Deserts (corresponds to LRR D), the Columbia/Snake River Plateau (LRR B), and Mediterranean California (LRR C) (Figure 1-1). Important characteristics of each subregion are described briefly below. However, most of the indicators presented in this Regional Supplement are applicable across all subregions.

Interior Deserts (LRR D)

The Interior Deserts subregion consists of two distinct parts: the “hot desert” and the “cold desert.” Each part also contains extensive areas of mountains dominated by chaparral and coniferous forests. The hot desert consists of the combined Mojave, Sonoran, and Chihuahuan Deserts in southeastern California, southern Nevada, Arizona, New Mexico, and west Texas. The hot desert receives most of its winter precipitation in the form of rain (Barbour and Billings 1989). Average annual precipitation ranges from approximately 2 to 10 inches (50 to 250 mm) in the valleys with higher amounts in the mountains. Average annual temperatures range from 50 to 75 °F (10 to 24 °C) (Bailey 1995). Summers are long and very hot. Significant rainfall occurs both in winter and summer. Winter frontal storms from the Pacific Ocean produce widespread rainfall of low intensity. Summer convective thunderstorms are common and may produce very high-intensity and short-duration rainfall in limited areas, leaving nearby areas dry. In addition, tropical cyclones that move northeastward across the Pacific Ocean toward Baja California and mainland Mexico can bring intense rain and occasional flooding to the area (Field 2004). The vegetation of the hot desert is derived mainly from the subtropical flora to the south. Several species are characteristic of the hot desert, but their abundance and distribution vary across the area. Creosote bush (*Larrea divaricata*) is commonly associated with the hot desert, along with other xeric shrubs, succulents, cacti, and short grasses. In various portions of the hot desert area, characteristic plants include Joshua tree (*Yucca brevifolia*), palo verde (*Cercidium* spp.), ocotillo (*Fouquieria splendens*), mesquite (*Prosopis* spp.), saguaro cactus (*Carnegiea gigantea*), and cholla and prickly pear cacti (*Opuntia* spp.).

The cold desert lies generally north of the hot desert and east of the Sierra Nevada Mountain range, and includes the basin-and-range province of eastern California, Nevada, southeastern Oregon, and Utah, and the Colorado Plateau in Arizona, Utah, Colorado, and New Mexico. Average annual temperatures range from 40 to 55 °F (4 to 13 °C) and winters are cold. The area receives 5 to 20 inches (130 to 500 mm) of precipitation each year; winter precipitation falls mainly as snow. Winter Pacific frontal storms associated with low pressure systems are an increasingly important source of moisture as one moves from south to north. These storms produce rain and snowfall of relatively low intensity and long duration over wide areas. Little rain falls during summer, except in the mountains (Bailey 1995, Field 2004). The basin-and-range province is dominated by fault-block mountain ranges and broad valleys, whereas the Colorado Plateau consists mainly of uplifted and highly eroded sedimentary rocks. Sagebrush (*Artemisia tridentata*) and rabbit brush (*Chrysothamnus nauseosus*) dominate much of the cold desert area, with saltbush (*Atriplex* spp.), iodine bush (*Allenrolfea occidentalis*), and greasewood (*Sarcobatus vermiculatus*) on the more alkaline soils. Pinyon-juniper (*Pinus* spp.-*Juniperus* spp.) and ponderosa pine (*P. ponderosa*) woodlands occupy large areas of the Colorado Plateau, interspersed with native grasslands and shrub-steppes.

Columbia/Snake River Plateau (LRR B)

The Columbia/Snake River Plateau lies east of the Cascade Mountains in Washington, Oregon, and southern Idaho. Much of the subregion is covered by deposits of loess, volcanic ash, and basalt. The climate is semiarid with average annual temperatures of about 50 °F (10 °C) and average annual precipitation in lowland areas ranging from less than 10 inches (250 mm) to approximately 20 inches (500 mm). Summers are dry. Natural vegetation across much of the area is dominated by sagebrush, saltbush, and short grasses, with greasewood on alkali flats. Willows and sedges are common along streams and in wet areas at the bases of the mountains (Bailey 1995). The Palouse area of southeastern Washington and west-central Idaho once supported extensive prairie ecosystems dominated by perennial bunchgrasses such as bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*). However, this area has largely been converted to irrigated agriculture.

Mediterranean California (LRR C)

Mediterranean California is characterized by relatively warm, wet winters and dry summers. Average temperatures range from approximately 50 to 65 °F (10 to 18 °C) in the lowlands and coast ranges, and 35 to 55 °F (2 to 13 °C) in the Sierra Nevada Mountains. Average annual precipitation is as little as 6 inches (150 mm) in the upper San Joaquin Valley and as much as 40 inches (1,000 mm) or more in the Sierras. The area is influenced mainly by winter frontal storms from the Pacific Ocean. Most precipitation falls from November to April; summers in the lowlands can be very dry (Bailey 1995, CEC 1997). Mediterranean California contains a variety of landscapes including broad valleys, foothills, mountains, and coastal areas. The subregion supports a diverse mix of plant communities including chaparral, coastal strand, coastal sage scrub, valley grassland, oak woodland, foothill woodland, coniferous forest, and alpine meadow (Hickman 1993).

Types and Distribution of Wetlands

While the Arid West is characterized by limited amounts of water, the varied landscapes included in this broad region support many different wetland types. Overall, however, wetlands and other shallow aquatic habitats occupy only about 1-5% of the land surface in the region (Dahl 1990).

Detailed information on the extent of wetlands is available for selected parts of the Arid West Region. Nevada, for example, considered one of the drier states in the country, contains approximately 1.7 million acres of wetlands (Peters 2005), or about 2% of the land surface. It is estimated that just under 1% of Arizona's land surface is wetland (Dahl 1990). Wetlands currently occupy approximately 4.6% of California's Central Valley, although this is much less than the 30% wetland coverage that is estimated to have been present in the 1850s (Frayer, Peters, and Pywell 1989). Most of the reduction was due to wetland conversion for agricultural purposes in the early 1900s. For the Arid West Region as a whole, between 30-90% of wetland acreage that existed in the late 1700s has been converted to other uses (Dahl 1990).

In many parts of the Arid West, ribbons of wetland are concentrated along rivers and streams that flow through parched landscapes. These temporarily or seasonally flooded wetlands are often interspersed with non-wetland woody riparian habitats. Emergent marsh complexes are found in large basins, often as remnants of ancient lakes. Large examples include the Malheur and Klamath marshes in the high desert of Oregon and the Lahontan Valley wetlands in northern Nevada. The Arid West Region includes approximately 450 miles of coastline in central and southern California, where scattered salt marshes have developed along the shores of protected estuarine bays, river mouths, and lagoons. Fresh tidal marshes are very limited in this coastal stretch due to the relatively steep gradient of most rivers entering the Pacific Ocean.

Many types of wetlands and shallow aquatic habitats are unique to the Arid West Region. In desert areas, springs and seeps often support small marshes (cienegas), oases, and other wetland types (U.S. Geological Survey 1996). Desert playas are intermittent shallow lakes that develop in the flat, lower portions of arid basins during the wet season (Brostoff, Lichvar, and Sprecher 2001). They are mostly unvegetated and may not contain water every year. Salt lakes (e.g., Great Salt Lake) and their associated salt flats, as well as inland salt marshes, are also characteristic of the Great Basin.

The channeled scablands of eastern Washington contain a mosaic of depressional marshes, old flood channels, and ephemeral ponds. The pock-marked surface was formed when the volcanic rock in the area was deeply scoured by massive flooding thought to have occurred 12,000 to 20,000 years ago during and following the last Pleistocene glaciation (Houston and Vial 1995). Small, temporarily and seasonally ponded depressions called vernal pools occur in scattered areas from San Diego County, California, to the Modoc Plateau in southern Oregon. These wetlands are found in a variety of landscapes where they are usually underlain by an impermeable layer such as a hardpan, claypan, or basalt. Vernal pools often fill and empty several times during the rainy season. Other wetland types in the Arid West include seeps near the bases of slopes, wet meadows, wetlands associated with the fringes of reservoirs, the wetter portions of riparian forests, and man-made depressions in mined areas, agricultural lands, suburban areas (e.g., golf courses), and wetland restoration sites.

Irrigated Wetlands

Irrigation has been practiced in some portions of the Arid West for more than 125 years and has changed the natural hydrologic regime over large areas. When practiced over many years, the application of irrigation water can alter soil characteristics (e.g., color, redox features, and salt content) and vegetation of affected areas. Long-term irrigation has created new wetlands and altered existing wetlands throughout the region.

Common types of irrigation include flood, sprinkler, and drip. Flood irrigation is the most common form in the Arid West and is often practiced on a very large scale. A single irrigation diversion may serve several ranchers or farmers over many square miles. Streams are diverted by means of dams, weirs, or other structures into man-made delivery channels that convey the water by gravity rather than by electric pumps or other artificial means. Irrigation channels are commonly constructed in uplands along the topographic contour with just enough slope to cause water to flow where it is needed. In flood irrigation, water is applied either as sheet flows or in furrows across a gently sloped pasture or field. The delivery channel is either blocked by temporary gates to cause water to overflow as a sheet, or is withdrawn via siphon tubes directly into furrows. Furrow irrigation is generally used to produce crops, such as lettuce or strawberries. Excess water flows off the irrigated area and collects in a series of drainage or wastewater ditches to be used by downstream irrigators or returned to a tributary.

Overhead sprinkler irrigation systems are typically of two types: center pivot or linear. In center pivot irrigation, pressurized water is sprayed over a crop from a long arm that rotates on wheels in a circle or partial circle around a center point. Linear irrigation systems involve a line of sprinklers on wheels that traverses the field from one side to the other. Sprinkler irrigation is more expensive than flood irrigation due to the costs of the system itself and the energy costs of generators and electric motors used to pump water from wells. Sprinkler irrigation is more common in areas where groundwater is plentiful and the value of the irrigated crop is high. Sprinkler systems produce considerably less runoff than flood irrigation systems.

Drip irrigation delivers water at very low pressure through buried or surface mains and branches of PVC tubing. A network of drip outlet points or emitters carry water directly to plant roots. Drip irrigation systems produce very little waste and are generally used in small areas.

Irrigation augments the natural hydrology of the affected areas in both intended and unintended ways, through leakage of water from delivery channels and ditches, application of water to irrigated pastures and fields, and overflow of unused or excess irrigation water into other areas down gradient. The added water, over time, may create new wetlands or augment and enlarge previously existing wetlands. For example, seep wetlands may develop in former uplands due to leakage from irrigation canals and ditches; prolonged flooding and soil saturation may induce redoximorphic features and hydrophytic vegetation in irrigated pastures; and the accumulation of excess irrigation water in basins and swales may augment previously existing wetlands, raising their water tables and expanding their margins farther up slope. Indicators given in this Regional Supplement can be used to identify all wetlands, whether natural or created artificially by human activity. The appropriate Corps of Engineers District Regulatory Office should be consulted when it is necessary to distinguish between naturally occurring and irrigation-induced wetlands for Clean Water Act regulatory purposes.

2 – Hydrophytic Vegetation Indicators

Introduction

In wetlands, the presence of water for long periods during the growing season exerts a controlling influence on the vegetation and dictates the kinds of plants that can establish and maintain themselves. Therefore, certain characteristics of the vegetation are strong evidence for the presence of wetlands on a site. The Corps Manual emphasizes the plant community concept. Hydrophytic vegetation decisions are based on the assemblage of plant species growing on a site, rather than the presence or absence of particular indicator species. In general, hydrophytic vegetation is present when the plant community is dominated by species that can tolerate prolonged inundation or soil saturation during the growing season.

Many factors besides site wetness affect the composition of the plant community in an area, including regional climate, local weather patterns, topography, soils, and plant distributional patterns at various spatial scales. The Arid West Region is best described as having extreme variability in many of these influencing characteristics. Therefore, community composition reflects the adaptive capabilities of the plant species present, superimposed on a complex spatial pattern of hydrologic, edaphic, and other environmental conditions. Disturbances and climatic fluctuations, such as floods, wildfires, grazing, drought, and recent site modifications, are also important. They can set back or alter the course of plant succession and may even change the hydrophytic status of the community. See Chapter 5 for discussions of specific regional problematic vegetation types.

Arid western landscapes provide habitat for a variety of plant species that have special adaptations for survival in areas with saline conditions and ephemeral water sources. Halophytes and phreatophytes, for example, are associated with many wetland settings in the Arid West. The morphological and physiological adaptations of halophytes allow these species to exist in highly saline soil and water conditions. The long taproots of phreatophytes are adapted to reach deep subsurface water tables, allowing these species to survive in locations that otherwise only receive intermittent surface-water inputs. Although often found in wetlands, halophytes and phreatophytes can sometimes be misleading indicators of wetland conditions when they dominate the plant community in an area that is highly saline but lacks wetland hydrology or hydric soils, or they occur in an area where groundwater is below the depth required for wetland delineation purposes.

The Arid West is well known for its high degree of spatial and temporal variability in rainfall amounts (Reid and Frostick 1997). In addition to seasonal variability, decadal-scale climatic shifts affect the amount and frequency of precipitation and influence many wetland types in the region. Climatic fluctuations can affect the presence or abundance of wetland species both seasonally and through a series of drought years. Shifts in species composition of woody shrubs and trees are generally not dramatic. Decade-long drought conditions may stress woody plants but they typically survive and are present at drought-influenced wetland sites. Herbaceous communities, however, respond much more quickly. Areas subject to seasonal hydrology show some of the greatest shifts in wetland species composition in the region. Some regional examples of wetland types that are influenced by seasonal and longer term climatic fluctuations include, but are not limited to, vernal pools, grassy playas, seeps, and springs.

Growing Season

Beginning and ending dates of the growing season are needed to evaluate certain wetland indicators. The beginning date is particularly important in evaluating observations of flooding, ponding, or shallow water tables on potential wetland sites. For convenience nationwide, the U.S. Army Corps of Engineers (2005) recommends a procedure for estimating growing season dates based on the median dates (i.e., 5 years in 10, or 50% probability) of 28 °F (-2.2 °C) air temperatures in spring and fall, based on long-term records gathered at National Weather Service meteorological stations. However, this approach is often impractical in the Arid West due to differences in elevation, aspect, and other conditions between project sites and the location of the nearest weather station. Biological activity affects the ability of saturated soils to go anaerobic, and two indicators of biological activity that are readily observable in the field are soil temperature and the growth of vascular plants. Therefore, one or more of the following procedures may be used in the Arid West to determine the start of the growing season on a particular project site. The growing season has begun if either condition is met.

1. The growing season has begun in spring when plants comprising 20% or more of the total vegetation cover within the wetland or surrounding areas are emerging (e.g., spring ephemerals), greening up, breaking bud, leafing out, or flowering. Observations should be made in the local plant community with the highest level of growth activity. Supporting data, such as the species observed and their coverage in the study area, should be collected and reported in field notes or the delineation report. The observed growing season date should also be discussed in relation to the median date of 28 °F air temperatures in spring as reported in the county soil survey or in WETS tables available from the NRCS National Water and Climate Center for the nearest appropriate weather station. WETS tables are available on the internet at http://www.wcc.nrcs.usda.gov/climate/wetlands.html.

2. The growing season has begun in spring when soil temperature measured at 20 inches (50 cm) depth is ≥41 °F (5 °C). Soil temperature can be measured directly in the field by inserting a soil thermometer into the wall of a freshly dug soil pit. Again, growing season observations based on soil temperature should be discussed in relation to the median date of 28 °F air temperatures in spring as reported in the county soil survey or in WETS tables for the nearest appropriate weather station.

Guidance on Vegetation Sampling and Analysis

In most cases, hydrophytic vegetation decisions are based on the wetland indicator status (Reed 1988) of species that make up the plant community. Species in the facultative categories (FACW, FAC, and FACU) are recognized as occurring in both wetlands and uplands to varying degrees. Although most wetlands are dominated mainly by species rated OBL, FACW, and FAC, some wetland communities may be dominated primarily by FACU species and cannot be identified by dominant species alone. In those cases, other indicators of hydrophytic vegetation must also be considered. This situation is not necessarily due to inaccurate wetland indicator ratings; rather, it is due to the broad tolerances of certain plant species that allows them to be widely distributed across the moisture gradient. Therefore, for some species, it is difficult to assign a single indicator status rating that encompasses all of the various landscape and ecological settings it can occupy.

Hydrophytic vegetation indicators and procedures presented in this chapter are designed to identify the majority of wetland plant communities in the Arid West. However, some wetland communities may lack any of these indicators. These situations are considered in Chapter 5 (Difficult Wetland Situations in the Arid West).

General guidance on sampling of vegetation for wetland-delineation purposes is given in the Corps Manual for both the Routine and Comprehensive methods. Those procedures are intended to be flexible and may need to be modified for application in a given region or on a particular site. The following guidance on vegetation sampling is intended to supplement the Corps Manual for applications in the Arid West.

Wetland Plant Indicator Status Ratings

For the purposes of this supplement, only the five basic levels of wetland indicator status (i.e., OBL, FACW, FAC, FACU, and UPL) (Reed 1988) are used to determine whether vegetation is hydrophytic. Plus (+) and minus (–) modifiers are not used. For Clean Water Act purposes, wetland delineators should use the latest plant lists approved by Headquarters, U.S. Army Corps of Engineers (Figure 2-1).

Plot and Sample Sizes

Hydrophytic vegetation determinations under the Corps Manual are based on samples taken in representative locations within the community. Completely random sampling of the vegetation is not required except for Comprehensive determinations or whenever representative sampling might give misleading results, such as in areas with very patchy or heterogeneous plant cover. For Routine determinations in fairly uniform vegetation, one or more plots in each community are usually sufficient for an accurate determination. Sampling of a multi-layered community is usually accomplished using a graduated series of plots, one for each stratum, or a number of small plots nested within the largest plot (Figure 2-2). Nested plots can be helpful in forested stands with highly variable understories or in very diverse communities. Plant abundance data are averaged across the multiple small plots. When using nested plots, developing a species-area curve is helpful to determine the number of plots needed to assure that the majority of species associated with an area and community type have been observed (Tiner 1999). An adequate number of samples is indicated by the point at which the curve begins to level off and the probability of encountering new species declines. See Figure 2-3 for an example of a species-area curve.

Figure 2-1. Plant list regional boundaries (red lines) currently used by the U.S. Fish and Wildlife Service, National Wetlands Inventory, in the Arid West.

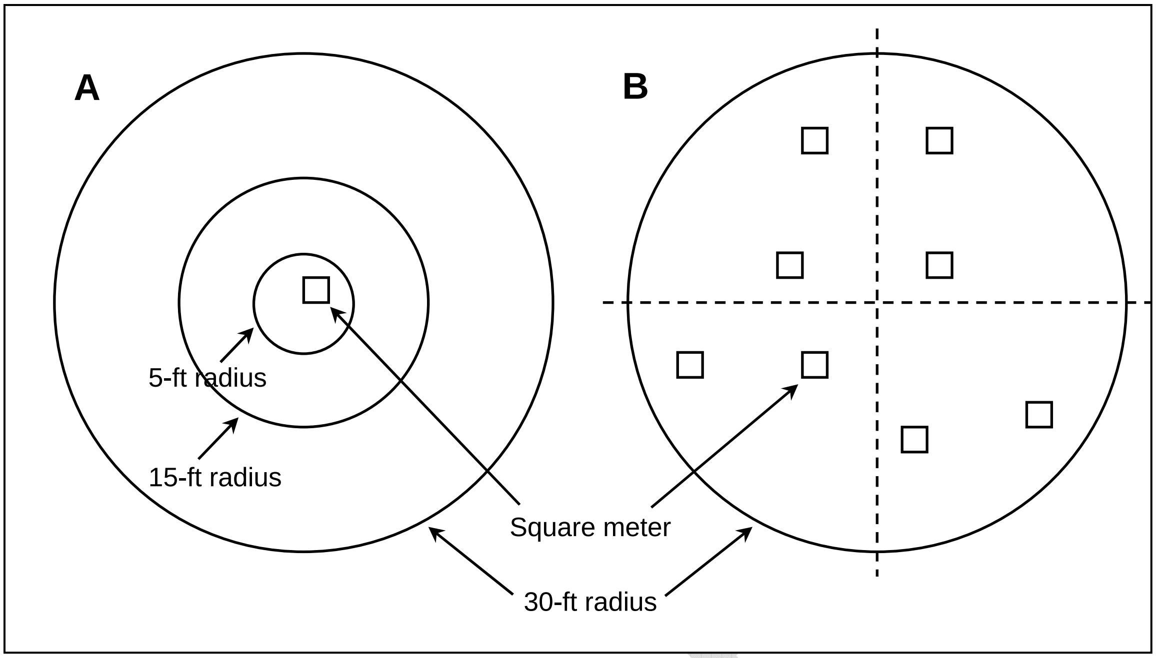

Figure 2-2. Examples of plot arrangements for vegetation sampling. (A) Single plots in graduated sizes. (B) Nested square-meter plots within the 30-ft radius plot.

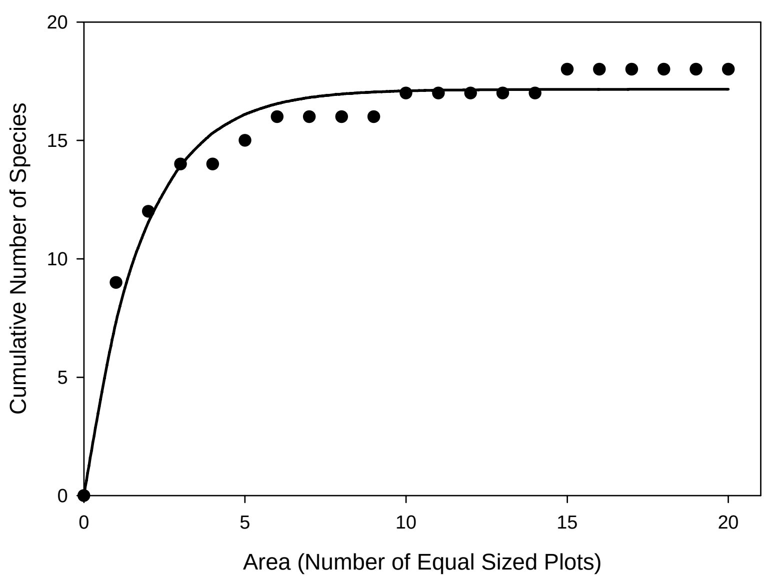

Figure 2-3. Example of a species-area curve. Solid circles indicate the cumulative number of species recorded as additional plots were sampled. In this example, approximately six to eight plots were sufficient to detect most of the species present in the community.

The appropriate size and shape for a sample plot depend on the type of vegetation (i.e., trees, shrubs, herbaceous plants, etc.) and the size or shape of the plant community or patch being sampled. The size of a plot needs to be large enough to include significant numbers of individuals in all strata, but small enough so that plant species or individuals can be separated and measured without duplication or omission, and the sampling can be done in a timely fashion (Barbour, Burk, and Pitts 1987, Cox 1990). For hydrophytic vegetation determinations, the abundance of each species is determined by using areal cover estimates. Plot sizes should make visual sampling both accurate and efficient. In the Arid West, the following plot sizes are suggested.

1. Trees – 30 ft radius

2. Saplings and shrubs – 15 ft radius

3. Herbaceous plants – 5 ft radius

4. Woody vines – 30 ft radius

The sampling plot should not be allowed to extend beyond the edges of the plant community being sampled or to overlap an adjacent community having different vegetation, soil, or hydrologic conditions. This may happen if vegetation patches are small or occur as narrow bands or zones along a topographic gradient. In such cases, plot sizes and shapes should be adjusted to fit completely within the vegetation patch or zone. For example, in linear riparian communities where the width of a standard plot may exceed the width of the plant community, an elongated rectangular plot or belt transect that follows the stream is recommended. If possible, the area sampled should be equivalent to the 30-ft-radius plot (2,827 square feet) for the tree stratum or the 15-ft-radius plot (707 square feet) for the sapling/shrub stratum. Thus the sapling/shrub stratum could be sampled using a 10×71-ft plot lying completely within the riparian fringe. An alternative approach involves sampling a series of small subplots (e.g., 5×5 ft or 10×10 ft) in the riparian community and averaging the data across subplots. The appropriate number of subplots to sample can be determined by applying the species-area approach shown in Figure 2-3.

A 30-ft radius tree plot works well in most forests but can be increased to 35 or 40 ft or more in a nonlinear forest stand if tree diversity is high or diameters are large, as in some foothill and montane forests. Highly diverse or patchy communities of herbs or other low vegetation may be sampled with nested 1-meter-square quadrants randomly located within a 30-ft radius (Figure 2-2B). Furthermore, point-intercept sampling performed along a transect is an alternative to plot-based methods that can improve the accuracy and repeatability of vegetation sampling in diverse or heterogeneous communities (Tiner 1999).

Definitions of Strata

Vegetation strata are sampled separately when evaluating indicators of hydrophytic vegetation. The structure of vegetation varies greatly in wetland communities across the region. Throughout much of the Arid West, short-statured woody plants (i.e., <1 m high or "sub-shrubs") are a common growth form. The Corps Manual combines short woody plants and herbaceous plants into a single "herb" stratum for sampling purposes. However, in the Arid West, more information about the plant community is gained when short shrubs and herbaceous plants are sampled separately. Therefore, the following vegetation strata are recommended for use across the Arid West. This system places short woody shrubs in the sapling/shrub stratum and limits the herb stratum to only herbaceous plant species. Unless otherwise noted, a stratum for sampling purposes is defined as having ≥5% total plant cover. If a stratum has <5% cover during the peak of the growing season, then those species and their cover values can be combined with the next lower stratum for sampling purposes.

1. *Tree stratum* – Consists of woody plants ≥3 inches (7.6 cm) DBH.

2. *Sapling/shrub stratum* – Consists of woody plants <3 inches DBH, regardless of height.

3. *Herb stratum* – Consists of all herbaceous (non-woody) plants, regardless of size.

4. *Woody vines* – Consists of all woody vines regardless of height.

Snow and Ice

Excessive snow and ice is defined as an accumulation that covers the ground and makes it impractical to identify plant species and estimate plant cover. The following options are recommended:

1. If possible, the delineation should be postponed until conditions improve.

2. If the delineation cannot be postponed, an off-site determination at the planning level can be made by utilizing data sources such as NWI maps, soil surveys, and aerial photographs. These sources may be supplemented with limited on-site data, including those plant species that can be identified. Later, when the site and climatic conditions are favorable, an on-site visit must be made to verify the off-site determination.

Hydrophytic Vegetation Definition and Indicators

The Corps Manual defines hydrophytic vegetation as the total macrophytic plant life that occurs in areas where inundation or soil saturation is either permanent or of sufficient frequency and duration to exert a controlling influence on the plant species present. Hydrophytic vegetation is identified by applying the indicators described in this section.

The following indicators should be applied in the sequence presented. Hydrophytic vegetation is present if any of the indicators is satisfied. However, some indicators have the additional requirement that indicators of hydric soil and wetland hydrology must also be present. All of these indicators are applicable throughout the entire Arid West Region.

The dominance test (Indicator 1) is the basic hydrophytic vegetation indicator and should be applied in every wetland determination. Most wetlands in the Arid West have plant communities that will pass the dominance test, and this is the only indicator that needs to be used in most situations. However, some wetland plant communities may fail a test based only on dominant species. Therefore, in those cases where indicators of hydric soil and wetland hydrology are present, the vegetation should be re-evaluated with the prevalence index (Indicator 2), which takes non-dominant plant species into consideration. In addition, plant morphological adaptations (Indicator 3) can be used to distinguish certain wetland plant communities in the Arid

West, when indicators of hydric soil and wetland hydrology are present. Finally, certain problematic wetland situations may lack any of these indicators and are described in Chapter 5.

Procedure

The procedure for using hydrophytic vegetation indicators is as follows:

1. Apply the dominance test (Indicator 1) first.
   a. If the plant community passes the dominance test, the vegetation is hydrophytic and no further vegetation analysis is required.
   b. If the plant community fails the dominance test, and indicators of hydric soil and/or wetland hydrology are absent, then hydrophytic vegetation is absent unless the site meets requirements for a problematic wetland situation (see Chapter 5).
   c. If the plant community fails the dominance test, but indicators of hydric soil and wetland hydrology are both present, proceed to step 2.

2. Calculate the prevalence index (Indicator 2). This and the following step assume that at least one indicator of hydric soil and one primary or two secondary indicators of wetland hydrology are present.
   a. If the plant community satisfies the prevalence index, the vegetation is hydrophytic. No further vegetation analysis is required.
   b. If the plant community fails the prevalence index, proceed to step 3.

3. Apply Indicator 3 (Morphological Adaptations).
   a. If the indicator is satisfied, the vegetation is hydrophytic.
   b. If none of the indicators is satisfied, then hydrophytic vegetation is absent unless indicators of hydric soil and wetland hydrology are present and the site meets the requirements for a problematic wetland situation (Chapter 5).

Indicator 1: Dominance test

Description: More than 50% of the dominant plant species across all strata are rated OBL, FACW, or FAC.

User Notes: Use the 50/20 rule described below to select dominant species from each stratum of the community. Combine dominant species across strata and apply the dominance test to the combined list. Once a species is selected as a dominant, its cover value is not used in the dominance test; each dominant species is treated equally. Thus, a plant community with seven dominant species across all strata would need at least four dominant species that are OBL, FACW, or FAC to be considered hydrophytic by this indicator. Species that are dominant in two or more strata should be counted two or more times in the dominance test.

Procedure for Selecting Dominant Species by the 50/20 Rule: Dominant plant species are the most abundant species in the community; they contribute more to the character of the community than do the other non-dominant species present. The "50/20 rule" is a repeatable and objective procedure for selecting dominant plant species and is recommended when data are available for all species in the community. The rule can also be used to guide visual sampling of plant communities in rapid wetland determinations.

Dominant species are chosen independently from each stratum of the community. In general, dominants are the most abundant species that individually or collectively account for more than 50% of the total coverage of vegetation in the stratum, plus any other species that, by itself, accounts for at least 20% of the total. For the purposes of this regional supplement, absolute percent cover is the recommended abundance measure for plants in all vegetation strata. See Table 2-1 for an example application of the 50/20 rule in evaluating a plant community. Steps in selecting dominant species by the 50/20 rule are as follows:

1. Estimate the absolute percent cover of each species in the first stratum. Since the same data may be used later to calculate the prevalence index, the data should be recorded as absolute cover and not converted to relative cover.

2. Rank all species in the stratum from most to least abundant.

3. Calculate the total coverage of all species in the stratum (i.e., sum their individual percent cover values). Absolute cover estimates do not necessarily sum to 100%.

4. Select plant species from the ranked list, in decreasing order of coverage, until the cumulative coverage of selected species *exceeds* 50% of the total coverage for the stratum. If two or more species are equal in coverage (i.e., they are tied in rank), they should be selected as a group. The selected plant species are all considered to be dominants. All dominants must be identified to species.

5. In addition, select any other species that, by itself, is *at least* 20% of the total percent cover in the stratum. Any such species is also considered to be a dominant and must be accurately identified.

6. Repeat steps 1-5 for any other stratum present. Combine the lists of dominant species across all strata. Note that a species may be dominant in more than one stratum (e.g., a woody species may be dominant in both the tree and sapling/shrub strata).

Table 2-1
Example of the selection of dominant species by the 50/20 rule.

Stratum	Species Name	Wetland Indicator Status	Percent Cover	Dominant?
Herb	*Ambrosia psilostachya*	FAC	3	Yes
	Distichlis spicata	FACW	3	Yes
	Agrostis exarata	FACW	2	No
	Polypogon monspeliensis	FACW	2	No
	Oenothera californica	UPL	1	No
		Total cover	11	
	50/20 Thresholds: 50% of total cover = 5.5% 20% of total cover = 2.2%			
Sapling/shrub	*Baccharis salicifolia*	FACW	10	Yes
	Salix lasiolepis	FACW	5	Yes
	Chrysothamnus nauseosus ssp. albicaulis	UPL	2	No
		Total cover	17	
	50/20 Thresholds: 50% of total cover = 8.5% 20% of total cover = 3.4%			
Tree	*Salix lasiolepis*	FACW	20	Yes
Hydrophytic Vegetation Determination	Total number of dominant species across all strata = 5. Percent of dominant species that are OBL, FACW, or FAC = 5/5 = 100%. Therefore, this community is hydrophytic by Indicator 1 (Dominance Test).			

Indicator 2: Prevalence index

Description: The prevalence index is ≤3.0.

User Notes: At least 80% of the total vegetation cover on the plot (summed across all strata) must be of species that have been correctly identified and have an assigned wetland indicator status, including UPL for dry-site species not recorded on the list of wetland plants.

Procedure for Calculating a Plot-Based Prevalence Index: The prevalence index is a weighted-average wetland indicator status of all plant species in the sampling plot, where each indicator status category is given a numeric code (OBL = 1, FACW = 2, FAC = 3, FACU = 4, and UPL = 5) and weighting is by abundance (percent cover). It is a more comprehensive analysis of the hydrophytic status of the community than one based on just a few dominant species. It is particularly useful (1) in communities with only one or two dominants, (2) in highly diverse communities where many species may be present at roughly equal coverage, and (3) when strata differ greatly in total plant cover (e.g., total herb cover is 90% but shrub cover is only 10%). The prevalence index is used in this supplement to determine whether hydrophytic vegetation is present on sites where indicators of hydric soil and wetland hydrology are present but the vegetation initially fails the dominance test.

The following procedure is used to calculate a plot-based prevalence index. The method was described by Wentworth, Johnson, and Kologiski (1988) and modified by Wakeley and Lichvar (1997). It uses the same field data (i.e., percent cover estimates for each plant species) that were used to select dominant species by the 50/20 rule, with the added constraint that at least 80% of the total vegetation cover on the plot must be of species that have been correctly identified and have an assigned indicator status. For any species that occurs in more than one stratum, cover estimates are summed across strata. Steps for determining the prevalence index are as follows:

1. Identify and estimate the absolute percent cover of each species in each stratum of the community. Sum the cover estimates for any species that is present in more than one stratum.

2. Organize all species (across all strata) into groups according to their wetland indicator status (i.e., OBL, FACW, FAC, FACU, or UPL) and sum their cover values within groups. Do not include species that were not identified. Species that were identified correctly but are not listed on the wetland plant list are assumed to be upland (UPL) species. For species with no regional indicator (NI), apply the national indicator status to the species. If there is no national indicator status or if more than one national indicator status (excluding + and – designations) is assigned, do not use the species to calculate the prevalence index.

3. Calculate the prevalence index using the following formula:

$$PI = \frac{A_{OBL} + 2A_{FACW} + 3A_{FAC} + 4A_{FACU} + 5A_{UPL}}{A_{OBL} + A_{FACW} + A_{FAC} + A_{FACU} + A_{UPL}}$$

where:

PI	=	Prevalence index
A_{OBL}	=	Summed percent cover values of obligate (OBL) plant species;
A_{FACW}	=	Summed percent cover values of facultative wetland (FACW) plant species;
A_{FAC}	=	Summed percent cover values of facultative (FAC) plant species;
A_{FACU}	=	Summed percent cover values of facultative upland (FACU) plant species;
A_{UPL}	=	Summed percent cover values of upland (UPL) plant species.

The prevalence index should range between 1 and 5. See Table 2-2 for an example calculation of the prevalence index using the same data set as in Table 2-1. The following web link provides free public-domain software for simultaneous calculation of the 50/20 rule and the prevalence index: http://www.crrel.usace.army.mil/rsgisc/wetshed/wetdatashed.htm.

Table 2-2
Example of the Prevalence Index using the same data as in Table 2-1.

Indicator Status Group	Species name	Percent Cover by Species	Total Cover by Group	Multiply by:[1]	Product
OBL species	None	0	0	1	0
FACW species	*Distichlis spicata* *Agrostis exarata* *Baccharis salicifolia* *Salix lasiolepis*[2] *Polypogon monspeliensis*	3 2 10 25 2	42	2	84
FAC species	*Ambrosia psilostachya*	3	3	3	9
FACU species	*None*	0	0	4	0
UPL species	*Oenothera californica* *Chrysothamnus nauseosus ssp. albicaulis*	1 2	3	5	15
Sum			48 (A)		108 (B)
Hydrophytic Vegetation Determination		Prevalence Index = B/A = 108/48 = 2.25 Therefore, this community is hydrophytic by Indicator 2 (Prevalence Index).			

[1] Where OBL = 1, FACW = 2, FAC = 3, FACU = 4, and UPL = 5.
[2] *Salix lasiolepis* was recorded in two strata (see Table 2-1) so the cover estimates for this species were summed across strata.

Indicator 3: Morphological adaptations

Description: Morphological adaptations for life in wetlands are present on FACU or UPL plant species. The plant community passes either the dominance test (Indicator 1) or the prevalence index (Indicator 2) after reconsideration of the indicator status of certain individual plants that exhibit such adaptations.

User Notes: Some hydrophytes in the Arid West develop easily recognized physical characteristics, or morphological adaptations, when they occur in wetland areas. Some of these adaptations may help them to survive prolonged inundation or saturation in the root zone; others may simply be a consequence of living under such wet conditions. Common morphological adaptations in the Arid West include but are not limited to adventitious roots, shallow root systems developed on or near the soil surface, and aerenchyma tissue in herbaceous species. These adaptations on FAC, FACW, or OBL species are additional evidence for the presence of a hydrophytic plant community. Morphological adaptations may also develop on FACU and UPL species when they occur in wetlands, indicating that those individuals are functioning as hydrophytes in that setting.

To apply this indicator, these morphological features must be observed on >50% of the individuals of a FACU or UPL species living in an area where indicators of hydric soil and wetland hydrology are present. Follow this procedure:

1. Confirm that the morphological feature is present mainly in the potential wetland area and is not also common on the same species in the surrounding uplands.

2. For each FACU or UPL species that exhibits morphological adaptations, estimate the percentage of individuals that have the features. Record this percentage on the data form.

3. If >50% of the individuals of a FACU or UPL species have morphological adaptations for life in wetlands, then that species is considered to be a hydrophyte and its indicator status on that plot should be re-assigned as FAC. All other species retain their published indicator status. Record any supporting information on the data sheet, including a description of the morphological adaptation(s) present and any other observations of the growth habit of the species in adjacent wetland and upland locations (photo documentation is recommended).

4. Recalculate the dominance test (Indicator 1) and/or the prevalence index (Indicator 2) using a FAC indicator status for this species. The vegetation is hydrophytic if either test is satisfied.

3 – Hydric Soil Indicators

Introduction

The National Technical Committee for Hydric Soils (NTCHS) defines a hydric soil as a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (USDA Soil Conservation Service 1994). Nearly all hydric soils exhibit characteristic morphologies that result from repeated periods of saturation or inundation for more than a few days. Saturation or inundation, when combined with microbial activity in the soil, causes the depletion of oxygen. This anaerobiosis promotes certain biogeochemical processes, such as the accumulation of organic matter and the reduction, translocation, or accumulation of iron and other reducible elements. These processes result in characteristic morphologies that persist in the soil during both wet and dry periods, making them particularly useful for identifying hydric soils in the field.

This chapter presents indicators that are designed to help identify and delineate hydric soils in the Arid West Region. Indicators are not intended to replace or relieve the requirements contained in the definition of a hydric soil. This list of indicators is dynamic; changes and additions are anticipated with new research and field testing. These indicators are a subset of the NTCHS *Field Indicators of Hydric Soils in the United States* (USDA Natural Resources Conservation Service 2005) that are commonly found in the Arid West. A change to an indicator by the NTCHS represents a change to this subset of indicators for the Arid West. To use the indicators properly, a basic knowledge of soil/landscape relationships and soil survey procedures is necessary.

Most of the hydric soil indicators presented in this Supplement are applicable throughout the Arid West Region; however, some are specific to certain subregions. As used in this supplement, subregions are equivalent to the Land Resource Regions (LRR) recognized by the USDA Soil Conservation Service (1981) (see Chapter 1, Figure 1-1). It is important to understand that boundaries between subregions are actually broad transition zones. Although an indicator may be noted as most relevant in a specific subregion, it may also be applicable in adjacent subregions.

The indicators are used to help identify the hydric soil component of wetlands; however, some hydric soils do not have any of the currently listed indicators. The absence of any listed indicator does not preclude the soil from being hydric. Guidance for identifying hydric soils that lack indicators can be found in this chapter (see the sections on documenting the site and its soils) and in Chapter 5 (Difficult Wetland Situations in the Arid West).

Concepts

Hydric soil indicators are formed predominantly by the accumulation or loss of iron, manganese, sulfur, or carbon compounds. The presence of hydrogen sulfide gas (rotten egg odor) is a strong indicator of a hydric soil, but this indicator is found in only the wettest sites containing sulfur. While indicators related to iron or manganese depletion or concentration are the most common, they cannot form in soils whose parent materials contain low amounts of Fe or Mn. Soils formed in such materials may have low-chroma colors that are not related to saturation and reduction. For such soils, features formed through accumulation of organic carbon should be used.

Organic Accumulation

Since the efficiency of soil microbes is considerably lower in an anaerobic environment, less organic matter and organic carbon is consumed. Therefore, in saturated or inundated soils, organic matter and carbon begin to accumulate. The result is the development of thick organic surfaces on the soil or dark organic-rich surface mineral layers.

Iron Reduction, Translocation, and Accumulation

Saturated or inundated soils. In an anaerobic environment, soil microbes reduce ferric iron (Fe^{+3}) to ferrous iron (Fe^{+2}). Areas in the soil where iron is reduced often develop characteristic bluish-gray or greenish-gray colors known as *gley*. Ferric iron is insoluble but ferrous iron easily enters the soil solution. Iron that is reduced in some areas of the soil enters into the soil solution and is moved or translocated to other areas of the soil. Areas that have lost iron typically develop characteristic whitish-gray or reddish-gray colors and are known as *iron depletions.* If a soil reverts to an aerobic state, iron that is in solution will oxidize and become concentrated in patches and along pores and root channels. These areas of oxidized iron are called *redox concentrations.* Since water movement in these saturated or inundated soils can be multi-directional, iron depletions and redox concentrations can occur anywhere in the soil and have irregular shapes and sizes.

Sulfate Reduction

Sulfur is the last of the elements to be reduced by microbes in an anaerobic environment. The microbes convert SO_4^{-2} to H_2S, or hydrogen sulfide. This results in a very pronounced “rotten egg” odor in some soils that are inundated or saturated for very long periods. In non-saturated or non-inundated soils, sulfate is not reduced and there is no odor.

Cautions

A soil that is artificially drained or protected (for instance, by levees) is hydric if the soil in its undisturbed state would meet the definition of a hydric soil. To be determined hydric, these soils should generally have one or more of the indicators.

Morphological features of hydric soils indicate that saturation and anaerobic conditions have existed under either contemporary or recent hydrologic conditions. Features that do not reflect contemporary or recent hydrologic conditions of saturation and anaerobiosis are relict features. Typically, contemporary and recent hydric soil features have diffuse boundaries; relict hydric soil features have abrupt boundaries. Additional guidance for some of the most common problem hydric soils can be found in Chapter 5. When soil morphology seems inconsistent with the landscape, vegetation, or observable hydrology, it may be necessary to obtain the assistance of an experienced soil or wetland scientist to determine whether the soil is hydric.

Procedures for Sampling Soils

Observe and Document the Site

The common temptation is to excavate a small hole in the soil, note the presence of any indicators, make a decision, and leave. Before any decision can be made, however, the overall site and how it interacts with the soil must be understood and documented.

At each site, examine and describe on the data form the site features listed below before looking for hydric soil indicators. Use all of the evidence that is available. If one or more of the listed soil indicators is present, the soil is hydric. Use the additional information about the site to understand why the soil is hydric. If no hydric soil indicators are present, use the additional site information to determine if the soil is indeed non-hydric or if it represents a 'problem' hydric soil.

- *Hydrology*–Is standing water observed on the site or is water observed in the soil pit? What is the depth of the water table in the area? Is there indirect evidence of ponding or flooding?

- *Slope*–Is the site level or nearly level so that surface water does not run off readily, or is it steeper where surface water would run off from the soil?

- *Slope shape*–Is the surface concave, where water would tend to collect and possibly pond on the soil surface? Is it flat, where water would not readily run off? On hillsides, are there convergent slopes, where surface or groundwater may be directed toward a central stream or swale? Or is the surface or slope shape convex, causing water to run off or disperse?

- *Landform*–Is the soil on a low terrace or floodplain that may be subject to seasonal high water tables or flooding? Is it at the toe of a slope where runoff may tend to collect or groundwater emerge at or near the surface? Has the microtopography been altered by cultivation?

- *Soil materials*–Is there a restrictive layer in the soil that would slow or prevent the infiltration of water? This could include consolidated bedrock, cemented layers such as duripans and petrocalcic horizons, layers of silt or substantial clay content, or strongly contrasting soil textures (e.g., silt over sand). Or is there relatively loose soil material (sand, gravel, or rocks) or fractured bedrock that would allow the water to flow laterally down slope?

- *Vegetation*–Does the vegetation at the site indicate wetter conditions than at other nearby sites, or is it similar to what is found at nearby upland sites?

The questions above should be considered at any site. Always look at the features of the immediate site and compare them to the surrounding areas. Try to contrast the features of wet and dry sites that are in close proximity. When observing slope features, look first at the area immediately around the sampling point. For example, a nearly level bench or depression at the sampling point may be more important to site wetness than the overall landform on which it occurs. By understanding how water moves across the site, the reasons for the presence or absence of hydric soil indicators should be clear.

Observe and Document the Soil

To document a hydric soil, first remove any loose leaves, needles, or bark from the soil surface. Do not remove the organic surface layers of the soil, which usually consist of plant remains in varying stages of decomposition. Dig a hole and describe the soil profile to a depth of at least 20 inches (50 cm) from the soil surface. Digging may be difficult in some areas due to rocks and hardpans. Use the completed profile description to determine which indicators have been matched.

Deeper examination of the soil may be required when field indicators are not easily seen within 20 inches (50 cm) of the surface. It is always recommended that soils be excavated and described as deep as necessary to make reliable interpretations. For example, examination to less than 20 inches (50 cm) may suffice in soils with surface horizons of saturated organic material or mucky mineral material. Conversely, depth of excavation will often need to be greater than 20 inches (50 cm) in soils with thick dark surface horizons because the upper horizons of these soils, due to the masking effect of organic material, often contain no easily visible redoximorphic features. At some sites, it is necessary to make exploratory observations to 40 inches (1 m) or more. These observations should be made with the intent of documenting and understanding the variability in soil properties and hydrologic relationships on the site.

Whenever possible, excavate the soil deep enough to determine if there are layers or materials present that might restrict soil drainage. This will help to understand why the soil may or may not be hydric. Consider taking photographs of both the soil and the overall site. There may be no opportunity to return for more data.

Depths used in the indicators are measured from the muck surface, or from the mineral soil surface if an organic surface is absent. For indicators A1 (Histosols) and A2 (Histic Epipedon), depths are measured from the top of the organic material (peat, mucky peat, or muck). All colors noted in this supplement refer to moist Munsell® colors. Soil colors specified in the indicators do not have decimal points; however, intermediate colors do occur between Munsell chips. Soil chroma should not be rounded to qualify as meeting an indicator. For example, a soil matrix with a chroma between 2 and 3 should be listed as having a chroma of 2+. This soil material does not have a chroma of 2 and would not meet any indicator that requires a chroma of 2 or less.

Particular attention should be paid to changes in microtopography over short distances. Small changes in elevation may result in repetitive sequences of hydric/non-hydric soils, making the delineation of individual areas of hydric and non-hydric soils difficult. Often the dominant condition (hydric or non-hydric) is the only reliable interpretation. The shape of the local landform can greatly affect the movement of water through the landscape. Significant changes in parent material or lithologic discontinuities in the soil can affect the hydrologic properties of the soil. After a sufficient number of exploratory excavations have been made to understand the soil-hydrologic relationships at the site, subsequent excavations can be limited to the depth needed to identify hydric soil indicators.

Unless otherwise indicated, all mineral layers above any of the indicators must have a dominant chroma of 2 or less, or the layer(s) with dominant chroma of more than 2 must be less than 6 inches (15 cm) thick to meet any hydric soil indicator.

Hydric Soil Indicators

A1. Histosol

Technical Description: Classifies as a Histosol (except Folists)

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: A Histosol has 16 inches (40 cm) or more of the upper 32 inches (80 cm) as organic soil material (Figure 3-1). Organic soil material has an organic carbon content (by weight) of 12 to 18 percent or more, depending on the clay content of the soil. The material includes muck (sapric soil material), mucky peat (hemic soil material), or peat (fibric soil material). See the glossary of *Field Indicators of Hydric Soils in the United States* for definitions of muck, mucky peat, peat, and organic soil material.

Figure 3-1. Indicator A1 (Histosols). In this example, muck (sapric soil material) is 31 inches thick.

A2. Histic Epipedon

Technical Description: A histic epipedon

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: Most histic epipedons are surface horizons 8 inches (20 cm) or more thick of organic soil material. Aquic conditions or artificial drainage are required (see *Soil Taxonomy*, USDA Natural Resources Conservation Service 1999); however, aquic conditions can be assumed if indicators of hydrophytic vegetation and wetland hydrology are present. See the glossary of *Field Indicators of Hydric Soils in the United States* for definitions. See indicator A1 for organic carbon requirements. Slightly lower organic carbon contents are allowed in plowed soils.

A3. Black Histic

Technical Description: A layer of peat, mucky peat, or muck 8 inches (20 cm) or more thick starting within 6 inches (15 cm) of the soil surface having hue 10YR or yellower, value 3 or less, and chroma 1 or less.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: This indicator does not require proof of aquic conditions or artificial drainage. See the glossary of *Field Indicators of Hydric Soils in the United States* for definitions of peat, mucky peat, and muck. See Indicator A1 for organic carbon requirements.

A4. Hydrogen Sulfide

Technical Description: A hydrogen sulfide (rotten egg) odor within 12 inches (30 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: Any time the soil smells of hydrogen sulfide (rotten egg odor), sulfur is currently being reduced and the soil is definitely in an anaerobic state. In some soils, the odor is well pronounced; in others it is very fleeting as the gas dissipates rapidly. If in doubt, quickly open several small holes in the area of concern to determine if a hydrogen sulfide odor is really present. This indicator is most commonly found in areas that are permanently saturated or inundated.

A5. Stratified Layers

Technical Description: Several stratified layers starting within 6 inches (15 cm) of the soil surface. One or more of the layers has value 3 or less with chroma 1 or less and/or it is muck, mucky peat, peat, or mucky modified mineral texture. The remaining layers have chroma 2 or less.

Applicable Subregions: Applicable to LRR C.

User Notes: Use of this indicator may require assistance from a trained soil scientist with local experience. An undisturbed sample must be observed. Individual strata are dominantly less than 1 inch (2.5 cm) thick. A hand lens is an excellent tool to aid in the identification of this indicator. Many alluvial soils have stratified layers at greater depths; these are not hydric soils. Many alluvial soils have stratified layers at the required depths, but lack chroma 2 or less; these do not fit this indicator. Stratified Layers occur in any type soil material.

A9. 1 cm Muck

Technical Description: A layer of muck 0.5 inch (1 cm) or more thick with value 3 or less and chroma 1 or less starting within 6 inches (15 cm) of the soil surface.

Applicable Subregions: Applicable to LRR D; for testing in LRR C. This indicator may be used in LRR C if indicators of hydrophytic vegetation and wetland hydrology are present and the landscape setting is appropriate (see the section on Problematic Hydric Soils in Chapter 5).

User Notes: Normally the muck layer is at the soil surface; however, it may occur at any depth within 6 inches (15 cm). Muck is sapric soil material with at least 12 to 18 percent organic carbon. Organic soil material is called muck (sapric soil material) if virtually all of the material has undergone sufficient decomposition to limit recognition of the plant parts. Hemic (mucky peat) and fibric (peat) soil materials do not qualify. To determine if muck is present, first remove loose leaves, needles, bark, and other easily identified plant remains. This is sometimes called leaf litter, a duff layer, or a leaf or root mat. Then examine for decomposed organic soil material. Generally, muck is black and has a greasy feel; sand grains should not be evident. Determination of this indicator is made below the leaf or root mat; however, root mats that meet the definition of hemic or fibric soil material are included in the decision-making process for indicators A1 (Histosols) and A2 (Histic Epipedon). See the glossary of *Field Indicators of Hydric Soils in the United States* for the definition of muck.

A11. Depleted Below Dark Surface (formerly F4)

Technical Description: A layer with a depleted or gleyed matrix that has 60 percent or more chroma 2 or less starting within 12 inches (30 cm) of the soil surface that has a minimum thickness of either:

a. 6 inches (15 cm), or
b. 2 inches (5 cm) if the 2 inches (5 cm) consists of fragmental soil material.

Loamy/clayey layer(s) above the depleted or gleyed matrix must have value 3 or less and chroma 2 or less. Sandy layer(s) above the depleted or gleyed matrix must have value 3 or less, chroma 1 or less, and at least 70 percent of the visible soil particles must be covered, coated or similarly masked with organic material.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: This indicator often occurs in Mollisols, but also applies to soils that have umbric epipedons and dark colored ochric epipedons. For soils that have dark colored epipedons greater than 12 inches (30 cm) thick, use indicator A12. Two percent or more distinct or prominent redox concentrations (Table 1), including iron/manganese soft masses, pore linings, or both, are required in soils that have matrix value/chroma of 4/1, 4/2, and 5/2 (Figure 3-2). See indicator A12 for the definition of a gleyed matrix. See the glossary of *Field Indicators of Hydric Soils in the United States* for the definition of fragmental soil material.

A *depleted matrix* is defined as:

> The volume of a soil horizon or subhorizon from which iron has been removed or transformed by processes of reduction and translocation to create colors of low chroma and high value. A, E, and calcic horizons may have low chromas and high values and may therefore be mistaken for a depleted matrix. However, they are excluded from the concept of depleted matrix unless common or many, distinct or prominent redox concentrations (Table 3-1) as soft masses or pore linings are present. In some places the depleted matrix may change color upon exposure to air (reduced matrix); this phenomenon is included in the concept of a depleted matrix. The following combinations of value and chroma identify a depleted matrix:
>
> - Matrix value 5 or more and chroma 1 with or without redox concentrations as soft masses and/or pore linings, or
> - Matrix value 6 or more and chroma 2 or 1 with or without redox concentrations as soft masses and/or pore linings, or
> - Matrix value 4 or 5 and chroma 2 with 2 percent or more distinct or prominent redox concentrations as soft masses and/or pore linings, or
> - Matrix value 4 and chroma 1 with 2 percent or more distinct or prominent redox concentrations as soft masses and/or pore linings (USDA Natural Resources Conservation Service 2002).

Figure 3-2. Illustration of values and chromas that require 2 percent or more redox concentrations and those that do not (for hue 10YR) to meet the definition of a depleted matrix.

Table 3-1
Tabular key for contrast determination using Munsell notation

Hues are the same (Δ h = 0)			*Hues differ by 2 (Δ h = 2)*		
Δ Value	**Δ Chroma**	**Contrast**	**Δ Value**	**Δ Chroma**	**Contrast**
0	≤1	Faint	0	0	Faint
0	2	Distinct	0	1	Distinct
0	3	Distinct	0	≥2	Prominent
0	≥4	Prominent	1	≤1	Distinct
1	≤1	Faint	1	≥2	Prominent
1	2	Distinct	≥2	---	Prominent
1	3	Distinct			
1	≥4	Prominent			
≤2	≤1	Faint			
≤2	2	Distinct			
≤2	3	Distinct			
≤2	≥4	Prominent			
3	≤1	Distinct			
3	2	Distinct			
3	3	Distinct			
3	≥4	Prominent			
≥4	---	Prominent			

Hues differ by 1 (Δ h = 1)			*Hues differ by 3 or more (Δ h ≥ 3)*		
Δ Value	**Δ Chroma**	**Contrast**	**Δ Value**	**Δ Chroma**	**Contrast**
0	≤1	Faint	Color contrast is prominent, except for low chroma and value.		Prominent
0	2	Distinct			
0	≥3	Prominent			
1	≤1	Faint			
1	2	Distinct			
1	≥3	Prominent			
2	≤1	Distinct			
2	2	Distinct			
2	≥3	Prominent			
≥3	---	Prominent			

Note: If both colors have values of ≤3 and chromas of ≤2, the color contrast is *Faint* (regardless of the difference in hue).
Adapted from USDA Natural Resources Conservation Service (2002)

A12. Thick Dark Surface (formerly F5)

Technical Description: A layer at least 6 inches (15 cm) thick with a depleted or gleyed matrix that has 60% or more chroma 2 or less starting below 12 inches (30 cm) of the surface. The layer(s) above the depleted or gleyed matrix must have value 2.5 or less and chroma 1 or less to a depth of at least 12 inches (30 cm) and value 3 or less and chroma 1 or less in any remaining layers above the depleted or gleyed matrix. Any sandy material above the depleted or gleyed matrix must have at least 70% of the visible soil particles covered, coated, or similarly masked with organic material.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: The soil has a depleted matrix or gleyed matrix below a black or very dark gray surface layer 12 inches (30 cm) or more thick (Figure 3-3). This indicator is most often associated with overthickened soils in concave landscape positions. Two percent or more distinct or prominent redox concentrations (Table 1), including iron/manganese soft masses, pore linings, or both, are required in soils that have matrix value/chroma of 4/1, 4/2, and 5/2 (Figure 3-2). See indicator A11 for the definition of a depleted matrix.

Soils that have a *gleyed matrix* have the following combinations of hue, value, and chroma and the soils are not glauconitic (USDA Natural Resources Conservation Service 2002):

1. Hue 10Y, 5GY, 10GY, 10G, 5BG, 10BG, 5B, 10B, or 5PB with value 4 or more and chroma 1; or
2. Hue 5G with value 4 or more and chroma 1 or 2; or
3. Hue N with value 4 or more (Figure 3-4).

In some places, the gleyed matrix may change color upon exposure to air (reduced matrix). This phenomenon is included in the concept of a gleyed matrix (USDA Natural Resources Conservation Service 2002).

Figure 3-3. This soil has a depleted matrix immediately below the dark surface, which is approximately 15 inches thick.

Figure 3-4. For hydric soil determinations, a gleyed matrix has the hues and chroma identified in this illustration with a value of 4 or more.

S1. Sandy Mucky Mineral

Technical Description: A mucky modified sandy mineral layer 2 inches (5 cm) or more thick starting within 6 inches (15 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: *Mucky* is a USDA texture modifier for mineral soils. The organic carbon content is at least 5 percent and ranges to as high as 14 percent for sandy soils. The percentage requirement is dependent upon the clay content of the soil; the higher the clay content, the higher the organic carbon requirement. For example, mucky fine sand has at least 5 percent but not more than about 12 percent organic carbon. See the glossary of *Field Indicators of Hydric Soils in the United States* for the definition of mucky modified mineral texture.

Material high in organic carbon could fall into one of three categories: organic, mucky mineral, or mineral. In lieu of laboratory data, the following estimation method can be used for soil material that is nearly saturated with water. Gently rub the nearly saturated soil material between forefinger and thumb. If upon the first or second rub the material feels gritty, it is mineral soil material. If after the second rub the material feels greasy, it is either mucky mineral or organic soil material. Now gently rub the material 2 or 3 more times. If after these additional rubs it feels gritty, it is mucky mineral soil material. If it still feels greasy, it is organic soil material (see indicators A1, A2, A3, or A9 in this chapter, or A10 in Chapter 5).

S4. Sandy Gleyed Matrix

Technical Description: A gleyed matrix that occupies 60 percent or more of a layer starting within 6 inches (15 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: See indicator A12 for the definition of a gleyed matrix. The gleyed matrix only has to be present within 6 inches (15 cm) of the surface. Soils with gleyed matrices are saturated for significant periods; therefore, no minimum thickness of gleyed layer is required.

S5. Sandy Redox

Technical Description: A layer starting within 6 inches (15 cm) of the soil surface that is at least 4 inches (10 cm) thick and has a matrix with 60 percent or more chroma 2 or less with 2 percent or more distinct or prominent redox concentrations as soft masses and/or pore linings (Figure 3-5).

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: Distinct and prominent are defined in the glossary of *Field Indicators of Hydric Soils in the United States* and Table 1. Redox concentrations include iron and manganese masses (reddish mottles) and pore linings (Vepraskas 1992). Included within the concept of redox concentrations are iron/manganese bodies as soft masses with diffuse boundaries. Common (2 to less than 20 percent) to many (20 percent or more) redox concentrations (USDA Natural Resources Conservation Service 2002) are required.

Figure 3-5. Redox features begin at about 2 inches.

S6. Stripped Matrix

Technical Description: A layer starting within 6 inches (15 cm) of the soil surface in which iron/manganese oxides and/or organic matter have been stripped from the matrix exposing the primary base color of soil materials. The stripped areas and translocated oxides and/or organic matter form a diffuse splotchy pattern of two or more colors. The stripped zones are 10 percent or more of the volume; they are rounded and approximately 0.5 to 1 inch (1 to 3 cm) in diameter.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: This indicator includes the indicator previously named streaking (Environmental Laboratory, 1987). Common to many (USDA Natural Resources Conservation Service 2002) areas of stripped (uncoated) soil materials 0.5 to 1 inch (1 to 3 cm) in size is a requirement. Commonly the splotches of color have value 5 or more and chroma 1 and/or 2 (stripped) and chroma 3 and/or 4 (unstripped). The matrix may lack the 3 and/or 4 chroma material. The mobilization and translocation of the oxides and/or organic matter is the important process and should result in splotchy coated and uncoated soil areas.

F1. Loamy Mucky Mineral

Technical Description: A mucky modified loamy or clayey mineral layer 4 inches (10 cm) or more thick starting within 6 inches (15 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: *Mucky* is a USDA texture modifier for mineral soils. The organic carbon is at least 8 percent, but can range to as high as 18 percent. The percentage requirement is dependent upon the clay content of the soil; the higher the clay content, the higher the organic carbon requirement. See the glossary of *Field Indicators of Hydric Soils in the United States* for the definition of mucky modified mineral texture. Loamy mucky soil material is difficult to distinguish in the field without laboratory testing.

F2. Loamy Gleyed Matrix

Technical Description: A gleyed matrix that occupies 60 percent or more of a layer starting within 12 inches (30 cm) of the soil surface (Figure 3-6).

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: Gley colors are not synonymous with gray colors. Gley colors are those colors that are on the gley pages (Gretag/Macbeth 2000). They have hue N, 10Y, 5GY, 10GY, 5G, 10G, 5BG, 10BG, 5B, 10B, or 5PB, with value 4 or more. The gleyed matrix only has to be present within 12 inches (30 cm) of the surface. Soils with gleyed matrices are saturated for significant periods; therefore, no minimum thickness of gleyed layer is required. See indicator A12 for the definition of a gleyed matrix.

Figure 3-6. This gleyed matrix begins at the soil surface.

F3. Depleted Matrix

Technical Description: A layer with a depleted matrix that has 60 percent or more chroma 2 or less that has a minimum thickness of either:

a. 2 inches (5 cm) if 2 inches (5 cm) is entirely within the upper 6 inches (15 cm) of the soil, or
b. 6 inches (15 cm) and starts within 10 inches (25 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: This is one of the most common indicators found at the boundary of wetlands. Redox concentrations including iron/manganese soft masses or pore linings, or both, are required in soils with matrix value/chroma of 4/1, 4/2, and 5/2 (Figures 3-7 and 3-8). Redox concentrations are not required for soils with matrix value 5 or more and chroma 1, or value 6 or more and chroma 2 or 1. The low chroma matrix must be caused by wetness and not a relict or parent material feature. See indicator A11 for the definition of a depleted matrix.

Figure 3-7. Indicator F3, Depleted Matrix. Redox concentrations within a low chroma matrix.

Figure 3-8. Redox concentrations at 2 inches.

F6. Redox Dark Surface

Technical Description: A layer at least 4 inches (10 cm) thick entirely within the upper 12 inches (30 cm) of the mineral soil that has:

a. matrix value 3 or less and chroma 1 or less and 2 percent or more distinct or prominent redox concentrations as soft masses or pore linings, or
b. matrix value 3 or less and chroma 2 or less and 5 percent or more distinct or prominent redox concentrations as soft masses or pore linings.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: This is a very common indicator used to delineate wetlands. Redox concentrations in high organic matter mineral soils with a dark surface are often small and difficult to see. The organic matter masks some or all of the concentrations that may be present. Careful examination is required to see what are often brownish redox concentrations in the darkened materials. In some instances, drying of the samples makes the concentrations (if present) easier to see. A hand lens may be helpful in seeing and describing small redox concentrations. Care should be taken to examine the interior of soil peds for redox concentrations. Dry colors, if used, need to have matrix chromas of 1 or 2, and the redox concentrations need to be distinct or prominent.

In soils that are wet because of subsurface saturation, the layer immediately below the dark epipedon should have a depleted or gleyed matrix (see indicators A11 and A12). Soils that are wet because of ponding or have a shallow, perched layer of saturation may not always have a depleted/gleyed matrix below the dark surface. This morphology has been observed in soils that have been compacted by tillage and other means. It is recommended that delineators evaluate the hydrologic source and examine and describe the layer below the dark colored epipedon when applying this indicator.

F7. Depleted Dark Surface

Technical Description: Redox depletions, with value 5 or more and chroma 2 or less, in a layer at least 4 inches (10 cm) thick entirely within the upper 12 inches (30 cm) of the mineral soil that has:

a. matrix value 3 or less and chroma 1 or less and 10 percent or more redox depletions, or
b. matrix value 3 or less and chroma 2 or less and 20 percent or more redox depletions.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: Care should be taken not to mistake mixing of an E or calcic horizon into the surface layer as depletions. The pieces of E and calcic horizons are not redox depletions. Knowledge of local conditions is required in areas where E and/or horizons that contain calcium carbonate may be present. In soils that are wet because of subsurface saturation, the layer immediately below the dark surface should have a depleted or gleyed matrix. Redox depletions should have associated microsites with redox concentrations that occur as Fe pore linings or masses within the depletion(s) or surrounding the depletion(s).

F8. Redox Depressions

Technical Description: In closed depressions subject to ponding, 5 percent or more distinct or prominent (Table 1) redox concentrations as soft masses or pore linings in a layer 2 inches (5 cm) or more thick entirely within the upper 6 inches (15 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: This indicator occurs on depressional landforms, such as vernal pools, playa lakes, rainwater basins, and potholes; but not microdepressions on convex landscapes. Closed depressions often occur within flats or floodplain landscapes. Note that there is no color requirement for the soil matrix.

F9. Vernal Pools

Technical Description: In closed depressions subject to ponding (Figure 3-9), presence of a depleted matrix with 60 percent or more chroma 2 or less in a layer 2 inches (5 cm) thick entirely within the upper 6 inches (15 cm) of the soil surface.

Applicable Subregions: Applicable throughout the Arid West Region (LRR B, C, and D).

User Notes: Most often soils pond water for two reasons: they occur on landscape positions that collect water and they have a restrictive layers that prevents water from moving downward through the soil. Normally this indicator occurs at the soil surface. Redox concentrations including iron/manganese soft masses or pore linings, or both, are required in soils that have matrix value/chroma of 4/1, 4/2, and 5/2. See indicator A11 for the definition of a depleted matrix.

Figure 3-9. Inundation in a vernal pool.

Use of Existing Soil Data

Soil Surveys

Soil surveys are available for many areas of the Arid West and can provide useful information regarding soil properties and soil moisture conditions for an area. Soil surveys in the Arid West, however, vary considerably in the mapping scale and the amount of ground-truthing used to document the survey. A list of available soil surveys is located at http://soils.usda.gov/survey/online_surveys/. Most detailed surveys in the region are mapped at a scale of 1:24,000 (2.64 inches/mile). At this scale, the smallest soil areas delineated are about 5 acres in size. Map units do not contain only one soil type, but may have several inclusions of soil with similar properties and also soils that are quite dissimilar. Those soils that are hydric are noted in the *Hydric Soils List* published as part of the survey report. The survey will provide information as to whether an area contains predominantly hydric or non-hydric soils, but it does not provide site-specific information. The soil survey provides valuable information but it does not preclude the need for on-site examination of a site. Some soil surveys in the Arid West are mapped at scales ranging from 1:63,360 to 1:250,000. Here the smallest areas delineated range anywhere from 25 to 100 acres in size. The surveys provide helpful information but cannot be used alone to make a hydric soil determination.

Hydric Soils Lists

Hydric Soils Lists are developed for each of the detailed soil surveys. Using criteria approved by the National Technical Committee for Hydric Soils, these lists rate each soil component as either hydric or non-hydric based on soil property data. If the soil is rated as hydric, information is provided regarding which hydric criteria are met and on what landform the soil typically occurs. Hydric Soils Lists are very useful. Remember, however, that these soil surveys only separate different soil areas down to about five acres in size. The identification of a soil as hydric on a hydric soils list should be used as a tool, indicating that hydric soil will likely be found within a given area. However, not all areas within a polygon identified as having hydric soils may be hydric.

Hydric Soils Lists available for individual detailed soil surveys are known as Local Hydric Soils Lists. They are published for each survey area. Local Hydric Soils Lists have been compiled into a National Hydric Soils List. However, use of Local Hydric Soils Lists is preferred since they are more current and reflect local variations in soil properties. Local Hydric Soils Lists may be available through the NRCS Electronic Field Office Technical Guide (eFOTG) for a particular state and county (http://www.nrcs.usda.gov/technical/efotg/index.html) or through state or county NRCS offices.

4 – Wetland Hydrology Indicators

Introduction

Wetland hydrology indicators are used in combination with indicators of hydric soil and hydrophytic vegetation to determine whether an area is a wetland under the Corps Manual. Soils and vegetation generally reflect a site's long-term to medium-term wetness history. The function of wetland hydrology indicators is to provide evidence that the site has a *continuing* wetland hydrologic regime and that hydric soils and hydrophytic vegetation are not relicts of a past hydrologic regime. Therefore, to the extent possible, wetland hydrology indicators are evidence of ongoing or recent flooding, ponding, or soil saturation or provide other evidence that hydric soils and hydrophytic vegetation reflect contemporary site conditions.

Hydrology indicators are the most ephemeral of wetland indicators. Those involving direct observation of surface water or saturated soils are usually present only during the normal wet portion of the growing season and may be absent during the dry season or during drier-than-normal years. The Arid West is characterized by extended dry seasons in most years and by extreme temporal and spatial variability in rainfall, even in "normal" years. Many wetlands in the region are dry for much of the year and, at those times, may lack hydrology indicators entirely. Therefore, *lack of an indicator is not evidence for the absence of wetland hydrology*. See Chapter 5 (Difficult Wetland Situations in the Arid West) for help in identifying wetlands that may lack wetland hydrology indicators during the dry season or drought years. On the other hand, some indicators could be present on a nonwetland site immediately after a heavy rain or during a period of unusually high precipitation, river stages, runoff, or snowmelt. Therefore, it is important to take weather conditions prior to the site visit into account to minimize both false-positive and false-negative wetland hydrology decisions. An understanding of normal seasonal and annual variations in rainfall, temperature, and other climatic conditions is essential in interpreting hydrology indicators in the Arid West. Some useful sources of climatic data are described in Chapter 5.

When wetland hydrology indicators are absent from an area that has indicators of hydric soil and hydrophytic vegetation, further information may be needed to evaluate wetland hydrology. If possible, one or more site visits should be scheduled to coincide with the normal wet portion of the growing season, the period of the year when the presence or absence or wetland hydrology indicators is most likely to reflect the true wetland/nonwetland status of the site. In addition, analytical techniques involving aerial photography or other remote sensing data, gauge data, runoff estimates, scope-and-effect equations for ditches and subsurface drain lines, or groundwater modeling may also be useful (e.g., USDA Natural Resources Conservation Service 1997). On highly disturbed or problematic sites, direct hydrologic monitoring may be needed to determine whether wetland hydrology is present (U. S. Army Corps of Engineers 2005). See Chapter 5 for further information.

Wetland Hydrology Indicators

In this chapter, wetland hydrology indicators are presented in four groups. Indicators in Group A are based on the direct observation of surface water or groundwater during a site visit. Group B consists of indirect evidence that the site was flooded or ponded recently, although the site may not be inundated currently. These indicators include water marks, drift deposits, sediment deposits, and similar features. Group C consists of indirect evidence that the soil was saturated recently. Some of these indicators, such as oxidized rhizospheres surrounding living roots and the presence of reduced iron or sulfur in the soil profile, indicate that the soil has been saturated for an extended period. Group D consists of vegetation and soil features that indicate contemporary rather than historical wet conditions. Wetland hydrology indicators are intended as one-time observations of site conditions that provide support for wetland determinations in areas where hydric soils and hydrophytic vegetation are present.

Within each group, indicators are divided into two categories – *primary* and *secondary* – based on their estimated reliability in this region. One primary indicator from any group is sufficient to conclude that wetland hydrology is present; the area is a wetland if indicators of hydric soil and hydrophytic vegetation are also present. In the absence of a primary indicator, two or more secondary indicators from any group are required to conclude that wetland hydrology is present. Indicators of wetland hydrology include, but are not necessarily limited to, those listed in Table 4-1 and described on the following pages. Other evidence of wetland hydrology may also be used with appropriate documentation.

Table 4-1. List of wetland hydrology indicators for the Arid West		
Indicator	**Category**	
	Primary	**Secondary**
Group A – Observation of Surface Water or Saturated Soils		
A1 – Surface water	X	
A2 – High water table	X	
A3 – Saturation	X	
Group B – Evidence of Recent Inundation		
B6 – Surface soil cracks	X	
B7 – Inundation visible on aerial imagery	X	
B8 – Water-stained leaves	X	
B10 – Biotic crust	X	
B11 – Aquatic invertebrates	X	
B12 – Crayfish burrows	X	
B1 – Water marks	X	X (riverine)
B2 – Sediment deposits	X	X (riverine)
B3 – Drift deposits	X	X (riverine)
B9 – Drainage patterns		X
Group C – Evidence of Recent Soil Saturation		
C1 – Hydrogen sulfide odor	X	
C2 – Oxidized rhizospheres along living roots	X	
C4 – Presence of reduced iron	X	
C6 – Recent iron reduction in plowed soils	X	
C7 – Muck surface	X	
C8 – Saturation visible on aerial imagery	X	
C3 – Dry-season water table		X
C5 – Salt deposits		X
C9 – Mud casts		X
Group D – Evidence from Other Site Conditions or Data		
D4 – Shallow aquitard	X	
D7 – FAC-neutral test		X

Group A – Observation of Surface Water or Saturated Soils

Indicator: A1 – Surface water

Category: Primary

General Description: This indicator consists of the direct, visual observation of surface water (flooding or ponding) during a site visit (Figure 4-1).

Cautions and User Notes: Care must be used in applying this indicator because surface water may be present on a nonwetland site immediately after a rainfall event or during periods of abnormally high precipitation, runoff, tides, or river stages. Surface water observed during the nongrowing season may be an acceptable indicator if experience and professional judgment suggest that wet conditions normally extend into the growing season. Surface water may be absent from a wetland during the normal dry season or during extended periods of drought. Even under normal rainfall conditions, wetlands may have surface water present only one year in two (i.e., ≥50% probability). In addition, inundation may be infrequent, brief, or entirely lacking in groundwater-dominated wetland systems.

Figure 4-1. Wetland with surface water present.

Indicator: A2 – High water table

Category: Primary

General Description: This indicator consists of the direct, visual observation of the water table ≤12 inches (30 cm) below the surface in a soil pit, auger hole, or shallow monitoring well (Figure 4-2). This indicator includes perched water tables and discharge water tables (e.g., in seeps) where water may enter the hole from the surface soil layers.

Cautions and User Notes: Sufficient time must be allowed for water to drain into a newly dug hole and to stabilize at the water-table level. The required time will vary depending upon soil texture. In some cases, the water table can be determined by examining the wall of the soil pit and identifying the upper level at which water is seeping into the pit. A water table within 12 inches of the surface observed during the nongrowing season may be an acceptable indicator if experience and professional judgment suggest that wet conditions normally extend into the growing season. Care must be used in interpreting this indicator because water-table levels normally vary seasonally and are a function of both recent and long-term precipitation. Even under normal rainfall conditions, wetlands may have water tables within 12 inches of the surface only one year in two (i.e., ≥50% probability). For an accurate determination of the water-table level, the soil pit, auger hole, or well should not penetrate any restrictive soil layer capable of perching water near the surface.

Figure 4-2. High water table observed in a soil pit.

Indicator: A3 – Saturation

Category: Primary

General Description: Visual observation of saturated or near-saturated conditions ≤12 inches (30 cm) below the soil surface as indicated by (1) glistening of water on soil ped faces and broken interior surfaces, or (2) release of pore water when the soil sample is gently shaken or squeezed. This indicator must be associated with an existing water table located immediately below the saturated zone.

Cautions and User Notes: This indicator reflects saturated or near-saturated conditions, indicating that the soil sample was taken either below the water table or within the capillary fringe above the water table. Recent rainfall events and the proximity of the water table at the time of sampling should be considered in applying this indicator. Water glistening in soil cracks or on ped faces does not meet this indicator unless ped interiors are also saturated as indicated by glistening on broken interior surfaces (Figure 4-3). Gentle shaking is effective in releasing pore water mainly in coarse-textured soil materials. Shaking a sample in the palm of the hand produces free water by rearranging soil particles and collapsing water-filled voids between particles. Gentle squeezing is most effective in soils with high organic content.

Figure 4-3. Water glistens on the surface of a saturated soil sample.

Group B – Evidence of Recent Inundation

Indicator: B6 – Surface soil cracks

Category: Primary

General Description: Surface soil cracks consist of shallow cracks that form when mineral or organic sediments dry and shrink, often creating a network of cracks or small polygons (Figure 4-4).

Cautions and User Notes: This indicator is usually seen in fine sediments in seasonally ponded depressions, lake fringes, or floodplains. Use caution in areas of recent sediment deposition in nonwetlands. This indicator is distinguished from biotic crusts by the lack of visible algal remains or flakes on the soil surface.

Figure 4-4. Surface soil cracks in a seasonally ponded wetland.

Indicator: B7 – Inundation visible on aerial imagery

Category: Primary

General Description: One or more recent aerial photographs or satellite images show the site to be inundated.

Cautions and User Notes: Care must be used in applying this indicator because surface water may be present on a nonwetland site immediately after a heavy rain or during periods of unusually high precipitation, runoff, tides, or river stages. Surface water observed during the nongrowing season may be an acceptable indicator if experience and professional judgment suggest that wet conditions normally extend into the growing season. Surface water may be absent from a wetland during the normal dry season or during extended periods of drought. Even under normal rainfall conditions, wetlands may have surface water present only one year in two (i.e., ≥50% probability). If 5 or more years of aerial photography are available, the procedure described by the USDA Natural Resources Conservation Service (1997) is recommended.

Indicator: B8 – Water-stained leaves

Category: Primary

General Description: Water-stained leaves are fallen leaves that have turned dark grayish or blackish in color due to inundation for long periods.

Cautions and User Notes: Water-stained leaves are not commonly seen in arid areas but can be found in depressional wetlands and along streams in shrub-dominated or forested habitats. Staining occurs in leaves that are in contact with the soil surface while inundated for long periods. Water-stained leaves maintain their blackish or dark grayish colors when dry. They should contrast strongly with fallen leaves in nearby upland landscape positions.

Indicator: B10 – Biotic crust

Category: Primary

General Description: This indicator includes ponding-remnant biotic crusts, benthic microflora, and the dried remains of free-floating algae left on or near the soil surface after dewatering.

Cautions and User Notes: Biotic crusts (also known as cryptobiotic or cryptogamic crusts) are soil aggregates held together by microorganisms and the substances they produce. Organisms producing these crusts include blue-green and green algae, diatoms, lichens, and fungi. Ponding-remnant crusts form in areas that previously held standing water, such as around the margins of drying wetland pans (Brostoff, Lichvar, and Sprecher 2001; Brostoff 2002) (Figures 4-5, 4-6, and 4-7). Upon drying, they often form polygons with characteristic upturned edges and often have a darker surface layer than the soil materials below. They develop in open areas where vegetation is patchy or scattered and are common in sparsely vegetated playas and pans. Benthic microflora (also known as microphytobenthos) are algae or diatoms that form soil aggregates or layers in coastal or saline wetlands (Figure 4-8). In addition, free-floating algae (Figure 4-9) may leave dried remains on the soil surface or on low vegetation after dewatering. Certain types of biotic crusts, such as rough-surfaced or pedicellate crusts (Figure 4-10) and asphalt-like crusts (Figure 4-11), do not develop or are destroyed in areas that become inundated. These crusts may or may not occur in saturated areas, but they are negative indicators of standing water.

Figure 4-5. Ponding-remnant biotic crust showing typical polygon formation with up-turned edges and the surface layer darker than those below. Dried algal surfaces distinguish these from mud cracks.

Figure 4-6. Ponding-remnant biotic crust showing polygons and curls detached from the underlying sediments.

Figure 4-7. Ponding-remnant biotic crust showing domed surface with dried algal caps.

Figure 4-8. Dark-colored material is benthic microflora consisting of blue-green and green algae in a hypersaline intertidal marsh.

Figure 4-9. Remains of floating algal material in a seasonally inundated *Juncus*-dominated marsh.

Figure 4-10. Rough or pedicellate crust indicates no recent history of standing water. This type of crust is not an indicator of wetland hydrology.

Figure 4-11. Asphalt-like crust (rectangular areas were experimentally removed) indicates no recent history of standing water. This type of crust is not an indicator of wetland hydrology.

Indicator: B11 – Aquatic invertebrates

Category: Primary

General Description: Presence of live individuals or dead remains (e.g., shells, chitinous exoskeletons, eggs) of aquatic invertebrates, such as aquatic snails, clams, insects, ostracods, and other crustaceans on the soil surface (Figure 4-12).

Cautions and User Notes: Shells and exoskeletons are resistant to tillage but may be moved by equipment beyond the boundaries of the wetland. They may also persist in the soil for many years after dewatering. Use caution in areas containing relict ostracod shells and other remains, such as on historic lake terraces in the Great Basin.

Figure 4-12. Shells of aquatic snails in a seasonally ponded fringe wetland.

Indicator: B12 – Crayfish burrows

Category: Primary

General Description: Presence of crayfish burrows, as indicated by openings in soft ground up to 2 inches (5 cm) in diameter, often surrounded by chimney-like mounds of excavated mud.

Cautions and User Notes: Both native and introduced crayfishes can be found in the Arid West Region. Crayfish breathe with gills and require at least periodic contact with water. Crayfish burrows are usually found near streams and ponds where the seasonal high water table is at or near the surface (Figure 4-13).

Figure 4-13. Crayfish burrow.

Indicator: B1 – Water marks

Category: Primary (Secondary in riverine situations)

General Description: Water marks are discolorations or stains on bark of woody vegetation, rocks, bridge pillars, buildings, fences, or other fixed objects as a result of inundation (Figure 4-14).

Cautions and User Notes: When several water marks are present, the highest reflects the maximum extent of recent inundation. Water marks indicate a water-level elevation and can be extrapolated from nearby objects across lower elevation areas. Use caution with water marks that may have been caused by extreme, infrequent, or very brief flooding events. In regulated systems, such as reservoirs, water-level records can be used to distinguish unusually high pools from normal operating levels. Streams and dry washes in arid regions tend to have highly variable flows, responding quickly to rainfall events and returning to more normal levels in a few hours or days. Therefore, water marks in riverine situations may reflect higher-than-normal flows and should be considered secondary indicators of wetland hydrology.

Figure 4-14. Water marks on a boulder.

Indicator: B2 – Sediment deposits

Category: Primary (Secondary in riverine situations)

General Description: Sediment deposits are thin layers or coatings of mineral material (e.g., silt or clay) or organic matter (e.g., pollen), sometimes mixed with other detritus, remaining on plant stems or leaves, rocks, and other objects after inundation and dewatering.

Cautions and User Notes: Sediment deposits may remain for a considerable period before being removed by precipitation or subsequent inundation. Sediment deposits on vegetation or other objects indicate the minimum inundation level. This level can be extrapolated across lower elevation areas. Use caution with sediment left after infrequent high flows or very brief flooding events. This indicator does not include thick accumulations of sand or gravel in fluvial channels that may reflect historic flow conditions or recent extreme events. In the mountains, use caution with sediment that may be left following spring snowmelt when silt and other material trapped in the snowpack is deposited directly on the ground surface. Streams and dry washes in arid regions tend to have highly variable flows, responding quickly to rainfall events and returning to more normal levels in a few hours or days. Therefore, sediment deposits in riverine situations may reflect higher-than-normal flows and should be considered secondary indicators of wetland hydrology.

Indicator: B3 – Drift deposits

Category: Primary (Secondary in riverine situations)

General Description: Drift deposits consist of rafted debris that has been deposited on the ground surface or entangled in vegetation or other fixed objects. Debris consists of remnants of vegetation (e.g., branches, stems, and leaves), man-made litter, or other waterborne materials. Drift material may be deposited at or near the high water line in ponded or flooded areas, piled against the upstream side of trees, rocks, and other fixed objects, or widely distributed within the dewatered area (Figure 4-15).

Cautions and User Notes: Deposits of drift material are often found adjacent to streams or other sources of flowing water in wetlands. They also occur in tidal marshes, along lake shores, and in other ponded areas. The elevation of a drift line can be extrapolated across lower elevation areas. Use caution with drift lines that may have been caused by extreme, infrequent, or very brief flooding events. Streams and dry washes in arid areas tend to have highly variable flows, responding quickly to rainfall events and returning to more normal levels in a few hours or days. Therefore, drift deposits in riverine situations may reflect higher-than-normal flows and should be considered secondary indicators of wetland hydrology. Use caution as drift material can persist for many years in an arid climate.

Figure 4-15. Drift deposit of leaves in a seasonally ponded wetland.

Indicator: B9 – Drainage patterns

Category: Secondary

General Description: This indicator consists of flow patterns visible on the soil surface or eroded into the soil, low vegetation bent over in the direction of flow, absence of leaf litter or small woody debris due to flowing water, and similar evidence that water flowed across the ground surface.

Cautions and User Notes: Drainage patterns are usually seen in areas where water flows over a flat or concave surface, such as in areas adjacent to streams (Figure 4-16), in seeps, vegetated swales, and tidal flats. Use caution in areas affected by recent extreme or unusual flooding events.

Figure 4-16. Vegetation bent over in the direction of water flow across a stream terrace.

Group C – Evidence of Recent Soil Saturation

Indicator: C1 – Hydrogen sulfide odor

Category: Primary

General Description: A hydrogen sulfide (rotten egg) odor within 12 inches (30 cm) of the soil surface.

Cautions and User Notes: To produce hydrogen sulfide, the soil must be saturated at the time of sampling and must have been saturated long enough to become highly reduced. These soils are often permanently saturated and anoxic at or near the surface. To apply this indicator, dig the soil pit no deeper than 12 inches to avoid release of hydrogen sulfide from deeper in the profile.

Indicator: C2 – Oxidized rhizospheres along living roots

Category: Primary

General Description: This indicator consists of iron oxide coatings or plaques on the surfaces of living roots and/or iron oxide coatings or linings on soil pores immediately surrounding living roots within 12 inches (30 cm) of the soil surface (Figure 4-17).

Cautions and User Notes: Iron oxide coatings are the result of oxygen leakage from living roots into the surrounding anoxic soil, causing oxidation of ferrous iron present in the soil solution. They are evidence of saturated and reduced soil conditions during the plant's lifetime. Iron concentrations or plaques may form on the immediate root surface or may coat the soil pore adjacent to the root. In either case, the oxidized iron must be associated with living roots to indicate contemporary wet conditions. Care must be taken to distinguish iron oxide coatings from organic matter associated with plant roots. Viewing with a hand lens may help distinguish mineral from organic material. Iron coatings sometimes show concentric layers in cross section and may transfer iron stains to the fingers when rubbed.

Figure 4-17. Iron oxide plaque (orange coating) on a living root. Iron also coats the channel or pore from which the root was removed.

Indicator: C4 – Presence of reduced iron

Category: Primary

General Description: Presence of reduced (ferrous) iron in the upper 12 inches (30 cm) of the soil profile, as indicated by a ferrous iron test or by the presence of a soil that changes color upon exposure to the air.

Cautions and User Notes: The reduction of iron occurs in soils that have been saturated long enough to become anoxic and chemically reduced. Ferrous iron is converted to oxidized forms when saturation ends. Thus, the presence of ferrous iron indicates that the soil is saturated and anoxic at the time of sampling, and has been saturated for an extended period. The presence of ferrous iron can be verified with alpha, alpha-dipyridyl dye (Figure 4-18, see NRCS Hydric Soils Technical Note 8, http://soils.usda.gov/use/hydric/ntchs/tech_notes/note8.html) or by observing a soil that changes color upon exposure to air (see the section on Problematic Hydric Soils in Chapter 5). Soil samples should be tested or examined immediately after opening the soil pit because ferrous iron may oxidize and colors change soon after the sample is exposed to the air. Use caution in soils that contain little weatherable iron.

Figure 4-18. When alpha, alpha-dipyridyl dye is applied to a soil containing reduced iron, a positive reaction is indicated by a pink or red coloration to the treated area.

Indicator: C6 – Recent iron reduction in plowed soils

Category: Primary

General Description: Presence of redox concentrations as pore linings in the surface layer of soils cultivated within the last two years.

Cautions and User Notes: Cultivation destroys or breaks up redox features in the plow zone. The presence of redox features indicates that the soil was saturated and reduced since the last episode of cultivation (Figure 4-19). Redox features often form around organic material incorporated into the plowed soil. Use caution with relict features that may be broken up but not destroyed by plowing.

Figure 4-19. Redox concentrations in a recently cultivated soil.

Indicator: C7 – Muck surface

Category: Primary

General Description: This indicator consists of a layer of muck on the soil surface.

Cautions and User Notes: Muck is highly decomposed organic material. It has low bulk density and a greasy feel. Any thickness of organic material on the soil surface is sufficient to meet this indicator. In an arid climate, muck accumulates only where soils are saturated to the surface most of the year. Muck that is dry for extended periods will oxidize and disappear.

Indicator: C8 – Saturation visible on aerial imagery

Category: Primary

General Description: One or more recent aerial photographs or satellite images show soil saturation.

Cautions and User Notes: This indicator is useful when plant cover is sparse or absent and the ground surface is visible from above. Saturated areas generally appear as darker patches within the field (Figure 4-20). Saturated soil signatures should correspond to mapped or field-verified hydric soils, depressions or drainage patterns, differential crop management, or other evidence of a seasonal high water table. Inundated and saturated areas may be present in the same field (see indicator B7) and difficult to distinguish; however, both are primary indicators. Care must be used in applying this indicator because saturation may be present on a nonwetland site immediately after a heavy rain or during periods of abnormally high precipitation, runoff, tides, or river stages. Saturation observed during the nongrowing season may be an acceptable indicator if experience and professional judgment suggest that wet conditions normally extend into the growing season. Saturation may be absent from a wetland during the normal dry season or during extended periods of drought. Even under normal rainfall conditions, wetlands may be saturated only one year in two (i.e., ≥50% probability). If 5 or more years of aerial photography are available, the procedure described by the Natural Resources Conservation Service (1997) is recommended. Use caution, as similar signatures may be caused by factors other than saturation. Onsite verification is recommended.

Figure 4-20. Aerial photograph of an agricultural field with saturated soils indicated by darker colors.

Indicator: C3 – Dry-season water table

Category: Secondary

General Description: This indicator consists of the visual observation of the water table between 12 – 24 inches (30 – 60 cm) of the surface during the normal dry season or during a drier-than-normal year.

Cautions and User Notes: Due to normal seasonal fluctuations, water tables in wetlands often drop below 12 inches during the summer dry season. A water table between 12 – 24 inches during the dry season, or during an unusually dry year, indicates a normal wet-season water table within 12 inches. Sufficient time must be allowed for water to drain into a newly dug hole and to stabilize at the water-table level. The required time will vary depending upon soil texture. In some cases, the water table can be determined by examining the wall of the soil pit and identifying the upper level at which water is seeping into the pit. For an accurate determination of the water-table level, the soil pit, auger hole, or well should not penetrate any restrictive soil layer capable of perching water near the surface. Water tables in wetlands often drop well below 24 inches during dry periods. Therefore, a dry-season water table below 24 inches does not necessarily indicate a lack of wetland hydrology. See Chapter 5 (section on Wetlands that Periodically Lack Indicators of Wetland Hydrology) for determining average dry-season dates and drought periods.

Indicator: C5 – Salt deposits

Category: Secondary

General Description: Salt deposits are whitish or brownish deposits of salts that accumulate on the ground surface through the capillary action and evaporation of groundwater (Figure 4-21).

Cautions and User Notes: Salt deposits occur in areas of seasonal moisture deficit where evaporation brings capillary water to the surface. They occur in depressions, seeps, flats, lake fringes, tidal areas, and on floodplain terraces after surface water has receded and the water table is near the surface.

Figure 4-21. Salt deposits (25-cent coin for scale).

Indicator: C9 – Mud casts

Category: Secondary

General Description: This indicator consists of dried casts or impressions made in the soil by vehicles or other heavy objects when soils were saturated or nearly saturated.

Cautions and User Notes: Mud casts generally occur on wet flats, in seeps, and on concave surfaces, such as depressions and swales, and should be clearly deeper and more pronounced in the wetland than in surrounding upland areas. Off-road vehicles, livestock, and human footprints all may form deep impressions in saturated soils. Use caution in recently plowed soils, where impressions may be due to compaction rather than saturation.

Group D – Evidence from Other Site Conditions or Data

Indicator: D4 – Shallow aquitard

Category: Primary

General Description: This indicator occurs in and around the margins of depressions, such as vernal pools, and consists of the presence of an aquitard within the soil profile that is potentially capable of perching water within 12 inches (30 cm) of the surface. Indicators of hydrophytic vegetation and hydric soil must also be present.

Cautions and User Notes: An aquitard is a relatively impermeable soil layer or bedrock that slows the downward infiltration of water and can produce a perched water table, generally in flat or depressional landforms. Potential aquitards include fragipans, cemented layers, dense glacial till, lacustrine deposits, and clay layers. Often redoximorphic features are evident in the layer(s) above the aquitard.

Indicator: D7 – FAC-neutral test

Category: Secondary

General Description: The plant community passes the FAC-neutral test.

Cautions and User Notes: The FAC-neutral test is performed by compiling a list of dominant plant species across all strata in the community, and dropping from the list any species with a Facultative indicator status (i.e., FAC, FAC–, and FAC+). The FAC-neutral test is met if >50% of the remaining dominant species are rated FACW and/or OBL. This indicator may be used in communities that contain no FAC dominants. If there are an equal number of dominants that are OBL and FACW versus FACU and UPL, nondominant species should be considered. This indicator is only applicable to wetland hydrology determinations.

5 – Difficult Wetland Situations in the Arid West

Introduction

Some wetlands can be difficult to identify because wetland indicators may be missing at times due to natural processes or recent disturbances. This chapter provides guidance for making wetland determinations in difficult-to-identify wetland situations in the Arid West. It includes regional examples of Problem Area wetlands and Atypical Situations as defined in the Corps Manual, as well as other situations that can make wetland delineation more challenging. Problem Area wetlands are defined as naturally occurring wetland types that periodically lack indicators of hydrophytic vegetation, hydric soil, or wetland hydrology due to normal seasonal or annual variability. In addition, some Problem Area wetlands may permanently lack certain indicators due to the nature of the soils or plant species on the site. Atypical Situations are defined as wetlands in which vegetation, soil, or hydrology indicators are absent due to disturbance by recent human activities or natural events. In addition, this chapter addresses certain procedural problems (e.g., sparse or patchy vegetation) that can make wetland determinations in the Arid West difficult or confusing. The chapter is organized into the following sections:

1. Problematic Hydrophytic Vegetation
2. Problematic Hydric Soils
3. Wetlands that Periodically Lack Indicators of Wetland Hydrology

The list of problematic wetland situations presented in this chapter is not intended to be exhaustive and other similar situations may exist in the region. See the Corps Manual for general guidance. In general, *wetland determinations on difficult or problematic sites must be based on the best information available to the field inspector, interpreted in light of his or her personal experience and knowledge of the ecology of wetlands in the region*.

Problematic Hydrophytic Vegetation

Many factors affect the structure and composition of plant communities in the Arid West, including climatic variability, ephemeral water sources, saline soils, and human land-use practices. As a result, some wetlands may exhibit indicators of hydric soil and wetland hydrology but lack any of the hydrophytic vegetation indicators presented in Chapter 2, at least at certain times. To identify and delineate these wetlands may require special sampling procedures or additional analysis of factors affecting the site. The following procedure addresses several examples of problematic vegetation situations in the Arid West.

Recommended Procedure

Problematic hydrophytic vegetation can be identified and delineated using a combination of observations made in the field and/or supplemental information from the scientific literature and other sources. These procedures should be applied only where indicators of hydric soil and wetland hydrology are present, unless one or both of these factors is also problematic, but no indicators of hydrophytic vegetation are evident. The following procedures are recommended:

1. Verify that at least one indicator of hydric soil and one primary or two secondary indicators of wetland hydrology are present. If indicators of either hydric soil or wetland hydrology are absent, the area is likely nonwetland. If indicators are present, proceed to Step 2 (Specific Problematic Vegetation Situations) or Step 3 (General Approaches to Problematic Hydrophytic Vegetation) and follow the suggested steps.

2. Specific Problematic Vegetation Situations

    a. *Temporal Shifts in Vegetation* – As described in Chapter 2, the species composition of some wetland plant communities in the Arid West can change in response to seasonal weather patterns and long-term climatic fluctuations. Wetland types that are influenced by these shifts include vernal pools, playa edges, seeps, and springs. Lack of hydrophytic vegetation during dry periods should not immediately eliminate a site from further consideration as a wetland. To the extent possible, the hydrophytic vegetation decision should be based on the plant community that is normally present during the wet portion of the growing season in a normal rainfall year. A site qualifies for further consideration if the plant community at the time of sampling fails the dominance test and/or prevalence index but indicators of hydric soil and wetland hydrology are present. The following sampling and analytical approaches are recommended in these situations:

        1. Seasonal Shifts in Plant Communities

            i. Use off-site data sources to determine whether the plant community that is normally present during the wet portion of the growing season is hydrophytic. Appropriate data sources include springtime aerial photography, NWI maps, soil survey reports, remotely sensed data, public interviews, and previous reports about the site. If necessary, re-examine the site at a later date to verify the hydrophytic vegetation determination.

            ii. Examine the site for identifiable plant remains, either alive or dead, or other evidence that the plant community that was present earlier in the same growing season was hydrophytic.

            iii. If possible, return to the site during the normal wet portion of the spring growing season and re-examine the site for indicators of hydrophytic vegetation.

            iv. If the vegetation on the site is substantially the same as that on a wetland reference site having similar soils and known wetland hydrology, then consider the vegetation to be hydrophytic (see step *3b* in this procedure).

        2. Long-Term Drought Conditions (lasting more than one growing season)

            i. Investigate climate records (e.g., WETS tables, drought indices) to determine if the area is under the influence of a long-term drought (for more information, see the section on Wetlands that Periodically Lack Indicators of Wetland Hydrology later in this chapter). If so, evaluate any off-site data that provide information on the plant community that exists on the site during normal years, including aerial photography, NWI maps, other remote sensing data, soil survey reports, public interviews, and previous site reports. Determine whether the vegetation that is present during normal years is hydrophytic.

ii. If the vegetation on the drought-affected site is substantially the same as that on a wetland reference site in the same general area having similar soils and known wetland hydrology, then consider the vegetation to be hydrophytic (see step *3b* in this procedure).

b. *Sparse and Patchy Vegetation* – Many wetlands located within the intermountain basins of the Arid West have sparse or patchy vegetation cover. Examples include some playas, clay pans, and saline wetlands that may be influenced by seasonal ponding of water or discharge of groundwater along their edges. These areas may have indicators of hydric soils and wetland hydrology, but the vegetation is not continuous across or along the boundary of the wetland. Delineation of these areas can be confusing due to the interspersion of wetlands and other potential waters of the United States. For delineation purposes, an area should be considered vegetated if there is ≥5% areal cover of plants. Unvegetated areas have <5% plant cover. Patchy vegetation is a mosaic of both vegetated and unvegetated areas (Figure 5-1). In some cases, the unvegetated portions of a site may be considered as other waters of the US if they exhibit ordinary high water (OHW) indicators (33 CFR 328.3). Approved OHW indicators are available from the appropriate District regulatory office.

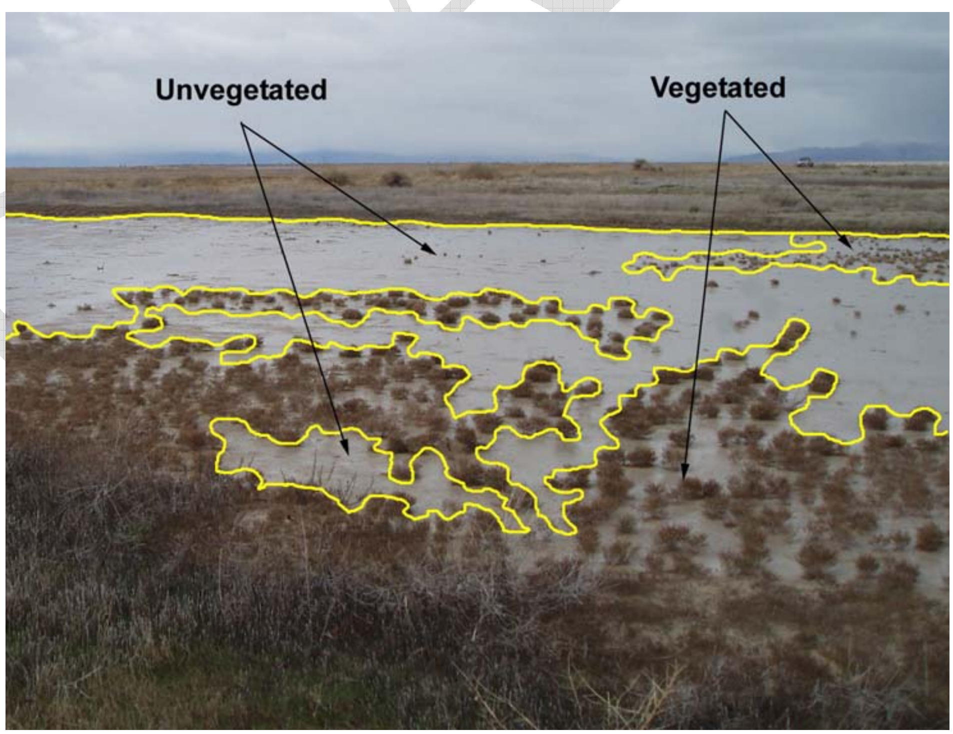

Figure 5-1. Example of sparse and patchy plant cover in a wetland. Areas labeled as vegetated have ≥5% plant cover.

Playas are one example of this problematic situation. Playas typically are located at the bottom of the drainage area in a basin or watershed. Their surfaces can be classified generally into two types: hard and soft (Stone 1956, Brostoff, Lichvar, and Sprecher 2001). In many locations, the main or central part of the playa surface is unvegetated and may not show the redoximorphic features of a hydric soil. The unvegetated parts of hard playas are potential waters of the US if they exhibit OHW indicators. However, the edges of the soft playas and some hard playas are vegetated and have wetland features. These edges can have sparse or patchy vegetation cover.

The following procedure is recommended in these situations:

1. Develop a site map showing the vegetated and unvegetated areas of concern. Sampling points should be placed in representative locations within both the vegetated and unvegetated areas.

2. In the vegetated areas (i.e., ≥5% plant cover), begin by using the standard 3-factor approach for identifying wetlands. If indicators of hydrophytic vegetation, hydric soil, and wetland hydrology are present, then these areas are wetlands. Use caution when vegetation, soils, or hydrology are problematic.

3. In unvegetated areas (<5% plant cover), and in vegetated areas that fail the 3-factor wetland test, examine the site for OHW indicators. If OHW indicators are present, these areas should be identified as potential nonwetland waters of the US.

4. If present, identify any unvegetated areas that lack OHW indicators but have indicators of hydric soil and wetland hydrology. These areas should be included in the delineation if they are part of a mosaic with vegetated wetlands and other waters.

5. The final delineation should encompass (a) all vegetated areas determined to be wetlands (i.e., indicators of hydrophytic vegetation, hydric soil, and wetland hydrology are present), (b) areas that are potential other waters of the US (i.e., OHW indicators are present), and (c) interspersed areas that are unvegetated but have indicators of hydric soils and wetland hydrology.

c. *Riparian Areas* – Riparian ecosystems are highly variable across the Arid West. Riparian corridors can be lined with hydrophytic vegetation, upland vegetation, unvegetated areas, or a mosaic of these types. Soils may lack hydric soil indicators in recently deposited materials (i.e., Entisols) even when indicators of hydrophytic vegetation and wetland hydrology are present. Surface hydrology can vary from perennial to intermittent and, after a flooding event, water tables can drop quickly to low levels. Many riparian areas contain remnant stands of tree species that may have germinated during unusually high water events or under wetter conditions than currently exist at the site (Figure 5-2). Other areas have a high frequency of phreatophytic species that are able to exploit groundwater that is too deep to support wetlands. Delineating wetlands and other waters in riparian corridors requires the application of both wetland and OHW indicators. The following procedure is recommended:

Figure 5-2. Mature *Populus deltoides* stand with xeric understory on the Arikaree River, Colorado.

1. In riparian areas having indicators of hydrophytic vegetation, hydric soils, and wetland hydrology, use the standard 3-factor test for identification of wetlands.

2. In riparian corridors lacking indicators of hydrophytic vegetation, hydric soils, and/or wetland hydrology, evaluate the site as a potential nonwetland water of the US using OHW indicators.

d. *Areas Affected by Grazing* – Both short- and long-term grazing can cause shifts in dominant species in the vegetation. Grazers can influence the abundance of plant species by selectively grazing certain palatable species (decreasers) or avoiding less palatable species (increasers) (Table 5-1). This shift in species composition due to grazing can influence the hydrophytic vegetation determination. Be aware that shifts in both directions, favoring either wetland species or upland species, can occur in these situations. Limited grazing does not necessarily affect the outcome of a hydrophytic vegetation decision. However, the following procedure is recommended in cases where the effects of grazing are so great that the hydrophytic vegetation determination would be unreliable or misleading.

1. Examine the vegetation on a nearby, ungrazed reference site having similar soils and hydrologic conditions. Ungrazed areas may be present on adjacent properties or in fenced exclosures or streamside management zones. Assume that the same plant community would exist on the grazed site, in the absence of grazing.

2. If grazing was initiated recently, use offsite data sources such as aerial photography, NWI maps, and public interviews to determine what plant community was present on the site before grazing began. If the previously ungrazed community was hydrophytic, then consider the current vegetation to be hydrophytic.

3. If an appropriate ungrazed area cannot be located or if the ungrazed vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soils and wetland hydrology.

Table 5-1
Example list of increaser and decreaser plant species in response to grazing in the Arid West.

Decreasers	Increasers
Sporobolus airoides	*Sitanion hystrix*
Oryzopis hymenoides	*Hordeum jubatum*
Schizachyrium scoparium	*Festuca idahoensis*
Spartina pectinata	*Distichlis stricta*
Phalaris arundinacea	*Mimulus guttatus*
Atriplex canescens	*Juncus balticus* and *J. mexicanus*
Salix spp.	*Equisetum arvense*

e. *Managed Plant Communities* – Many natural plant communities throughout the Arid West are managed to meet human goals. Examples include clearing of woody vegetation on rangelands, periodic disking or plowing, planting of native and non-native species (including cultivars or planted species that have escaped and become established on other sites), irrigation of pastures and hayfields, suppression of wildfires, and the use of herbicides. These actions can result in elimination of certain species and their replacement with other preferred species, changes in abundance of certain plants, and shifts in dominant species, possibly influencing a hydrophytic vegetation determination. The following procedure is recommended if the natural vegetation has been altered through management to such an extent that a hydrophytic vegetation determination would be unreliable:

1. Examine the vegetation on a nearby, unmanaged reference site having similar soils and hydrologic conditions. Assume that the same plant community would exist on the managed site, in the absence of human alteration.

2. If management was initiated recently, use offsite data sources such as aerial photography, NWI maps, and public interviews to determine what plant community was present on the site before the management occurred.

3. If the unmanaged vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soil and wetland hydrology.

f. *Areas Affected by Fires, Floods, and Other Natural Disturbances* – Site disturbances, such as those resulting from wildfires or floods, can dramatically alter the vegetation. Vegetation can be completely or partially removed, or its composition altered, depending upon the intensity of the disturbance. In the short term, the recovering vegetation can be dominated by pioneer species that are different from those in the undisturbed mature stand. The community may go through several seral stages as the site recovers. These responses can vary depending upon the community type and landscape position. Community succession in montane forests is likely to be more complex, involving a number of stages in stand development toward the climax condition. In basin areas, however, species composition of the recovering stand may be very similar to the original vegetation. Limited disturbance to the community does not necessarily affect the outcome of a hydrophytic vegetation decision. However, the following procedure is recommended in cases when the disturbance is so great that the hydrophytic vegetation determination would be unreliable or misleading.

1. Examine the vegetation on a nearby, undisturbed reference site having similar soils and hydrologic conditions. Assume that the same plant community would exist on the disturbed site, in the absence of disturbance.

2. If the disturbance was recent, use offsite data sources such as aerial photography, NWI maps, and public interviews to determine what plant community was present on the site before the disturbance occurred.

3. If the undisturbed vegetation condition cannot be determined, make the wetland determination based on indicators of hydric soil and wetland hydrology.

g. *Vigor and stress responses resulting from wetland conditions.* Plant responses to wet site conditions are commonly recognized. Crop stress in wet agricultural fields is easily identifiable both in the field and on aerial photography. Many plants develop observable stress-related features, such as browning or yellowing, when growing under wet conditions. Also, many species show an increase in abundance or plant vigor when growing on wet sites. These responses are not necessarily species specific or easily measurable. The following procedure can help determine whether an observed increase or decrease in plant vigor or stress is the result of growing in wetlands. The procedure assumes that indicators of hydric soil and wetland hydrology are present in the potential wetland area.

1. Compare and describe in field notes the size, vigor, or other stress-related characteristics of the affected species between the potential wetland area and the immediately surrounding uplands. Emphasize features that can be measured or photographed and this information included in the field report. If there are clear differences in plant vigor/stress responses between potential wetland and adjacent upland areas, proceed to step 2.

2. Observe and describe trends in plant vigor or stress conditions along the topographic or wetness gradient from the potential wetland to the adjacent uplands. Trends in plant vigor/stress responses must reflect the distribution of hydric soils, wetland hydrology indicators, topography, and/or landscape conditions appropriate to wetlands. If so, proceed to step 3.

3. Consider the area to be a wetland. Determine the wetland boundary based on indicators of hydric soil and wetland hydrology, spatial changes in plant vigor or stress, topography, and landscape characteristics.

h. *Early season germination of upland plants*. Early season germination of FACU and UPL plants in wetland areas prior to the onset of seasonal hydrology may allow these FACU and UPL species to out-compete wetland species and persist in wetland communities during the normal wet season. This can cause the site to fail the hydrophytic vegetation determination even during the normal wet portion of the growing season. These communities should be considered hydrophytic if indicators of hydric soil and wetland hydrology are present, the landscape setting is appropriate to wetland formation, and one or more of the following conditions is present.

1. Within the potential wetland area but not in the immediately surrounding uplands, FACU or UPL plant species show evidence of stress during the wet portion of the growing season (see item *3g* above).

2. Within the potential wetland area, OBL, FACW, and/or FAC plants show evidence of stress or suppression due to competition with early season germinating FACU and UPL plants.

3. Live or dead remains of OBL and/or FACW plant species are present in the community within the potential wetland but not in the immediately adjacent uplands.

3. General Approaches to Problematic Hydrophytic Vegetation – The following general procedures are provided to identify hydrophytic vegetation in difficult situations not necessarily associated with specific vegetation types or management practices, including wetlands dominated by FACU or UPL species that are functioning as hydrophytes. These procedures should be applied only where indicators of hydric soil and wetland hydrology are present but indicators of hydrophytic vegetation are not evident. The following approaches are recommended:

a. *Direct hydrologic observations.* Verify that the plant community occurs in an area subject to prolonged inundation or soil saturation during the growing season. This can be done by visiting the site at 2-3 day intervals during the portion of the growing season when surface water is most likely to be present or water tables are normally high. Hydrophytic vegetation is considered to be present, and the site is a wetland, if there is surface water present and/or a water table is ≤12 inches of the surface for ≥14 consecutive days during the growing season. If necessary, microtopographic highs and lows should be evaluated separately. The normality of the current year's rainfall should be considered in interpreting field results, as well as the likelihood that wet conditions will occur on the site at least every other year (for more information, see the section on Wetlands that Periodically Lack Indicators of Wetland Hydrology in this chapter).

b. *Reference sites.* If indicators of hydric soil and wetland hydrology are present, the site may be considered to be a wetland if the landscape setting, topography, soils, and vegetation are substantially the same as those on nearby wetland reference areas. Wetland reference areas may be established through long-term monitoring or by repeated application of the procedure described in item (a) above. Reference sites should be minimally disturbed and provide long-term access. Soils, vegetation, and hydrologic conditions should be thoroughly documented and the data kept on file in the district or field office.

c. *Technical literature.* Published scientific literature, from both refereed and non-refereed sources, including reliable internet sources, may be used to support a decision to treat specific FACU or UPL species as hydrophytes or certain plant communities as hydrophytic. Preferably, this literature should discuss the species' natural distribution along the moisture gradient, its capabilities and adaptations for life in wetlands, wetland types in which it is typically found, or other wetland species with which it is commonly associated.

Problematic Hydric Soils

Soils with Faint or No Indicators

Some soils that meet the hydric soil definition may not exhibit any of the indicators presented in Chapter 3. These problematic hydric soils exist for a number of reasons and require additional information, such as landscape position, presence or absence of restrictive soil layers, or information about hydrology, to identify properly. This section describes several soil situations in the Arid West Region that are considered hydric if additional requirements are met. In some cases, these hydric soils may appear non-hydric due to the color of the parent material from which the soils developed. In others, the lack of hydric soil indicators is due to conditions that inhibit the development of redoximorphic features despite prolonged soil saturation and anoxia. In addition, recently developed wetlands may lack hydric soil indicators because insufficient time has passed for their development. Examples of problematic hydric soils in the Arid West include, but are not limited to, the following.

1. **Moderately to Very Strongly Alkaline Soils.** Formation of redox concentrations and depletions requires that soluble iron and organic matter be present in the soil. In a neutral to acidic soil, iron readily enters into solution as reduction occurs and then precipitates in the form of redox concentrations as the soil becomes oxidized. Identifiable iron or manganese features do not readily form in saturated soil with high pH. High pH ($\geq$7.9) can be caused by many factors. In the Arid West, salt content is a common cause of high soil pH. If the pH is high, indicators of hydrophytic vegetation and wetland hydrology are present, and landscape position is consistent with wetlands in the area, the soil may be hydric in the absence of a recognized hydric soil indicator. In the absence of an approved indicator, thorough documentation of soil conditions, including pH, should be recorded in addition to the rationale for the soil being identified as hydric (e.g,. landscape, vegetation, hydrology, etc.). The concept of high pH includes USDA terms Moderately Alkaline,

Strongly Alkaline, and Very Strongly Alkaline (USDA Natural Resources Conservation Service 2002).

2. **Volcanic Ash.** Soils of volcanic origin that have high levels of volcanic ash (silica) are inherently low in iron, manganese, organic carbon, and sulfur. Hydric soil indicators are formed predominantly by the accumulation or loss of iron, manganese, sulfur, or carbon compounds and therefore cannot form in these soils. In the absence of an approved indicator, soil and landscape conditions should be documented thoroughly, along with the rationale for considering the soil to be hydric (e.g., landscape position, vegetation, evidence of hydrology, etc.).

3. **Sand and Gravel Bars within Floodplains.** Coarse-textured soils commonly occur on vegetated bars within the active channel of rivers and streams. In some cases, these soils lack hydric soil indicators due to yearly or seasonal deposition of new soil material, low iron or manganese content, and low organic matter content. Redox concentrations can sometimes be found on the bottoms of coarse fragments and should be examined closely to see if they satisfy an indicator. Furthermore, these soils should be considered hydric if they are ponded, flooded, or saturated for ≥14 consecutive days during the growing season in most years based on site-specific hydrologic observations or data and not on estimated soil properties, such as those given in county soil surveys.

4. **Recently Developed Wetlands.** Recently developed wetlands include mitigation sites, wetland management areas (e.g., for waterfowl), other wetlands intentionally or unintentionally produced by human activities, and naturally occurring wetlands that have not been in place long enough to develop hydric soil indicators. These soils should be considered hydric if they are ponded, flooded, or saturated for ≥14 consecutive days during the growing season in most years based on actual hydrologic observations or data and not on estimated soil properties.

5. **Seasonally Ponded Soils.** Seasonally ponded, depressional wetlands occur in basins and valleys throughout the Arid West. Most are perched systems, with water ponding above a restrictive soil layer, such as a hardpan or clay layer, that is at or near the surface (e.g., Vertisols). Some of these wetlands lack hydric soil indicators due to the limited saturation depth, saline conditions, or other factors. These soils should be considered hydric if they are ponded or saturated for ≥14 consecutive days during the growing season in most years based on actual hydrologic observations or data and not on estimated soil properties.

Soils with Relict or Induced Hydric Soil Indicators

Some soils in the Arid West exhibit redoximorphic features and hydric soil indicators that formed in the recent or distant past when conditions may have been wetter than they are today. These features have persisted even though wetland hydrology may no longer be present. For example, relict redoximorphic features can be found throughout the former lake basins of the Great Basin that were inundated during the Pleistocene epoch. In addition, wetlands drained for agricultural purposes starting in the 1800s, such as large areas of California's Central Valley, may contain persistent hydric soil features. Wetland soils drained during historic times are still considered hydric but they may no longer support wetlands. Relict and historic hydric soil features may be difficult to distinguish from contemporary features. However, if indicators of hydrophytic vegetation and wetland hydrology are present, then hydric soil indicators can be assumed to be contemporary.

There are also areas where hydric soil features have developed in former uplands due to human activities, such as the diversion of water for irrigation or other uses. The application of irrigation water to upland areas can create wetland hydrology and, given adequate time, induce the formation of hydric soil indicators. In some cases, an experienced soil scientist can distinguish naturally occurring hydric soil features from those induced by irrigation. Characterizing the naturally occurring hydrology is often important to the determination, and the timing of field observations can be critical. Observations made during the early part of the growing season, when natural hydrology is often at its peak and irrigation has not yet begun, may help to differentiate naturally occurring and irrigation-induced hydric soil features.

Indicators for Problematic Hydric Soils

The following indicators are intended to supplement those given in Chapter 3 and may be used to identify hydric soils in certain difficult-to-identify wetland situations. They are equivalent to the indicators designated for testing in the Arid West by the National Technical Committee for Hydric Soils (USDA Natural Resources Conservation Service 2005). These indicators may be used for Clean Water Act wetland determinations only where indicators of hydrophytic vegetation and wetland hydrology are present and the landscape setting is appropriate to the formation of wetlands. Use care in areas where vegetation and hydrology may also be problematic.

TF2. Red Parent Material

Technical Description: In parent material with a hue of 7.5YR or redder, a layer at least 4 inches (10 cm) thick with a matrix value 4 or less and chroma 4 or less and 2 percent or more redox depletions and/or redox concentrations as soft masses or pore linings, or both. The layer is entirely within 12 inches (30 cm) of the soil surface. The minimum thickness requirement is 2 inches (5 cm) if the layer is the mineral surface layer.

Applicable Subregions: Applicable to all subregions in the Arid West (LRR B, C, and D).

User Notes: Redox features most noticeable in red material include redox depletions and soft manganese masses that are black or dark reddish black.

A10. 2 cm Muck

Technical Description: A layer of muck 0.75 inch (2 cm) or more thick with value 3 or less and chroma 1 or less starting within 6 inches (15 cm) of the soil surface.

Applicable Subregions: Applicable to LRR B .

User Notes: Normally the muck layer is at the soil surface; however, it may occur at any depth within 6 inches (15 cm). See hydric soil indicator A9 for additional information.

Procedure

Soils that meet the definition of a hydric soil but do not exhibit any of the indicators described in Chapter 3 can be identified by the following recommended procedure. This procedure should be used only where indicators of hydrophytic vegetation and wetland hydrology are present but indicators of hydric soil are not evident. Use caution in areas where vegetation and hydrology are also problematic.

1. Verify that one or more indicators of hydrophytic vegetation are present (i.e., either indicators 1, 2, or 3). If so, proceed to step 2.

2. Verify that at least one primary or two secondary indicators of wetland hydrology are present. If so, proceed to step 3.

3. Thoroughly describe and document the soil profile and landscape setting. Verify that the area is in a landscape position that is likely to collect or concentrate water. Appropriate settings include the following. If the landscape setting is appropriate, proceed to step 4.

   a. Concave surface (e.g., depression or swale)
   b. Active floodplain or low terrace
   c. Level or nearly level area (e.g., 0 to 3 percent slope)
   d. Toe slope or an area of convergent slopes
   e. Fringe of another wetland or water body
   f. Area with a restrictive soil layer or aquitard within 24 inches (60 cm) of the surface
   g. Other (explain in field notes why this area is likely to be inundated or saturated for long periods)

4. Determine whether one or more of the following indicators of problematic hydric soils is present. See the descriptions of each indicator given earlier in this section. If one or more indicators is present, the soil is hydric. If indicators are not present, proceed to step 5.

   a. Red Parent Material (TF2)
   b. 1 cm Muck (A9) (applicable to LRR C; see Chapter 3)
   c. 2 cm Muck (A10) (applicable to LRR B)

5. Determine whether one or more of the following problematic soil situations is present. If present, consider the soil to be hydric. Explain on the data form or in attached field notes why it is believed that the soil lacks hydric soil indicators and why it is believed that the soil meets the definition of a hydric soil. If none of these problematic soil situations is present, proceed to step 6.

   a. Moderately to Very Strongly Alkaline Soils
   b. Volcanic Ash
   c. Sand and Gravel Bars within Floodplains
   d. Recently Developed Wetlands
   e. Seasonally Ponded Soils

f. Other (in field notes, describe the problematic soil situation and explain why it is believed that the soil meets the hydric soil definition)

6. Use one or more of the following approaches to determine whether the soil is hydric. These approaches are listed in order of increasing strength of evidence.

   a. Soils that have been saturated for long periods and have become chemically reduced may change color when exposed to air due to the rapid oxidation of ferrous iron (Fe^{+2}) to Fe^{+3} (Figures 5-3 and 5-4). If the soil contains sufficient iron, this can result in an observable color change, especially in hue or chroma. The soil is hydric if a mineral layer 4 inches (10 cm) or more thick starting within 12 inches (30 cm) of the soil surface that has a matrix value of 4 or more and chroma of 2 or less becomes redder by one or more pages in hue and/or increases one or more in chroma when exposed to air within 30 minutes.

      Care must be taken to obtain an accurate color of the soil sample immediately upon excavation. The colors should observed closely and examined again after several minutes. Do not allow the sample to begin drying, as drying will also result in a color change. As always, do not obtain colors while wearing sunglasses. Colors must be obtained in the field under natural light and not under artificial light.

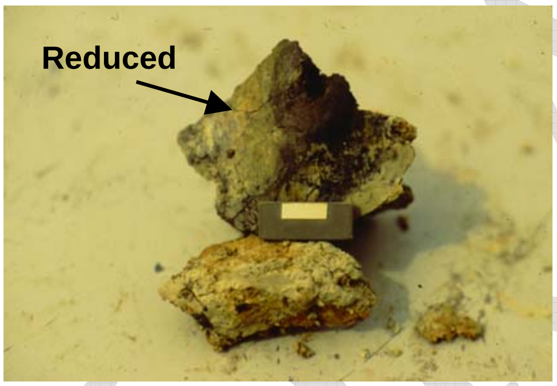

Figure 5-3. This soil exhibits colors associated with reducing conditions. Scale is 1 cm.

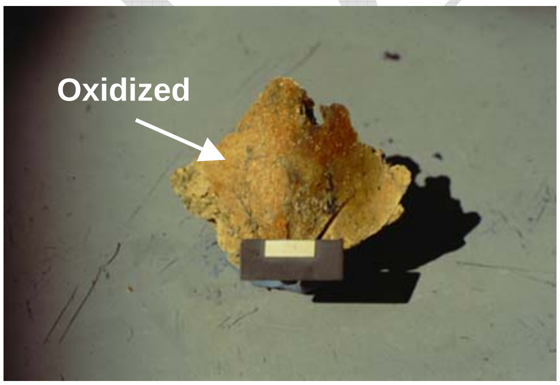

Figure 5-4. The same soil as in Figure 5-3 after exposure to the air and oxidation has occurred.

b. If the soil is saturated at the time of sampling, alpha-alpha dipyridyl dye can be used in the following procedure to determine if reduced (ferrous) iron is present. If ferrous iron is present as described below, then the soil is hydric.

   Alpha-alpha dipyridyl is a dye that reacts with reduced iron. In some cases, it can be used to provide evidence that a soil is hydric when it lacks other hydric soil indicators. The soil is likely to be hydric if application of alpha-alpha dipyridyl dye to mineral soil material in at least 60% of a layer at least 4 inches (10 cm) thick within a depth of 12 inches (30 cm) of the soil surface results in a positive reaction within 30 seconds evidenced by a pink or red coloration to the dye during the growing season.

   Using a dropper, apply a small amount of dye to a freshly broken ped face to avoid any chance of a false positive test due to iron contamination from digging tools. Look closely at the treated soil for evidence of color change. If in doubt, apply the dye to a sample of known upland soil and compare the reaction to the sample of interest. A positive reaction will not be present in soils that lack iron. This lack of a positive reaction to the dye does not preclude the presence of a hydric soil. Specific information about the use of alpha-alpha dipyridyl can be found in NRCS Hydric Soils Technical Note 8 (http://soils.usda.gov/use/hydric/ntchs/tech notes/note8.html).

c. Using gauge data, water-table monitoring data, or repeated direct hydrologic observations, determine whether the soil is ponded or flooded, or the water table is ≤12 inches (30 cm) from the surface, for ≥14 consecutive days during the growing season in most years (≥50% probability). If so, then the soil is hydric.

Wetlands that Periodically Lack Indicators of Wetland Hydrology

Description of the Problem

Wetlands are areas that are flooded or ponded or have soils that are saturated with water for long periods during the growing season in most years. If the site is visited during a time when it is inundated or the water table is near the surface, then the wetland hydrology determination is straightforward. However, the Arid West Region is characterized by long, hot summer dry seasons. During the dry season, surface water recedes from wetland margins, water tables drop, and many wetlands dry out completely. Superimposed on this seasonal variability are high spatial and annual variability in precipitation amounts. Wetlands in general are inundated or saturated in most years (≥50% probability) over a long-term record. However, many wetlands in the Arid West do not become inundated or saturated in some years and, during drought cycles, may not inundate or saturate for several years in a row.

Wetland hydrology determinations are based on indicators, many of which were designed to be used during dry periods when the direct observation of surface water or a shallow water table is not possible. However, some wetlands may lack any of the listed hydrology indicators, particularly during the long dry season or in a dry year. The evaluation of wetland hydrology requires special care on any site where indicators of hydrophytic vegetation and hydric soil are present but hydrology indicators appear to be absent. Among other factors, this evaluation should consider the timing of the site visit in relation to normal seasonal and annual hydrologic variability, and whether the amount of rainfall prior to the site visit has been normal. This section describes a number of approaches that can be used to determine whether wetland hydrology is present on sites where indicators of hydrophytic vegetation and hydric soil are present but hydrology indicators may be lacking due to normal variation in rainfall, runoff, and other factors.

Procedure

1. Verify that indicators of hydrophytic vegetation and hydric soil are present. Use caution in areas where soils and/or vegetation may also be problematic. Proceed to step 2.

2. Verify that the site is in a geomorphic position where wetlands are likely to occur (e.g., in a depression or swale, level or nearly level area, toe slope, area of convergent slopes, low terrace, active floodplain or backwater, the fringe of another wetland or water body, or on a soil with a shallow restrictive layer). If so, proceed to step 3.

3. Use one or more of the following approaches to determine whether wetland hydrology is present and the site is a wetland:

    a. *Site visits during the dry season*. Determine whether the site visit occurred during the normal annual "dry season." The dry season, as used in this supplement, is the period of the year when soil moisture is normally being depleted and water tables are falling to low levels in response to decreased precipitation and/or increased evapotranspiration, usually during late spring and summer. It also includes the beginning of the recovery period in late summer or fall. The Web-Based Water-Budget Interactive Modeling Program (WebWIMP) is one source for approximate dates of wet and dry seasons for any terrestrial location based on average monthly precipitation and estimated evapotranspiration (http://climate.geog.udel.edu/~wimp/). In general, the dry season in a typical year is indicated when evapotranspiration exceeds precipitation (negative values of DIFF), resulting in drawdown of soil moisture storage (negative values of DST) and/or a moisture deficit (DEF). Actual dates for the dry season vary by locale and year.

       In many wetlands, direct observation of flooding, ponding, or a shallow water table would be unexpected during the dry season. Wetland hydrology indicators, if present, would most likely be limited to indirect evidence, such as water marks, drift deposits, or surface cracks. In some situations, hydrology indicators may be absent. If the site visit occurred during the dry season on a site that contains hydric soils and hydrophytic vegetation and no evidence of hydrologic manipulation, then consider the site to be a wetland. If necessary, the wetland determination can be confirmed by re-visiting the site during the normal wet season and checking again for wetland hydrology indicators.

    b. *Periods with below normal rainfall*. Determine whether the amount of rainfall that occurred in the 2-3 months preceding the site visit was normal, above normal, or below normal based on the normal range reported in WETS tables. WETS tables are provided by the NRCS National Water and Climate Center (http://www.wcc.nrcs.usda.gov/climate/wetlands.html) and are calculated from long-term (30-year) weather records gathered at National Weather Service meteorological stations. To determine whether precipitation was normal prior to the site visit, actual rainfall in the current month and previous 2-3 months should be compared with the normal ranges for each month given in the WETS table (USDA Natural Resources Conservation Service 1997, Sprecher and Warne 2000). The lower and upper limits of the normal range are indicated by the columns labeled "30% chance will have less than" and "30% chance will have more than" in the WETS table. The USDA Natural Resources Conservation Service (1997, Section 650.1903) also gives a procedure that can be used to weight the information from each month and determine whether the entire period was normal, wet, or dry. In mountainous areas, average precipitation amounts can vary considerably over short distances. Therefore, use caution in areas where the elevation or other conditions differ between the site and the nearest weather station.

When precipitation has been below normal, wetlands may not flood, pond, or develop shallow water tables even during the typical wet portion of the growing season and may not exhibit other indicators of wetland hydrology. Therefore, if precipitation was below normal prior to the site visit, a site that contains hydric soils and hydrophytic vegetation and no evidence of hydrologic manipulation should be identified as a wetland. If necessary, the site can be re-visited during a period of normal rainfall and checked again for hydrology indicators.

c. *Drought years*. Determine whether the area has been subject to short- or long-term drought. Droughts lasting two to several years in a row are common in the Arid West. Drought periods can be identified by comparing annual rainfall totals with the normal range of annual rainfall given in WETS tables or by examining trends in drought indices, such as the Palmer Drought Severity Index (PDSI) (Sprecher and Warne 2000). PDSI takes into account not only precipitation but also temperature, which affects evapotranspiration, and soil moisture conditions. Human impacts to the water budget, such as irrigation, are not considered. The index is usually calculated on a monthly basis for major climatic divisions within each state. Therefore, the information is not site-specific. PDSI values range generally between –6 and +6 with negative values indicating dry periods and positive values indicating wet periods. An index of –1.0 indicates mild drought, –2.0 indicates moderate drought, –3.0 indicates severe drought, and –4.0 indicates extreme drought. Time-series plots of PDSI values by month or year are available from the National Climatic Data Center at (http://www.ncdc.noaa.gov/oa/climate/onlineprod/drought/xmgr.html#ds). If wetland hydrology indicators appear to be absent on a site that has hydrophytic vegetation and hydric soils, there is no evidence of hydrologic manipulation, and the region has been affected by drought, then the area should be identified as a wetland. Potential effects of drought on vegetation composition were discussed earlier in this chapter.

d. *Years with unusually low winter snowpack*. Determine whether the site visit occurred following a winter with unusually low snowpack. Some wetlands in the Arid West, particularly those located in or near mountain ranges, depend upon the melting winter snowpack as a major water source. In areas where the snowpack persists throughout the winter, water availability in spring and early summer depends in part on winter water storage in the form of snow and ice. Therefore, springtime water availability in a given year can be evaluated by comparing the liquid equivalent of snowfall over the previous winter (e.g., October through April) against 30-year averages calculated for NRCS Snowpack Telemetry (SNOTEL) sites (http://www.wcc.nrcs.usda.gov/factpub/ads/) or for National Weather Service meteorological stations (may require a fee, http://lwf.ncdc.noaa.gov/oa/ncdc.html). This procedure may not be reliable in areas where the snowpack is not persistent and water is released intermittently throughout the winter.

In years when winter snowpack is appreciably less than the long-term average, wetlands that depend on snowmelt as an important water source may not flood, pond, or develop shallow water tables and may not exhibit other wetland hydrology indicators. Under these conditions, a site that contains hydric soils and hydrophytic vegetation and no evidence of hydrologic manipulation should be considered to be a wetland. If necessary, the site can be re-visited following a winter with normal snowpack conditions and checked again for wetland hydrology indicators.

e. *Reference sites*. If indicators of hydric soil and hydrophytic vegetation are present on a site that lacks wetland hydrology indicators, the site may be considered to be a wetland if the landscape setting, topography, soils, and vegetation are substantially the same as those on nearby wetland reference areas. Wetland reference areas should have documented hydrology established through long-term monitoring or by repeated application of the procedure described in item *3a* of the procedure for Wetlands that Lack Indicators of Hydrophytic Vegetation in this chapter. Reference sites should be minimally disturbed and provide long-term access. Soils, vegetation, and hydrologic conditions should be thoroughly documented and the data kept on file in the district or field office.

f. *Hydrology tools*. The “Hydrology Tools” (USDA Natural Resources Conservation Service 1997) is a collection of methods that can be used to determine whether wetland hydrology is present on a potential wetland site that lacks indicators due to disturbance or other reasons, particularly on lands used for agriculture. Generally they require additional information, such as aerial photographs or stream-gauge data, or involve hydrologic modeling and approximation techniques. They should be used only when an indicator-based wetland determination is not possible or would give misleading results. An experienced hydrologist may be needed to help select and carry out the proper analysis. The seven tools are used to:

1. Analyze stream and lake gauge data
2. Estimate runoff volumes to determine duration and frequency of ponding in depressional areas
3. Evaluate wetness signatures on aerial photography, such as the slides taken annually in agricultural areas by the USDA Consolidated Farm Services Agency
4. Model water-table fluctuations in fields with parallel drainage systems using the DRAINMOD model
5. Estimate the “scope and effect” of ditches or subsurface drain lines
6. Use NRCS state drainage guides to estimate the effectiveness of agricultural drainage systems

7. Analyze data from groundwater monitoring wells (however, see U. S. Army Corps of Engineers (2005) for additional information.)

g. *Long-term hydrologic monitoring.* On sites where the hydrology has been manipulated by man (e.g., water diversion, ditching) or where natural events (e.g., downcutting of streams, volcanic activity) have altered conditions such that hydrology indicators may be missing or misleading, direct monitoring of surface and groundwater may be needed to verify the presence or absence of wetland hydrology. The U. S. Army Corps of Engineers (2005) provides minimum standards for the design, construction, and installation of water-table monitoring wells, and for the collection and interpretation of groundwater monitoring data, in cases where direct hydrologic measurements are needed to determine whether wetlands are present on highly disturbed or problematic sites. This standard calls for ≥14 consecutive days of flooding, ponding, or water table ≤12 inches (30 cm) below the soil surface during the growing season at a minimum frequency of 5 years in 10 (≥50% probability). An area that meets this hydrologic standard and contains hydric soils and hydrophytic vegetation is a wetland.

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Appendix A – Data Form

WETLAND DETERMINATION DATA FORM – Arid West Region (DRAFT)

Project/Site: ______________________ City/County: ______________________ Sampling Date: ____________

Applicant/Owner: ______________________________________ State: ________ Sampling Point: ____________

Investigator(s): ______________________ Section, Township, Range: ______________________

Landform (hillside, terrace, fan, etc.): ______________ Local relief (concave, convex, none): ____________ Slope (%): ______

Subregion (LRR): ______________ Lat: ____________ Long: ____________ Datum: __________

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ______ No ______ (If no, explain in Remarks.)

Are Vegetation ______, Soil ______, or Hydrology ______ significantly disturbed? Are "Normal Circumstances" present? Yes ______ No ______

Are Vegetation ______, Soil ______, or Hydrology ______ naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present?	Yes ______	No ______	**Is the Sampled Area within a Wetland?** **Yes ______ No ______**
Hydric Soil Present?	Yes ______	No ______	
Wetland Hydrology Present?	Yes ______	No ______	

Remarks:

VEGETATION

Tree Stratum (Use scientific names.)	Absolute % Cover	Dominant Species?	Indicator Status
1.			
2.			
3.			
4.			
Total Cover:			
Sapling/Shrub Stratum			
1.			
2.			
3.			
4.			
5.			
Total Cover:			
Herb Stratum			
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
Total Cover:			
Woody Vine Stratum			
1.			
2.			
Total Cover:			

% Bare Ground in Herb Stratum __________ % Cover of Biotic Crust __________

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: __________ (A)

Total Number of Dominant Species Across All Strata: __________ (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: __________ (A/B)

Prevalence Index worksheet:

Total % Cover of:	Multiply by:
OBL species ________	x 1 = ________
FACW species ________	x 2 = ________
FAC species ________	x 3 = ________
FACU species ________	x 4 = ________
UPL species ________	x 5 = ________
Column Totals: ________ (A)	________ (B)

Prevalence Index = B/A = ____________

Hydrophytic Vegetation Indicators:

___ Dominance Test is >50%

___ Prevalence Index is ≤3.0[1]

___ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)

___ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present.

Hydrophytic Vegetation Present? **Yes ______ No ______**

Remarks:

SOIL

Sampling Point: ___________

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix Color (moist)	Matrix %	Redox Features Color (moist)	Redox Features %	Type[1]	Loc[2]	Texture	Remarks

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix. [2]Location: PL=Pore Lining, RC=Root Channel, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

___ Histosol (A1)
___ Histic Epipedon (A2)
___ Black Histic (A3)
___ Hydrogen Sulfide (A4)
___ Stratified Layers (A5) (**LRR C**)
___ 1 cm Muck (A9) (**LRR D**)
___ Depleted Below Dark Surface (A11)
___ Thick Dark Surface (A12)
___ Sandy Mucky Mineral (S1)
___ Sandy Gleyed Matrix (S4)
___ Sandy Redox (S5)
___ Stripped Matrix (S6)
___ Loamy Mucky Mineral (F1)
___ Loamy Gleyed Matrix (F2)
___ Depleted Matrix (F3)
___ Redox Dark Surface (F6)
___ Depleted Dark Surface (F7)
___ Redox Depressions (F8)
___ Vernal Pools (F9)

Indicators for Problematic Hydric Soils[3]:

___ Red Parent Material (TF2)
___ 1 cm Muck (A9) (**LRR C**)
___ 2 cm Muck (A10) (**LRR B**)
___ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present.

Restrictive Layer (if present):

Type: ______________________________

Depth (inches): ______________________

Hydric Soil Present? Yes ______ No ______

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (any one indicator is sufficient)

___ Surface Water (A1)
___ High Water Table (A2)
___ Saturation (A3)
___ Water Marks (B1)(**Nonriverine**)
___ Sediment Deposits (B2) (**Nonriverine**)
___ Drift Deposits (B3)(**Nonriverine**)
___ Surface Soil Cracks (B6)
___ Inundation on Aerial Imagery (B7)
___ Water-stained Leaves (B8)
___ Biotic Crust (B10)
___ Aquatic Invertebrates (B11)
___ Crayfish Burrows (B12)
___ Hydrogen Sulfide Odor (C1)
___ Oxidized Rhizospheres on Living Roots (C2)
___ Presence of Reduced Iron (C4)
___ Recent Iron Reduction in Plowed Soil (C6)
___ Muck Surface (C7)
___ Saturation on Aerial Imagery (C8)
___ Shallow Aquitard (D4)
___ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

___ Water Marks (B1) (**Riverine**)
___ Sediment Deposits (B2) (**Riverine**)
___ Drift Deposits (B3) (**Riverine**)
___ Drainage Patterns (B9)
___ Dry Season Water Table (C3)
___ Salt Deposits (C5)
___ Mud Casts (C9)
___ FAC-Neutral Test (D7)

Field Observations:

Surface Water Present? Yes _____ No _____ Depth (inches): ____________

Water Table Present? Yes _____ No _____ Depth (inches): ____________

Saturation Present? (includes capillary fringe) Yes _____ No _____ Depth (inches): ____________

Wetland Hydrology Present? Yes ______ No ______

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

Remarks: