US Army Corps
of Engineers ®
St. Paul District

St. Paul District Corps of Engineers Regulatory Branch Guidance

Target Hydrology and Performance Standards for Compensatory Mitigation Sites

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I. Executive Summary

This guidance document is an update and expansion of previous guidance on this topic first developed in 2005 (Version 1.0) and updated most recently in 2014 (Version 5.0). Rather than using the minimum criteria for wetland hydrology as a performance standard, performance standards specifying the optimum target hydrology for specific wetland plant communities have been refined for Version 6.0. This guidance is a living document and periodic updates will be made as needed.

II. Purpose and Applicability

The purpose of this guidance is to ensure that consistent and enforceable hydrology performance standards, reflecting the best available science, are applied to compensatory mitigation proposals district-wide.

III. Introduction

Hydrology drives wetland systems. Therefore, a key component of compensatory mitigation is establishing "target hydrology," which is the hydrology necessary to achieve the goals/objectives of the compensation site. Target hydrology varies considerably depending upon a number of variables. The ideal for evaluating the hydrology of compensation sites includes collecting and applying data from reference wetlands. An example of how to apply data from reference wetlands is provided in Section VII below. It is acknowledged that this approach may not be practicable in some or many cases. In those cases where sufficient data from reference wetlands is lacking, performance standards are based on best available science for the specific wetland plant communities expected to be established at a compensation site. Section VIII of this guidance describes performance standards for target hydrology organized by wetland plant communities.

> The goal at compensation sites is not to establish the ***minimum*** wetland hydrology; the goal of this document is to provide information on how to establish the ***optimum*** hydrology for targeted wetland plant communities and associated functions and services.

Specifications for target hydrology are needed to ensure compensatory mitigation sites provide the target functions. Constructing compensation sites with no pre-project monitoring well data, and/or surface water runoff calculations, should be avoided to the extent practicable. A variation of 6 inches in the depth of inundation, or depth to the water table, can determine success or failure for establishing saturated soil, seasonally flooded, and temporarily flooded wetland types. It is not appropriate to estimate the proper elevation for a planned wetland compensation site and then excavate below that elevation to guarantee that the site will have water.

A compensation site that meets performance standards for both target hydrology and target vegetation is typically on the correct trajectory to meet goals/objectives.

IV. Monitoring Hydrology

Monitoring hydrology entails measuring the frequency, depth and duration of inundation and/or the water table in relation to the soil surface.

The Corps wetland hydrology technical standard for interpreting monitoring well data[1] (U.S. Army Corps of Engineers 2005) specifies depth to the water table. Therefore, depth to the water table—as opposed to the depth to saturated soils—is applied by the target hydrology performance standards.

Installation of monitoring wells in accordance with the Corps technical standard for water table monitoring (U.S. Army Corps of Engineers 2005) is the recommended approach for monitoring the hydrology of compensation sites. Guidance developed by the Minnesota Board of Water and Soil Resources (2013) provides detailed instructions and excellent illustrations for this purpose. Monitoring wells can be read manually, but instrumentation with dataloggers (transducers that record changes in pressure within the PVC pipe; also called leveloggers) is typically necessary (see IV.C. below). Monitoring wells/dataloggers are employed to determine both the depth/duration of the water table below the soil surface as well as the depth/duration of inundation.

A. Number of Monitoring Wells per Site. The number of monitoring wells necessary for monitoring the hydrology of a compensation site varies with size and complexity of the site. In *Water Table Monitoring Project Design,* Noble (2006) lists the following factors: acreage, topography, plant communities, hydrogeomorphic (HGM) wetland classes, soil types, and disturbances (e.g., ditches, berms). A monitoring plan should account for each of these variables in terms of the number and locations of the monitoring wells. Where a particular plant community/HGM class/soil type is larger than a few acres, a transect(s) of monitoring wells is recommended to ensure that hydrology is adequately characterized. In cases where a particular plant community/HGM class/soil type exhibits microtopographic relief, locations of monitoring wells should include representative lower elevations (e.g., hollows) and representative higher elevations (e.g., hummocks).

B. Timing of Monitoring Well Installation. Monitoring wells should be installed and data collection begun as soon as frost is out of the ground. If this is not feasible, monitoring wells should be installed and data collection begun as early in the growing season as possible. The "growing season" for a particular monitoring year is determined in accordance with the regional supplements to the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987).

C. Frequency of Recording Data. The frequency of water level readings must be sufficient to determine whether performance standards are met. Those standards are based on inundation and/or a water table ≤12 inches below the soil surface for a consecutive number of days. Therefore, daily readings are necessary to track whether the consecutive day specification is met. Once weekly, or twice weekly, etc., readings are not suitable because they do not confirm whether the consecutive day requirement is met. The recommended approach is installation of monitoring wells with dataloggers programmed to record multiple readings/day (4 to 6 readings per day are recommended).

D. Duration of Monitoring. Duration of monitoring hydrology at compensation sites is generally 3-5 growing seasons, but can be increased or decreased due to site-specific conditions and goals/objectives. If, for example, monitoring well data documents that target hydrology performance standards were met during ≥2 growing seasons that were within the normal range for precipitation, and the Corps is confident

[1] Inundation and/or a water table ≤12 inches below the soil surface for ≥14 consecutive days during the growing season in most years (≥50 percent probability).

that this hydrologic regime is sufficiently established to ensure long-term sustainability of the site, collection of additional hydrology data can be cancelled. Conversely, the duration of monitoring may be extended if a compensation site is not meeting performance standards, corrective measures are being implemented, or other factors warrant an extension.

E. Reference Wetlands. The following definitions are pertinent to this discussion.

- **Wetland Type**: for purposes of this discussion—[Plant Community + HGM Class[2] + Soil Type].[3]
- **Reference Wetlands**: wetlands whose hydrographs are used to develop hydrology performance standards.
- **Reference Standard Wetlands**: a subset of reference wetlands representing the least altered examples of a particular wetland type located within the least altered landscapes of a reference domain.
- **Reference Domain**: the geographic area (e.g., ecoregion, watershed) occupied by the reference wetlands of a particular wetland type.

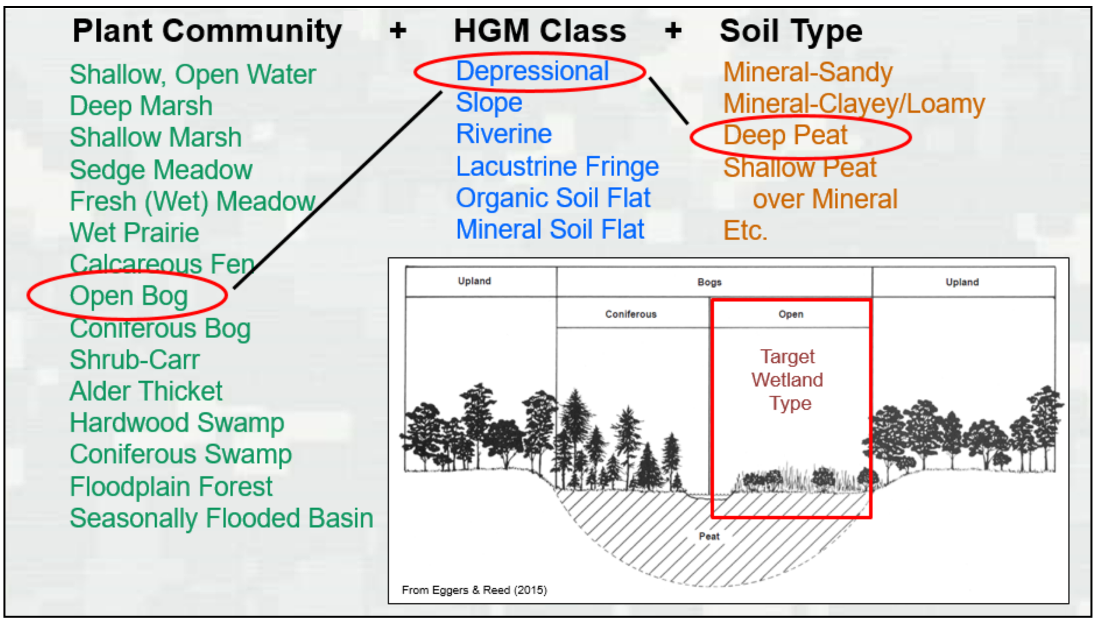


Figure 1: Example of wetland type using [Plant Community + HGM Class + Soil Type].

As described above, the ideal for evaluating the hydrology of compensation sites includes collecting and applying data from reference wetlands. Data from reference standard wetlands is the first preference as it characterizes the least altered wetlands. Secondarily, data from wetlands with some degree of disturbance—but intact, unaltered hydrology—may also have potential as reference sites for hydrology performance standards. Example: A sedge meadow community that was plowed during a drought period and then became dominated by reed canary grass when the drought ended and plowing ceased.

F. Sources of Wetland Hydrology Data. Hydrology data has been collected for most wetland types at various locations across Minnesota and Wisconsin. Examples include monitoring well data collected: (1) by watershed districts; (2) as part of monitoring previously constructed compensation sites; (3) for research projects; and (4) as part of baseline studies for proposed mining projects. These data can be useful if

[2] See Brinson (1993) for discussion of HGM classes.
[3] There are numerous ways to define "wetland type" and other definitions could be applied for purposes of hydrology performance standards. The approach of [Plant Community + HGM Class + Soil Type] is simple yet relatively comprehensive.

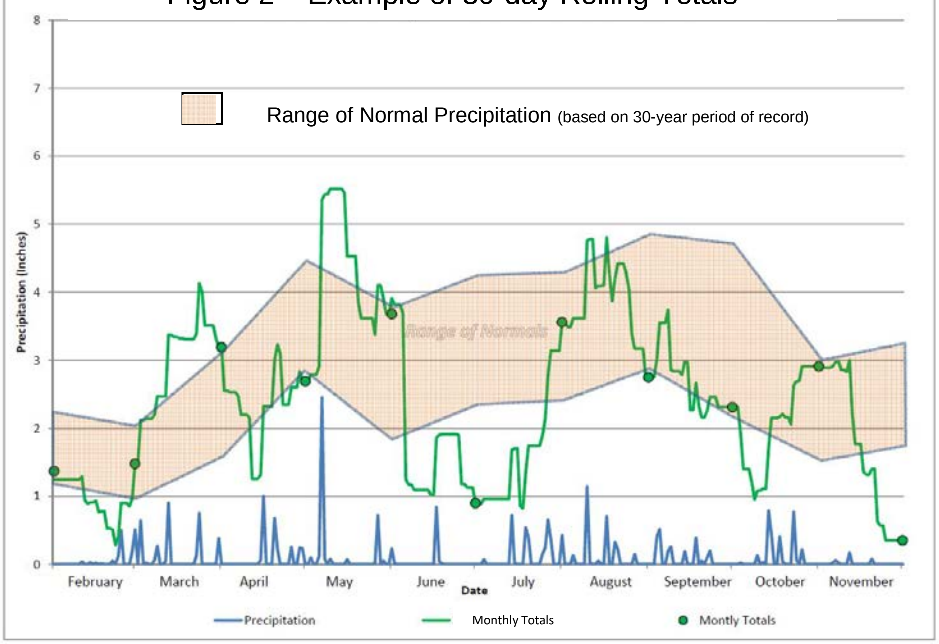
collected from wetlands that are of the same type, and within the same reference domain, as wetlands proposed at a compensation site.

V. Placing Hydrology Data in the Context of Antecedent Precipitation

An essential component of evaluating water level data is placing those data in the context of antecedent precipitation. In *Accessing and Using Meteorological Data to Evaluate Wetland Hydrology*, Sprecher and Warne (2000) recommend three approaches to categorize precipitation as normal, wetter than normal, or drier than normal, for a particular monitoring period: (1) *Hydrology Tools for Wetland Determination* (Woodward 1997)[4]; (2) the method of 30-day rolling totals of precipitation (Figure 2); or (3) a combination of (1) and (2). All of these are thoroughly addressed by Sprecher and Warne (2000). *Evaluating Antecedent Precipitation Conditions* (Minnesota Board of Water and Soil Resources 2015) provides an excellent step-by-step guide for applying these methods. The recommended approach for evaluating hydrology performance standards is to graph 30-day rolling totals for each monitoring year and include this information in monitoring reports submitted to the Corps.

Data generated by the weather station closest to the compensation site is used to determine whether antecedent precipitation was normal, wetter than normal, or drier than normal, based on the most recent 30-year period of record.[5] Percentiles derived from a sorted 30-year (e.g., 1981-2010) time series for a particular month are determined where the nine driest months in the time series have precipitation totals less than the 30th percentile ("drier than normal"), totals from the nine wettest months are higher than the 70th percentile ("wetter than normal"), and the 12 months in-between represent the middle range ("normal").

Figure 2 – Example of 30-day Rolling Totals



Source: Stantec

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[4] Updated in 2015, *Hydrology Tools for Wetland Identification and Analysis* (Weber 2015).

[5] In Minnesota, the State Climatology Office web site has calculated (interpolated) the antecedent precipitation determination for any location statewide: http://climate.umn.edu/gridded_data/precip/wetland/wetland.asp

Many types of reference wetlands can be naturally dry during drier than normal conditions. This fact is incorporated by some of the performance standards in Section VIII that require a minimum duration of inundation and/or a water table ≤12 inches below the soil surface during normal and wetter than normal hydrological conditions, but not drier than normal conditions. Lack of inundation and/or a water table ≤12 inches below the soil surface during drier than normal conditions is not necessarily a negative indicator in these cases, i.e., indicating that hydrology is not on the correct trajectory for success. But it also does not inform us of whether the requirements for inundation and/or depth to the water table would be met during normal and wetter than normal conditions. The key is to continue monitoring and base the decision on whether target hydrology performance standards are met using data collected during normal and wetter than normal hydrological conditions.

If the duration of inundation and/or a water table ≤12 inches below the soil surface specified for normal and wetter than normal hydrological conditions are met during drier than normal conditions, those reviewing/managing the site can evaluate this fact in context with the specific characteristics of that site. In some cases, meeting inundation and/or water table depth requirements during drier than normal conditions would be a positive indicator. Conversely, in the case of a depressional wetland fed solely by surface water inputs, it may indicate that the compensation site would be too wet during normal and wetter than normal conditions and as a result would not support the target vegetation.

A subset of drier than normal conditions—the extreme dry end—consists of "drought" conditions. For purposes of the target hydrology performance standards, drought conditions refer to Categories D0-D4 as determined by the U.S. Drought Monitor (Attachment A).

Some of the performance standards specify a precipitation event, e.g., the 10-year, 24-hour storm event. These data are available on-line using latitude/longitude or nearest weather station: http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=mn (or =wi for Wisconsin)

VI. Interpretation and Application of Performance Standards

Sections VII and VIII below address the development of performance standards and target hydrology for specific wetland types. The reader will note that all performance standards use binding terminology in that the standards direct that a certain type, amount and frequency of hydrology *shall* be established. This section addresses why this binding terminology is used as well as the flexibility that may be applied during both the determination of appropriate performance standards as well as the evaluation of compensation site performance. In other words, while this target would allow for optimum hydrology, the Corps has the flexibility to consider other hydroperiods as successful.

Once a performance standard is assessed as appropriate for a compensatory mitigation site, the Corps must be able to ensure that the standard is enforceable. Therefore, the use of terminology "shall" is essential. However, it is important to understand that there is some degree of flexibility during monitoring such that a site may not demonstrate the required hydrology but could still be considered successful. For example, while there is not flexibility to prescribe lesser durations of inundation and/or a water table ≤12 inches below the soil surface for at least 14 consecutive days because this is the minimum for wetland hydrology, other durations used in the performance standards (e.g., ≥28 consecutive days) are intended as a *target*.

Flexibility is particularly warranted when duration requirements are qualitative as opposed to being based on site-specific, quantitative data. Note that flexibility can be conditioned. Example: a water table ≤12 inches below the soil surface that is within 3 days of a minimum 28-consecutive day target could be considered as meeting the performance standard for that growing season provided that the target vegetation is observed to be on the correct trajectory for success. Using mitigation banking as an example, the Interagency Review Team can discuss a "plus or minus" flexibility range, with conditions, that would be appropriate given the characteristics of a particular bank site.

Flexibility is also achieved given that requirements for inundation and/or depth to the water table do not have to be met: (1) every growing season due to the exception for drier than normal hydrological conditions, which accounts for the fact that wetlands can be naturally dry during drier than normal conditions; and (2) during the "dry season"—the latter half of the growing season—in the case of performance standards for certain plant communities.

The range of inundation/depth to the water table specified by each performance standard provides flexibility as well. Shrub swamp and wooded swamp communities on mineral soils have an 18-inch range—6 inches of inundation to a water table 12 inches below the soil surface plus an additional allowance for extended durations of up to 12 inches of standing water in microdepressions. Performance standards for fresh (wet) meadow, sedge meadow, wet prairie, bog and fen communities have a 12-inch range for depth of the water table from the soil surface with an additional allowance for extended durations of up to 6 inches of standing water in microdepressions. Target hydrology for floodplain forest and seasonally flooded basin communities consists of temporary inundation ranging from an inch to several feet in depth. All of these acknowledge the variability in both water levels and topography that naturally occur in wetlands. Allowing for even greater ranges in inundation/water table depths, however, is not advised as it would promote undesirable outcomes such as conditions that are too dry (e.g., upland) or too wet to support the target plant communities (e.g., a cattail marsh becomes established instead of the targeted hardwood swamp community).

In summary, restoration, enhancement and creation of wetlands is an evolving science and still inexact in determining what may develop within a compensation site given various restoration methods, plantings, unforeseen circumstances, and other factors. The Corps has the discretion to evaluate the overall goals/objectives for a compensation site and determine whether the site has generated credits suitable for Clean Water Act purposes (e.g., banking), or that permittee-responsible compensation is sufficiently successful, even though the originally planned hydrologic regime was not established.[6]

VII. Developing Performance Standards for Target Hydrology

A three-step, preferential sequence is applied as follows.

A. **First Priority.** Use on-site, or in proximity, reference wetland(s) instrumented with monitoring wells/dataloggers for contemporaneous comparison to water levels of the compensation site wetlands. If, for example, the compensation site consists of restoring a depressional, sedge meadow community on organic soils, a monitoring well(s)/datalogger(s) would be established in a reference, depressional, sedge meadow community on organic soils on-site or in proximity to the compensation site. Depth and duration of the water table in relation to the soil surface could then be compared between restored and reference sedge meadow communities. A hydrology performance standard would need to set criteria for the range of differences between restored/enhanced/created wetlands and reference wetlands that would still meet target hydrology. Duration of a water table ≤12 inches below the soil surface that is plus or minus 20 percent of that of a reference wetland is one example.

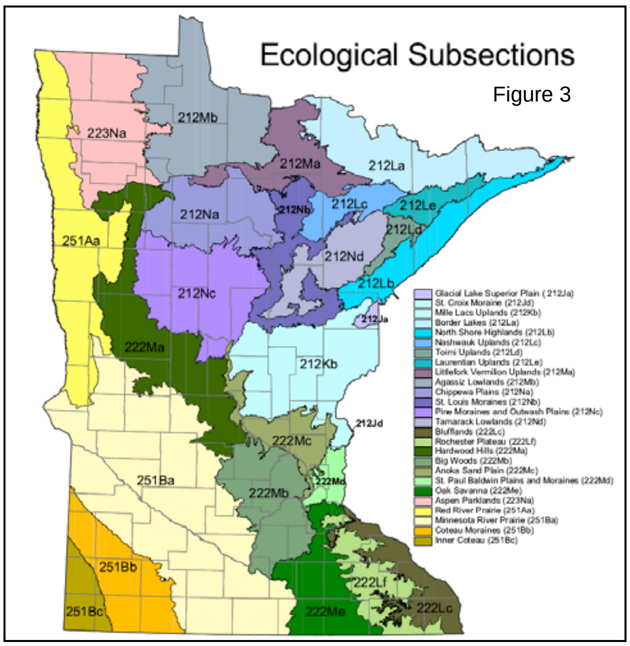
Example: *A reference wetland has a water table ≤12 inches below the soil surface for 50 consecutive days during a particular growing season. To be within the 20 percent variability range, a restored wetland would need to have a water table ≤12 inches below the soil surface for 40 to 60 consecutive days during that same growing season.*

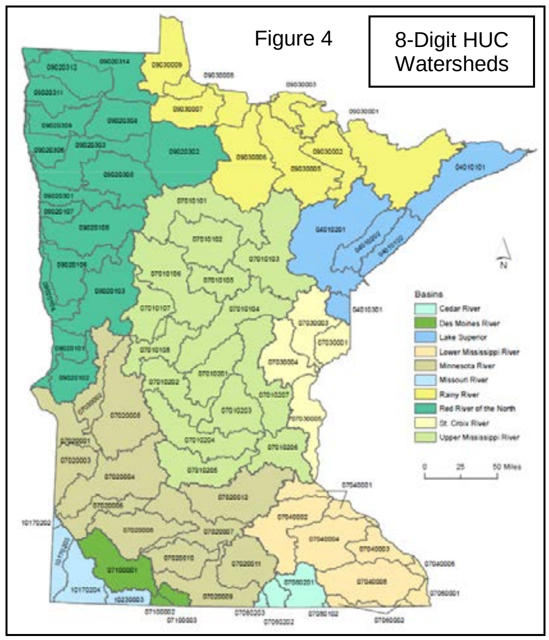
[6] In the case of a mitigation bank, crediting could range from full (maximum) credit to partial credit.

Simultaneous collection of hydrology data from both reference and restored/enhanced/created wetlands allows for direct comparisons across the entire range of normal, drier than normal, and wetter than normal, conditions that occur during a monitoring period. As a result, the subjectivity regarding the minimum number of consecutive days of inundation and/or a water table ≤12 inches below the soil surface can be avoided, and the evaluation of climatic conditions (Section V) is less critical.

While comparison of hydrology data from reference wetlands located on-site or in proximity to compensation site wetlands is the ideal for measuring the success of hydrologic restorations, it is often not practicable. In that event, proceed to the Second Priority.

B. **Second Priority.** Obtain monitoring well data from reference wetlands of the same wetland type—and located within the same reference domain—as that proposed for the compensation site. Most pertinent are data from the same subwatershed and/or ecoregion. Progressively broaden the search area within the reference domain, as necessary.





Figures 3 and 4. Is monitoring well data available from reference wetlands of the same wetland type—and within the same reference domain—as the compensation site? Start with the same ecoregion and 8-digit HUC as the compensation site, then progressively broaden the search area within the reference domain, as necessary.

Assemble and analyze hydrographs from reference wetlands to create a typical hydrograph to serve as the target hydrology for the compensation site. This is done for each wetland type proposed. For example, Figures 5, 6 and 7 illustrate hydrographs from reference wetlands [coniferous bog + organic soil flat + deep peat, acidic] within the same reference domain as a compensation site planned for that wetland type. A composite of the three hydrographs (Figure 8) establishes minimum and maximum brackets for water levels including periods of drought. The resulting hydrology performance standard is that water levels within the compensation site wetlands shall remain within the brackets shown by Figure 8 with a stipulation regarding drought conditions. Alternatively, the same data could be used to apply the performance standard as a narrative. In this example, the only occurrences of a water table greater than 12 inches below the soil surface occurred during drought conditions (as determined by the U.S. Drought Monitor). Thus, the performance standard could be stated as: *The water table, in relation to the soil surface, shall be +4 inches to -12 inches throughout the growing season with the exception of drought conditions (per U.S. Drought Monitor).*

Coniferous Bog + Organic Soil Flat + Deep Peat, Acidic

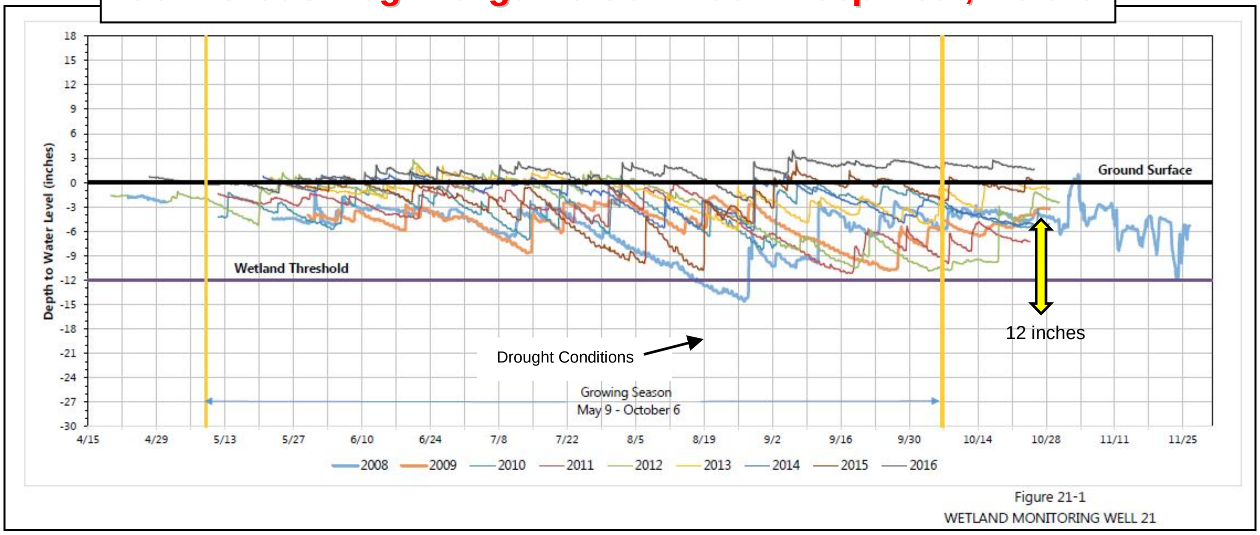


Figure 5: Reference Wetland 1 (ragged, horizontal lines are water table readings)

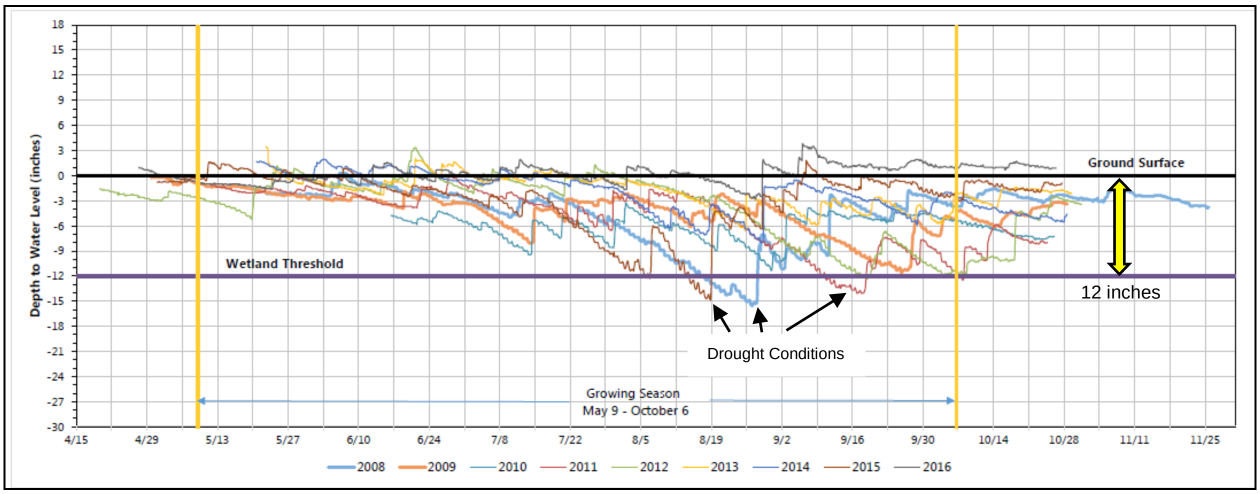


Figure 6: Reference Wetland 2

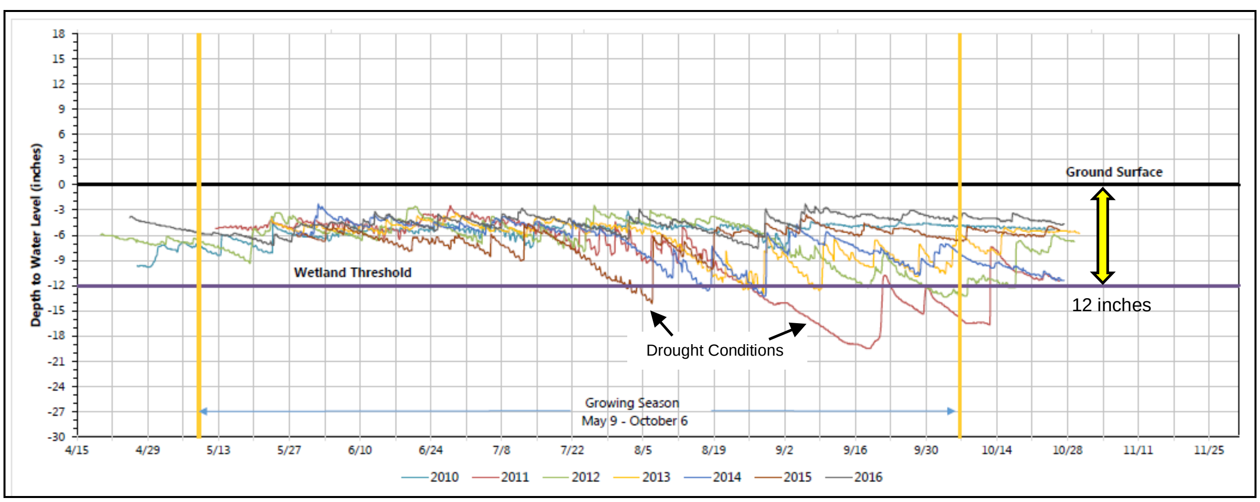


Figure 7: Reference Wetland 3

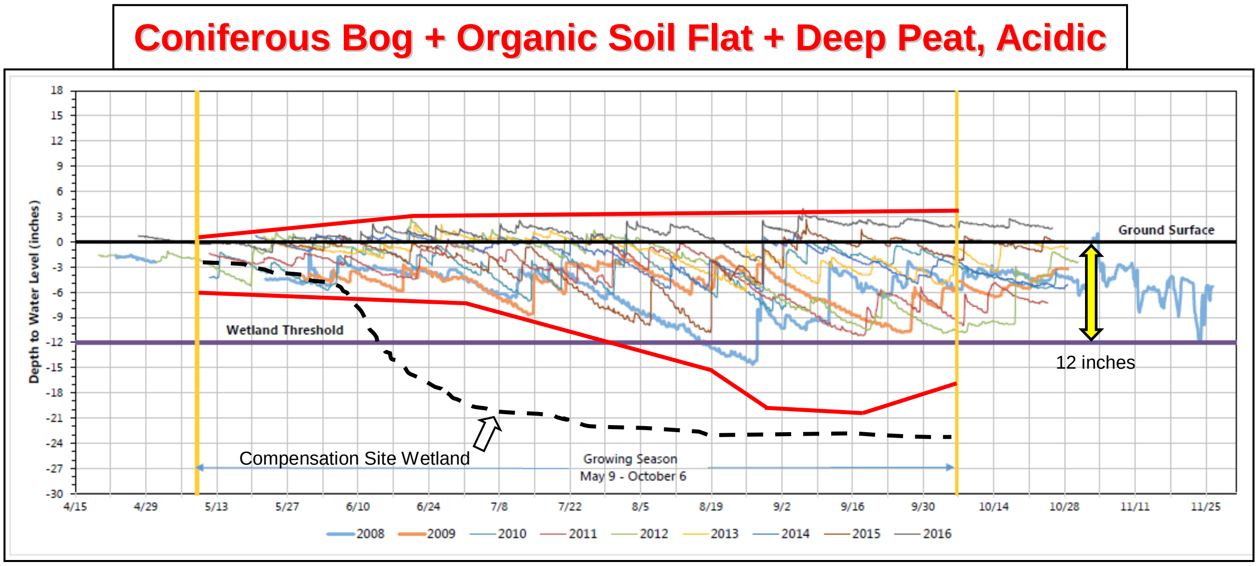


Figure 8: Composite hydrograph for three reference coniferous bogs: red brackets set upper and lower limits for variability in water table depths over nine growing seasons. The hydrology performance standard is met when water levels within the compensation site wetland remain within those brackets with the stipulation that water table levels more than 12 inches below the soil surface be correlated with drought conditions. The performance standard is not met, for example, if water levels deviate from the bracketed range as shown by the black dashed line.

C. **Third Priority.** If the Second Priority is not practicable, the next option is to develop performance standards specifying frequency, depth, duration and seasonality requirements based on best available science. Serving as the starting point is the wetland hydrology technical standard for interpreting monitoring well data and its minimum 14-consecutive day requirement for duration of inundation and/or a water table ≤12 inches below the soil surface during the growing season in ≥50 percent of years (U.S. Army Corps of Engineers 2005). Next, we can apply general categories of hydrologic regimes applicable to wetlands of Minnesota and Wisconsin. For example:

1. Seasonal Wetlands. A characteristic hydrograph applicable to a wide variety of wetlands in Minnesota and Wisconsin is inundation and/or a water table ≤12 inches below the soil surface for 4 to 8 weeks during the early growing season (April-May-June)—during normal and wetter than normal conditions—followed by water tables dropping more than 12 inches below the soil surface during the latter portion of the growing season (Figure 9). Recovery of the water table then typically occurs relatively rapidly after the close of the growing season when evapotranspiration rates plummet. Thus, 4 consecutive weeks (28 days) was applied as the minimum for inundation and/or a water table ≤12 inches below the soil surface for a number of the target hydrology performance standards described in Section VIII.

2. High Water Table throughout Growing Season. Another common, characteristic hydrograph—particularly for wetlands with organic soils and with groundwater as the dominant source of hydrology—is a water table ≤12 inches below the soil surface throughout the growing season with the exception of drought conditions.

3. Floodplain Forests. These wetlands have a well-defined hydrograph consisting of pulses of temporary inundation during flood events. See discussion in Section VIII for factors to consider in specifying metrics for performance standards.

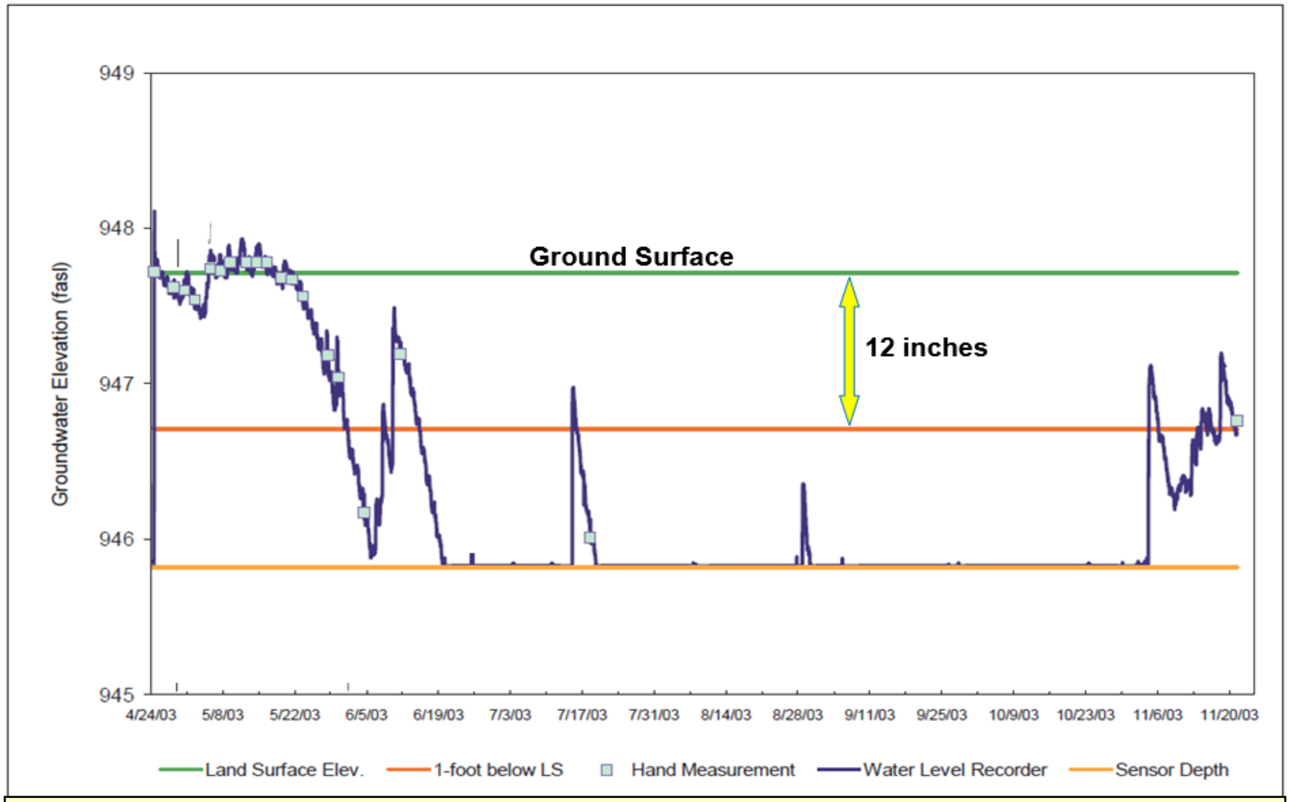


Figure 9
Typical Hydrograph for Seasonal Wetlands in Minnesota and Wisconsin

The above example shows inundation or a water table ≤12 inches below the soil surface for consecutive days from late April to the beginning of June after which the water table drops steeply and does not recover until after the end of the growing season in early November.

Section VIII details performance standards for specific wetland plant communities based on applying the Third Priority approach of best available science. It is important to acknowledge that the resulting frequency, depth, duration and seasonality requirements are qualitative as opposed to being based on quantitative data from reference wetlands. Thus, a degree of flexibility as described above is warranted given the many variables that can occur at compensation sites.

VIII. Target Hydrology for Specific Wetland Plant Communities[7]

The following specifications for target hydrology have two purposes. First, they provide a guide for design of a compensation site so that target plant communities are matched with the appropriate target hydrology. Second, they provide performance standards to evaluate success or failure of establishing target hydrology at compensation sites.

The target hydrology performance standard for each plant community is listed below in italics followed by user notes. Note that some plant communities (e.g., sedge meadows, shrub-carrs) have different performance standards for stands located on mineral soils versus organic soils.

[7] Plant communities are based on *Wetland Plants and Plant Communities of Minnesota and Wisconsin – Version 3.2* (Eggers and Reed 2015). Attachment B illustrates generalized cross sections of these communities.

A. **Seasonally Flooded Basins.** *Hydrology shall consist of inundation up to 36 inches in depth for a minimum of 14 consecutive days during the growing season under normal and wetter than normal hydrological conditions (per Sprecher and Warne 2000). Inundation shall be absent following the first 8 weeks of the growing season except during wetter than normal hydrological conditions (per Sprecher and Warne 2000).*

User Notes: This hydrologic regime fits "temporarily flooded" described by Cowardin et al. (1979) [e.g., PEMA] (Table 1). Seasonally flooded basins are characterized by temporary inundation during the growing season changing to mudflats that are subsequently colonized primarily by annual plant species. More frequent and/or longer periods of inundation would trend towards establishing marsh communities dominated by perennial, emergent aquatics, while longer-term soil saturation would trend towards wet/sedge meadows dominated by perennial grass/sedge/forb mixtures.

Table 1 – Cowardin Hydrologic Regimes

A = Temporarily Flooded: *Surface water is present for brief periods during the growing season, but the water table usually lies well below the soil surface for most of the season.*
B = Saturated: *The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present.*
C = Seasonally Flooded: *Surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. When surface water is absent, the water table is often near the soil surface.*
F = Semi-Permanently Flooded: *Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the soil surface.*
G = Intermittently Exposed: *Surface water is present throughout the year except in years of extreme drought.*
H = Permanently Flooded: *Water covers the land surface throughout the year in all years.*

B. **Floodplain Forests.** *Hydrology shall consist of inundation for a minimum of 14 consecutive days during the growing season under normal and wetter than normal hydrological conditions (per Sprecher and Warne 2000). Depth of inundation shall range up to ___ feet* {specify maximum depth based on site-specific conditions}*. Duration of inundation during the growing season shall not exceed 28 consecutive days for a single flood event* {see user notes} *except: (1) during wetter than normal hydrological conditions (per Sprecher and Warne 2000); and (2) side channels and other depressional areas can have standing water for extended duration.*

User Notes: This hydrologic regime fits "temporarily flooded" described by Cowardin et al. (1979) [e.g., PFOA] (Table 1). Twenty-eight consecutive days is suggested as the maximum duration of inundation for a single flood event, but site-specific data should be applied to determine this specification as longer durations may be more appropriate within floodplains of large river systems. Note that the minimum 14 consecutive days of inundation would typically result in an additional number of days with a water table ≤12 inches below the soil surface depending upon soil texture. This is incorporated into the subject performance standard by virtue of specifying a minimum of 14 consecutive days of inundation. Less frequent and/or shorter-term inundation would be less likely to support the target floodplain forest community as it would be conducive for competition and colonization by non-hydrophytic species, which could result in an upland community. Seasonal as opposed to temporary inundation coupled with longer-term periods of a water table ≤12 inches below the soil surface would trend towards shrub swamp and hardwood swamp communities. At the wetter end of the spectrum, longer-term inundation would trend towards establishing marsh communities.

An alternative approach, if stream gauging data and one-foot contour interval mapping of the compensation site are available, is to specify frequency and duration of inundation using elevations. For example, the performance standard could specify that ≥14 consecutive days of inundation during the growing season shall occur at the following annual frequencies: (1) ≥90 percent for the lowest elevation; (2) ≥70 percent for elevations one foot higher; and (3) ≥50 percent for elevations two feet higher (Figure 10).

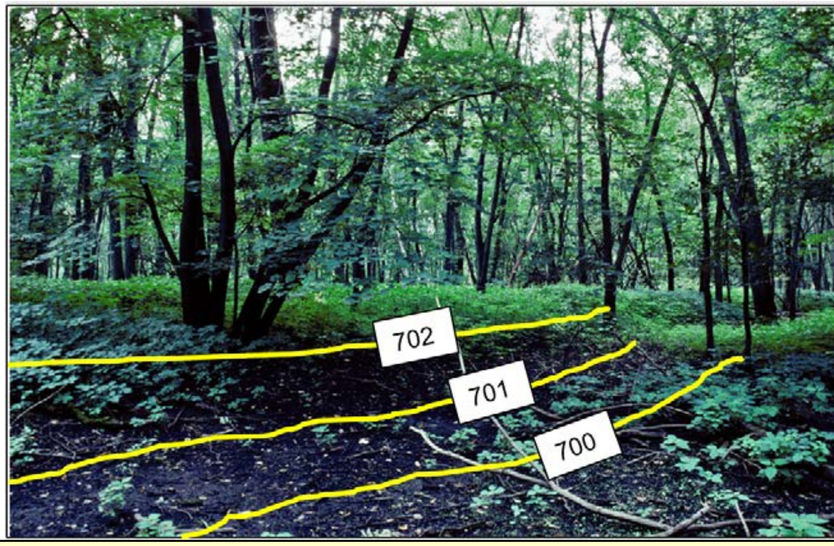


Figure 10
Example: **Target Hydrology for Floodplain Forest Communities**

Hydrology shall consist of inundation for a minimum of 14 consecutive days during the growing season at the following annual frequencies:

- Elevations below 700: $\geq$90%
- Elevations 700-701: $\geq$70%
- Elevations 701-702: $\geq$50%

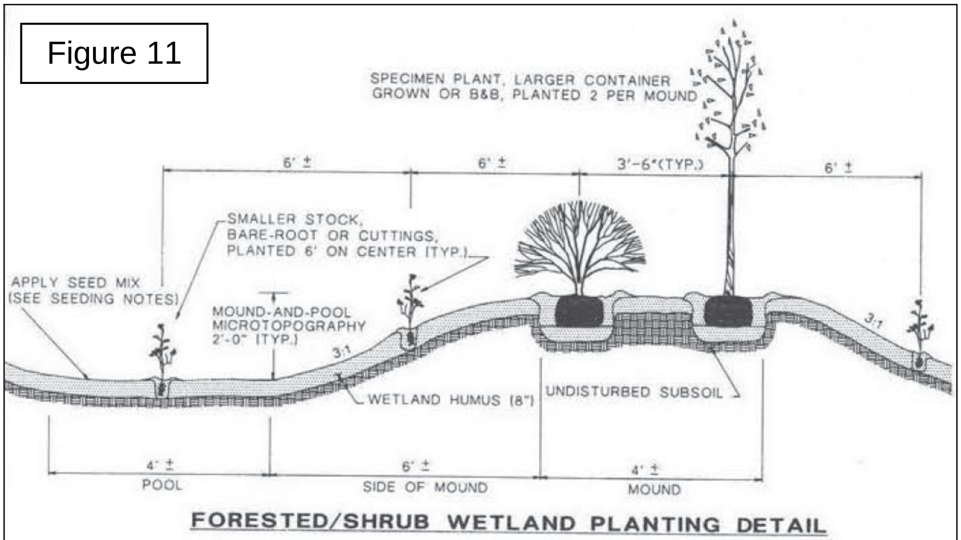
More than one flood event within a single growing season can occur in floodplain forests of Minnesota and Wisconsin, e.g., a flood event in April due to snowmelt/precipitation and a second flood event in July due to heavy precipitation events. Target hydrology is met as long as the duration of inundation for each flood event does not exceed the specification in the performance standard and the exceptions listed in the performance standard do not apply.

For floodplain forest compensation sites that are to be planted with woody stock, note that woody seedlings/saplings—including those of hydrophytic species—are sensitive to anaerobic conditions in the root zone and could be stressed or drowned out by inundation/soil saturation. Seedlings/saplings typically need to be planted on mounded soils (hummocks) to promote initial root system development (Figure 11). Or, if feasible, hydrologic restoration can be delayed for 2-3 growing seasons to allow for initial root system development.

For additional information, Matthews and Pociask (2015) provide an in-depth analysis of tree survival within floodplain forest compensatory mitigation sites in Illinois.

C. **Hardwood Swamps, Shrub-Carrs and Alder Thickets (Mineral Soils).** *Hydrology shall consist of a water table 12 inches or less below the soil surface, to inundation up to 6 inches in depth, for a minimum of 28 consecutive days, or two periods of 14 or more consecutive days, during the growing season under normal and wetter than normal hydrological conditions (per Sprecher and Warne 2000). Inundation greater than 6 inches in depth during the growing season shall not occur except following the 10-year, 24-hour—or greater—precipitation events. Duration of inundation greater than 6 inches depth shall be less than 14 consecutive days. An exception can be made for sites with hummocky microtopography—hollows between hummocks can have standing water depths up to 12 inches for extended duration.*

Figure 11



From Barry et al. (1996)

User Notes: This hydrologic regime includes both the "saturated" and "seasonally flooded" regimes described by Cowardin et al. (1979) [e.g., PSSB or C] (Table 1). For compensation sites that are to be planted with woody stock, note that woody seedlings/saplings—including those of hydrophytic species—are sensitive to anaerobic conditions in the root zone and could be stressed or drowned out by inundation/soil saturation. Seedlings/saplings typically need to be planted on mounded soils (hummocks) to promote initial root system development (Figure 11). Or, if feasible, hydrologic restoration can be delayed for 2-3 growing seasons to allow for initial root system development.

D. **Fresh (Wet) Meadows, Sedge Meadows and Wet Prairies (Mineral Soils).** *Hydrology shall consist of a water table 12 inches or less below the soil surface for a minimum of 28 consecutive days, or two periods of 14 or more consecutive days, during the growing season under normal and wetter than normal hydrological conditions (per Sprecher and Warne 2000). Inundation during the growing season shall not occur except: (1) at the start of the growing season (due to snowmelt/precipitation); and (2) following the 10-year, 24-hour—or greater—precipitation events. Depth of inundation during the growing season shall be 6 inches or less with duration of less than 14 consecutive days. An exception can be made for sites with hummocky microtopography—hollows between hummocks can have standing water depths up to 6 inches for extended duration.*

User Notes: This hydrologic regime fits "saturated" described by Cowardin et al. (1979) [e.g., PEMB] (Table 1). If the water table within the upper 12 inches is of a shorter duration or less frequent occurrence, it would reduce the competitive advantage of hydrophytic species versus non-hydrophytic species. Specifically, a drier regime would be more conducive to colonization and competition by undesirable and/or invasive FAC and FACU species including Canada goldenrod, Canada thistle, common ragweed, giant ragweed, stinging nettle, common buckthorn, common cocklebur and garlic mustard.

E. **Fresh (Wet) Meadows, Sedge Meadows, Hardwood Swamps, Coniferous Swamps, Shrub-Carrs, Alder Thickets, Open Bogs and Coniferous Bogs (Organic Soils).**

1. Performance Standard 1 (Typical): *Hydrology shall consist of a water table 12 inches or less below the soil surface from the start of the growing season to at least July 1st, with the exception of drought*

conditions (Categories D0-D4, Attachment A). The water table shall not drop more than ____ inches below the soil surface {see user notes for guidance on specifying maximum depths to the water table} *during the remainder of the growing season. Inundation during the growing season shall not occur except: (1) at the start of the growing season (due to snowmelt/precipitation); and (2) following the 10-year, 24-hour—or greater—precipitation events. Depth of inundation shall be 6 inches or less with duration of less than 14 consecutive days. An exception can be made for sites with hummocky microtopography—hollows between hummocks can have extended durations of standing water depths up to: (1) 6 inches for fresh (wet) meadows, sedge meadows, open bogs and coniferous bogs; or (2) 12 inches for hardwood swamps, coniferous swamps, shrub-carrs and alder thickets.*

User Notes: A water table 12 inches or less below the soil surface is specified from the start of the growing season to at least July 1st—with an exception for drought conditions—due to snowmelt, spring rains and lower evapotranspiration rates of the early growing season compared to mid- and late-summer, coupled with the water retention capacity of organic soils. A maximum depth to the water table during the remaining portion of the growing season is not specified herein for Performance Standard 1 because numerous variables are involved. Monitoring well data from reference wetlands would be ideal for determining an appropriate maximum depth to the water table for a specific compensation site. If these data are not available, examples of the types of information that could be considered for determining an appropriate maximum depth to the water table include:

a. Monitoring well data for reference wetlands in northern Minnesota, for example, showed a pattern of mid- to late-growing season water table drawdown of 14-24 inches below the soil surface under normal hydrological conditions, particularly in cases of shallower organic layers over mineral soils.

b. Schouwenaars (1988) states that successful regeneration of *Sphagnum* requires a water table within 16 inches of the soil surface during the growing season. Therefore, for compensation sites where *Sphagnum* regeneration is a component of the target vegetation, 16 inches could be specified as the maximum depth to the water table.

c. Ombrotrophic bogs (hydrology, minerals and nutrients received solely from precipitation and dust fall as opposed to runoff and/or groundwater [MnDNR 2003]) are highly responsive to precipitation events and dry periods between. Widely fluctuating water tables for these systems is the norm. Specifying a maximum depth to the water table may not be a critical factor unless *Sphagnum* regeneration is a component of the restoration (see b. above). Rather, the critical factor is confirming that during the growing season the water table is ≤12 inches below the soil surface for ≥14 consecutive days in response to precipitation events. A list of characteristic plant species of ombrotrophic bogs is provided by Appendix D in MnDNR (2003). This assemblage of plant species, coupled with absence of any minerotrophic species, can assist in identifying ombrotrophic bogs in the field.

2. Performance Standard 2 (For Predominantly Groundwater-Fed or Lacustrine Fringe Sites): *Hydrology shall consist of a water table 12 inches or less below the soil surface throughout the growing season with the exception of drought conditions (Categories D0-D4, Attachment A). Inundation during the growing season shall not occur except: (1) at the start of the growing season (due to snowmelt/ precipitation); and (2) following the 10-year, 24-hour—or greater—precipitation events. Depth of inundation shall be 6 inches or less with duration of less than 14 consecutive days. An exception can be made for sites with hummocky microtopography—hollows between hummocks can have extended durations of standing water depths up to: (1) 6 inches for fresh (wet) meadows, sedge meadows, open bogs and coniferous bogs; or (2) 12 inches for hardwood swamps, coniferous swamps, shrub-carrs and alder thickets.*

User Notes for Both Performance Standards 1 and 2: These hydrologic regimes fit within "saturated" described by Cowardin et al. (1979)[e.g., PSSB, PMLB](Table 1).

Continuous or nearly continuous saturation to the soil surface during the growing season is necessary to prevent oxidation and subsidence of organic (peat/muck) soils. A characteristic of organic soils is their high water retention capacity. With regard to the capillary fringe, saturation in organic soils can extend well above the water table.[8] For example, a water table 14-18 inches below the soil surface can result in soil saturation within the upper 12 inches. Layering within organic soils due to differing degrees of decomposition/plant materials can create "perched" conditions and horizontal flows, which can be important factors to consider in restoring hydrology.

Restoring hydrology to pre-disturbance (e.g., pre-ditching) conditions is not practicable for some compensation sites due to irreversible changes in the contributing watershed, or ditches that cannot be legally filled/blocked, or other factors. If Performance Standard 1 is not practicable, it is recommended that: (1) a soil scientist provides an analysis of the depth/composition/structure of the organic soils; and (2) hydrologic inputs/outputs of the site are quantified to the extent practicable. This information can then be factored into developing a site-specific hydrology performance standard that would meet the goals/objectives for restoration of that site.

For compensation sites that are to be planted with woody stock, note that woody seedlings/saplings—including those of hydrophytic species—are sensitive to anaerobic conditions in the root zone and could be stressed or drowned out by inundation/soil saturation. Seedlings/saplings typically need to be planted on mounded soils (hummocks) to promote initial root system development (Figure 11). Or, if feasible, hydrologic restoration can be delayed for 2-3 growing seasons to allow for initial root system development.

F. **Calcareous Fens.** *Hydrology shall consist of a water table 12 inches or less below the soil surface throughout the growing season with the exception of drought conditions (Categories D0-D4, Attachment A). Inundation during the growing season shall not occur with two exceptions: (1) hollows between hummocks can have standing water depths of up to 6 inches for extended duration; and (2) small marl pools or springs, which are natural features of some calcareous fens.*

User Notes: This hydrologic regime fits within "saturated" described by Cowardin et al. (1979) [e.g., PEMB] (Table 1). Continuous or nearly continuous saturation to the surface during the growing season is necessary to prevent oxidation and subsidence of organic soils as well as changes in water and soil chemistry. It also inhibits the ability of undesirable FAC and FACU species to colonize and/or dominate the compensation site.

G. **Shallow Marshes.** *Hydrology shall consist of inundation up to 6 inches in depth for at least 28 consecutive days during the growing season under normal and wetter than normal hydrological conditions (per Sprecher and Warne 2000)*{see user notes regarding duration of inundation}*. During the growing season, inundation up to 18 inches in depth following the 2-year, 24-hour—or greater—precipitation events is permissible provided that the duration does not exceed 28 consecutive days (i.e., water depth drops from 18 inches to 6 inches within 28 days).*

User Notes: Depth of inundation is from Shaw and Fredine (1971) and duration reflects the "seasonally flooded" hydrologic regime described by Cowardin et al. (1979) [e.g., PEMC] (Table 1). However, inundation can be semi-permanent for shallow marshes in riverine or lacustrine fringe settings [e.g., PEMF]

[8] Varies considerably due to different degrees of decomposition (sapric vs. hemic vs. fibric), source of plant material (woody vs. sedge vs. *Sphagnum*), and overall heterogeneity of the organic layers.

(Table 1) especially where water levels are maintained by control structures. Therefore, the specification for duration of inundation should be based on site-specific conditions (28 consecutive days during the growing season, used above, is a starting point). Long-term inundation by water depths greater than 6 inches would establish deep marsh communities while even deeper, nearly permanent water depths would establish shallow, open water communities. Another factor to be aware of is excessive "bounce" in water levels that can result in unvegetated open water or mudflats, or at best monotypes or mixed stands of reed canary grass, cattails and/or *Phragmites*.

H. **Deep Marshes.** *Hydrology shall consist of inundation 6 to 48 inches in depth throughout the growing season with the exception of drought conditions (Categories D0-D4, Attachment A).*

User Notes: Water depths are based on Shaw and Fredine (1971) and duration is based on the "semi-permanently flooded" to "intermittently exposed" hydrologic regimes described by Cowardin et al*.* (1979) [e.g., PEMF, PAB/EMG] (Table 1).

I. **Shallow, Open Water Communities.** *Hydrology shall consist of permanent to nearly permanent water depths of 48 to 80 inches*.

User Notes: Water depths are based on Shaw and Fredine (1971) as well as being sufficient to preclude establishment of emergent vegetation. Water depths greater than 80 inches (e.g., about 2 meters) are generally considered deep water habitats as opposed to wetlands. Duration is based on the "intermittently exposed" to "permanently flooded" hydrologic regimes described by Cowardin et al*.* (1979) [e.g., L2ABH] (Table 1).

IX. Conclusion

Matching target hydrology with target vegetation at compensation sites is essential to achieve a higher degree of success in offsetting loss of wetland functions due to projects authorized by the Corps regulatory program. Use of data from reference wetlands is the preferred approach to developing hydrology performance standards. If sufficient data from reference wetlands is not available, best available science is applied. As described above, should a compensation site develop a different hydrologic regime than initially planned, it is not necessarily a failure. The Corps will determine whether that hydrologic regime is supporting native wetland plant communities and, overall, whether the compensation site wetlands are providing functions and services that adequately offset those lost due to authorized impacts.

Table 2 summarizes key points regarding target hydrology.

Table 2 – Summary
1. Use monitoring wells with dataloggers set for 4 to 6 readings/day
2. Install monitoring wells and begin data collection as soon as frost is out of the ground
3. Use reference wetlands, when feasible, to compare hydrology to that of restored/enhanced/created Wetlands
4. Use 30-day rolling totals to characterize precipitation during each monitoring year
5. Use site-specific data to tailor hydrology performance standards to achieve the goals/objectives for a particular compensation site
6. Apply best professional judgment and, when warranted, flexibility

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This guidance will be in effect until revised or rescinded.

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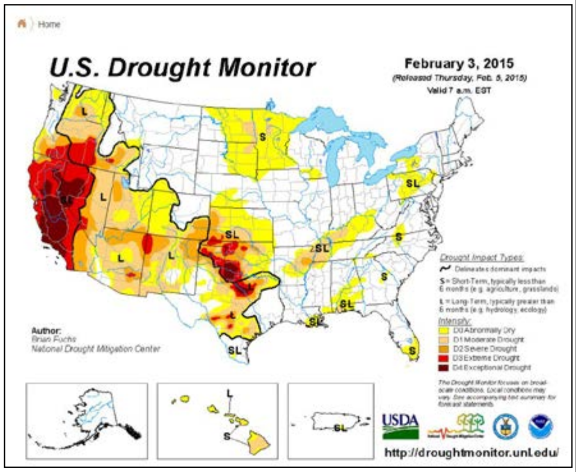
Attachment A
Drought Severity Classification

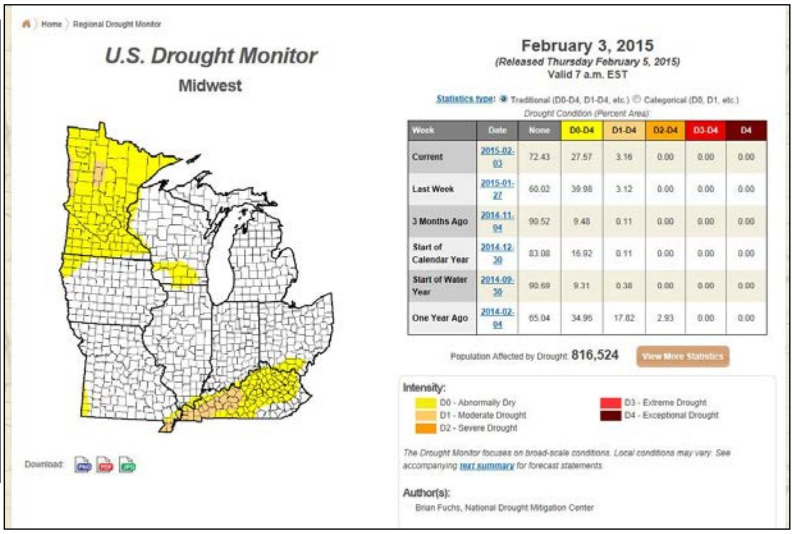
Drought Severity Classification

Category	Description	Possible Impacts	Ranges: Palmer Drought Index	Ranges: CPC Soil Moisture Model (Percentiles)	Ranges: USGS Weekly Streamflow (Percentiles)	Ranges: Standardized Precipitation Index (SPI)	Ranges: Objective Short and Long-term Drought Indicator Blends (Percentiles)
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered	-1.0 to -1.9	21-30	21-30	-0.5 to -0.7	21-30
D1	Moderate Drought	Some damage to crops, pastures; streams, reservoirs, or wells low, some water shortages developing or imminent; voluntary water-use restrictions requested	-2.0 to -2.9	11-20	11-20	-0.8 to -1.2	11-20
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed	-3.0 to -3.9	6-10	6-10	-1.3 to -1.5	6-10
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions	-4.0 to -4.9	3-5	3-5	-1.6 to -1.9	3-5
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies	-5.0 or less	0-2	0-2	-2.0 or less	0-2

Source: National Drought Mitigation Center
http://droughtmonitor.unl.edu/AboutUs/ClassificationScheme.aspx

Example graphics:





Attachment B

Generalized Cross Sections Illustrating Wetland Plant Communities Cited in the Text

(From Eggers and Reed 2015)

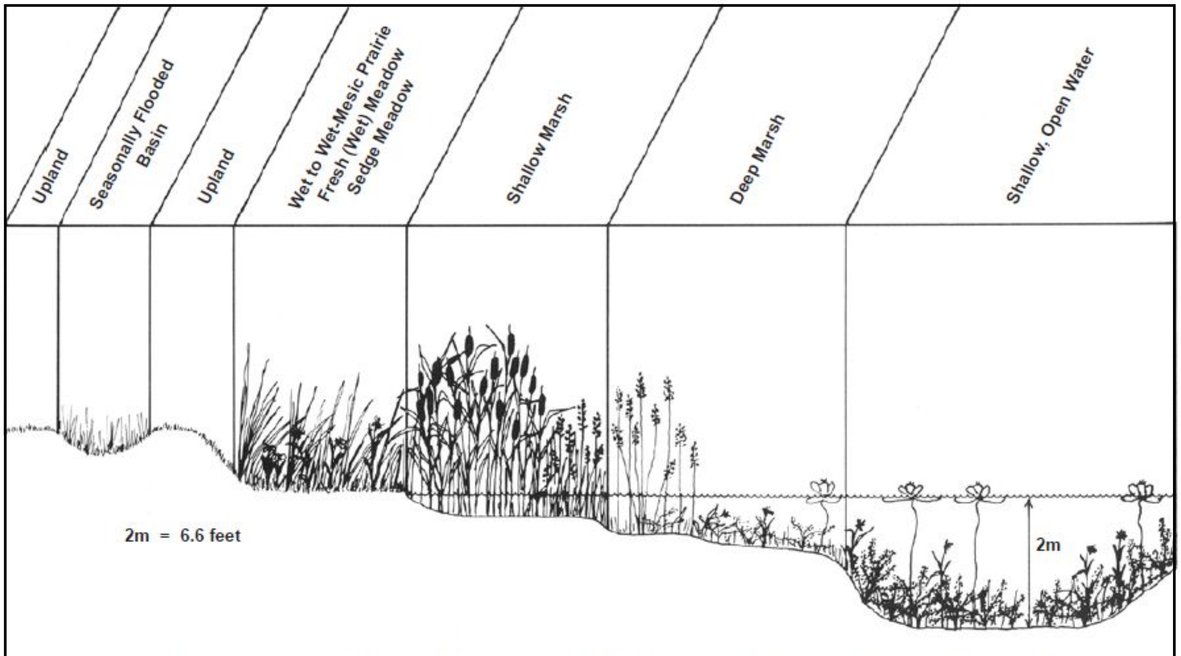


FIGURE 6 - **Generalized Cross Section of a Meadow-Marsh-Open Water Complex**

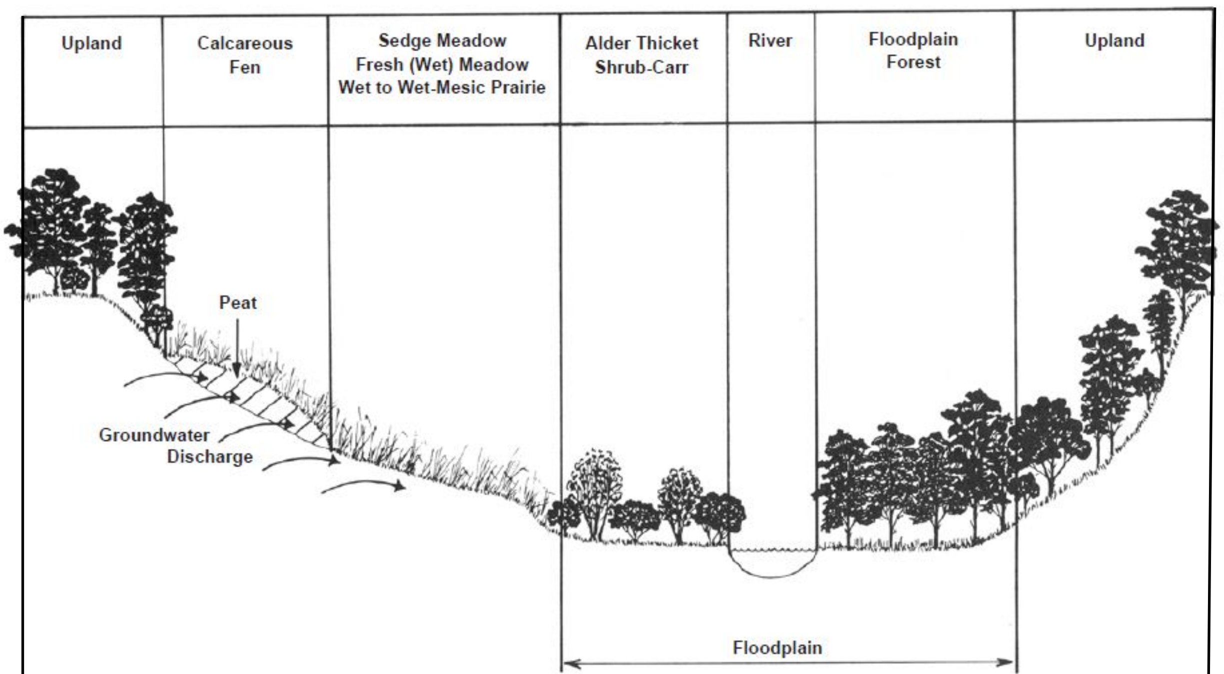


FIGURE 7 - **Generalized Cross Section of Wetland Plant Communities in a River Valley**

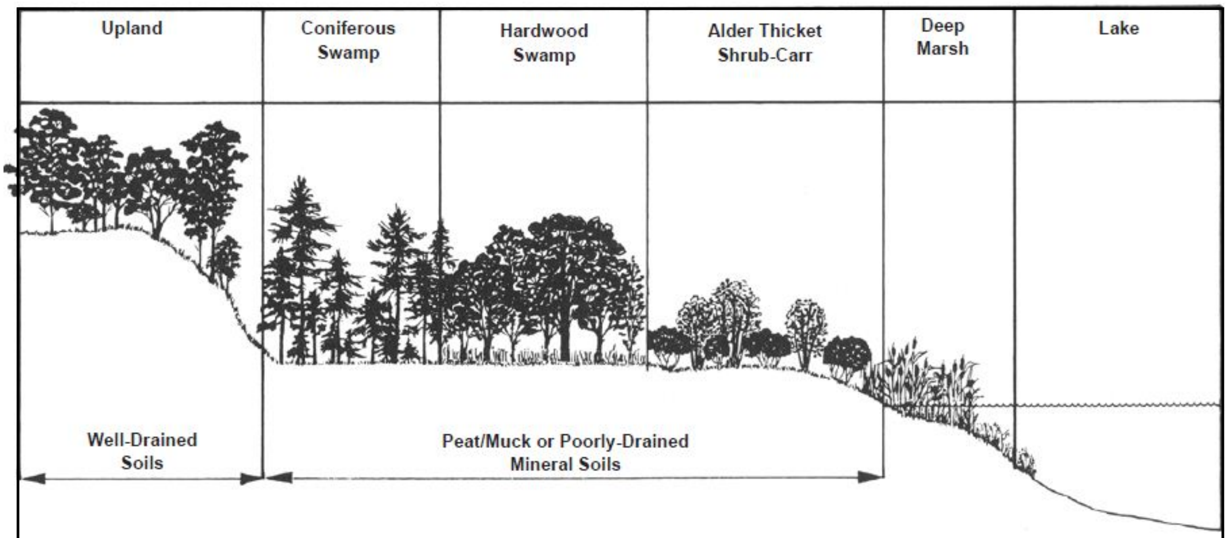


FIGURE 8 - **Generalized Cross Section of Wetland Plant Communities in a Lake Basin**

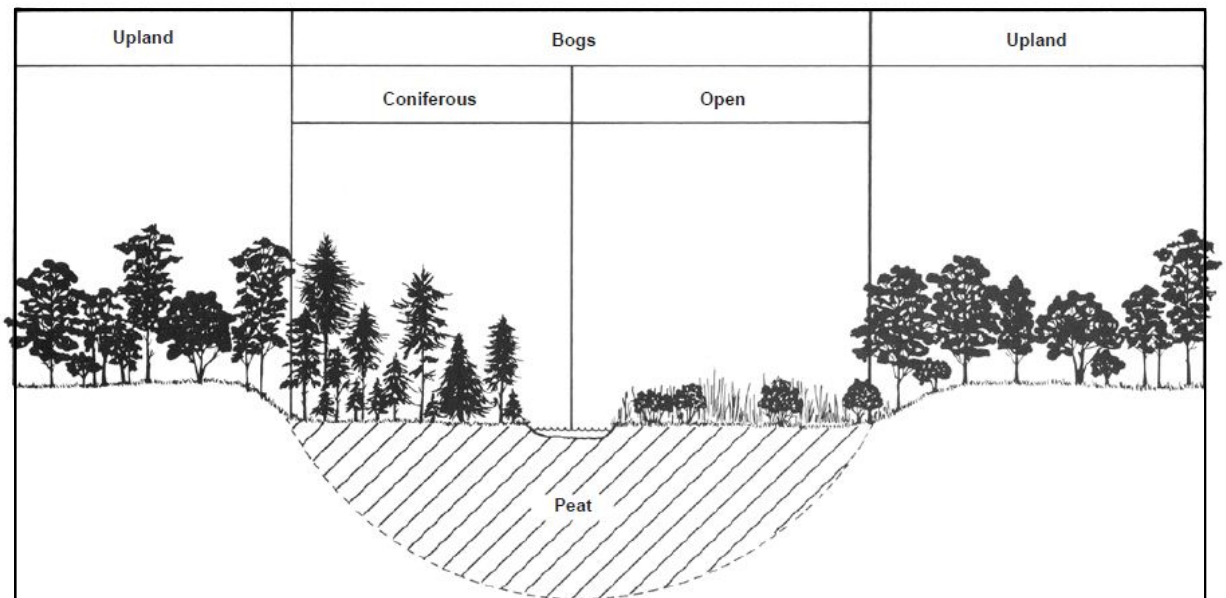


FIGURE 9 - **Generalized Cross Section of a Bog**

Attachment C
Scientific Names for Plant Species Cited in the Text

Common Name	Scientific Name
Canada goldenrod	*Solidago canadensis*
Canada thistle	*Cirsium arvense*
Cattails	*Typha* spp.
Common buckthorn	*Rhamnus cathartica*
Common cocklebur	*Xanthium strumarium*
Common ragweed	*Ambrosia artemisiifolia*
Garlic mustard	*Alliaria petiolata*
Giant ragweed	*Ambrosia trifida*
Phragmites	*Phragmites australis*
Reed canary grass	*Phalaris arundinacea*
Stinging nettle	*Urtica dioica*