Hydric Soils Technical Note 11: Hydric Soils Technical Standard and Data Submission Requirements for Field Indicators of Hydric Soils

Revised December 2015

PURPOSE: This document describes the Technical Standard for Hydric Soils (HSTS), which provides a quantitative method to determine if a soil meets the definition of a hydric soil. The HSTS is primarily used to: 1) Identify a hydric soil when field indicator may not be present (e.g., wetland restoration, mitigation, creation, construction); 2) Evaluate the current functional hydric status of a soil (e.g., changes in hydrology); and 3) Propose changes to existing hydric soil indicators (e.g., expanding geographic area of application; revision to technical requirements).

The following sections describe the HSTS and provide guidance regarding the collection and submission of data to the National Technical Committee for Hydric Soils (NTCHS) to validate that a site has met the HSTS. The submission of clear, concise data to the NTCHS promotes technical accuracy, transparency, and efficient decision making in support of hydric soil and wetland resource management. This document describes the minimum data necessary; however, the NTCHS may request additional supporting data depending on specific circumstances.

TECHNICAL STANDARD: The HSTS was developed and approved by the NTCHS and provides a method to demonstrate that a soil currently meets the definition of a hydric soil. Hydric soils are defined as soils "formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part" (Federal Register 1994). As a result, the HSTS requires proof of 1) anaerobic conditions and 2) soil saturation for at least 14 consecutive days for most soils, or for 7 consecutive days for a total of 18 annual days for Vertisols in Louisiana and Texas 3) during normal rainfall periods when soil microbes are active. The following section presents the technical requirements for anaerobic conditions and soil saturation.

1) Anaerobic conditions - The HSTS provides for three methods to document anaerobic conditions in the soil.

   a) *Indicator of Reduction in Soils (IRIS) tubes*

A minimum of three of five Indicator of Reduction in Soil (IRIS) tubes must have 30 percent iron removed from a zone 15 cm (6 in) or more thick. The zone of removal must begin within 15 cm of the soil surface for all soil textures.

   b) *Oxidation-reduction potential (Eh) measurements using platinum electrodes*

A minimum of three of five platinum electrodes must have measurements of Eh <175 mv at pH 7. Eh is adjusted for pH on a line with a slope of negative 60 (Figure 1). Soil pH measurement must be collected in-situ each time an Eh measurement is made at the location of one of the five platinum electrodes. Electrodes should be installed at 25 cm (10 in) for most soils, 12.5 cm (5 in) in sandy textured soils, and 10 cm (4 in) in soils that are flooded or ponded and typically do not saturate to greater depths.

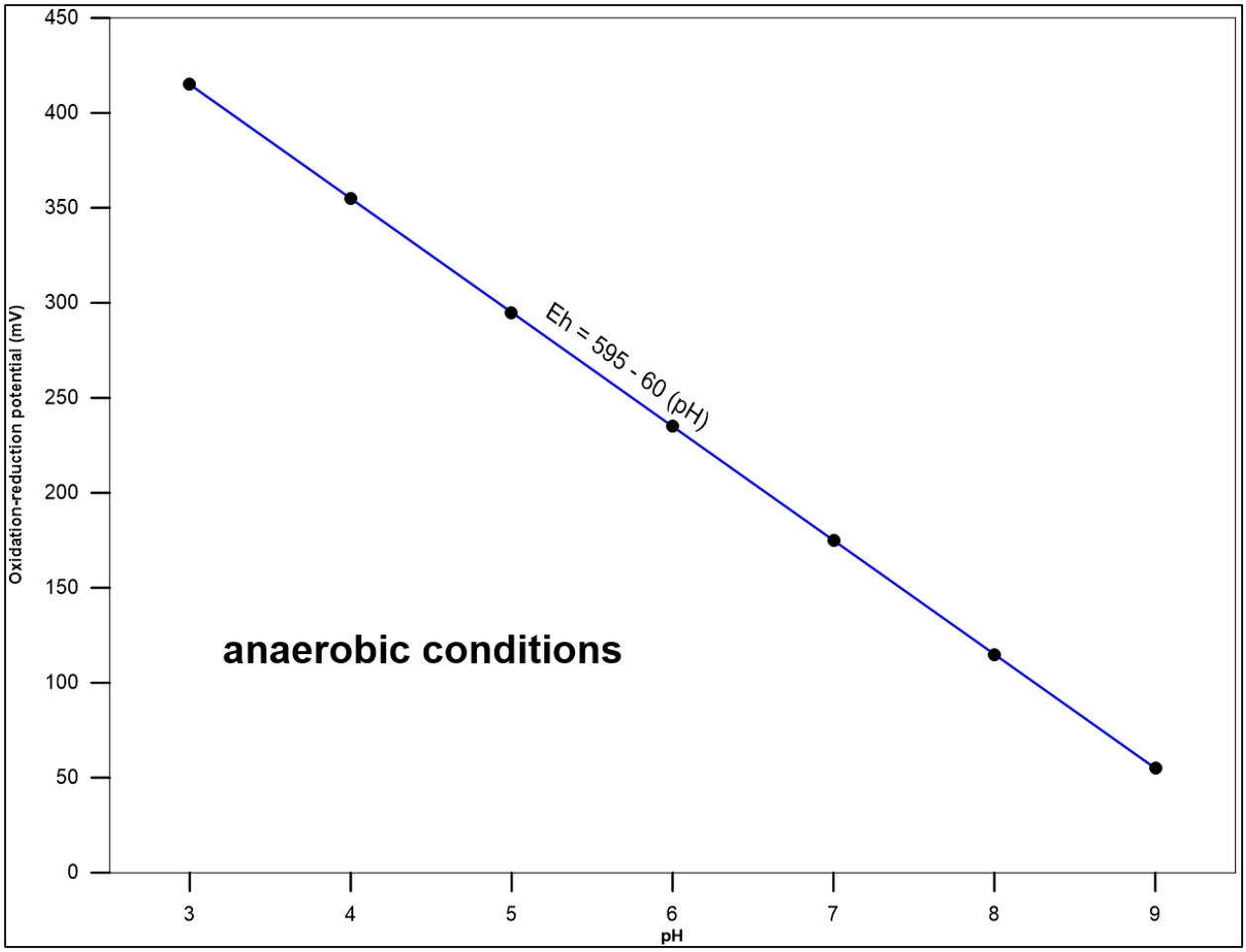


Figure1. Eh-pH diagram utilized to determine if oxidation-reduction potential measurements are considered anaerobic for the purposes of hydric soil identification. The NTCHS has established this as the standard for soils with a pH of 3 to 9. Oxidation-reduction potential measurements occurring below the line are considered anaerobic.

c) Alpha-alpha-dipyridyl dye

A positive reaction to alpha-alpha-dipyridyl dye must occur within 60 percent or more of a specific layer in at least two of three soil samples. Alpha-alpha dipyridyl reaction must occur within a 5 cm (2 in) layer of the upper 10 cm (4 in) in soil that inundate but not saturate, a 6.25 cm layer (2.5 in) of the upper 12.5 (5 in) cm in sandy textured soils, and 10 cm (4 in) of the upper 30 cm (12 in) for clayey textured soils.

2) Saturated Conditions

Saturated conditions are determined by the depth to free water measured in a piezometer or shallow well. Soil saturation must occur for at least 14 consecutive days in most soils. Vertisols in Louisiana and Texas require soil saturation for at least 7 consecutive days with saturation occurring for a minimum of 18 days annually. Soil saturation must occur within 25 cm (10 in) of the soil surface in all soils at an estimated frequency of >50 percent (i.e. five years in ten).

3) Rainfall Normality

Rainfall normality evaluations examine the 30th and 70th percentile averages based on long-term (e.g., 30 years) average precipitation records. A period of normal or dryer than normal rainfall 3 months prior to and throughout the study period is necessary to validate the presence of a hydric soil.

BACKGROUND: The identification of hydric soils represents an important component of wetland resource management including requirements of the Clean Water Act (National Research Council 1995; Tiner 1999) and Food Security Act (USDA NRCS 1994). Hydric soils are defined as soils that "formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part" (Federal Register 1994). In a field setting, hydric soils are identified using field indicators which are based on readily observable morphological features such as soil color, texture, and the presence of redoximorphic features (Vepraskas 2001). Over the past several decades, soils research has linked the underlying biogeochemical process occurring in wetlands with the morphological patterns observed in hydric soils (Vepraskas and Sprecher 1997). These studies resulted in the development of the HSTS.

The NTCHS maintains sole responsibility of the final approval for changes to the list of field indicators and encourages research investigating hydric soil morphology and identification across the country. As a result, scientists conducting research on hydric soil identification are required to submit data to NTCHS in support of proposed changes to the Field Indicators of Hydric Soils in the United States (Field Indicators; NRCS 2010). In the past, incomplete or disorganized data were among the reasons that field indicator proposals were unsuccessful, resulted in requests for additional data, and led to delays in revisions to the Field Indicators.

The NTCHS is aware of the time and cost involved in collecting hydric soil data in support of field indicator revisions. The section below provides guidance regarding data submission requirements to promote accurate and efficient response to field indicator proposals. The NTCHS suggests that anyone planning to initiate a study based all or in part on the HSTS consult with the NTCHS or reviewing agency to be sure the study meets the all of the requirements necessary for acceptance.

DATA REQUIREMENTS: Field studies should utilize data collected at paired hydric/nonhydric soil locations (Figure 2; Berkowitz and Sallee 2011). Paired locations should be co-located approximately within 3 meters (m) (10 ft.) of each other. The paired locations approach is required to demonstrate that hydric soil conditions exist within the hydric location and remain absent in the nonhydric location. A minimum of three paired hydric/nonhydric study areas at different locations are required for consideration of additions or changes to field indicators. Within each paired hydric/nonhydric location, the data required for submission of changes to the list of field indicators includes three components:

1) Soil descriptions
2) Evidence that the soil meets the HSTS
3) Analysis of rainfall normality.

All data should be presented to the NTCHS at least 60 days prior to scheduled meeting, providing time for Committee members to review and evaluate the data.

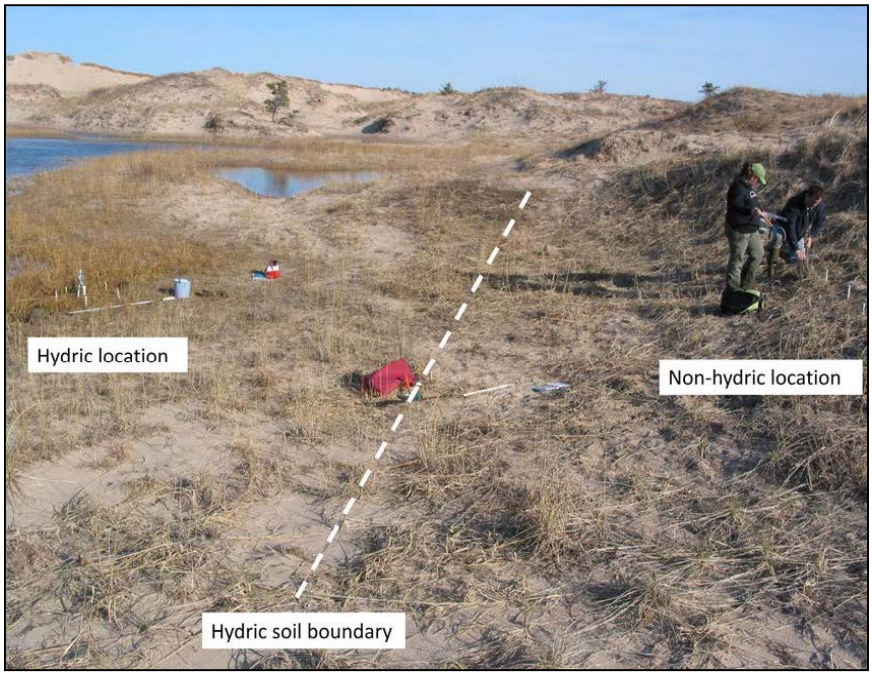


Figure 2. Example of paired hydric/nonhydric sample locations (Berkowitz and Noble 2014). Within each location, 1) soils descriptions, 2) HSTS data, and 3) rainfall normality analysis will be collected, analyzed, and submitted to NTCHS for review.

1) Soil descriptions

Soil descriptions are not specifically required in the HSTS but are necessary to show that the soil does not meet an existing field indicator or meets a proposed field indicator. Data requirements for hydric soil field indicator development should include descriptions of the morphological features occurring within each paired hydric/nonhydric sample location. Soil descriptions must include data on soil layer depth, matrix color, oxidation-reduction (redox) feature presence abundance, type, and location, soil texture, and any existing hydric soil indicators met. If no hydric soil indicators were met, the soil characteristics preventing application of an existing field indicator should be identified (Figure 3). For example, some hydric soils exhibit high chroma, limited depth of saturation, or parent materials capable of masking redoximorphic features (Rabenhorst and Burch 2006; Berkowitz and Sallee 2011).

The soil descriptions required are equivalent to data collected as part of a wetland delineation as described in U.S. Army Corps of Engineers (USACE) 2010 and 2012. The forms provided in the Regional Supplements to the U.S. Army Corps of Engineers Wetland Delineation Manual are designed specifically for the documentation of hydric soil characteristics (Figure 3) (Environmental Laboratory 1987). It is important to include the original descriptions; however, soil descriptions for each paired hydric/non-hydric site should be summarized in a clear and concise format (Table 1). Landscape and soil profile pictures collected at hydric and nonhydric sample locations provide useful supportive evidence and are recommended (Figures 2 and 4).

Table 1. Example of soil descriptions at paired hydric (H) and adjacent nonhydric (N) sites examining high chroma sandy soils in Michigan, USA (NRCS 2010; Berkowitz and Sallee 2011). All redox concentrations were distinct or prominent; PL = pore lining, M = matrix. Note that the example provides data from one paired hydric/nonhydric location; multiple locations are required for hydric soil field indicator development or revision (Berkowitz and Noble 2014).

Site	Layer	Depth (cm)	Matrix color	Matrix (%)	Redox (%)	Type and location	Texture	Field indicator
High chroma1(H)	1	0-10	10YR 4.5/2	100			Sandy	None
	2	10-20	10YR 4.5/3	97	3	PL/M	Sandy	
	3	20-50	10YR 5/3	97	3	PL/M	Sandy	
High chroma1(N)	1	0-10	10YR 6/3	100			Sandy	None
	2	10-50	10YR 5/3	100			Sandy	

SOIL Sampling Point: 1A

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
0-2	10YR 3/1	50		-			loamy/clayey	50% uncoated sand grains
2-5	10YR 3/1	97	7.5 YR 4/3	3	C	PL/M	loamy/clayey	
5-8	10YR 4/2	90	7.5YR 5/6	10	C	PL/M	loamy/clayey	
8-12	2.5Y 5/3	70	10YR 5/6	15	C	PL/M	loamy/clayey	10YR 4/2 15% organic coated sand grains

[1]Type: C=Concentration, D=Depletion, RM=Reduced Matrix, MS=Masked Sand Grains. [2]Location: PL=Pore Lining, 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)
- ☐ Organic Bodies (A6) **(LRR P, T, U)**
- ☐ 5 cm Mucky Mineral (A7) **(LRR P, T, U)**
- ☐ Muck Presence (A8) **(LRR U)**
- ☐ 1 cm Muck (A9) **(LRR P, T)**
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Coast Prairie Redox (A16) **(MLRA 150A)**
- ☐ Sandy Mucky Mineral (S1) **(LRR O, S)**
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Dark Surface (S7) **(LRR P, S, T, U)**
- ☐ Polyvalue Below Surface (S8) **(LRR S, T, U)**
- ☐ Thin Dark Surface (S9) **(LRR S, T, U)**
- ☐ Loamy Mucky Mineral (F1) **(LRR O)**
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)
- ☐ Marl (F10) **(LRR U)**
- ☐ Depleted Ochric (F11) **(MLRA 151)**
- ☐ Iron-Manganese Masses (F12) **(LRR O, P, T)**
- ☐ Umbric Surface (F13) **(LRR P, T, U)**
- ☐ Delta Ochric (F17) **(MLRA 151)**
- ☐ Reduced Vertic (F18) **(MLRA 150A, 150B)**
- ☐ Piedmont Floodplain Soils (F19) **(MLRA 149A)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 149A, 153C, 153D)**

Indicators for Problematic Hydric Soils[3]:

- ☐ 1 cm Muck (A9) **(LRR O)**
- ☐ 2 cm Muck (A10) **(LRR S)**
- ☐ Reduced Vertic (F18) **(outside MLRA 150A,B)**
- ☐ Piedmont Floodplain Soils (F19) **(LRR P, S, T)**
- ☐ Anomalous Bright Loamy Soils (F20) **(MLRA 153B)**
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

[3]Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if observed):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes _____ No _____

Remarks:

No hydric soil indicator met
not A11 - 5-8in. less than 6in. thick
not A16 - 2-5in. less than 4in. thick
not F3 - 5-8in. not entirely within the upper 6in. and less than 6in thick
not F6 - 0-2in. no redox and 2-5in. less than 4 in. thick
not F8 - not in a closed depression
would meet F20 except for landscape requirement

Data logger #: 193443

5 IRIS tubes

US Army Corps of Engineers — Atlantic and Gulf Coastal Plain Region – Version 2.0

Figure 3. Soil description of monitored site that did not meet an existing hydric soil indicator. Note that the dataform provides information regarding what soil components prevented an existing field indicator from being met.

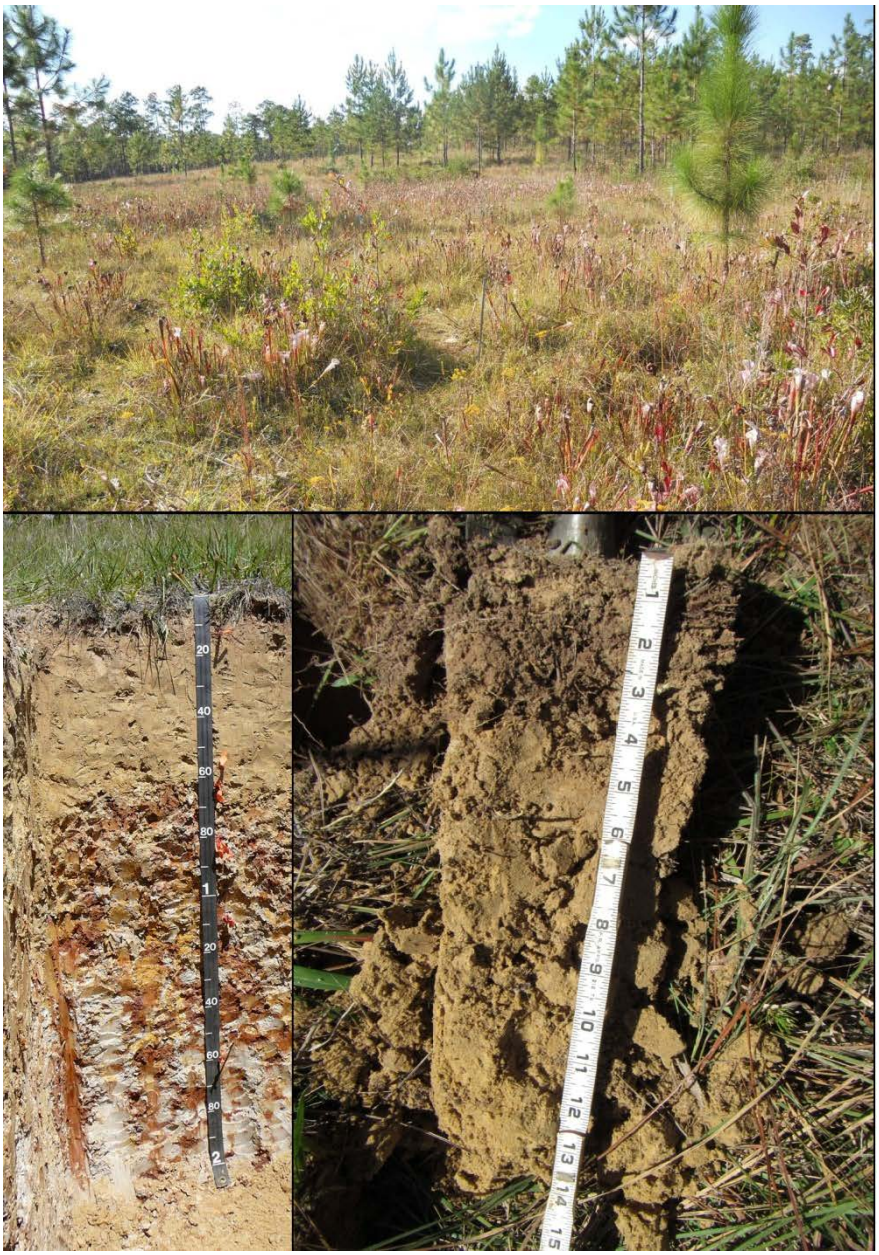


Figure 4. Photographs displaying the landscape setting investigated using paired hydric/nonhydric study locations, deep and shallow soil profiles (modified from Berkowitz et al. 2014).

2) Evidence that the soil meets the HSTS

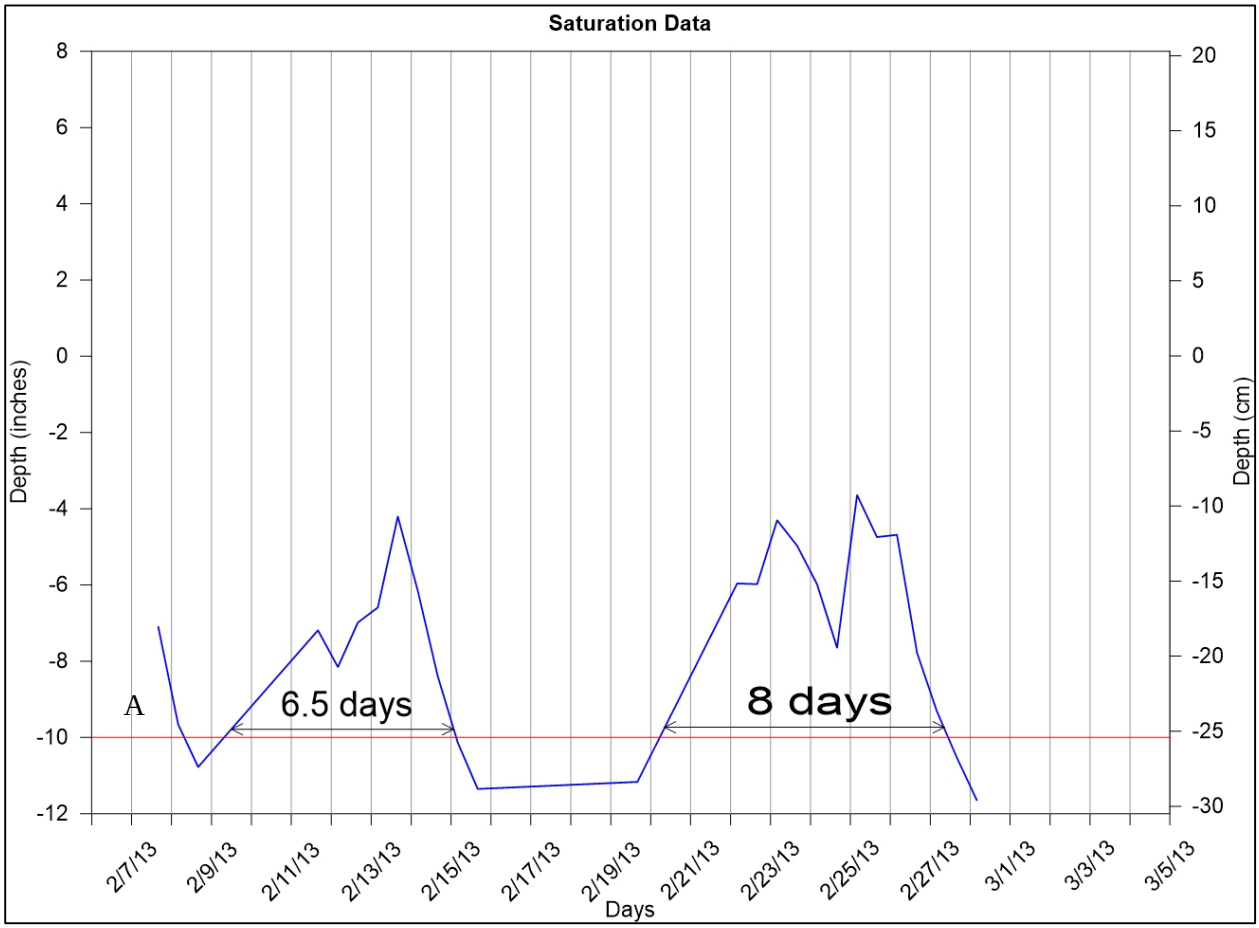
In addition to soil descriptions, paired hydric/nonhydric study sites must undergo the instrumentation necessary to evaluate the HSTS (Figure 5). The HSTS is used to determine if a soil meets the definition of a hydric soil as described above. The HSTS requires data to demonstrate adequate a) saturated conditions and b) establish that soils display anaerobic conditions.

Figure 5. Equipment installed in support of HSTS data collection. Note that a nest of five Indicator of Reduction in Soils (IRIS) tubes surrounds a shallow groundwater monitoring well. The well is outfitted with an automated data logger.

a) Saturated conditions

Saturated conditions occur when the soil water pressure is zero or positive. Saturated conditions are measured using a piezometer or shallow water table well. Saturated conditions should be documented by either automated data loggers or direct observations of the water table. If automated data loggers are used, it is recommended that recordings be made twice daily. If automated data loggers are not available, the HSTS requires a minimum period for water table data collection of one water table measurement per week. However, more frequent measurements during wet periods can be helpful in determining the duration of saturated conditions. Water table monitoring should be conducted across a full year or a minimum of one dry-wet-dry cycle. As outlined in the HSTS, soil saturation must occur for at least 14 consecutive days in most soils. Vertisols in Louisiana and Texas require soil saturation for at least 7 consecutive days with saturation occurring for a minimum of 18 days annually. Soil saturation must occur within 25 cm (10 in) of the soil surface to meet the requirements of the HSTS.

Water table data should be presented for each piezometer or well at each study location and summarized in tabular and graph form indicating where the saturated conditions criteria described above have been met (Table 3; Figure 6). Guidance on construction and installation of piezometers and wells in addition to automated data logger installation, monitoring, and data analysis can be found in Installing Monitoring Wells in Soils (Version 1.0) (Sprecher 2008) and the Technical Standard for Water-table Monitoring of Potential Wetland Sites (U. S. Army Corps of Engineers 2005.)



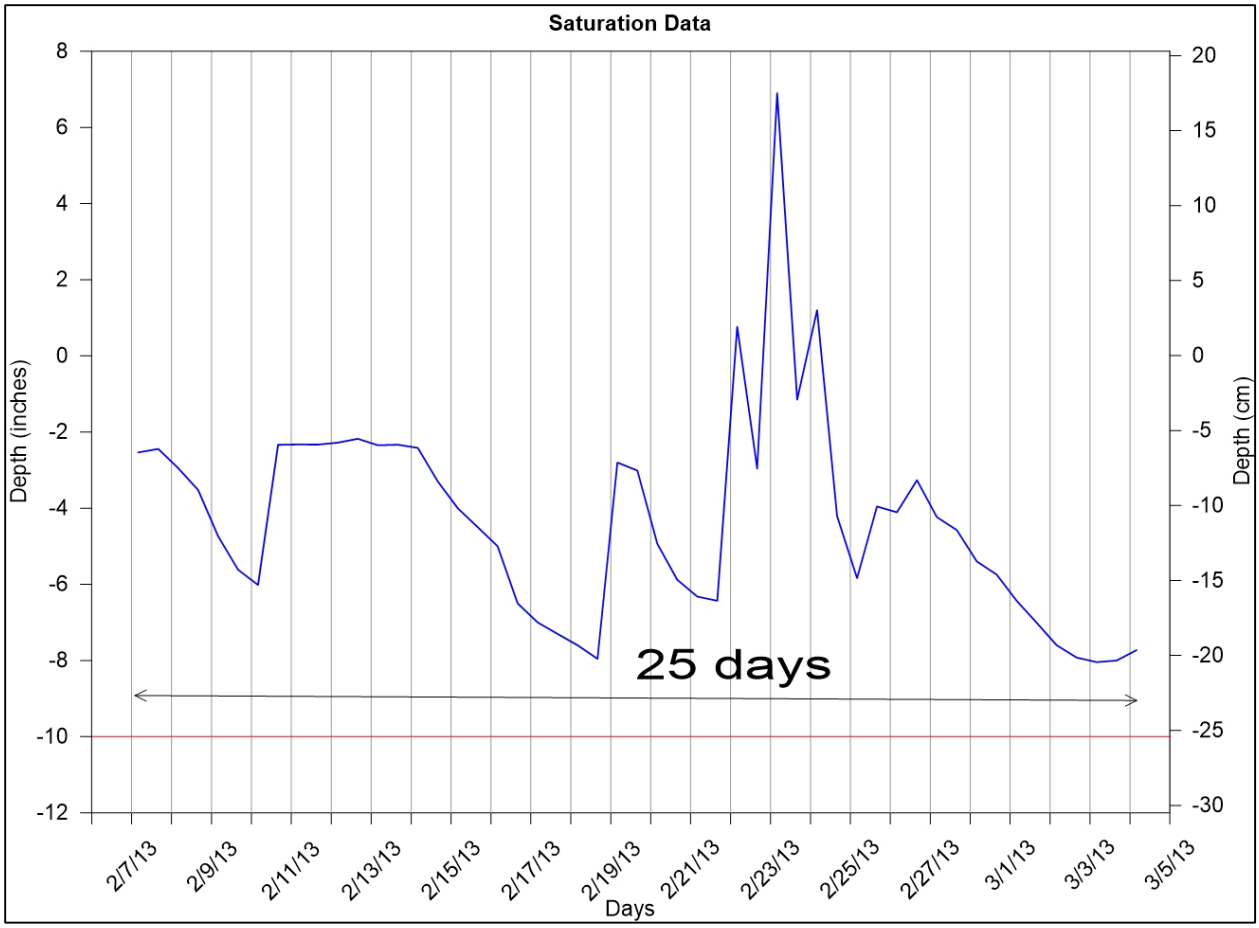


Figure 6. A) Example of soil saturation data collected at a study location with sandy textured soil that does not meet the saturated conditions requirement of the HSTS. The water table does not remain within 10 inches (25 cm) of the soil surface for 14 consecutive days. B) Saturation data from a study location that does meet the saturated conditions criteria of the HSTS. The water table remains within 10 inches (25 cm) of the soil surface for more than 14 consecutive days. All measurements occurred during the growing season.

b) Anaerobic conditions

The anaerobic conditions criteria of the HSTS require data demonstrating the presence or absence of anaerobic conditions within the upper part of each hydric soil study location or for at least fourteen consecutive days (for Vertisols in Louisiana and Texas the minimum time period is seven consecutive days for a total of eighteen annual days). Anaerobic conditions can be demonstrated through the application of (i) IRIS tubes, (ii) α-α-dipyridyl dye or strips, or (iii) soil oxidation-reduction potential measurements using platinum electrodes. The determination of anaerobic conditions must correspond to the period when soil saturation monitoring is being conducted.

i. IRIS tubes: IRIS tubes are generally ½ in., schedule 40, polyvinyl chloride (PVC) pipe coated with iron oxide paint. Under saturated and anaerobic conditions, the paint becomes reduced and soluble, and some of the iron oxide paint is removed (Rabenhorst 2010), leaving visibly lighter colored areas where the iron oxide has been removed. Using IRIS-tube data to verify anaerobic conditions requires at least three of five IRIS tubes to display iron removed from 30% of a zone 15 cm (6 in) long starting with 15 cm (6 in) of the soil surface. Figure 7 illustrates three possible examples of 30% iron removal from an IRIS tube. IRIS tubes do not require the measurement of Eh and soil pH. Photos of the IRIS tubes are helpful to support the data (Figure 8). IRIS-tube data should be presented in tabular format (Table 2), indicating how many tubes were installed at each study location, the amount of iron removal observed from each tube, the depth at which iron removal began, and the number of tubes that met the anaerobic conditions criteria. These data will be incorporated with the saturated conditions results to address which sample locations met the requirements of the HSTS (Table 3). Castenson and Rabenhorst (2006), Rabenhorst and Burch (2006), Rabenhorst (2008), and Berkowitz (2009) provide additional guidance on the application and analysis of IRIS tubes. IRIS tubes are commercially available or can be manufactured in the laboratory (Rabenhorst and Burch 2006).

Table 2. Example of IRIS tube data from one paired hydric (H)/non-hydric (N) study location.

Site	Tube#	Installation date	Removal date	# Days	% Removed	Zone of Removal (cm)		>30% Removal	Notes
						Top	Length		
H	H1	2/1/2013	3/15/2013	42	95	10	35	Yes	
H	H2	2/1/2013	3/15/2013	42	50	18	27	No	removal begins below 15 cm
H	H3	2/1/2013	3/15/2013	42	70	10	35	Yes	
H	H4	2/1/2013	3/15/2013	42	45	12	33	Yes	
H	H5	2/1/2013	3/15/2013	42	20	12	33	No	<30% removal
Hydric Site 1								3/5	Meets Anaerobic Conditions Criteria
N	N1	2/1/2013	3/15/2013	42	10	20	10	No	<30% removal
N	N2	2/1/2013	3/15/2013	42	20	25	20	No	<30% removal
N	N3	2/1/2013	3/15/2013	42	25	25	20	No	<30% removal
N	N4	2/1/2013	3/15/2013	42	30	28	17	No	removal begins below 15 cm
N	N5	2/1/2013	3/15/2013	42	15	25	20	No	<30% removal
Nonhydric Site 1								0/5	Fails Anaerobic Conditions Criteria

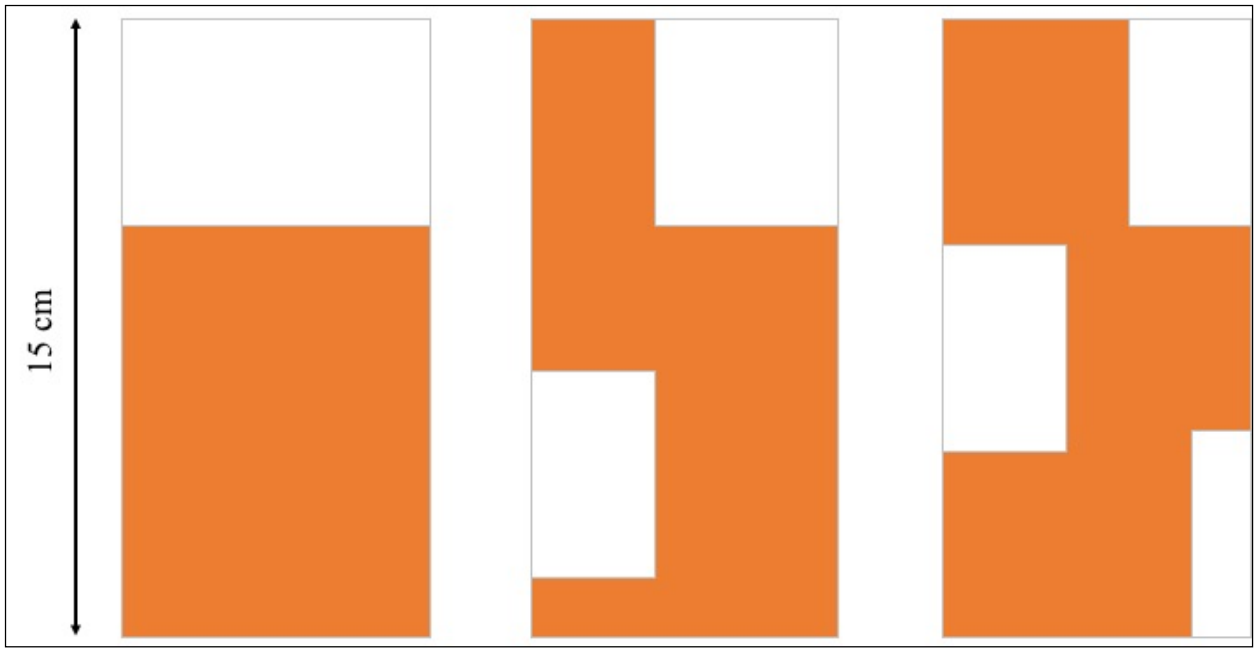


Figure 7. This figure illustrates three examples of 30 percent removal of iron coating from a 15 cm (6 in) section of an IRIS tube.

Figure 8. Typical iron removal patterns from IRIS-tube study (Berkowitz 2009). IRIS tubes display 5%, 10%, 30%, 45%, and 85% iron removal from left to right. The last three tubes on the right of the photo display sufficient removal to meet the anaerobic conditions criteria.

Table 3. Example of summary data indicating anaerobic conditions, saturated conditions, and HSTS results collected at paired hydric and nonhydric study locations.

	Parameter			**Summary**		
Study Area	**IRIS Tubes with >30% Removal**	**αα-dipyridyl dye reaction**	**Consecutive Days of Saturation**	**Anaerobic Conditions**	**Saturated Conditions**	**HSTS**
Hydric site 1	4/5	Yes	26	Yes	Yes	Yes
Nonhydric site 1	1/5	No	5	No	No	No
Hydric site 2	5/5	Yes	89	Yes	Yes	Yes
Nonhydric site 2	2/5	No	15	No	Yes	No
Hydric site 3	3/5	Yes	37	Yes	Yes	Yes
Nonhydric site 3	0/5	No	8	No	Yes	No

ii. Alpha-alpha dipyridyl dye: α-α-dipyridyl dye is a liquid dye that turns pink when it reacts with ferrous iron. Alpha-alpha-dipyridyl is commercially available as a coating on paper strips, or as a solid chemical that must be mixed and buffered in a laboratory setting. When using coated paper strips, the paper strip may turn pink, or the coating may be transferred to the soil (Figure 9). The data collected using α-α-dipyridyl dye or strips require a positive reaction within 60% or more of a specific soil layer observed in at least two of three soils samples or at least three out of five paper strips. Alpha-alpha dipyridyl reaction must occur within a 5 cm (2 in) layer of the upper 10 cm (4 in) in sandy textured soils, a 6.25 cm (2.5 in) of the upper 12.5 cm (5 in) in loamy sandy textured soils, and 10 cm (4 in) of the upper 30 cm (12 in) for clayey textured soils. Reaction to α-α-dipyridyl dye must be documented throughout the same period saturated conditions are recorded. Results of α-α-dipyridyl dye reaction should be documented with photographs and summarized in tabular form (Table 3; Figure 9). *Hydric Soil Tech Note 8: Use of alpha-alpha-dipyridyl* (NTCHS 2009) provides additional guidance on the use of α-α-dipyridyl dye.

Figure 9. Example of soil demonstrating anaerobic conditions through the application of αα-dipyridyl dye from paper strips. Note that the reaction occurs over 60% of the soil surface.

iii. Soil oxidation-reduction potential measurements: Measurements of soil oxidation-reduction potential (Eh) require the installation and monitoring of five replicate platinum (Pt) electrodes within surface soil layers. Patrick et al. (1996) and others provide guidance on the construction, cleaning, and calibration of Pt electrodes for collecting field measurements of soil Eh. Eh measurements must undergo a reference electrode correction to reflect values based on the standard hydrogen electrode. Saturated calomel (correction factor = 244 at 25 °C) and silver/silver-chloride (correction factor = 197 at 25 °C) are two of the most commonly used reference electrodes. The type of reference electrode and correction factor used must be reported with the data to the NTCHS. Additionally, Eh measurements must account for the soil pH, and soil pH must be measured at the same time as Eh measurements are recorded (Vepraskas and Faulkner 2001; Faulkner et al. 1989).

The scientific literature reports various Eh-pH diagrams used to determine when anaerobic conditions have occurred. The slope of the Eh-pH diagram lines are based on both theoretical (e.g., Nernst equation) and experimental values (Bohn 1985; Vepraskas and Faulkner 2001; Masscheleyn 1990). The NTCHS has established a corrected Eh-pH line with a *y*-intercept of 595 and slope of 60 [Eh = 595-60(pH); Figure1] as a conservative value for interpretation of anaerobic conditions for the

purpose of identifying hydric soils. As a result, soil with a pH value of 7.0 requires a corrected Eh value below 175 millivolts (mV) to be considered anaerobic while a soil with pH value of 5.0 is considered anaerobic below a corrected Eh of 295 mV.

Table 4 provides an example of how Eh measurements should be displayed, including data on sampling period, replicates, uncorrected and corrected Eh measurements, soil pH values, and whether each Pt electrode is considered anaerobic. A minimum of three out of five replicate Pt electrode measurements must be anaerobic in order for a soil to meet the anaerobic conditions requirement of the Hydric Soil Technical Standard. Figure 10 provides an example of how Eh data should be presented to demonstrate whether or not the anaerobic conditions criteria of the HSTS have been met.

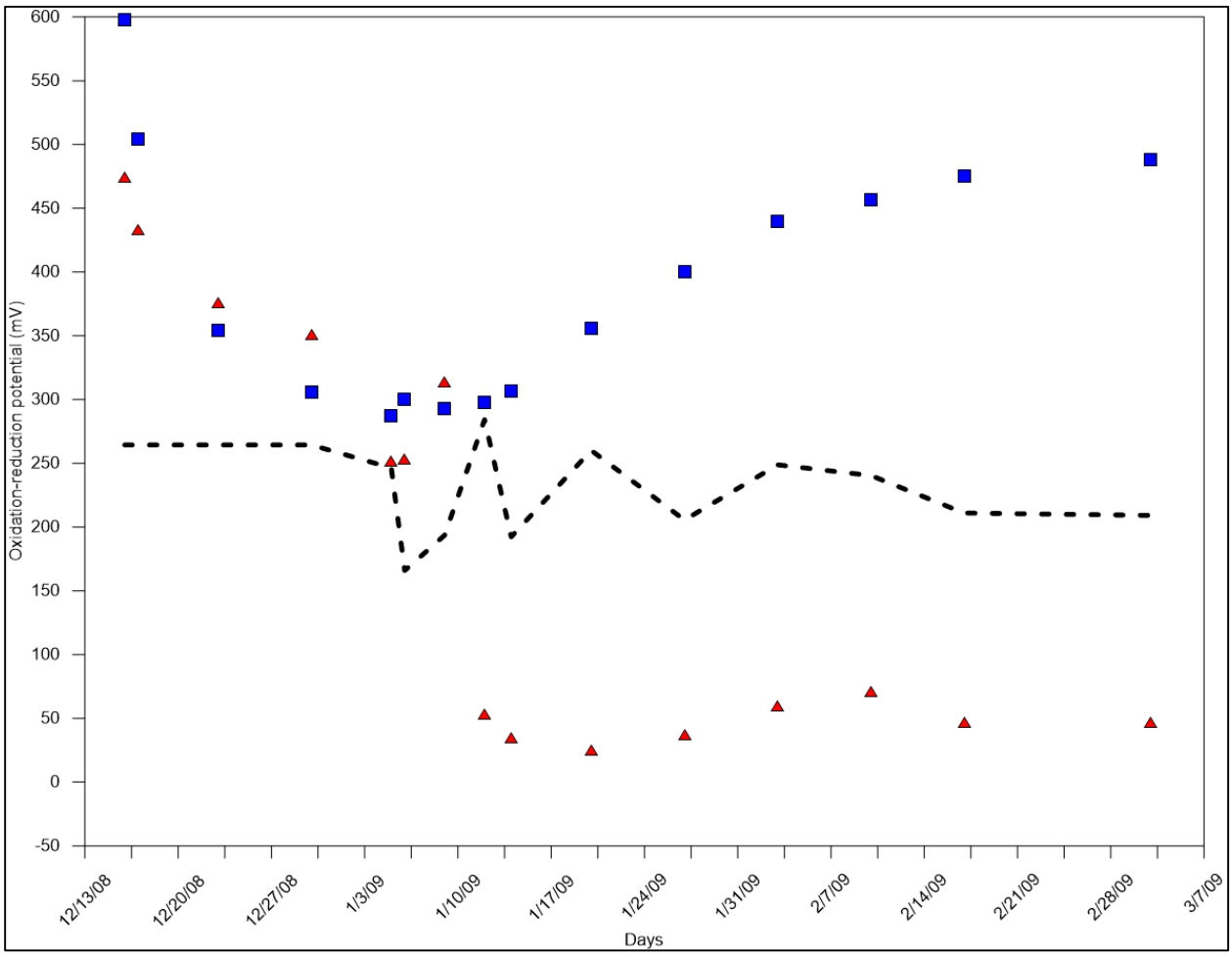


Figure 10. Example of data from two Pt electrodes. The dashed line represents the Eh required for the soil to be considered anaerobic, which fluctuates due to changes in soil pH during the study period. Measurements occurring below the line are considered anaerobic. The Eh values represented by squares never display anaerobic conditions. The Eh values represented by triangles become anaerobic on 12 January 2009 and remain reduced through the monitoring period.

Table 4. Example of data from five Pt electrodes at paired hydric (H) and non-hydric (N) study sites. One of the five probes at N1 displayed anaerobic conditions and would fail to meet the anaerobic conditions requirements of the HSTS; H1 displayed three of five probes with anaerobic conditions. H1 would meet the anaerobic conditions requirement of the HSTS for that date. *Reference electrode type: Ag/AgCl correction factor +197

Date	Site	Replicate Probe #	Reading (mV)	Reference Probe Correction* (mV)	Soil pH	Required for Reduction (595-60*(pH))	Reduced
01/28/09	N1	1	176	373	6.2	223	No
01/28/09	N1	2	302	499	6.2	223	No
01/28/09	N1	3	163	360	6.2	223	No
01/28/09	N1	4	70	267	6.2	223	No
01/28/09	N1	5	306	503	6.2	223	No
01/28/09	H1	1	33	230	5.51	264.4	Yes
01/28/09	H1	2	95	292	5.51	264.4	No
01/28/09	H1	3	-15	182	5.51	264.4	Yes
01/28/09	H1	4	-89	108	5.51	264.4	Yes
01/28/09	H1	5	154	351	5.51	264.4	No

3) Analysis of rainfall normality

Analysis of rainfall normality is required to determine if the requirements of the HSTS are met within a period of normal or drier than normal rainfall. This approach addresses whether or not the HSTS would be met at a frequency of 50% (i.e., five years in ten), and avoids potential the mis-identification of hydric soils when data collection occurred during a wetter than normal period. Rainfall analysis should be based on data collected onsite or at a nearby location with similar elevation and climate. Precipitation data must be analyzed using the Direct Antecedent Rainfall Evaluation Method (DAREM), Moving Total Antecedent Rainfall Method, or Adjusted Moving Total Antecedent Rainfall Method (USDA 1997; Sprecher and Warne 2000). These methods evaluate the rainfall prior to and during the soil data collection period to determine if the study occurred during a period of normal, above-normal, or below-normal rainfall. Rainfall normality evaluations examine the 30th and 70th percentile averages based on long-term (e.g., 30 years) average precipitation records. Sumner et al. (2009) provides additional guidance on determining rainfall normality. The following list provides scenarios under which HSTS data may not be reliable or additional data collection may be required:

a) If the HSTS is met during a wetter than normal period, the study must be extended until a normal or drier than normal rainfall period occurs; preventing the mis-identification of hydric soils based upon a wetter than normal observation period.
b) If the HSTS is not met during a dryer than normal period, the study must be extended until normal conditions occur; preventing the omission of hydric soils based upon a drier than normal observation period.

c) Normal or wetter than normal rainfall conditions must occur if the purpose of the study is to demonstrate that a soil is non-hydric.

Data concerning rainfall normality should be submitted to NTCHS in a clear and organized format demonstrating periods of rainfall normality in conjunction with periods of saturated and anaerobic conditions (Figures 11 and12). USDA (1997) and Sprecher and Warne (2000) describe the DAREM method. The following section and Figure 11 provides an example of the procedure for determining rainfall and antecedent moisture normality:

a) Fill in the "Name" column denoting the "Month examined" and the prior 3 months. For example, to evaluate rainfall normality and hydric soil conditions for the month of December, examine the rainfall values in September, October, and November (Figure 11).
b) Fill in the "30th percentile" and "70th percentile" columns using information from the station's WETS table (Figure 12).
c) In column "Measured Rainfall," enter the monthly rainfall values from onsite data or from the closest available meteorological station.
d) Compare the measured monthly rainfall values for each month's 30th and 70th percentiles for monthly rainfall values. In the column "Condition", enter "Dry" if the measured rainfall value was below the 30th percentile, "Normal" if the measured rainfall value was between the 30th percentile and the 70th percentile, or "Wet" if the measured rainfall value was above the 70th percentile.
e) In the column "Condition Value," enter "1" for drier-than-normal months, "2" for normal months, and "3" for wetter-than-normal months.
f) Multiply the "Condition Value" by the "Month Weight" to obtain the value to enter into the column "Score."
g) Add the three products in the last column to obtain the sum at the bottom of that column. The sum should be a whole number between 6 and 18.
h) Conclude whether the prior period was drier than normal, normal, or wetter than normal by comparing the calculated sum to the following range of values: Dry = 6–9; Normal = 10–14; Wet = 15–18.
i) Complete the rainfall analysis for the entire study period and summarize the results indicating when the saturated conditions requirements of the HSTS were met (Table 5).

Prior Month	**Name**	**WETS 30th percentile**	**WETS 70th percentile**	**Measured Rainfall**	**Condition**	**Condition Value**	**Month Weight**	**Score**	**Result**
Baldwin Co.		Weather station							
3rd	Sept	2.89	7.04	5.01	Normal	2	1	2	
2nd	Oct	1.08	3.74	3.2	Normal	2	2	4	
most recent	Nov	3.24	6.25	0.89	Dry	1	3	3	**Dry**

Month examined	Dec						**Total**	**9**	
Baldwin Co.		Weather station							
3rd	Oct	1.6	4.11	4.28	Wet	3	1	3	
2nd	Nov	3.15	6.2	1.47	Dry	1	2	2	
most recent	Dec	4.03	6.53	8.82	Wet	3	3	9	
Month examined	Jan						**Total**	**14**	**Normal**
Baldwin Co.		Weather station							
3rd	Nov	3.06	5.4	16.6	Wet	3	1	3	
2nd	Dec	3.39	5.83	4.1	Normal	2	2	4	
most recent	Jan	1.6	4.11	4.28	Wet	3	3	9	
Month examined	Feb						**Total**	**16**	**Wet**
Dry = 6–9, Normal = 10–14, Wet = 15–18									

Figure11. Example of DAREM analysis demonstrating rainfall normality determination for HSTS requirements (Berkowitz et al. 2014).

WETS Station : CHATOM, AL1566
Latitude: 3128 Longitude: 08815 Elevation: 00290
State FIPS/County(FIPS): 01129 County Name: Washington
Start yr. - 1971 End yr. - 2000

Month	Temperature (Degrees F.) avg daily max	avg daily min	avg	Precipitation (Inches) avg	30% chance will have less than	more than	avg # of days w/.1 or more	avg total snow fall
January	60.0	35.5	47.8	6.70	4.36	8.05	7	0.0
February	65.0	38.2	51.6	5.99	4.12	7.13	6	0.0
March	72.8	44.8	58.8	6.88	5.31	7.98	6	0.2
April	79.0	50.9	64.9	5.29	3.14	6.42	5	0.0
May	85.6	59.7	72.7	5.64	3.35	6.85	6	0.0
June	90.2	66.0	78.1	4.73	3.36	5.60	6	0.0
July	92.8	69.0	80.9	5.92	3.77	7.13	7	0.0
August	92.0	68.2	80.1	4.59	3.19	5.46	6	0.0
September	88.3	62.9	75.6	4.14	2.30	5.04	5	0.0
October	79.8	51.9	65.8	3.35	1.71	4.22	3	0.0
November	69.8	43.3	56.5	4.96	3.17	5.98	6	0.0
December	62.6	37.8	50.2	5.44	4.03	6.38	6	0.1
Annual	-----	-----	-----	------	53.80	66.03	--	----
Average	78.2	52.3	65.3	------	------	------	--	----
Total	-----	-----	-----	63.63	------	------	69	0.2

Figure12. Example of WETS table data indicating the 30th and 70th percentiles for monthly rainfall.

Table 5. Example of rainfall normality analysis results based on the DAREM approach. For each month during the study period, the previous 3 months rainfall was evaluated and utilized to determine normality as described in Sumner et al. (2009). The symbol † indicates the months during which a minimum of 14 consecutive days of saturated conditions occurred as required by the HSTS (NTCHS 2007; modified from Berkowitz et al. 2014).

Month	Jackson Co.	Washington Co.	Baldwin Co.
November	Normal	Wet	Normal
December	Dry	Normal †	Dry †
January	Normal	Normal †	Normal †
February	Dry	Normal †	Wet †
March	Normal	Wet	Normal
April	Normal	Normal	Normal

SUMMARY: The NTCHS makes determinations regarding the field indicators of hydric soils utilized to identify and delineate hydric soils for the purpose of wetland delineation. In support of that goal, NTCHS developed the HSTS, providing a quantitative method for demonstrating whether or not a soil meets the definition of a hydric soil. Development or revision of hydric soil indicators requires data collection and analysis including 1) soil descriptions, 2) evidence of saturated and anaerobic conditions as outlined in the HSTS, and 3) analysis of rainfall normality. In order to ensure technically sound and timely NTCHS decisions, collected data must be analyzed and submitted to NTCHS in an organized format based on field studies initiated at paired hydric/nonhydric study plots. The submitted data should include both results and summary tables as described above. Research investigating field indicators of hydric soils promotes further understanding of hydric soil pedology, morphology, and processes, thus improving the identification and management of wetland resources throughout the Nation.

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