

PERFORMANCE STANDARDS AND MONITORING PROTOCOL FOR PERMITTEE-
RESPONSIBLE NONTIDAL WETLAND MITIGATION SITES

April 20, 2018

- A. Nontidal wetland mitigation sites shall conform to the following performance standards by the end of the monitoring period, unless otherwise determined by the Maryland Department of the Environment (MDE) and the U.S. Army Corps of Engineers (Corps).
- B. Reporting and Performance Standards: All required documentation, including monitoring reports and as-built surveys shall be submitted to MDE and the Corps. MDE and the Corps will use visual observations during site visits and monitoring reports to evaluate attainment of performance standards and in determining whether part of or the entire mitigation site is successful or whether corrective actions are warranted. With the exception of standards for Invasive Species and Wetland Species Richness, success will be determined on a plot, well, field, or cell basis. Presenting averages or means of plot data across a site is not satisfactory to demonstrate success. Monitoring reports must provide adequate data to demonstrate to MDE and the Corps that the project site is meeting the performance standards. For performance standard criteria, year one begins the year the mitigation construction and planting is complete, unless this occurs after April 15, in which case year one will not begin until the following year. All of the following standards will be used to assess project success and must be achieved each monitoring year:
1. Wetland Area(s):
 - I. **Wetland Vegetation Dominance:** Wetland vegetation dominance, defined as a vegetation community where more than 50% of all dominant plant species across all strata are rated obligate (“OBL”), facultative wet (“FACW”), or facultative (“FAC”), using the vegetation sampling procedures as described in the appropriate regional supplement to the Corps of Engineers Wetland Delineation Manual, must be achieved; and
 - II. **Aerial Cover Vegetative Standards:**
 - a. For sites that require monitoring in year one, a minimum of 50% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native (FAC or wetter) species.
 - b. By the end of year two, a minimum of 60% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native (FAC or wetter) species.
 - c. By the end of year three, a minimum of 70% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native (FAC or wetter) species.
 - d. By the end of year five and each monitoring year thereafter, a minimum of 85% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native (FAC or wetter) species.
 - e. Volunteer species should support functions consistent with the project design goals; and
 - III. **Non-Native and Invasive Species:** The goal of any mitigation site is to have no non-native or invasive species. However, if non-native or invasive species are present, no more than 10% of relative plant cover¹ over the entire mitigation site shall be made up by

¹ “Relative plant cover” is defined as the cover of a particular species as a percentage of total plant cover. Thus,

non-native or invasive species, with no individual colony greater than or equal to 5% of relative plant cover. No more than 5% of relative plant cover over the entire site shall be made up of *Phragmites australis*², *Persicaria perfoliata*, or *Lythrum salicaria*. Native status will be based on the Natural Resources Conservation Service Plants Database. *Phalaris arundinacea* and *Typha* spp. may also be considered as invasive species by MDE and the Corps. Alternatively, the Permittee may propose appropriate reference sites as justification for MDE and the Corps to consider different site-specific standards for non-native and invasive species; and

IV. Wetland Species Richness:

- a. For scrub/shrub wetlands, establish a minimum of three species of native wetland shrubs (FAC or wetter) with no more than 75% relative cover of one species, over the entire mitigation site. Loblolly pine cannot be more than 35% relative cover.
- b. For forested wetlands, establish a minimum of three species of native wetland trees and two species of native wetland shrubs (FAC or wetter) with no more than 75% relative cover of one species, over the entire mitigation site. Loblolly pine cannot be more than 35% relative cover; and

V. Wetland Vegetation Density for Scrub-Shrub and Forested Wetlands: For scrub-shrub or forested wetlands, native wetland (FAC or wetter) plant density of at least 435 living trees/shrubs per acre with a minimum height of 10 inches shall be achieved by the end of the first year a monitoring report is required and maintained each monitoring year thereafter through the end of the monitoring period; and

VI. Wetland Vegetation Cover for Forested Wetlands: For forested wetlands, average tree height of tallest five native wetland (FAC or wetter) trees within each sample plot shall be at least three feet in height at year three and at least five feet in height at year five and each monitoring year thereafter. Canopy cover³ of native wetland (FAC or wetter) trees and shrubs must be at least 30% by the end of the monitoring period; and

VII. Wetland Hydrology: Wetland hydrology, defined as 14 consecutive days of flooding or ponding, or a water table 12 inches (30 cm) or less below the soil surface, during the growing season at a minimum frequency of 5 years in 10 (50 percent or higher probability). For the purpose of this determination, the growing season should be based on median dates (i.e., 50 percent probability) of 28°F air temperatures in spring and fall, based on the long-term data for the nearest appropriate weather station, as recorded in the WETS tables available from the NRCS National Water and Climate Center (https://www.wcc.nrcs.usda.gov/climate/navigate_wets.html), or as specified in the appropriate regional supplement to the Corps of Engineers Wetland Delineation Manual; and

VIII. Wetland Soils: The entire wetland restoration or creation area must meet the Hydric Soil Technical Standard (Technical Note 11) developed by the National Technical Committee for Hydric Soils for saturated conditions and anaerobic conditions:

- a. Free water must exist within 10 inches (25 cm) of the ground surface for at least 14

relative cover will always total 100%, even when total absolute cover is quite low.

² American Common Reed, *Phragmites australis* subsp. *americanus*, while uncommon, is not considered to be an invasive plant.

³ “Canopy cover” is defined as the percentage of ground covered by tree and shrub leaves, when the edges of the leaves are mentally projected down to the ground surface.

- consecutive days; and
- b. Anaerobic conditions must exist within 10 inches (25 cm) of the ground surface for at least 14 consecutive days. Anaerobic conditions may be determined by one of the following methods, as detailed in the Hydric Soil Technical Standard:
 - i. Positive reaction to alpha-alpha dipyridyl, determined as least weekly.
 - ii. Reduction of iron determined with IRIS devices (tubes or films) installed for 30 days.
 - iii. Measurement of redox potential (Eh) using platinum electrodes, determined at least weekly.

2. Buffer Area(s) Performance Standards are only required to be met if the buffer is getting mitigation credit:

I. **Aerial Cover Vegetative Standards:**

- a. For sites that require monitoring in year one, a minimum of 50% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native species.
- b. By the end of year two, a minimum of 60% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native species.
- c. By the end of year three, a minimum of 70% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native species.
- d. By the end of year five and each monitoring year thereafter, a minimum of 85% of the mitigation site shall be vegetated (either by planted or volunteer plants) by native species.
- e. Volunteer species should support functions consistent with the project design goals; and

II. **Non-Native and Invasive Species:** The goal of any Bank is to have no non-native or invasive species. However, if non-native or invasive species are present, no more than 10% of relative plant cover¹ over the entire site shall be made up by non-native or invasive species, with no individual colony greater than or equal to 5% of relative plant cover. No more than 5% of relative plant cover over the entire site shall be made up of *Phragmites australis*², *Persicaria perfoliata*, or *Pueraria montana*. Native status will be based on the Natural Resources Conservation Service Plants Database. Alternatively, the Sponsor may propose appropriate reference sites as justification for the IRT to consider different site-specific standards for non-native and invasive species; and

III. **Vegetation Density for Forested Buffers:** For forested buffers, native plant density of at least 435 living trees/shrubs per acre with a minimum height of 10 inches shall be achieved by the end of the first year a monitoring report is required and maintained each monitoring year thereafter through the end of the monitoring period.

C. **Monitoring Timeframe:** The Permittee will be responsible for submitting monitoring reports to MDE and the Corps for a period of time specified in the Phase II Mitigation Plan Approval Letter or the Permit. Monitoring reports should be concise and effectively provide the information necessary to assess the status of the compensatory mitigation project. Reports should provide information necessary, including supporting data such as plans, maps, and photographs, to illustrate site conditions and whether the compensatory mitigation project is meeting its objectives and performance standards. If five years of monitoring is required, monitoring reports shall be submitted annually. If ten years of monitoring is required, monitoring reports shall be submitted for years 2, 3, 5, 7, and 10 (“monitoring years”) following completion of construction and planting of the mitigation

site or phase thereof. Monitoring reports, a paper copy and an electronic version, must be submitted to MDE and the Corps by December 31 of each monitoring year. Monitoring must be conducted a minimum of once per year during the years that monitoring reports are required. Monitoring may be terminated or the extent of monitoring may be reduced over part or the entire site at the discretion of MDE and the Corps. Conversely, MDE or the Corps may extend the original monitoring period upon a determination that performance standards have not been met or the mitigation site is not on track to meet them.

D. Monitoring Reports: The monitoring period begins the year the mitigation planting occurs, unless planting occurs after April 15, in which case the monitoring period will not begin until the following year. For each monitoring report, vegetative monitoring shall be conducted between May 1 and September 30 for forested/scrub-shrub systems and between June 15 and September 30 for emergent systems. Site visits should preferably be during a period with normal precipitation and groundwater levels. The following information must be included with the monitoring report:

1. A Monitoring and Performance Standards Summary Table must be completed and attached to the beginning of the Monitoring Report.

2. Overview / Background Data:

- I. Title page indicating the permit name, permit tracking number (parent tracking number and NT number), mitigation site name (if applicable), phase (if applicable), monitoring year, and preparer identification (name, address, phone number, and email address).
- II. Written description of the location, any identifiable landmarks of the mitigation site, including information to locate the site perimeter(s), and coordinates of the mitigation site (expressed as latitude and longitude).
- III. Date(s) of site inspections.
- IV. A brief paragraph describing the purpose of the mitigation site, including the authorized impact acreage and type of aquatic resource impacted, proposed mitigation acreage and aquatic resource type approved as part of the Phase II Wetland Mitigation Plan or Permit. Include the dates the mitigation construction was started and the planting was completed.
- V. A brief narrative description of the mitigation site addressing its position in the landscape, adjacent waterbodies, and adjacent land use.
- VI. Describe methods used to evaluate performance standards. Plot locations should be clearly identified on the appropriate maps.
- VII. A short statement on whether the performance standards are being met.
- VIII. A narrative description of existing site conditions and how the mitigation site has or has not achieved the goals, objectives and performance standards established for the project.
- IX. Dates of any recent corrective or maintenance activities conducted since the previous report submission.
- X. If monitoring or site inspections were conducted between years of required monitoring (e.g., year four in a 10-year monitoring period), this data should also be included.

- XI. Specific recommendations for any additional corrective or remedial actions.
 - XII. Estimate the percent of the mitigation site that is establishing into wetland and the type of wetland system (ex: forested, scrub-shrub, emergent). If this differs from what was planned, show the boundaries of the actual wetland area/types on the plans or maps.
 - XIII. Estimate the percent of the mitigation site buffer that is establishing into forested buffer. If this differs from what was planned, show the boundaries of the actual forested buffer area on the plans or maps.
 - XIV. Discussion of growing season and how it was determined for this site.
3. Requirements: List the monitoring requirements and performance standards, as specified in the Phase II Wetland Mitigation Plan Approval Letter, and/or special conditions of the permit and evaluate whether the compensatory mitigation project site, including each area (plot, well, field or cell as appropriate), is successfully achieving the approved performance standards or trending towards success.
 4. Summary data: Summary data should be provided to substantiate the success and/or potential challenges associated with the compensatory mitigation project.
 5. Photographs: Take one set of photographs from established photographic points any time between May 1 and September 30 of each monitoring year (pictures should be taken at the same time of year when possible). Photo location points should be identified on the appropriate maps and labeled with the direction in which the photo was taken. Submitted photos should be formatted to print on a standard 8.5 by 11-inch piece of paper, dated, and clearly labeled with the direction from which the photo was taken. It is highly recommended that aerial photos are also provided, as these are good indicators of hydrology and vegetative cover.
 6. Maps and Plans: Maps should be provided to show the location of the compensatory mitigation site relative to other landscape features, habitat types, locations of photographic reference points, transects, sampling data points (e.g., vegetation plots, wells, soil samples, etc.), and/or other features pertinent to the mitigation plan. GPS coordinates should be shown on the plans for each photographic reference point and sample plot. In addition, the submitted maps and plans should clearly delineate the mitigation site perimeter(s), which will assist the project managers in locating the mitigation area(s) during subsequent site inspections. Each map or diagram should be formatted to print on a standard 8.5 by 11-inch piece of paper and include a legend and the location of any photos submitted for review. As-built plans should be included if they were not already submitted to MDE and the Corps.
 7. Conclusions: A general statement shall be included that describes the conditions of the compensatory mitigation project. If performance standards are not being met, a brief explanation of the difficulties and potential remedial actions proposed by the Permittee, including a timetable, must be provided. MDE and the Corps will ultimately determine if the mitigation site is successful for a given monitoring period.
 8. Monitoring Report Measurements. Monitoring reports should include all of the following information for the overall site, and each plot, well, field or cell:

- I. Wetland Area(s):

- a. Vegetation:
 - i. Estimate the actual and relative percent cover by plant species, in order of dominance, across all strata for each plot. Include this information in a table. For each species listed in the table include native/non-native status and wetland indicator status. Summarize the data by plot, field/cell and overall site.
 - ii. For scrub-shrub or forested wetlands, estimate the percent survival of planted trees and number of native wetland (FAC or wetter) trees/shrubs per acre (including volunteer woody species at least ten inches). Data should be summarized for each plot and also by field/cell and overall site. Please note that projects where the vegetation is inconsistent throughout the site may not meet the performance standards (e.g. a site where some portions have high densities of woody species but other portions have low densities).
 - iii. For scrub-shrub or forested wetlands, measure the height of the tallest five trees within each sample plot in each monitoring year. In the final year of monitoring, measure canopy cover of native wetland (FAC or wetter) trees and shrubs.
 - iv. Summarize the results from the vegetation plot study, including how the vegetation meets/does not meet performance standards. Data should be summarized for each plot, by field/cell, and for the entire site. Include a discussion of water movement into and through the site. **Do not include the raw plot data in your monitoring report.**
- b. Hydrology:
 - i. Estimate percent of site that is inundated or saturated to the surface on the dates of the site visits.
 - ii. Monitoring data for surface water and groundwater, including hydrograph of measured depth to water table, after calibrating for above-ground height of well. Data should be included for each well separately.
 - iii. Discuss how precipitation during this monitoring year compares with historical precipitation data for that location.
 - iv. Summarize results of the hydrology monitoring for each well, by field/cell, and for the entire site, including if each meets/does not meet the performance standards. Estimate percent of site that has wetland hydrology.
- c. Soils:
 - i. Monitoring data to determine if hydric soils are actively developing. Data should be included for each sample location. This must include evidence that saturated and anaerobic soil conditions are being met, as measured by alpha-alpha dipyriddy, IRIS devices (tubes or films), or platinum electrodes.
 - ii. Provide a soil profile description with accompanying soil photos for each soil location tested above.
 - iii. Summarize results of the soil monitoring for each sample location, by field/cell, and for the entire site, including if each meets/does not meet the performance standards.
- d. Remediation:
 - i. Describe any problems observed within the mitigation site, such as: excessive inundation, insufficient hydrology, seasonal drought conditions, invasion by undesirable species of plants or wildlife, disease condition for

plants, poor plant establishment, adverse water quality impacts (i.e., excessive sediment loading, water pollution, etc.), human encroachment, and slope failures or erosion problems.

ii. Describe the proposed remedial measures to address the problems noted above.

e. Remedial measures proposed by the Permittee are subject to review and approval by MDE and the Corps prior to implementation. In the event that remedial measures are implemented, the monitoring period may be extended on a case-by-case basis. The treatment of non-native invasive plant species does not need the approval of MDE and the Corps, but should be completed at the correct time of year by someone with a current pesticide applicator certification and the required MDE toxic materials permit.

II. Buffer Area(s):

a. Vegetation

- i. Estimate the actual and relative percent cover by plant species across all strata for each plot. Include this information in a table. For each species listed in the table, include native/non-native status. Summarize the data by plot, field/cell and overall site.
- ii. For scrub-shrub or forested buffers, estimate the percent survival of trees and the number of native trees/shrubs per acre (including planted or volunteer woody species at least ten inches). Data should be summarized for each plot and also by field/cell and overall site. Please note that projects where the vegetation is inconsistent throughout the site may not meet the performance standards (e.g. a site where some portions have high densities of woody species but other portions have low densities).
- iii. Measurements of vegetation based upon performance standard and methods used to evaluate the vegetative success of the mitigation site. **Do not include the raw plot data in your monitoring report.**

b. Remediation:

- i. Describe any problems observed within the upland buffer, such as: invasion by undesirable species of plants or wildlife, disease condition for plants, poor plant establishment, human encroachment, and slope failures or erosion problems.
- ii. Describe the proposed remedial measures to address the problems noted above.

c. Remedial measures proposed by the Permittee are subject to review and approval by MDE and the Corps prior to implementation. In the event that remedial measures are implemented, the monitoring period may be extended on a case-by-case basis. The treatment of non-native invasive plant species does not need the approval of MDE and the Corps, but should be completed at the correct time of year by someone with a current pesticide applicator certification and the required MDE toxic materials permit.

Below are the recommended techniques for monitoring mitigation sites. Alternate techniques may be considered, but must be approved in writing by the MDE and the Corps prior to the commencement of the monitoring period.

Recommended Wetland Vegetation Density Measurement Technique

- a. The following method for measuring the success of the vegetative colonization should be conducted once between May 1 and September 30 for forested/shrub-shrub systems and between June 15 and September 30 for emergent systems during each year requiring submittal of a monitoring report, unless an alternate schedule is agreed upon by MDE and the Corps.
- b. Vegetation sample plots shall be located on a stratified random basis over the site in order to sample all areas of wetlands at locations adjacent to each photo location marker. Plots should be located within each planned and actual vegetative type and hydrologic regime. Plot locations should be determined prior to construction and shown on the mitigation plan. Once the sample plots are approved as part of the mitigation plan, they should be stationary, unless the Permittee recommends, and MDE and the Corps agree to moving the sample plots. Potential justification for moving sample plots may include that the plot location is an outlier or the actual vegetative type/hydrologic regime differs from what was planned, resulting in some representative areas not being monitored. The following minimum numbers of samples will be required:
 - i. If the site is < 5 acres, then a minimum of 3 plots/acre is necessary.
 - ii. If the site is > 5 acres but less than 20 acres, then a minimum of 3 plots/acre is required for the first 5 acres, then 2 plots/acre is required for the remaining acreage.
 - iii. If the site is > 20 acres, then a minimum of 2 plots/acre is required for the first 20 acres, then 1 plot/acre is required for the remaining acreage.
 - iv. All cells, fields, or blocks shall be sampled. A targeted vegetation monitoring approach that correlates monitoring stations with vegetative signatures on aerial photography may be useful for larger mitigation sites.
- c. Each plot shall be of a size no less than 400 square feet for woody plants and 3'x3' for herbaceous plants (or circular with approximately the same surface area). The vegetation data shall be collected during the growing season and shall include:
 - i. Dominant vegetative species identification
 - ii. Percent ground cover assessment
 - iii. Number of woody plant stems greater than 10 inches in height (total and #/acre)
 - iv. The percentage of dominant species FAC or wetter
 - v. Percent survival by planted species
 - vi. A non-native/invasive species assessment including percent cover

Recommended Buffer Vegetation Density Measurement Technique

- a. The following method for measuring the success of the vegetative colonization should be conducted once between May 1 and September 30 of each year requiring submittal of a monitoring report, unless an alternate schedule is agreed upon by MDE and the Corps.
- b. Vegetation sample plots shall be located on a stratified random basis over the site in order to sample all areas of wetland buffer at locations adjacent to each photo location marker. Plots should be located within each planned and actual vegetative type and hydrologic regime. Plot locations should be determined prior to construction and shown on the mitigation plan. Once the sample plots are approved as part of the mitigation plan, they should be stationary, unless the Permittee recommends, and MDE and the Corps agree to moving the sample plots. Potential justification for moving sample plots may include that the plot location is an outlier or the actual vegetative type differs from what

was planned, resulting in some representative areas not being monitored. The following minimum numbers of samples will be required:

- i. If the site is < 5 acres, then a minimum of 3 plots/acre is necessary.
 - ii. If the site is > 5 acres but less than 20 acres, then a minimum of 3 plots/acre is required for the first 5 acres, then 2 plots/acre is required for the remaining acreage.
 - iii. If the site is > 20 acres, then a minimum of 2 plots/acre is required for the first 20 acres, then 1 plot/acre is required for the remaining acreage.
 - iv. All cells, fields, or blocks shall be sampled. A targeted vegetation monitoring approach that correlates monitoring stations with vegetative signatures on aerial photography may be useful for larger mitigation sites.
- c. Each plot shall be of a size no less than 400 square feet for woody plants (or circular with approximately the same surface area). The vegetation data shall be collected during the growing season and shall include:
- i. Total actual and relative percent cover of native plant species.
 - ii. Number of native woody plant stems greater than 10 inches in height (total and #/acre).
 - iii. A non-native/invasive species assessment including relative percent cover.

Recommended Groundwater Well Placement and Data Collection

- a. Determine if this wetland is groundwater fed or has a perched water table. Soil profile descriptions must be assessed prior to well installation to identify any restrictive layers to downward water movement. Wells should be installed so they do not penetrate the restrictive layer, but are instead no deeper than the top of the restrictive layer (as discussed in the 2005 Corps document entitled *Technical Standard for Water-Table Monitoring of Potential Wetland Sites ERDC TN-WRAP-05-02*). In most cases, a standard monitoring well installed to 15 inches below the soil surface should be used. Shallower installation depths should be utilized if restrictive soil depths are located within 15 inches of the soil surface. Well design and installation shall be consistent with current Corps' guidance.
- b. Specific details on the groundwater monitoring wells and locations shall be provided in the mitigation plan, and must be approved by MDE and the Corps.
- c. The following minimum numbers of groundwater wells will generally be required. The Permittee may propose alternate well requirements as part of the mitigation plan, based on justification from the proposed mitigation design:
 - i. If the site is < 10 acres, then a minimum of 1 well/acre is necessary.
 - ii. If the site is 10 to 20 acres, then a minimum of 1 well/acre is necessary for the first 10 acres, then 1 well/2 acres is necessary for the remaining acreage.
 - iii. If the site is > 20 acres, then a minimum of 1 well/acre is necessary for the first 10 acres, 1 well/2 acres is necessary for the next 10 acres, and 1 well/5 acres is necessary for the remaining acreage.
 - iv. Hydrologic zones differentiated by a 1-foot change in elevation should have a minimum of one groundwater monitoring well installed.
 - v. For sites with multiple cells, each cell should have at least one well.
- d. Begin the collection of groundwater well data within fourteen days of the start of the growing season. Take groundwater well readings once every 7 days for the first two months of the growing season and every 30 days for the remainder of the growing season. Record to the nearest inch. Well data should be collected every year during the monitoring period. If well data confirms the presence of wetland hydrology during multiple years of monitoring, the Permittee may request that well data not be required every year. MDE and the Corps will consider the evidence of hydrology, based on the monitoring reports, site visits, and local precipitation, to approve or deny this request.
- e. The growing season should be based on median dates (i.e., 50 percent probability) of 28°F air temperatures in spring and fall, based on the long-term data for the nearest appropriate weather

station, as recorded in the WETS tables available from the NRCS National Water and Climate Center (https://www.wcc.nrcs.usda.gov/climate/navigate_wets.html), or as specified in the appropriate regional supplement to the Corps of Engineers Wetland Delineation Manual.

- f. Measure and record any surface water present at the monitoring wells.
- g. Include a copy of the plan showing the location of the wells and surface elevation beside each well. Summarize the information regarding groundwater and surface water elevations, and provide monthly rainfall data for the areas.

Indicator of Saturated and Anaerobic Conditions to Demonstrate the Presence of Active Hydric Soil Conditions

- a. The Hydric Soil Technical Standard (HSTS) developed by the National Technical Committee for Hydric Soils (Technical Note 11) requires documentation of anaerobic conditions and saturated conditions for a soil to be considered hydric:
 - i. For a soil to meet the Saturated Conditions part of the HSTS, free water must exist within 10 inches (25 cm) of the ground surface for at least 14 consecutive days; and
 - ii. Anaerobic conditions must exist within 10 inches (25 cm) of the ground surface for at least 14 consecutive days. Anaerobic conditions may be determined by one of the following methods, as detailed in the HSTS:
 - (1) Positive reaction to alpha-alpha-dipyridyl, determined at least weekly.
 - (2) Reduction of iron determined with IRIS devices (tubes or films) installed for 30 days.
 - (3) Measurement of redox potential (Eh) using platinum electrodes, determined at least weekly.

Methods to demonstrate the presence of anaerobic conditions are outlined at (https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051608.pdf).

- b. If using alpha-alpha dipyridyl to show soil reduction, soils should be measured at least weekly during the growing season, at a depth of six inches. Note that alpha-alpha dipyridyl is also available as paper strips for easier measurement.
- b. Soil testing should be conducted during the time of the growing season anticipated to have the highest amount of soil reduction (often in the early growing season).
- c. Samples should be taken in a representative portion of the mitigation site with similar micro topography, vegetative community, etc., rather than in the lowest/wettest areas. Some samples should also include the areas with higher elevations. Additional tests should be taken for larger sites and sites with higher changes in elevation.
- d. Plot locations shall be determined after baseline hydrology data are collected for two years to select areas that represent various hydroperiods. At least one soil sample plot location should be established for each hydroperiod present at the mitigation site. Soil sample plots shall be located within five feet of the monitoring well, and shall be performed during each monitoring year. Additional soil monitoring plots may need to be established where saturation occurs between 5% and 12.5% of the growing season to provide corroborative evidence that wetland hydrology is present. Additional soil monitoring may also be required if soil monitoring occurs during extremely wet or dry years.
- d. Include a copy of the plan showing the location of the soil data collection, summarize the information, and provide monthly rainfall data for the area.
- e. If soil testing confirms the presence of actively reducing soil conditions during multiple years of monitoring, the Permittee may request that soil testing not be required every year. MDE and the Corps will consider the evidence of anaerobic soil conditions, based on the monitoring reports, site visits, and local precipitation, to approve or deny this request.

Recommended Method of Indicator of Reduction in Soils (IRIS) Film Placement and Data Collection.

- a. Label Fe-coated films.
- b. Roll one Fe-coated film into 1” clear polycarbonate delivery tube, with Fe-coating facing out.
- c. Create a pilot hole in the soil using a 1” push probe. The hole should be slightly deeper (1-2”) than final depth of film.
- d. Insert rod into the delivery tube, being sure to hook the rod into the hole at the bottom of the film.
- e. Insert the “loaded” delivery tube into the hole until the mark on the tube is at the soil surface (50 cm).
- f. Holding the rod to ensure the film stays in the soil, pull out the delivery tube.
- g. Pull out the rod, being careful not to pull out the film.
- h. Insert foam plug into the top of the film, using two O-rings to secure the film around the plug.
- i. If the films are installed to shallower depths (e.g., gravel layer inhibits full depth for pilot hole), mark the depth of the soil surface on the films with a permanent marker.
- j. Install five replicates, up to a meter apart, within the study area.
- k. Films should be left in place for two to four weeks and then should be removed and replacement films can be installed in the same holes for an additional two to four weeks. Films left in for longer than four weeks cannot be used to meet required performance standards.
- l. Gently wash off any adhering soil from the films.
- m. Estimate the amount of paint removed from each film by overlaying with a mylar grid and marking and counting the grid⁴, or by using some other IRT-approved procedure.
- n. Find a six-inch area on the film, entirely within the upper 12 inches, with the most paint removed. Estimate the percentage of paint removed from this six-inch area and document the depth of this six-inch area.
- o. To meet the Technical Standard for reducing soil conditions as currently specified in the National Technical Committee on Hydric Soils, 30% or more of paint within this six-inch section must be removed.
- p. At least three of the five replicates must show this paint removal for the soil to demonstrate that it is reducing.

Recommended Method of Indicator of Reduction in Soils (IRIS) Tube Placement and Data Collection
(summarized from the 2008 document entitled *Protocol for Using and Interpreting IRIS Tubes*).

- a. Create a pilot hole in the soil using a 7/8” push probe. The hole should be slightly deeper (1-2”) than final depth of tube.
- b. Be sure tubes are labeled.
- c. Insert the IRIS tube into the hole until the mark on the tube is at the soil surface (50 cm). If they are installed to shallower depths, mark the depth of the soil surface with a permanent marker.
- d. Install five replicates, up to a meter apart, within the study area.
- e. Tubes should be left in place for two to four weeks and then should be removed and replacement tubes can be installed in the same holes for an additional two to four weeks. Tubes left in for longer than four weeks cannot be used to meet required performance standards.
- f. Gently wash off any adhering soil from the tubes.
- g. Estimate the amount of paint removed from each tube by wrapping a mylar grid around tube and by marking and counting the grid, or by using some other IRT-accepted procedure.
- h. If visual estimations are used, to improve accuracy, have two (or more) people estimate the amount of paint removed, then average the two sets of data.
- i. Find a six-inch area on the tube, entirely within the upper 12 inches, with the most paint removed.

⁴ Rabenhorst, M.C. 2012. Simple and Reliable Approach for Quantifying IRIS Tube Data. *Soil Sci. Soc. Am. J.* 76: 307-308.

Estimate the percentage of paint removed from this six-inch area and document the depth of this six-inch area.

- j. To meet the Technical Standard for reducing soil conditions as currently specified in the National Technical Committee on Hydric Soils, 30% or more of paint within this six-inch section must be removed.
- k. At least three of the five replicates must show this paint removal for the soil to demonstrate that it is reducing.

Recommended Method of Application of the Alpha-Alpha Dipyridyl Paper Test Strips

- a. To meet the anaerobic condition requirement using alpha-alpha dipyridyl test strips, tests should show positive reaction to alpha-alpha dipyridyl at least three times in a row (e.g., sample on Day 1, sample a week later, sample another week later).
- b. Excavate a soil pit to a depth of at least 14-16 inches*. A fresh slice of the profile should be cut from the side of the pit and laid out for observation and characterization. Apply the test strips to the targeted layer(s) at several locations within the representative area to ensure that the majority of the layer is reduced. Document at what depth the positive reaction(s) to the test occurred. The procedure for problematic soils (Step 4d) discussed in Chapter 5 of the Regional Supplements requires that at least 60% of a layer 4 inches or more thick and located within 12 inches of the surface, react positively from liquid alpha-alpha dipyridyl solution. **Note: The depth of soil excavations for profile characterization can be much deeper depending upon the required depth and thickness requirements of some hydric soil indicators.*
- c. It is important that the test strips are applied only to a fresh, broken face of the desired layer(s). Do not add moisture to soil samples or rub soil against or on to the paper, simply press the paper against a fresh, broken ped face on the soil sample(s). Be sure not to test soil samples that have been exposed to digging equipment to prevent false positive reactions. Record all observations of soil moisture, limit of saturation and the depth to water table on a data form and or in your notes.
- d. A positive reaction on the paper (turning pink or red) should occur in a few moments but can take longer especially during colder periods. The manufacturer indicates that the reaction normally takes place within about 30 seconds.
- e. To increase the validity of your findings, test the targeted layers at several different locations within the same representative area and any other layers which meet an indicator.
- f. Testing multiple samples can exhaust your supply quickly but you can double your reserves by cutting the strips in half. Be careful not to use cutting instruments that could contaminate a sample.
- g. The test should be performed as soon as you remove the sample and all information (depths, layers, etc.) recorded in the appropriate fields of the data form (i.e. hydrology remarks, soil layer comments, soil remarks, etc.). Your soil profile description should also be performed as soon as possible using one of the representative pits. In addition to photo documenting your soil profile, document the application of the strips before and after any potential reaction.
- h. If the soil is allowed to dry before implementing the test strips or characterization of the profile, dig another representative pit and start over.