THE MARYLAND WETLAND ASSESSMENT METHOD (MDWAM)

United States Army Corps of Engineers - Regulatory Branch for use within the Baltimore District in the State of Maryland

The Maryland Wetland Assessment Method (MDWAM)

Wetlands Module, Interim Version 1.0

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Appendices (See attached documents)

Appendix A: Additional Figures and Photo Examples
Appendix B: Example Metric Photos
Appendix C: MDWAM Wetland Data Forms and Final Scoring Sheets
Appendix D: Example Wetland Assessments and Completed Data Forms

List of Figures

List of Tables

FOREWARD

The MDWAM Version 1.0 was developed by USACE, Baltimore District, Regulatory Branch. A multidisciplinary team led by the USACE was assembled in 2018 to study the feasibility of developing a rapid assessment methodology for use in the State of Maryland. The primary objective of MDWAM is to develop a defensible tool to evaluate wetland condition in a rapid and repeatable manner to increase the consistency of the USACEs permit decision making process under Section 404 of the Clean Water Act.

In addition, this tool was developed to improve understanding of wetland functions and conditions to better inform impact avoidance/minimization efforts, evaluation of project alternatives, development of plans, and development and monitoring of compensatory mitigation (here forth referred to as “mitigation”) efforts. The Final Mitigation Rule (32 CFR 332) encourages the use of functional and conditional assessment methodologies in determining mitigation needs for impacts and evaluating and monitoring mitigation work (33 CFR 332.3 (f)(1)). MDWAM Version 1.0 was developed to fill the need of a Maryland-specific functional and conditional assessment methodologies for wetland impact and mitigation evaluation pursuant to Section 404 of the Clean Water Act.

MDWAM can provide regulatory project proponents and applicants with a tool to objectively assess wetland conditions for project planning, alternative comparison, and impact assessment and avoidance. MDWAM can be used in restoration and mitigation planning and permitting including development of mitigation requirements, mitigation plans, monitoring protocols to determine wetland mitigation success, and long-term monitoring.

After an extensive review of many of the current rapid assessment methods, the MDWADT chose the Texas Rapid Assessment Method, *Version 2.0* (TXRAM) as the template from which MDWAM would be developed. Despite some obvious regional differences, the team determined that the basic format, concepts, core elements, metrics, etc., could be modified for use in Maryland. Additionally, information critical in the development of MDWAM were also adopted from several other methodologies referenced in this document.

MDWAM assesses wetland condition based on five core elements, including landscape, hydrology, soils, physical structure, and biotic structure. Each of the five elements have associated metrics, which are scored by selecting the best fit from a list of descriptive narrative conditions for each metric based on observations in the wetland. The metric scores are then compiled into numerical scores for each element and an overall score for the wetland. These standardized scores can then be used for comparison to other MDWAM scores for wetlands in the same class and ecoregion.

The application of MDWAM requires an experienced investigator skilled in the accurate identification of plants, soils, and other field indicators used in the delineation of wetlands. The user must be knowledgeable of the functions and ecosystem processes of wetlands in Maryland, specifically, the four wetland classes identified in MDWAM. Users should have adequate expertise interpreting supporting information such as aerial imagery. While MDWAM can be completed individually, interdisciplinary teams of at least two people with a combination of these skills is recommended to ensure consistent and accurate data collection and analyses. Field trainings in the methods outlined herein are recommended to ensure that the methods are executed correctly and consistently.

Rapid assessment methods are intended to be performed in one day or less to be most useful for most regulatory actions (Berkowitz et al 2023). Upon completion of an accurate wetland delineation, it is anticipated that users will require approximately 1-2 hours of additional time to complete MDWAM depending upon their experience level and knowledge of the wetland classes identified by MDWAM. This includes office and field analysis of the data collected for small to medium size wetlands (~5.0 acres or less). However, larger, and more complex wetlands will likely require additional time investment.

MDWAM Version 1.0 is intended as an interim document to be used for a period of approximately one year. This interim period will enable the USACE and its partners to review solicited comments based on beta testing by all potential users. Subsequent revisions, if warranted, will be implemented by the team, and presented in a final, Version 2.0 at the conclusion of the interim period. This document should be cited as:

United States Army Corps of Engineers. 2024. *MDWAM, Interim Version 1.0.*

1.0 INTRODUCTION

1.1 Purpose

Baltimore District of USACE, Regulatory Branch, in collaboration with the MDWADT, developed this manual to provide a rapid assessment method for evaluating the ecological condition of non-tidal wetlands within the State of Maryland. MDWADT performed an extensive review of many current wetland rapid assessment methodologies before selecting TXRAM as a template for the subsequent development of MDWAM. In contrast to TXRAM, MDWAM contains only a wetland module focused strictly on non-tidal wetlands in Maryland due to the previous development of a stream module as part of a Maryland Stream Mitigation Framework. This manual describes the intended use, scope, background, procedures, and guidelines for the MDWAM. The information produced by MDWAM will be integral in calculating adverse impacts and compensatory mitigation associated with USACE authorized activities under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act of 1899. If implemented correctly, MDWAM will provide a consistent method for wetland assessment and will support the integrity of data collection and comparison.

1.2 The Goal and Intended Use of MDWAM

MDWAM provides a rapid, repeatable, and field-based method that generates a single overall score of wetland integrity and health. MDWAM is level two of the Environmental Protection Agency's three-level approach to wetlands assessment (landscape level, rapid assessment, and intensive assessment). MDWAM was developed for wetland types of Maryland as a tool for the evaluation of the current and potential future wetland conditions. MDWAM does not focus on specific ecologic functions or societal values provided by wetlands. While MDWAM will usually be sufficient to support most regulatory actions, the additional assessment of specific functions may be requested by the USACE as MDWAM is not an intensive, quantitative functional assessment. On a case-by-case basis, the USACE will determine the amount of information and analysis that will be required to meet regulatory requirements based upon the degree of the environmental impact (as determined by the functions of the aquatic resource and the nature of the proposed activity) and the scope of the project. Lastly, Maryland Department of the Environment (MDE) may also use MDWAM to evaluate wetland condition.

MDWAM will provide information for the evaluation of the current and potential future ecological conditions of areas that meet the definition of a wetland. It should be noted that current state regulations may include additional aquatic resources that meet the definition of wetlands excluded from federal regulations in place at the time of the evaluation associated with various regulatory actions. MDWAM is not to be used to determine jurisdiction (i.e., waters of the United States). The extent of potential waters of the United States are determined using the most current USACE delineation method and guidance for jurisdictional determinations for other waters, which are published jointly for that purpose by USACE and the United States Environmental Protection Agency (USEPA).

Potential uses of the MDWAM are described below:

- Restoration Potential: The tool can assist in determining the level of restoration a project can achieve through evaluation of site constraints, watershed stressors, and selection of parameters for functional lift.

- Watershed Stressors: MDWAM can be used to determine factors that limit the potential wetland functional lift that can be achieved by a restoration project, including for the purpose of compensatory mitigation.

- Site Selection: The tool may assist in determining if a site can benefit from a restoration project and if the site has significant limitations that would inhibit a project from being successful. Site selection is critical to determine whether a proposed restoration project can achieve enough functional lift to meet the project goals and objectives and provide sufficient compensatory mitigation. Rapid field assessment methods coupled with the "Mitigation Site Evaluation Report for Maryland" can be used to assess and select a site at the development phase of a project.

- Function-Based Goals and Objectives: The tool can be used to describe project goals that match the restoration potential of a site. Quantifiable objectives and performance criteria can be developed that link restoration activities to measurable changes in wetland functional categories and function-based parameters assessed by the tool.

- Functional Lift: The tool can quantify functional lift from a proposed or constructed wetland restoration project. Lift is estimated during the proposal, design, or mitigation plan phase, and is calculated for each post-construction monitoring event.

- Functional Loss: The tool can determine functional loss based on a comparison of existing condition and predicted proposed condition scores. Loss is estimated during the proposal, design, or mitigation plan phase, and can be used to compare impacts from project alternatives.

- Compensatory Mitigation: The tool can be applied to compensatory mitigation projects, including permittee-responsible mitigation, in-lieu fee mitigation, and mitigation banks. The tool can help determine if the proposed mitigation activities will provide sufficient functional lift to offset unavoidable adverse impacts to wetlands. It can also be used to develop monitoring plans and assess a project's success against proposed and/or reference standards.

- Mitigation Banking: MDWAM assessments should always be conducted on proposed wetland mitigation features early in the bank development process. These rapid assessment methods are valuable as a mitigation site screening tool and for establishing the baseline functional condition of proposed sites (e.g., preservation sites should generally have results that indicate a high functional condition, while enhancement and restoration sites should have results that indicate an impaired functional condition). This tool may help demonstrate the specific functional areas where improvements may be made. The district recommends submitting the results of the assessment at the Prospectus/initial site review stage, but it is not a requirement of any regulation or district procedure at that early stage of review. The use of MDWAM does not replace the need to conduct more thorough assessments and measurements of existing conditions on proposed wetland mitigation sites later in the bank site development process.

Several metrics for wetlands often require the assessment of landscape conditions beyond the wetland boundaries to identify potential factors which may influence its current and future condition. MDWAM utilizes both on-site field observations and/or remote sensing data (particularly where access is limited or unavailable).

Within the USACE Regulatory Program, MDWAM will be useful in the characterization of a wetlands ecological condition, assessment of potential wetlands impacts, comparison of project alternatives, development of wetland compensatory mitigation proposals, and monitoring of potential mitigation sites. Where historically altered wetlands are proposed to be restored, enhanced and/or rehabilitated, MDWAM can provide baseline data on wetland condition.

Typically, an assessment should be conducted in the following circumstances:

1. 1.When an applicant requests a waiver from the limitations found in the NWP.

2. To support a decision to require mitigation other than is normally required.

3. When mitigation is being required for impacts that are less than 1/10-acre of wetlands.

4. To support decisions regarding a requirement to avoid and/or minimization impacts to higher quality wetlands.

5. Enforcement actions where restoration and/or mitigation is being required.

6. For the development and monitoring of wetland compensatory proposals.

Therefore, MDWAM can be an important tool in developing monitoring requirements and tracking performance standards for wetland mitigation over time. Furthermore, MDWAM may be used to evaluate the future, proposed ecological conditions of a wetland but there may be other evaluations, information, and guidelines required (see Section 1.5 Other Technical Evaluations). If other uses of MDWAM are proposed, the USACE should be consulted prior to implementation especially if in conjunction with a regulatory action.

MDWAM scores are intended to be interpreted and compared between resources of the same wetland class. Comparison of scores among different wetland classes may not provide an accurate depiction of condition and functions the wetland provides in the landscape or watershed setting. Additionally, MDWAM was developed to interpret and compare wetlands withing the same ecoregion to accurately reflect differences in condition. While there are considerations for differing ecoregions in the metric scoring, MDWAM does not intend to normalize the scores for each ecoregion.

A MDWAM score for wetlands in different ecoregions may not reflect the same condition. For example, a wetland with a lower score than a wetland in a different ecoregion does not necessarily mean that it provides a lower level of function within its watershed and landscape compared to a wetland of the same class that scores higher. Consequently, MDWAM scores should generally be interpreted for wetlands of the same class and ecoregion, including the use of a reference standard of highest condition (which may not reach the theoretical maximum score). In Maryland, this is usually the least disturbed condition. However, since compensatory mitigation evaluations are generally based on the assessment of conditions and functions aquatic sites provide within a limited watershed area or ecoregion [as outlined in the 2008 Final Rule on Compensatory Mitigation for Losses of Aquatic Resources (USACE and USEPA 2008)], the differences between resource type and ecoregions are potentially a concern from a regulatory process perspective.

MDWAM is an assessment module for wetlands and does not apply to other waters such as streams, lentic open waters (e.g., lakes and ponds), vegetated shallows, mudflats, or other aquatic features that do not meet the current definition of a wetland. As stated above, streams in Maryland will be evaluated within the current Maryland Stream Methodology Framework (MSMF). For example, a narrow wetland fringe along a stream may be better assessed using the MSMF while on the other hand, MDWAM should be used in situations where there is a distinct wetland abutting a stream channel or a bed and banks that contain a wetland with multi-threaded channels where the area functions primarily as a wetland (see Figures 1-4 below). In situations that have been modified by disturbance or stress (e.g., channelization), a resource may be in a state of transition from one type of aquatic feature to another based on channel morphology, sediment loads, hydrology/hydraulics, and other factors. It is recommended that the USACE be consulted in complex or atypical situations where it is unclear if the MSMF or MDWAM should be employed. While the user may consider exercising professional judgment in these situations, the USACE retains the final authority to decide which method applies to an aquatic feature.

Figure 1. (adapted from USACE 2015). Where a narrow wetland fringe is present on the banks of a stream, a stream assessment and/or stream buffer assessment should be used to assess stream or buffer quality as needed (See MSMF V.1. Final, USACE 2023). *MDWAM would generally not be used in this situation.*

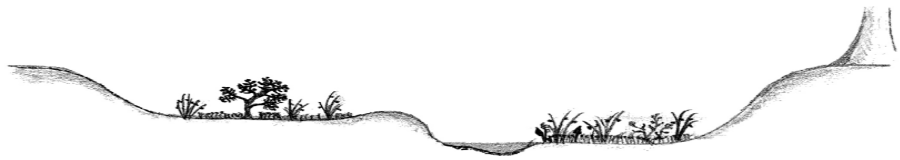

Figure 2. Example of a stream with an abutting wetland and an adjacent wetland, where the stream is assessed using a stream assessment and the wetlands are assessed using MDWAM (adapted from USACE 2015). *These will likely be riverine and / or slope wetlands.*

Figure 3. Example of a bed and banks that contain a wetland with minor multi-thread channels where the area functions primarily as a wetland and is assessed using MDWAM (adapted from USACE 2015). *This situation is common in degraded watersheds but also found naturally in slope wetlands where multiple groundwater discharge paths may be observed.*

Figure 4. Example of a wetland within bed and banks of very small streams or a confined valley where the area functions primarily as a wetland and is assessed using MDWAM (adapted from USACE 2015). *This is another situation that is common in degraded watersheds but can also occur naturally in slope wetlands.*

Most of the field testing of MDWAM Version 1.0 was conducted during the period of 2021-2023 by interagency teams to evaluate and calibrate this wetland module. The field testing consisted of applying MDWAM to over 200 wetlands in two ecoregions that occur in the Baltimore District primarily in the State of Maryland. Some field testing occurred in neighboring Delaware and Pennsylvania for convenience but within the same Major Land Resource Areas (MLRAs) and ecoregions which extend across borders.

1.3 Geographic Scope

The geographic scope of MDWAM is the State of Maryland. MDWAM may have utility in the adjacent states, particularly those areas within the same reference domain or geographic area from which reference wetlands have been selected (Brinson 1995). The MDWAM reference domain includes several ecoregions which spill over into the adjoining states. However, MDWAM has not been extensively tested and field calibrated outside of Maryland. MDWAM is based on an adaptation of the USEPA Level III Ecoregions as illustrated in Figure 5 below (Griffith 1994). The six Level III Ecoregions currently recognized in Maryland include: 1) Central Appalachians; 2) Ridge and Valley; 3) Blue Ridge; 4) Northern Piedmont; 5) Southeastern Plains; and 6) Mid-Atlantic Coastal Plain.

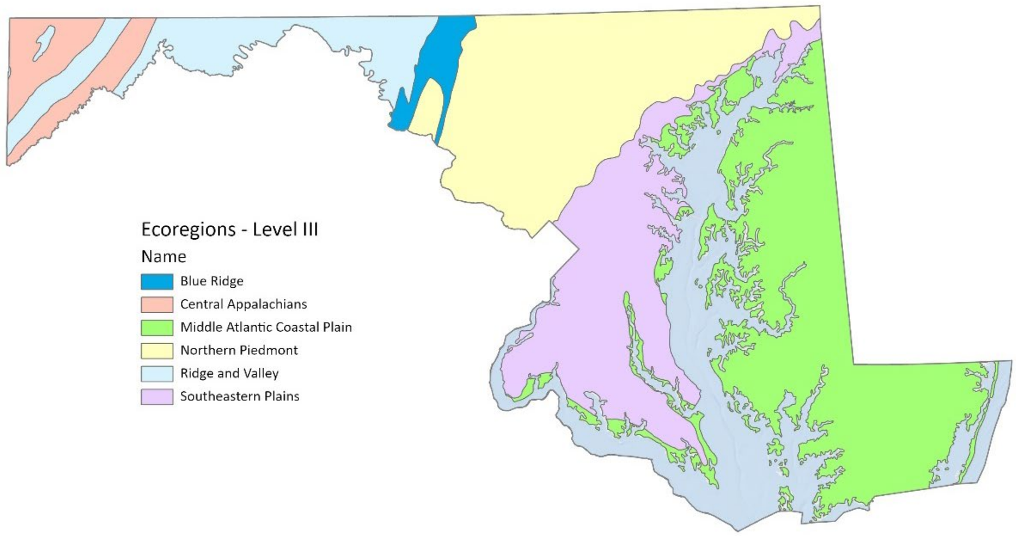

Figure 5. USEPA Level III Ecoregions *(Source:* Griffith 1994*)*

For the purposes of MDWAM, the MDWADT determined that enough similarity exists among wetlands in several of the EPA designated ecoregions to consolidate them into two ecoregions (Eastern Mountains and Piedmont Ecoregion and Coastal Plain Ecoregion) as presented below in Figure 6. While some differences were recognized, the team determined through field testing that the two consolidated MDWAM ecoregions are similar enough to generate comparable scores of wetland integrity and health for regulatory purposes. The combination of these ecoregions aligns with the common resources and current practices used in wetland identification and delineation in the State of Maryland. MDWAM ecoregions further align with the Eastern Mountains and Piedmont (USACE 2012) and the Atlantic and Gulf Coastal Plain (USACE 2010) Regional Supplements to the 1987 Corps of Engineers Wetland Delineation Manual and, the United States Department of Agriculture (USDA) Natural Resources Conservation Service's Land Resource Regions and MLRAs (USDA 2022).

Lastly, a basic goal of MDWAM is to maximize use of the data collected in conjunction with wetland delineation to reduce the time and overall cost of submissions associated with regulatory actions.

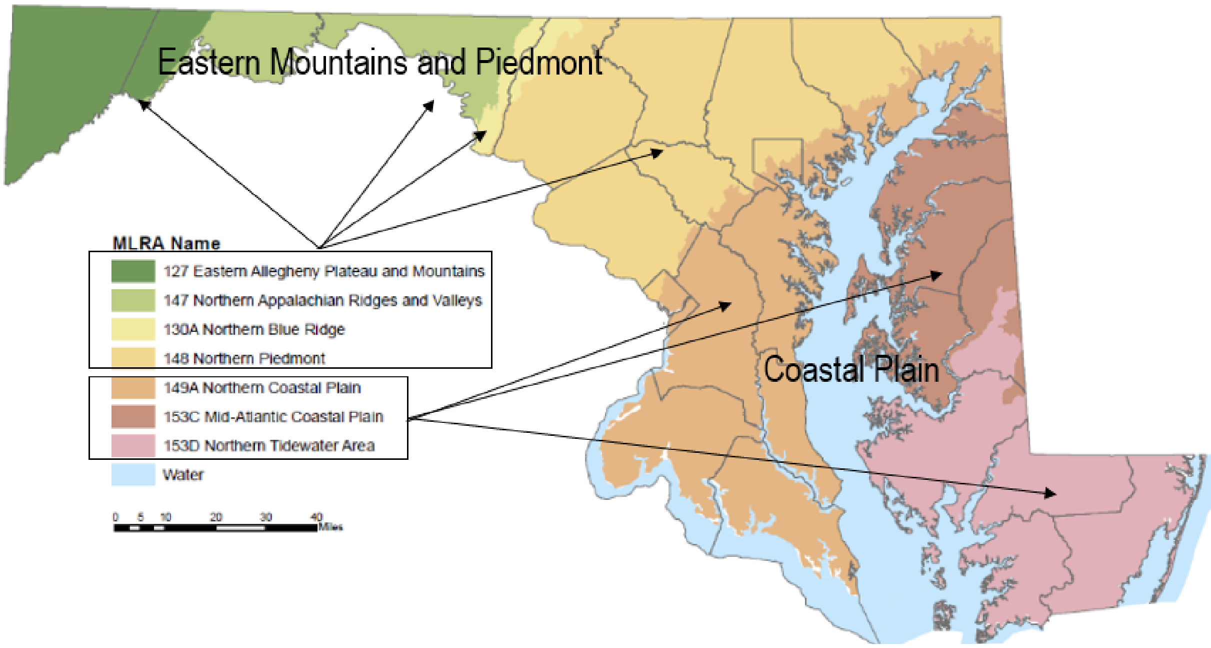

Figure 6. *Six EPA Level III Ecoregions (Figure 5) were consolidated into two MDWAM Ecoregions: MLRAs 127, 130A, 147 and 148 were combined into the Eastern Mountains and Piedmont Ecoregion and MLRAs 149A, 153C and 153D were combined into the Coastal Plain Ecoregion (adapted from USDA 2022).*

1.4 Assessment Extent and Timing Based on Project Scope

The implementation of MDWAM may vary in the extent and timing of an assessment for different types of projects. For example, the assessment may be performed during or after a delineation of wetlands. Unless otherwise determined, in collaboration with USACE, wetland assessments will be performed after the completion of a delineation of all aquatic resources located within the project review area. Users should exercise professional judgment when planning the timing of the assessment in conjunction with other project activities and may also coordinate with the USACE for additional guidance. For instance, some metrics will be more accurately scored seasonally (e.g., vegetative composition and structure).

In applying MDWAM, a wetland assessment area (WAA) is evaluated to determine a score of ecological condition. The WAA establishes the geographic boundary for the MDWAM analysis of the wetland being evaluated. Additionally, the WAA is defined as the area where all measures and metrics are observed and scored to calculate the overall MDWAM score. The effective use of MDWAM requires consistency and repeatability among users when determining the WAA to allow the results of MDWAM to be productive and informative as to the condition of the evaluated wetland(s). A WAA should always be representative of the wetland that is being assessed whether it is a small wetland, large mosaic of wetlands, etc. The wetland assessment extent guidelines in Table 1 are intended to assist users in consistently setting the WAA boundary.

Table 1. Guidelines for determining the Wetland Assessment Area (adapted from USACE 2015, Mack 2001):

The identification and delineation of WAA boundaries is a critical step in the MDWAM procedures which will have a direct influence on the overall score. Delineating the WAA boundary may be complicated, particularly from supporting information. A skilled aerial photo interpreter can identify approximate wetland boundaries, but field verification is vital in refining them. The following guidelines are provided to inform the accurate and consistent identification of WAA boundaries. These guidelines, which are supported by the scientific literature, focus on encompassing the entire wetland that has uniform hydrologic processes in a single WAA. The following steps and guidelines will be used to define the WAA (Figures 8-11). Example photos are available in Appendix A.	
1	Identify the potential wetland area of interest (i.e., impacted areas, mitigation areas, etc.).
2	Evaluate the strength and consistency of hydrologic signatures using multi-temporal aerial photos. Light Detection and Ranging (LiDAR) and other supporting information can also be used to validate potential hydrology signatures.
3	From aerial photo interpretation, identify areas with uniform hydrology signatures and areas of significant hydrologic change in the wetland. <u>Hydrology is the primary criterion</u> used in determining the WAA boundary. The WAA should consist of the entire wetland and follow the wetland boundary unless significant hydrologic change is detected. WAA boundaries should be delineated between contiguous or connected wetlands where distinct changes to the volume, flow, source, or velocity of water moving through the wetland occurs. These changes may be natural such as (topographic, channel migration, beaver activity, debris, etc.) or from human disturbances including the addition of fill, excavation, land clearing and leveling, surface or subsurface drainage, channelization, etc. The final WAA boundary should encompass all wetland areas with uniform hydrologic processes, except as described below. Mapped soil units and hydric soils can often be useful in verifying hydrologic signatures.
4	Regardless of the composition of the vegetative community (e.g., herbaceous, scrub-shrub, forested, etc.), all contiguous wetland areas of the same wetland class (see additional discussion regarding wetland class in Section 2.2.3) that have a high degree of hydrologic interaction should be included in the same WAA.
5	The boundary of the WAA will also be established where conditions vary due to disturbance or stress. For example, a single mineral flat wetland that is partially mature, diverse forest but also partially early successional, low diversity forest (e.g., due to historic agricultural or silvicultural use) may require separate WAAs for the two different areas (Figures 7A-B and 10) due to past stressors (i.e., soil/vegetation alteration). Rationale for dividing a wetland area with uniform hydrologic processes into multiple WAAs should be described and documented in the MDWAM data sheet and final scoring sheet. For example, a historic wetland where a portion of the wetland has been converted to cropland but is now in various stages of recovery may require separate WAAs.
6	As described number 4 above, it is not necessary to establish separate WAAs in wetlands that are a mosaic of several different vegetation communities (i.e., no disturbance) if the area has largely uniform hydrologic processes and a high degree of hydrologic interaction. For example, any wetland class with multiple vegetative communities (e.g., forested, and emergent communities) will have a single WAA (Figure 8B and C) provided uniform hydrologic processes and a high degree of hydrologic interaction exist.

7	Artificial boundaries such as political boundaries, property lines, roads, railroads, pipelines, etc. are generally not to be used for the WAA boundary except where they coincide with a hydrologic change or a change in condition due to disturbance or stress as indicated above. However, linear fills associated with crossings usually cause a change to hydrologic processes both up and down stream of a crossing. These wetlands will generally be divided into two separate WAAs. Furthermore, as in the case of linear projects where property access may only be available for a portion of the wetland, the WAA may be set accordingly and described in the MDWAM data sheet and final scoring sheet.	
8	Apply the following guidelines for wetlands that are contiguous with open water to determine the WAA. Areas of floating or submerged aquatic vegetation (SAV) must be included with open waters.	
	a	For open water areas less than or equal to 20 acres (i.e., ponds, small impoundments), the WAA should include all wetlands of the same class that are contiguous to that area of open water.
	b	For open water areas greater than 20 acres (e.g., reservoirs), individual WAAs are required for each separate wetland contiguous to the open water area.
	c	A separate WAA is required for wetlands that are contiguous to an open water area but whose hydrology is predominantly influenced by a different water source such as slope wetlands fed by groundwater discharge. These wetlands will be distinctly different than other wetlands contiguous to the open water area.
9	Where two or more wetlands directly abut a channel, separate WAAs should be established if:	
	a	The wetlands are located on opposite sides of a channel where the average channel width is greater than 100 feet, or
	b	The wetlands are separated by a non-wetland corridor (along the channel) greater than 100 feet.
10	Using the guidelines above, adjustments to the WAA can be made in the field during or after the delineation. Figures are provided in this section below and in Appendix A.	

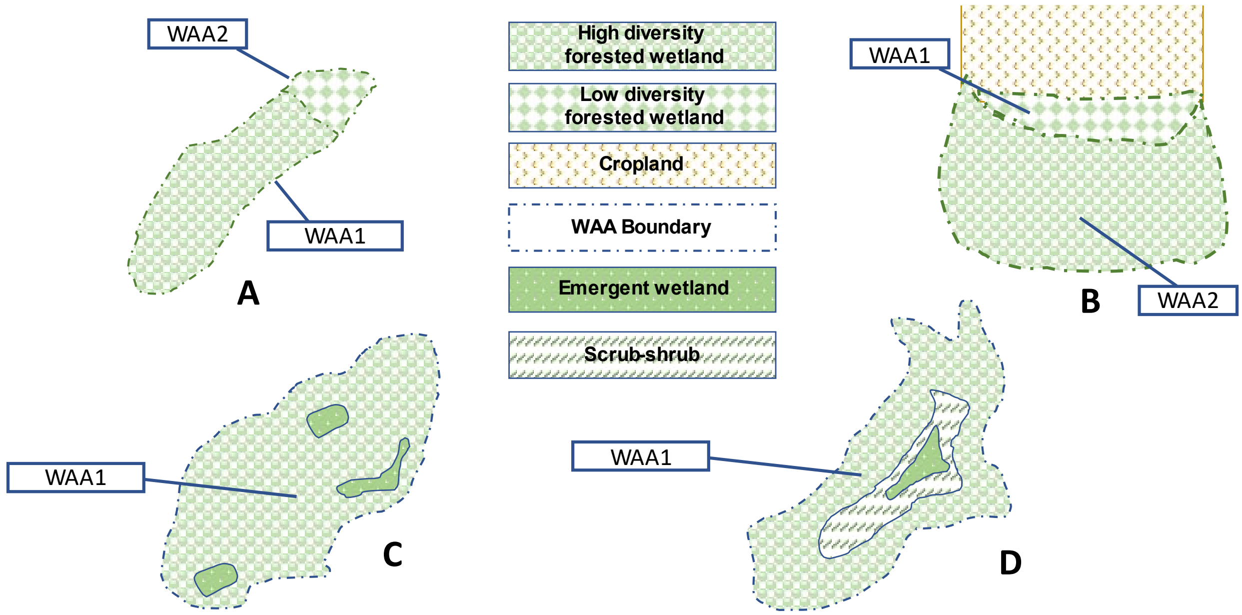

Figure 7. Examples of WAA guidelines for complex situations. *Past vegetative alterations often result in varying levels of diversity in a vegetation community as in examples (A-B). This will often require the wetland to be separated into two WAAs despite having similar hydrology. Examples (C-D) represent wetlands with multiple communities contained in a single WAA. These communities are not the result of alterations and require a single WAA if hydrologically similar. See Appendix A for additional examples.*

The type of project will often be the first step in identifying the boundaries of the WAA.

Based on the following, the user may streamline the assessment by considering the extent and timing required for a specific project. Determine if the proposed project will: 1) result in the placement of fill material into waters of the United States, or 2) result in the mitigation (e.g., restoration, establishment, enhancement, or preservation) for impacts to waters of the United States. The determination of assessment extent and timing based on project type may not fit every project or situation, so professional judgment and USACE coordination may be necessary. The USACE has the authority to make the final determination on the location of the WAAs within the proposed project area. Figures 8-10 provide examples to illustrate the WAA boundary for different project types discussed below and based on the guidelines in Table 1.

The assessment extent will differ between linear and non-linear project types for projects resulting in the placement of fill material into wetlands and other aquatic resources. Linear projects are those projects constructed for the purpose of getting people, goods, or services from a point of origin to a terminal point and typically include roadways, railroads, pipelines, and transmission lines. Non-linear projects are all other types of projects that typically result in “made land” resulting from the elimination of a wetland or other aquatic resource.

Linear projects within the Baltimore District typically have rights-of-way (ROW) that can be quite variable in width (30 to 200 feet or more) depending upon the type of linear project. Where the ROW is narrow, a single WAA may be located at each individual crossing location (Figure 8A), or the crossing may require the use of multiple WAAs based on the guidelines in Table 1 (Figure 8B-C). For situations where the ROW for a linear project exceeds 200 feet, users should consult with the USACE to determine if additional measures are warranted. The location of these WAAs should be determined in the field during the delineation of wetlands using the guidelines set forth in Table 1. For projects proposing multiple alignments, MDWAM will be useful in determining the best, or least damaging alternative. Because linear projects typically require crossing multiple WAAs, users may consider inferring scores for wetlands that are similar in condition (see Section 2.2.7.2 inferring scores).

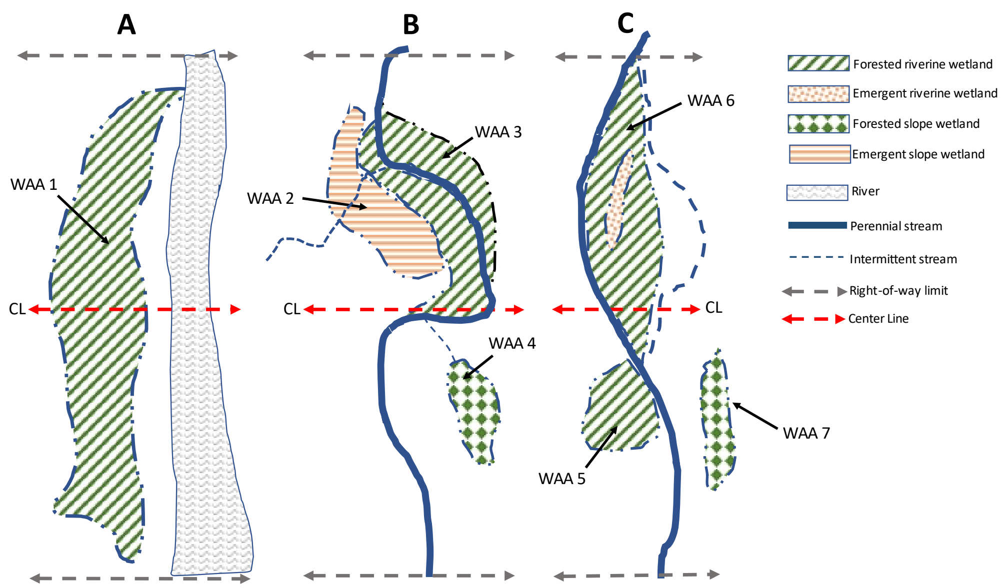

Figure 8. Example of assessment extent for linear projects. *Crossing A requires one WAA, while crossings B and C require multiple WAAs (adapted from USACE 2015).*

Non-linear projects may be any size, including large commercial developments or small residential fills. The assessment extent will also differ between non-linear projects where the construction/impact area is known as opposed to not known prior to the assessment. If the construction/impact area for the project is known prior to the assessment, then a delineation of wetlands should be performed within the construction/impact area boundary. The WAAs for MDWAM will then be in those wetlands that would be impacted by the proposed project (Figure 9) or any alternatives. The location of these WAAs may be determined after the delineation of using the guidelines set forth in Table 1. MDWAM should then be completed within each WAA (as described in this wetland module) upon completion of the delineation of wetlands or in a subsequent field visit.

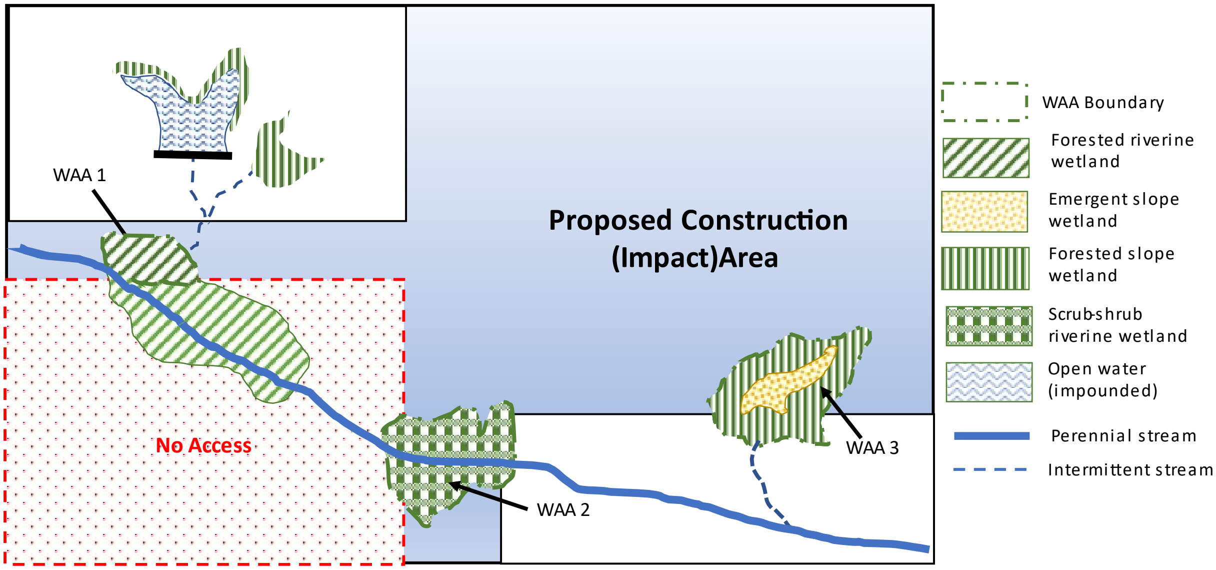

Figure 9. Example of assessment extent on non-linear projects with a known construction area (adapted from USACE 2015).

Non-linear projects in which the construction/impact area is <u>not known</u> prior to the assessment may utilize two different options to determine the WAAs. The first option for determining the WAAs for these non-linear projects is to complete a preliminary in-office review of pertinent supporting information of the project area. This includes identifying all potential wetlands as viewed on recent aerial photography and other available supporting information such as: topographic, NWI and soil mapping; LiDAR; and Geographic Information System (GIS) layers. Users are directed to the Maryland Watershed Resource Registry (WRR) which provides a wide selection of mapping tools. The WAA boundaries will be subsequently delineated based on photointerpretation (Figure 10). The WAAs should be located within the photo-interpreted wetland boundaries based on the guidelines set forth in Table 1. MDWAM should then be completed within each WAA (as described in the wetland module, Section 2.0) in conjunction with the delineation of wetlands. A proposed mitigation bank is an example where the design has yet to be developed. For projects with multiple alternatives, MDWAM can be useful in determining which alternative has less adverse impacts on wetlands, requires the minimum compensation, thereby assisting in the overall consideration of project costs.

The second option for these non-linear projects is to determine the WAAs after the delineation of waters of the United States within the project area. The WAAs should be the wetlands identified during the delineation based on the guidelines set forth in Table 1. MDWAM should then be completed within each WAA (as described in the wetland module, Section 2.0) after the delineation of wetlands is complete or in a subsequent field visit. Where multiple wetland classes occur, be sure to separate them so MDWAM is applied to them individually.

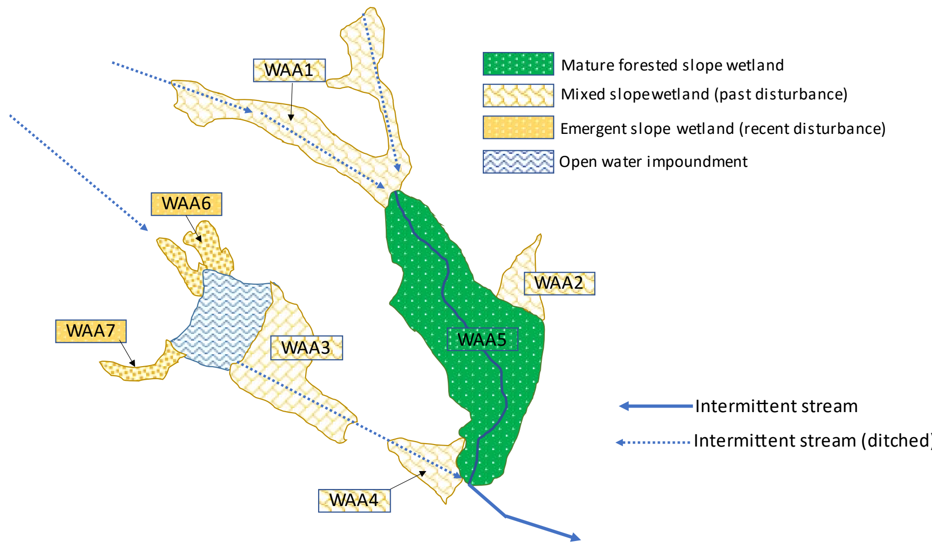

Figure 10. Example of assessment extent on large non-linear projects without a known construction area or for mitigation/conservation such as a potential mitigation bank. *Many of the polygons above may be prime areas for potential restoration, rehabilitation and or enhancement.*

For those projects that will result in the mitigation for impacts to wetlands, the location of the WAAs should be determined after completing a delineation within the project area. The WAAs should be in those waters of the United States identified during the delineation based on the guidelines set forth in Table 1. MDWAM should then be completed within each WAA (as described in the wetland module, Section 2.0) in a subsequent field visit (Figure 10). The recommended option is to submit the delineation of wetlands to the USACE for verification and a jurisdictional determination prior to determining the WAAs to assure MDWAM is completed for all wetlands.

Finally, for all project types, the WAA boundary may be adjusted in the field in accordance with the guidelines in Table 1. In addition, the locations of the WAAs for large and/or complex wetlands may need to be verified by the USACE prior to the completion of the MDWAM field assessment. Coordination with the USACE on the locations of the WAAs is not a requirement but a recommendation for the completion of MDWAM in an efficient and timely manner. USACE coordination is recommended for large projects such as individual permit applications and potential mitigation banks. The USACE has the authority to make the final determination on the location of the WAAs within the proposed project area.

1.5 Other Technical Evaluations

Appropriate functional or condition assessment methods or other suitable metrics should be used, where practicable, in evaluating applications for proposed wetland impacts and compensatory mitigation requirements. MDWAM will be implemented by the USACE Baltimore District to assess wetland types and condition when evaluating unavoidable adverse impacts and compensatory mitigation requirements associated with USACE authorized activities under Section 404 of the Clean Water Act. Use of MDWAM may result in a consistent and more efficient review that is rooted in sound science and is compliant with all applicable laws.

Additionally, the inclusion of MDE in a joint development process with the Baltimore District, will support the use of the MDWAM by both state and federal agencies across the state of Maryland, should Maryland also adopt use of MDWAM, further supporting a consistent regulatory review.

MDWAM is intended to serve as a rapid evaluation tool useful in the evaluation of wetland impact sites and compensatory mitigation projects for those USACE Baltimore District Regulatory Program applications suitable for general permit (i.e., NWP, SPGP, RGP) authorizations and individual permits without significant adverse environmental impacts. MDWAM may be applied to assist in the minimal adverse environmental effects determination for general permit authorizations and associated compensatory mitigation proposals, when required. For activities authorized by general permits, it may not be practicable to use MDWAM in some circumstances. Furthermore, MDWAM should be applied, when available and appropriate, for larger, more complex projects requiring an application for an individual permit and associated compensatory mitigation requirements. Project proponents should contact the appropriate Baltimore District office to determine whether MDWAM or another method should be used for a particular permit application.

A relatively small percentage of the Section 404 actions will require a variety of more comprehensive or resource-specific evaluation techniques. Supplemental techniques and other technical evaluations of aquatic resources may be required for a subset of USACE Regulatory Program actions. For example, MDE has recently developed two separate *Rapid Ecological Integrity Assessments of Wetlands in Riparian Areas of Maryland* (Brewer et al 2023; Brewer and Harrison 2023). Note that this does not preclude the need for evaluations of cultural resources, endangered species, and other factors as part of public interest review for regulatory actions.

Other evaluations may include, but are not limited to, habitat modeling, biotic sampling, fluvial geomorphic classification, water quality investigations, wildlife habitat studies, hydrologic/hydraulic modeling, or others. Additionally, some actions—such as proposed mitigation activities—may require other evaluations such as those listed above commensurate with the proposed activities and the need to quantify the proposed influence on ecological conditions/functions of aquatic resources. Other technical evaluations may be used in the USACE Regulatory Program in addition to MDWAM but are not intended to replace, or be incorporated into, MDWAM scores. MDWAM is not certified for use in USACE Civil Works ecosystem restoration and mitigation projects. Engineer Circular 1105-2-412, “Assuring the Quality of Planning Models’ (USACE 2011), reflects USACE policy requiring the use of certified or approved models for all planning activities.

2.0 THE WETLAND MODULE

MDWAM is intended to aid in assessing the condition of different non-tidal wetland classes found within the USACE Baltimore District in Maryland. This document contains Sections on background information, procedures, and guidelines for evaluating and scoring a series of metrics to arrive at an overall score of wetland integrity.

2.1 Background Information

This section will provide background on the use of MDWAM for wetlands including the key terms, concepts and assumptions, and the metrics.

2.1.1 Key Terms and Definitions

The following definitions are provided to ensure consistency in the use of key assessment terms which were adapted from USACE 2015 and Collins 2008.

Wetland Assessment Area (WAA): The portion of a wetland that is evaluated and scored using MDWAM. This encompasses the entire wetland area with uniform hydrologic processes; however, multiple wetland assessment areas may be needed for wetlands with varying conditions related to disturbance or stress. Additional information on how the assessment area is set can be found in Section 1.4.

Buffer: The area surrounding a wetland that influences or controls the effects of stressors and disturbance (that originate outside the wetland) on wetland condition.

Canopy: The canopy is typically the uppermost layer of vegetation in a plant community; in forested wetland types, the tree stratum composes the canopy. A recently disturbed forested wetland that supports saplings and shrubs but no trees, has no canopy.

Channel: A channel is a natural water-carrying trough cut vertically into low areas of the land surface by erosive action of concentrated flowing water or a ditch or canal excavated for the flow of water.

Condition: The quality, integrity, or health of a wetland determined by the interactions of hydrologic, biologic, chemical, and physical processes. Condition is also the ability of a wetland to support and maintain its complexity and capacity for self-organization.

Disturbance: A natural event or human alteration that affects the processes and subsequently the condition of a wetland.

Delta wetlands: These are wetlands that have formed in the alluvial fan (delta) of incoming streams near their confluence with a standing body of water (i.e., impoundments). Due to the reduction in energy to transport materials, wetlands often form in the deposited materials where the hydroperiod is sustained by the level of the impoundment.

Elevation gradients: Areas within a wetland where changes in height (benches) affect the level of saturation/inundation or the path of water flow. Elevation gradients typically have greater than 6 inches of difference with a corresponding change in saturation/inundation, soil condition, and/or vegetation.

Emergent vegetation/emergent plant: An emergent plant is a rooted herbaceous plant that has parts extending above a water surface (Environmental Laboratory 1987).

Floodplain, active: The land beside a river that receives overbank flooding when discharge exceeds channel capacity (USACE 2006).

Flow, groundwater: This term refers to water that flows below the land surface through a porous medium normally under saturated conditions (USACE 2006).

Flow, near-surface: This term refers to flow that occurs just below the surface of a wetland in a layer that is often more permeable than the more consolidated sediments just below. Near-surface flow often occurs in the rhizosphere where hydraulic permeability is high (USACE 2006).

Flow, surface: This term refers to non-channelized flow (unchannelized) that occurs above the surface or overland flow (USACE 2006).

Function: A process or attribute (physical, chemical, or biological) that is performed by a wetland that supports its integrity and occurs regardless of if it is deemed valuable by society.

Metric: A characteristic or indicator of wetland condition (variable) that is evaluated and scored in the rapid assessment and which combined with other metrics into a category of landscape, hydrology, soils, physical structure, or biotic structure.

Micro-topography: Both micro-highs and micro-lows that are generally interspersed, local in extent, and typically have 3–6 inches of elevation difference from the surrounding area with a corresponding change in saturation/inundation, soil condition, and/or vegetation.

Nontidal Wetlands: Generally, wetlands that are not subject to the ebb and flow of the tide and less than 0.5 ppt salinity (Cowardin et al. 1979).

Open waters: Consist of all standing or flowing aquatic habitats including areas of floating or SAV (true aquatics species). In general, these are deepwater habitats as defined by Cowardin et al. (1979) and are not included in a WAA.

Physical habitat types: Different structural surfaces and features that support the living requirements of flora and fauna (e.g., un-vegetated pools, thick herbaceous cover, plant hummocks, standing snags).

Plant zones: Different associations of plants or patches within a community that are organized along elevation or hydrologic gradients over the surface of a wetland.

Process: A series of steps that occur to move or change a particular resource (e.g., water, energy, nutrients).

Stress/Stressor: A human activity or human-caused event which affects one or more wetland functions by altering the wetland from reference condition. Wetland type, size, and severity of the stressor are key in how a wetland may respond to stressors. Examples of stressors may include nutrient enrichment/eutrophication, organic loading and reduced dissolved oxygen, contaminant toxicity, acidification, salinization, sedimentation/burial, turbidity/shade, vegetation removal, thermal alteration, dehydration, inundation, fragmentation of habitat (Adamus and Brandt 1990), and soil disturbance. It is a basic assumption that stressors will reduce wetland condition. However, in some instances, stressors may benefit the opportunity of some water quality functions.

Value (not related to soil color): The worth or desirability assigned to something (e.g., a wetland attribute) by society (i.e., humans).

Refer to the references listed below for other terms used in this manual which are not defined above (such as regulatory and wetland delineation terms).

- Brinson, M.M. 1993. *A Hydrogeomorphic Classification for Wetlands*. Technical Report WRP-DE-4, United States Army Engineer Waterways Experiment Station, Vicksburg, MS.

- Code of Federal Regulations, Title 33, Part 328, Section (§) 328.3 Definitions.

- Environmental Laboratory. 1987. *Corps of Engineers Wetlands Delineation Manual*. Technical Report Y-87-1, United States Army Engineer Waterways Experiment Station, Vicksburg, MS.

- USACE. 2010. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Version 2.0)*. Ed. J.S. Wakeley, R.W. Lichvar, and C.V. Noble. ERDC/EL TR-10-20. Vicksburg, MS: United States Army Engineer Research and Development Center.

- USACE. 2012. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Eastern Mountains and Piedmont Region (Version 2.0).* Ed. J.S. Wakeley, R.W. Lichvar, and C.V. Noble. ERDC/EL TR-08-28. Vicksburg, MS:United States Army Engineer Research and Development Center.

- United States Department of Education (USDE)-National Resources Conservation Service (NRCS). 2018. *Field Indicators of Hydric Soils in the United States,* Version 8.2. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

2.1.2 Concepts and Assumptions

In developing MDWAM, several concepts were followed, and assumptions made for wetlands concerning their structure and function. The development of metrics, scoring and application of MDWAM results evolved with these concepts and assumptions in mind. The concepts and assumptions are described below.

First, MDWAM avoids the time intensive and expensive quantitative measurement of specific ecological functions or societal values by presenting a relatively rapid, qualitative measurement of the overall condition (i.e., integrity) of a wetland. An assessment of wetland condition infers the relative functional capacity of a wetland (Stein et al. 2009) by providing a general evaluation and integrated score of overall ecosystem health which are based on physical and biological structural attributes. MDWAM provides a rapid and repeatable assessment method by measuring wetland condition through a single score rather than investing in the difficulty of quantifying multiple functions of a wetland and the issues associated with combining multiple functions into a single score (Fennessy et al. 2007). By measuring the level of integrity where a wetland is positioned, MDWAM assesses the integration of physical, chemical, and biological processes that maintain an ecosystem over time. The USACE Regulatory Program requires an assessment methodology for most authorized activities under the Section 404 of the Clean Water Act. MDWAM meets these requirements.

MDWAM follows the concept that the condition of a wetland is determined by interactions among internal and external hydrological, biological, chemical, and physical processes. Factors that are paramount in controlling natural abiotic and biotic processes in a wetland are climate and geology. These factors also directly influence the hydrology of a wetland, which is the most important determinant of the establishment and maintenance of wetland processes (Mitsch and Gosselink 2000) because the physiochemical environment of a wetland (e.g., oxygen availability, nutrient availability, sediment input) is determined and modified by hydrology.

Consequently, MDWAM places heaviest weight in scoring to this core element of a wetland. The physiochemical environment subsequently influences the biota (e.g., vegetation, animals, and microbes) that inhabit a wetland. Wetland biota can modify the physiochemical environment and hydrology through their influence on both abiotic and biotic processes (e.g., microbes transform nutrients, plants trap sediment, and animals harvest vegetation). Modifications to the hydrology of a wetland by the physiochemical environment may impact or change the topography by altering the flow and circulation of water (e.g., through accumulation of sediment and debris).

Another assumption of MDWAM is that the condition of a wetland is influenced by the quantity and quality of water and sediment either generated within or by exchange between the site and the immediate surroundings (Collins et al. 2008). Climate, geology, and land use generally control water and sediment resources that affect a wetland. Natural disturbances are controlled by geology and climate while land use determines the human stressors impacting a wetland. The influence of geology, climate, and land use are mediated by the biological components of a wetland (primarily vegetation) by controlling the quantity and quality of water and sediment moving into and through the wetland. Buffers in the surrounding landscape, beyond wetland boundaries, tend to reduce the effects of stressors and disturbance on wetland condition (e.g., capture nutrients, dissipate flow, reduce sediment deposition).

MDWAM does not address the potential effects of climate change, but this is a serious consideration due to the potential impact to wetland processes and functions. For instance, the effects of sea level rise are becoming evident in some coastal areas. Precipitation pattern changes and increased temperatures are becoming evident in some non-tidal wetland areas. These changes effect hydroperiod, flow patterns and groundwater recharge rates as well as vegetation losses due to increase in salinity.

In a report focusing on the Mid-Atlantic Region, the USACE (2015b) recognizes the potential impacts of future climate considering the exposure and dependency of many of its projects on the natural environment. The report discusses the importance of considering science-based methods for incorporating climate change information into assessments that support water resources decisions and actions, which would include the Section 404 Regulatory Program.

The assessment of a wetland using MDWAM assumes that wetland condition varies along a gradient based on stressors, and the condition that results can be evaluated based on a set of visible field metrics (Sutula et al. 2006). MDWAM also assumes that the condition of a wetland improves with an increase in structural complexity (Collins et al. 2008). Therefore, the scoring of wetlands using MDWAM assumes that the value of a wetland is determined by the ecological services provided to society, and the diversity of ecological services (which increases as structural complexity increases) is more important than the level of any one service.

In addition, MDWAM assumes that the condition of a wetland is directly related to its overall ability to perform various functions (Fennessy et al. 2007), and thus the overall MDWAM score for a wetland can be used as an indicator or surrogate of the wetland’s level of performance of ecological processes typical for that wetland class as not all wetlands perform all functions, or to the same degree and magnitude of functions (Smith et al. 1995). Table 2 presents some of functions a wetland may perform (adapted from Smith et al. 1995) and the related ecosystem processes for each. Additionally, Table 3 lists the MDWAM metrics related to the ecosystem processes.

Table 2. Wetland Functions and the type of ecosystem processes *(adapted from USACE 2015)***.**

Wetland Function	Ecosystem Processes
Particulate Retention	Physical
Nutrient Cycling	Biological, Chemical
Element/Compound Removal	Physical, Chemical, or Biological
Organic Carbon Export/storage	Physical, Chemical, or Biological
Biotic Community Maintenance (Diversity/Abundance)	Biological
Energy Dissipation/Floodwater Storage	Physical
Groundwater Flow/Discharge Moderation	Physical
Subsurface Water Storage	Physical
Surface Water Storage	Physical

Table 3. MDWAM Metrics Related to ecosystem processes *(adapted from USACE 2015)***.**

Ecosystem Process	Metrics
Physical	Aquatic Context
	Buffer
	Water Source
	Hydroperiod
	Hydrologic Flow
	Surface Drainage Features
	Sedimentation
	Topographic Complexity
Chemical	Organic Carbon Storage
	Biogeochemical Cycling
	Soil Modification
Biological	Herbaceous Cover
	Edge Complexity
	Physical Habitat Richness
	Plant Strata
	Species Richness
	Non-native/Invasive Infestation
	Interspersion
	Vegetation Alterations
	Plant Life Forms

Wetlands which have excellent condition (i.e., reference standard or relatively undisturbed) will perform the functions typical of that wetland class at the full reference standard/unaltered levels (Fennessy et al. 2007) as its ecological integrity is intact (Pruitt and Plewa 2024). If the focus of a conditional assessment is overall wetland integrity or health, then it serves as an indicator of the integration of multiple functions in a self- sustaining ecosystem (Stein et al. 2010).

MDWAM scores serve as an indicator of multiple functions performed by a particular wetland class and should only be interpreted and compared between wetlands of the same class. While considerations for wetland classes are built into some metrics evaluations and scoring, the comparison of scores between different wetland classes will not necessarily present an accurate analysis of condition and functions. MDWAM was developed with the assumption that differences in condition will be most accurate by interpreting and comparing wetland scores within the same ecoregion. While MDWAM has considerations for metric scoring, the intent is not to normalize the scores for every ecoregion. Wetlands scoring the same in different ecoregions is not necessarily a reflection of the same condition and similarly, a wetland with a lower score in a different ecoregion does not necessarily indicate it has lower condition. Therefore, for purposes of comparison, MDWAM scores should be interpreted for wetlands of the same class and ecoregion. This includes the use of a reference standard of highest condition. It should be noted that a theoretical maximum score may not be attainable (Pruitt et al 2012).

A low conditional score for a wetland suggests it has low integrity (i.e., lower condition) but the wetland may be performing some functions in the landscape at a high level, such as carbon storage, nutrient cycling, or the dissipation of erosive forces. For example, emergent wetlands located between or downgrade from crop fields will likely have low integrity but may still provide functions related to water quality, often at a high level (i.e., higher conditional score) which is extremely important in agricultural settings. A low score by MDWAM does not mean that important functions are not being performed but rather, the level and range of function has likely been reduced from a reference condition of full ecological integrity. For example, wetlands located in landscape positions down-gradient of crop fields have the capacity to provide nutrient sinks or storage of phosphorus and function as a water quality buffer to streams and lakes (Pruitt and Rheinhardt 2023, Brinson 1990, Mitsch et al. 1977, Patrick et al. 1976). In addition, woody vegetation in forested wetlands may uptake and store nutrients on a long-term basis, thus protecting down-gradient water bodies (Mitsch et al. 1977, Lowrance et al. 1984).

Users should also be aware that the performance of one function at a high level (e.g., organic carbon storage) may reduce or eliminate the performance of another function (e.g., biogeochemical cycling) (Stein et al. 2010). For example, organic carbon storage in depression wetlands is often high, while biogeochemical cycling is generally low because of low variation of the hydroperiod. The USACE may require additional assessment using more intensive methods for wetlands with low condition but potentially provide important functions at a high level.

Because MDWAM is based on a visual evaluation of physical and biological characteristics in a wetland, the overall score of wetland condition may underestimate the potential contamination (e.g., pollution, chemical toxicity) of a wetland as chemical testing is not required. Therefore, additional analysis may be required to determine the influence on wetland health if it is suspected that a wetland has potentially been contaminated.

2.1.3 Metrics

The MDWAM contains 20 metrics for assessing observable characteristics of a wetland that are organized into five core elements. The core elements include landscape, hydrology, soils, physical structure, and biotic structure. The metrics organized by core element are listed in Table 4 below.

Table 4. MDWAM Wetland metrics by core element *(adapted from USACE 2015)*

Core Element	Metric
Landscape	Aquatic context
	Buffer
Hydrology	Water source
	Hydroperiod
	Hydrologic flow
	Surface drainage features
Soils	Organic carbon storage
	Biogeochemical cycling
	Sedimentation
	Soil modification
Physical Structure	Topographic complexity
	Edge complexity
	Physical habitat richness
Biotic Structure	Plant strata
	Species richness
	Non-native/invasive infestation
	Interspersion
	Herbaceous cover
	Vegetation alterations
	Plant life forms

The metrics were selected based on their use as scientifically based indicators of wetland condition that can be rapidly and consistently evaluated in the field or a combined analysis of supporting information in the office and field observations and data collections. The metrics are scored based on the selection of the best- fit from a set of narrative descriptions or numeric tables that cover the full range of possible measurement resulting from wetland condition. Adjustments to some metrics may be made regarding measurement or scoring in different wetland types or ecoregions. These are detailed in Section 2.2.

2.2 Procedures

2.2.1 Overview

The following sections describe the procedures for completing MDWAM for wetlands. Identifying the appropriate ecoregion and wetland class is the first step in using the MDWAM assessment procedures. A critical step in the MDWAM procedures is determining the WAA boundaries, which was discussed earlier in Section 1.4. Gathering and reviewing of background or supporting information should be completed prior to performing the assessment in the field. Another primary goal of MDWAM is the maximum use of data collected during the routine wetland delineation to reduce time and expense. It is recommended that the delineation is performed prior to or in conjunction with the assessment.

When performing the assessment in the field, the user should examine the entire WAA, where possible, and evaluate each metric by making observations and/or measurements. In many cases, the user may not have access to the entire WAA making the office determination paramount in accurately characterizing the WAA. Fortunately, technological advances provide a constant stream of new tools that can assist users in making informed decisions for offsite characterizations of several WAA metrics (e.g., aquatic context, buffer, interspersion, etc.).

The user will then complete the MDWAM wetland data sheet by selecting a narrative or numeric range with an associated score for each metric. Users should review supporting information such as aerial photography, LiDAR, etc., for those metrics that require additional office review to evaluate landscape and historic characteristics. Finally, the user should calculate the overall MDWAM score from the individual metric scores and review the data for quality control. Additional details on these procedures are provided in the sections below.

2.2.2 Ecoregion

The Baltimore District in Maryland is comprised of six EPA Level III ecoregions which differ somewhat in climate (precipitation and evaporation rates), geology/soils, vegetation, and particularly, land use (Figure 5). To address the differences in wetlands from these ecoregions, MDWAM has been developed with calibrations to some of the metric's scoring narratives/numeric ranges. Prior to performing MDWAM, it will be necessary to locate the appropriate ecoregion for the wetland being assessed. As described in Section 1.3, the ecoregions used in this assessment method were initially based on the EPAs Level III Ecoregions of Maryland (USEPA, Office of Research and Development). However, the MDWADT determined that many of these ecoregions were similar enough that consolidation into two ecoregions as illustrated in Figure 6 was appropriate. Furthermore, these combinations align with current NRCS Land Resource Regions and MLRA boundaries and the Regional Supplements to the 1987 Corps Manual, which are currently used by wetland practitioners in Maryland. Therefore, these ecoregions boundaries will be used in this assessment method.

For the most part, the appropriate ecoregion can easily be identified using this map along with the county and/or general location of the wetland to be assessed. If the wetland being assessed is located near the boundary of the two ecoregions, it will be necessary to review the site conditions (e.g., geology, soil, and vegetation characteristics) to accurately identify the appropriate ecoregion. Only one ecoregion should be selected for each WAA. Section 2.2.3 below and the photos in Appendix A and B provide examples of wetlands in different ecoregions.

2.2.3 Wetland Class

Because vegetation contributes to the function of wetlands, vegetative communities (e.g., forested, scrub/shrub, emergent) have historically been used to classify wetlands (e.g., Cowardin et al. 1979). However, because it is primarily hydrologic and geomorphic processes that influence the structure and function of wetland ecosystems, MDWAM follows the hydrogeomorphic (HGM) classification to classify wetlands (Brinson 1993) which is a well-known, scientifically based method for distinguishing wetlands that may have differences in functions. However, because of some variability of wetland classes in Maryland, MDWAM occasionally strays a bit from the original HGM classification. For instance, many wetlands due to their geomorphic setting would be classified as riverine wetlands by the HGM methodology. However, many former riverine wetlands in Maryland have become hydrologically disconnected from the channel and their adjacent floodplain (i.e., from the frequent overbank flood event), particularly in urban areas. Consequently, MDWAM often places these wetlands in other classes (e.g., slope wetlands) based more on the dominant water source.

Wetlands often exhibit great variation in class regionally, a challenge which faced the MDWADT. The team reviewed the HGM wetland classification and initially determined that five classes of non-tidal wetlands occur in Maryland. These included riverine, depression, slope, mineral flats, and lacustrine fringe classes of wetlands. However, because the lacustrine fringe class exists largely as fringe or delta wetlands associated with human impoundments, the team determined that these wetlands were a better fit as a regional subclass within the riverine class. MDWAM consists of four non-tidal wetland classes and eight regional subclasses which are discussed later in this section.

Furthermore, several of the metrics have been adjusted based on the wetland class being assessed to account for differences in the measurement and/or scoring of the indicators of wetland condition. Each WAA will include only one wetland class or subclass (Figures 8-10). In cases where the wetland class is unclear or where two classes may intergrade, the best fit from the four primary wetland classes should be selected based on the geomorphic setting, dominant water source and/or hydrodynamics. While eight subclasses are recognized, wetlands should first be placed in the appropriate wetland class. The primary objective of creating regional subclasses was to describe the variation within some wetland classes and for potential use in mitigation compensation calculations. Elements of the wetland classes used in MDWAM are presented in Table 5 (adapted from Brinson [1993] and Smith et al. [1995]) and are defined later in this section.

Table 5. ***MDWAM Wetland class and regional subclass by dominant water source, hydrodynamics, and geomorphic setting.***

HGM Class	*Regional Subclass*	*Dominant Water Source*	*Dominant Hydrodynamics / Magnitude*	*Typical Geomorphic Setting*
Riverine	Active Floodplain	Overbank flooding	Unidirectional and horizontal / high energy	Channel, floodplains, riparian corridors
	Floodplain Features	Backwater flooding from channel, groundwater	Typically unidirectional, and horizontal / moderate to high energy	Concave areas in floodplains and terraces
	Riverine Swamp Forest	Backwater and overbank flooding, groundwater	Bidirectional, horizontal / Low energy	Floodplains and riparian corridors
	Lacustrine Fringe	Tributary inflow	Bidirectional, horizontal / Low energy	Floodplain fringe and riparian corridors
Slope	Backslope	Groundwater	Unidirectional and horizontal / Low energy	Linear hillslope position
	Toe Slope	Groundwater	Unidirectional and horizontal / Low to moderate energy	Concave hillslope position, valley fringe, terraces
Depressions	None	Precipitation	Vertical, low energy	Topographic depressions
Mineral Flat	None	Precipitation	Vertical, low energy	Interfluves, broad flats, headwaters

Table 6. ***MDWAM Wetland regional subclass examples and flooding recurrence developed by MDWADT.***

Regional Subclass	Examples	Regular Overbank Flooding Potential (< 2-year intervals)
Active Floodplain	Bottomland hardwood forests; bars and benches within channel	Yes
Floodplain Features	Oxbows; secondary and abandoned channels	Yes, typically confined to the feature
Riverine Swamp Forest	Riverine swamp forest	Yes, but system is primarily driven by back flooding from tributaries and groundwater
Lacustrine Fringe	Human and beaver impoundments	Yes
Backslope	Headwater forested hillslopes; fens	No
Toe Slope	Backswamps; headwater and floodplain forests on terraces disconnected from the channel	No
Depressions	Delmarva Bays; disconnected oxbows and abandoned channels; human excavations or blockages	No
Mineral Flat	Hardwood and pine flatwoods	No

Where different wetland classes are located adjacent to one another or intergrade, these wetlands must be distinguished as separate WAAs and delineated boundaries to maintain the integrity of each wetland by class. A key for determining wetland classes and subclasses has been adapted from Smith et al. (1995) and Collins et al. (2008) and is presented in Figure 11. In general, the dominant water source and hydrodynamics should be considered when selecting the appropriate wetland class. In addition to the figures and photographs provided in this section, Appendix A presents additional examples illustrating wetland classes and subclasses.

An importing initial step in determining class and subclass of wetlands using MDWAM is accomplished by a comparison of soil mapping to wetland hydrology signatures viewed on aerial photography. Generally, this comparison will provide the user with a good preliminary determination of the classification of the WAA. This can be further supported by field documentation of the soil profile and characterization of the vegetation. Table 7 provides a list of potential hydric soil series commonly encountered by class, subclass, and ecoregion.

Figure 11. Wetland Class and Subclass key (adapted from Smith et al. 1995 and Collins et al. 2008). *Detailed descriptions for each class and subclass are provide below. Also see Tables 5-7 for characteristics for each.*

1. Wetland is <u>topographically flat, and precipitation</u> is the dominant source of water... **Mineral Soil Flat**

1. Wetland is <u>not</u> as above 2

2. Wetland is associated with a stream channel, floodplain, or riparian corridor ....**Riverine**

2a. Wetland is subject to <u>regular overbank flow</u> (1–2-year occurrence), as evidenced by field indicators of flooding and or recorded data................................. **Riverine Active Floodplain Subclass**

2b. Wetland is a <u>concave landform connected to a channel</u> and subject to regular overbank flow or back flooding with discernable inlets, outlets, or other connections to a stream . ... **Riverine Floodplain Feature Subclass**

2c. Wetland is in a floodplain with surface and or subsurface connections to a channel where groundwater from the valley fringe is the dominant input. Rarely subject to regular overbank flooding and the system is typically driven by back flooding from tributary and groundwater inputs .... **Riverine Swamp Forest Subclass**

2d. Wetland is in a floodplain or riparian corridor that is impounded (human or natural) .... **Lacustrine Fringe Subclass**

2. Wetland not as above 3

3. Wetland is a topographic depression surrounded by uplands, with or without outlets .... **Depression**

4. Wetland not as above 4

4a. Geomorphic setting is the linear position of a hillslope, and the dominant water source is groundwater .... **Backslope Wetland Subclass**

4b. Geomorphic setting is the concave position of a hillslope or a terrace, and the dominant water source is groundwater .... **Toe Slope Wetland Subclass**

RIVERINE WETLANDS

Riverine wetlands occur in floodplains, or a riparian geomorphic setting associated with a stream channel (Brinson 1993). This wetland class is heavily influenced or linked to the channel and its floodplain and may include wetlands that develop below the ordinary high-water mark of the channel. See Section 1.2 (Figures 1-4) to determine the assessment method to be used for the latter situation. The dominant water source is regular overbank flow from the channel (i.e., occurs every one to two years) but other sources include groundwater, subsurface hydraulic connections between the stream channel and the wetland, interflow, overland flow from adjacent uplands, tributary inflow, and precipitation. Many times, when overbank flow occurs, surface flows (i.e., flowthrough) may travel down the floodplain and dominate hydrodynamics, which is typically unidirectional and high in magnitude (i.e., energy). In headwater areas, riverine wetlands may intergrade with slope or depression wetlands as the channel disappears, or they may intergrade with poorly drained flats or uplands. A general diagram of a riverine wetland is presented in Figure 12.

In Maryland, the riverine class is not always straightforward due to a long history of destructive land use practices including agriculture, logging, and urbanization (Pruitt and Rheinhardt 2023). In the Piedmont (MLRA 148) and other mountainous sections of Maryland, many mid-gradient (e.g., third and fourth order) streams (Strahler 1952) are deeply incised primarily due to a host of land use practices. Consequently, many floodplains have become disconnected from the channel and overbank flooding is infrequent. Many times, where flooding is still relatively frequent (< 2-year intervals), it is of short duration and is often very destructive especially in urban settings. As a result, wetlands may no longer exist on the floodplains, have reduced hydroperiods, or occur only at the valley fringe or foot slope areas where groundwater discharge is the dominant water source and controlling influence on the remaining wetlands.

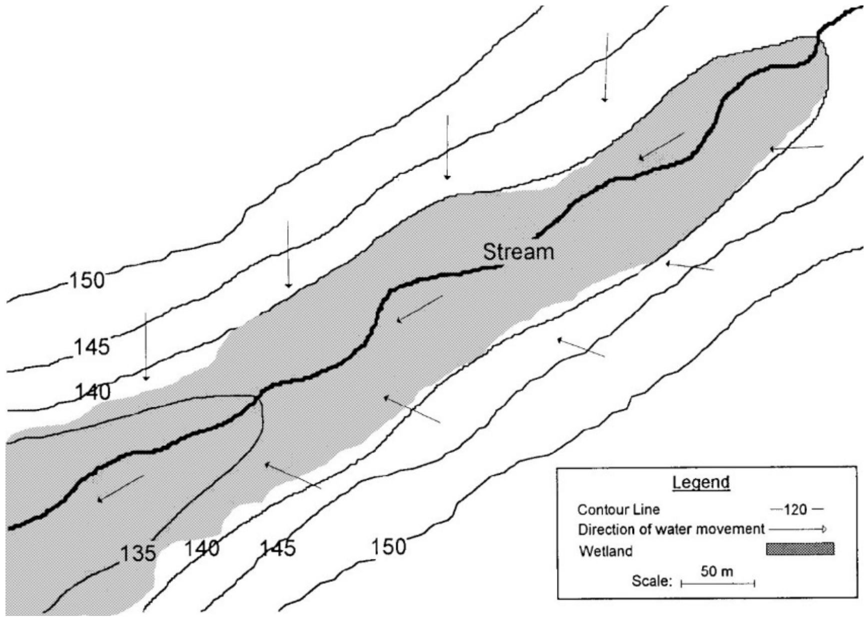

Figure 12. General diagram of the riverine wetland class (from Smith et al. 1995).

Despite the potential disconnection from the channel and /or floodplain, many wetlands in this class remain heavily influenced by adjacent stream channels. MDWAM recognizes four riverine subclasses: a) active floodplain; b) floodplain features; c) riverine swamp forest; and d) lacustrine fringe. Example aerial and ground photos of these different subclasses are presented in this section and in Appendix A.

a) *Active floodplain wetlands* – This subclass of riverine wetlands is located on nearly level floodplain areas adjacent to or within the channel and typically experiencing regular overbank flooding at 2-year intervals or less as described by Brinson (1993) and Smith et al (1995). Wetlands in this subclass may be identified as "active floodplain" by field observation of indicators of overbank flooding such as fine sediment coatings or deposits, scour, stratified layers, wrack lines, vertical zonation of plant communities, anastomose channels, and poorly developed soil profiles (entisols). Additionally, reliable recorded data may be used as confirmation of an active floodplain wetlands. Bottomland hardwood forests are an example of active floodplain riverine wetlands. Bars or benches (shelfing) located below the ordinary high-water mark of the channel that meet wetland criteria may be included in this subclass. As discussed earlier, channel incision, particularly in the Eastern Mountains and Piedmont Ecoregion has resulted in a reduction of flooding frequency and /or the lowering of water tables to the point many areas no longer meet wetland criteria or are limited to the valley fringe (Pruitt and Rheinhardt 2023). In the latter case, MDWAM often classifies many of these wetlands in the toe slope subclass.

Figure 13. LiDAR and aerial views of a Riverine Wetland (Active Floodplain Subclass) *along Severn Run in Anne Arundel County (Source: Watershed Resource Registry). Overbank flooding is exacerbated from the "pinch point" created from the highway fill. See Appendix B for additional photos.*

b) *Floodplain features* – These wetlands are distinguished from the other subclasses by their location and landform. These wetlands are concave features typically located on abandoned (disconnected) floodplains or terraces but remain connected and are heavily influenced by the channel which continues to be a dominant water source. They receive regular overbank or backwater flooding which is generally limited to within the feature itself. The hydrodynamics are typically unidirectional but sometimes bidirectional movement can occur between the stream and the feature. Floodplain features with groundwater input may be bidirectional, but the magnitude of water flow is typically not high energy as in the active floodplain wetlands.

The field indicators of overbank flooding mirror the active floodplain subclass, but regular flooding is generally confined within the feature boundaries. Furthermore, vegetation in these wetlands may be limited to the shallow or seasonally exposed boundaries, particularly if they are forested. Lastly, similar features that are, or have become completely disconnected from the channel and currently surrounded by uplands should be placed in the depression subclass. Examples of floodplain features include oxbows, secondary channels, and some human excavations.

***Figure 14. Aerial views of a Riverine Wetland (Floodplain Feature Subclass)**, the Oxbow Natural Area, along the Little Patuxent River in Anne Arundel County (Source: Watershed Resource Registry). This feature is occasionally beaver impounded representing a potential intergrade of subclasses. The red arrows indicate the direction of flow from the active channel (unidirectional) versus the yellow arrows for which flows are bidirectional. The latter is a channel which conducts flow from groundwater discharges emanating from the slopes to the south.*

c) *Riverine Swamp Forest* – These wetlands are in floodplains and found primarily in the Coastal Plain Ecoregion of Maryland adjacent to or abutting streams of 2nd order or higher (Strahler 1952). Riverine swamp forest wetlands differ from other riverine subclasses as indicators of regular overbank flooding (< 2-year intervals) are not always apparent. Nevertheless, these wetlands are heavily influenced by the adjacent channel through shallow subsurface hydraulic connections and backwater flooding. Bank full channel flow during wet periods typically results in backwater flooding of flows entering the floodplain from tributaries and or groundwater discharges which impede hydraulic head on and below the surface. As channel flows recede during the growing season in response to increased evapotranspiration, surface and shallow subsurface flows then move toward the channel. Therefore, the dominant hydrodynamics are bidirectional, horizontal, and low energy.

These floodplains are characterized by pit and mound topography where depressions exhibit multiple field indicators of inundation but often lack indicators of overbank flooding except in secondary or abandoned channels. Groundwater surface flows are common and generally exit through secondary channels or underlying coarser textured soils to the channel. These wetlands have very low variation of the hydroperiod as evidenced by thick dark mineral and / or organic soil surface horizons. This subclass is extremely important in providing functions such as long-term surface water storage, subsurface water storage, moderation of groundwater flow or storage, organic carbon storage and nutrient cycling to name a few.

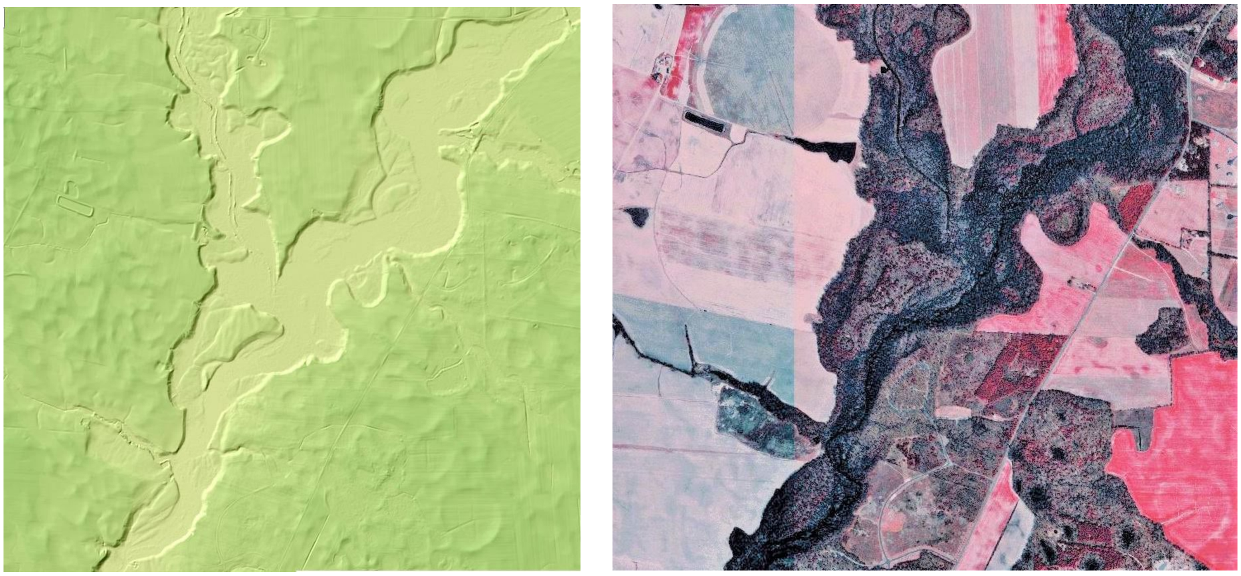

Figure 15. Aerial LiDAR views of a Riverine Wetland (Riverine Swamp Forest subclass) *abutting Tuckahoe Creek in Queen Annes and Caroline Counties (Source: Watershed Resource Registry)*

d) *Lacustrine Fringe Wetlands (human and beaver impounded)* – This subclass is comprised of human impoundments and active beaver dams (Figures 16-17). Both have water levels that are dependent upon one or more tributary inputs which determine the height, duration, and frequency of inundation. Tributary input is responsible for the bidirectional movement of water in the impoundment. During periods of high water, fringe and delta wetlands are inundated or back flooded as surface and or subsurface movement to the open water of the impoundment is impeded. This process is reversed as water levels in the impoundment decrease causing flow back to open water. It should be noted that most Maryland impoundments, especially small ponds, are usually not managed and water levels are dependent upon seasonal volume and frequency of inputs. Many small ponds, particularly in the Eastern Mountains and Piedmont ecoregion, are located "offline" (i.e., do not impound a stream) and are dependent upon groundwater inputs and thus, water levels are subject to significant seasonal fluctuation.

Lacustrine fringe wetlands primarily consist of emergent herbaceous vegetation, whereas SAV and floating vegetation are included with open water areas as non-wetlands. When performing aerial photo interpretation, investigators should employ multi-temporal aerial imagery to prevent the inclusion of these communities in the WAA. This includes free floating aquatic plants such as *Lemna minor*, *Wolffia sp*., and *Spiradela polyrhiza* which are also not included in the WAA determination. As stated above, while fringe wetlands are generally dominated by herbaceous species, delta wetlands that form in alluvial deposits where streams enter standing bodies of water may have significant woody components and often intergrade with slope and other riverine subclasses making the WAA boundary difficult to determine.

Included in this subclass are beaver impoundments as the characteristics described above generally apply. In addition to man, beavers are a keystone species (i.e., ecologically dominant) that have the potential to significantly modify ecosystems (Rosell et al. 2005). MDWAM considers beaver activity a natural occurrence (i.e., modification) as they perform a key role in ecosystem processes in a wetland. For instance, beaver foraging has a considerable impact on the course of succession, species composition and structure of vegetation communities (Huntly

1995). Furthermore, beaver ponds often significantly modify or even create additional wetlands as well as potentially having profound effects on streams, many of them positive. Beaver ponds usually function as sediment traps, and they also accumulate organic matter, especially as anaerobic conditions caused by the restrained stream velocity decrease decay rates (Pollock et al, 1995). Correll et al (2000) found that a small beaver pond in a second order Maryland stream reduced the annual discharge of water by 8%. Additionally, they reported annual reductions in the discharge of total organic carbon and suspended solids. While beaver dams in headwaters with steep topography generally create small impoundments, dams in flood plains of larger order streams can flood considerable areas increasing storage of water. Lastly, while a single dam may have a small impact, a series of dams can produce a significant impact to stream flow (Grasse, 1951), thus moderating the peaks and troughs of annual discharge patterns. Thus, depending on the number and location, beaver dams, and the wetlands they produce can decrease peak discharge and stream velocity during a run-off event, thereby reducing the erosion potential and the possibility of flooding (Bergstrom, 1985; Harthun, 2000).

However, beaver modifications can be temporary circumstances and often create difficulties in determining wetland subclass particularly if the impoundment has recently been abandoned. Once abandoned, beaver meadows will often transition quickly to species associated with a more terrestrial community such as colonization by woody vegetation. Conversely, beaver impoundments can have a long-term negative effect on the recruitment of volunteer woody species as some areas will have an increase in hydroperiod due to changes to flow and circulation of waters from sediment deposition (see additional figures in Appendix A).

For the purposes of MDWAM, only active beaver impoundments (i.e., beaver are present and actively maintaining the impoundment) will be included in the lacustrine fringe subclass based on wetland functions associated with the impoundment. Evidence of current beaver activity may include fresh lodges and dams, cut, and chewed plants, beaver tracks, slides and/or scat. Other subclasses (riverine and slope) included in this manual should be considered where the impoundment of water is no longer the case.

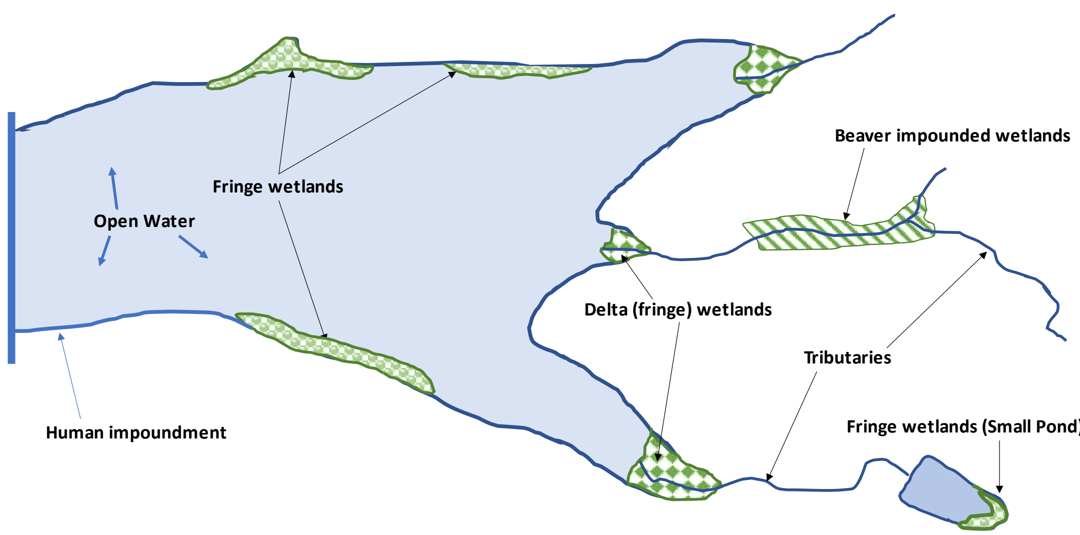

***Figure 16. Example diagram of human and beaver impounded lacustrine fringe wetlands**.* *Both have water levels that are controlled primarily by tributary input. Lacustrine wetland hydrodynamics are characterized by bi-lateral movement of waters. During the wet season, fringe and delta wetlands are flooded by the impoundment and conversely, water movement is toward the impoundment in the dry season.*

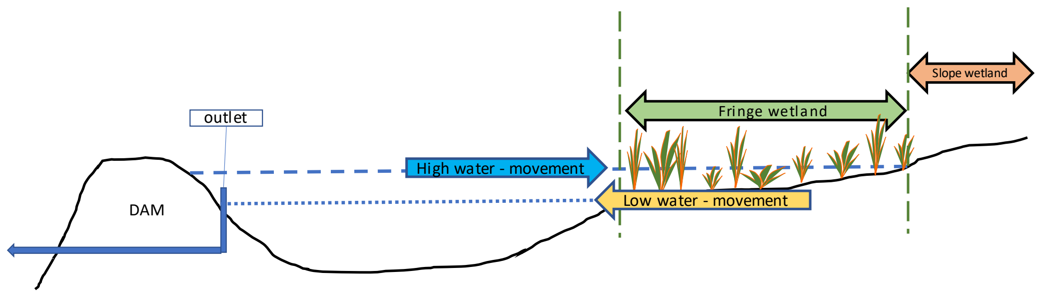

Figure 17. Cross-sectional view of a small pond illustrating seasonal bi-directional movement of waters. *Many small ponds are impounded primarily by groundwater discharge presenting the potential for significant fluctuation of water levels. Precipitation spikes can increase the frequency of bi-directional movement of water.*

DEPRESSION WETLANDS

The depression class of wetlands in Maryland are both natural and man induced. They generally occur as topographic depressions with a closed elevation contour that leads to accumulation of surface water (Figure 18). Depression wetlands may lose water through evapotranspiration, intermittent or perennial outlets, or recharge to groundwater (Brinson 1993). Dominant water source is precipitation but may receive contributions from groundwater discharge, interflow, and overland flow from adjacent uplands. The direction of water movement is normally from the surrounding uplands (i.e., higher elevations) toward the center of the depression. Depression wetlands may have any combination of inlets and outlets or lack them completely. The predominant hydrodynamics are vertical fluctuations (primarily seasonal) which are low in magnitude. Delmarva Bay wetlands (Figures 19-21) are an example of depression wetlands in the coastal plain ecoregion. Colluvial deposits in karst depressions, oxbows on upland terraces and human excavated depressions are typical wetlands of this subclass in the Eastern Mountains and Piedmont.

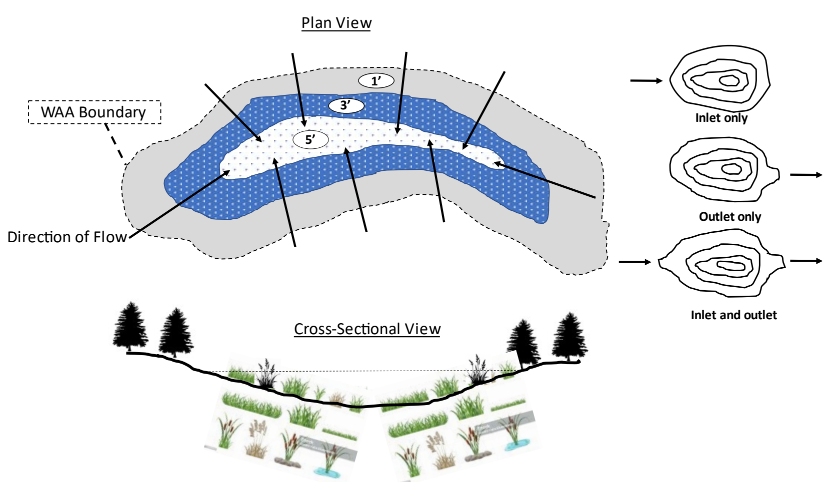

Figure 18. Example diagrams of depression wetlands (revised from Smith et al. 1995).

Figure 19. LiDAR and aerial images of depression wetlands. A Cluster of Delmarva Bay wetlands in Caroline County *(Source: Watershed Resource Registry)*

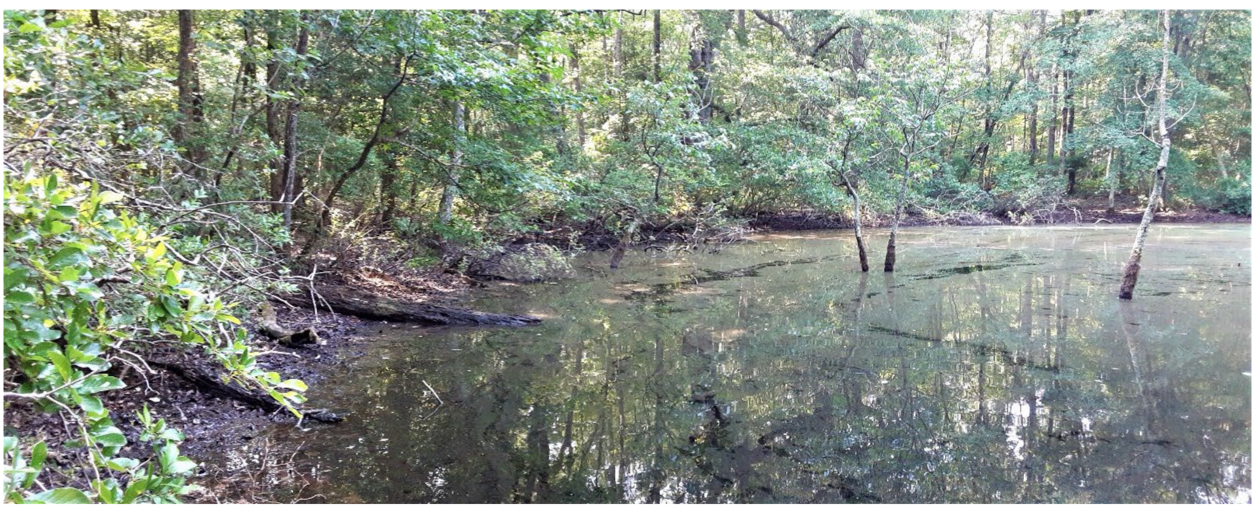

Figure 20. Stolt and Rabenhorst (1987) described two distinct classes of Delmarva Bay wetlands. *This is a ground view basin fill class of depression wetland in Caroline County. These bays are characterized by steep sides with water depths of several feet and loess deposits. This wetland is perennially inundated with high potential for carbon storage often supporting unique aquatic fauna.*

***Figure 21. Ground view of a sandy bottom Delmarva Bay in Queen Annes County**. Another class described by Stolt and Rabenhorst (1987). This class is characterized by mucky loam surfaces over deep sands. These depressions generally are flat bottomed, often less than 2 feet deep, and are seasonally to perennially saturated with surface waters disappearing shortly after leaf out due to evapotranspiration. They are also wetlands capable of significant carbon storage.*

SLOPE WETLANDS

Slope wetlands occur where groundwater outcrops and results in a discharge of water to the land surface (Figures 22-23). They normally occur on sloping land with elevation gradients ranging from steep to slight. Slope wetlands lack closed contours, so they are generally incapable of depression storage differentiating them from depression wetlands. The dominant water sources are groundwater supplemented by overland flow and interflow from surrounding uplands but may also include precipitation. Hydrodynamics are dominated by downslope unidirectional water flow, but slope wetlands can also occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. MDWAM recognizes two subclasses of slope wetlands, backslope and toe slope.

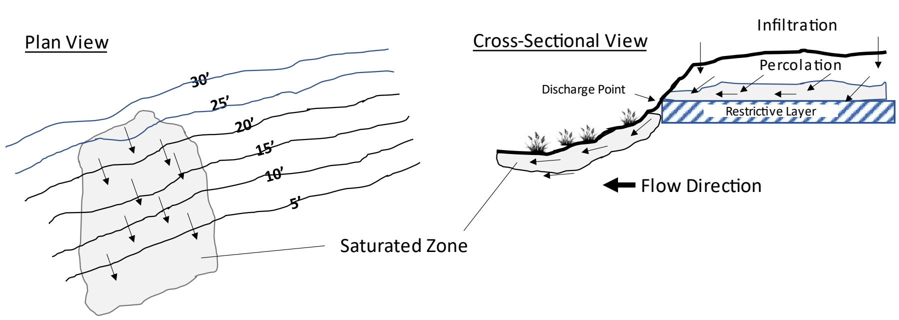

Figure 22. Example diagram of a slope wetland class (adapted from Smith et al. 1995).

a) *Backslope wetlands* usually occur in headwaters on the steeper, linear portion of a hillslope usually above the foot slope position which generally delineates the valley wall or fringe (Figure 23). Backslope wetlands often sustain perennial discharge as evidenced by the presence of dark mineral and/or organic surfaces. Backslope wetlands exhibit a strong downslope movement of water to a channel or intergrade with toe slope wetlands. Occasionally, these wetlands reenter the ground surface especially in karst geology, talus slopes and due to human-induced disturbances, for example, excessive sandy deposits along the fall line of coastal plain. Water-stained leaves, abundant micro topography, iron (Fe) deposits, oxidized rhizospheres, sphagnum, and drainage patterns (groundwater discharges) are common field indicators observed in backslope wetlands. Examples of backslope wetlands include headwater forested slopes and open or shrubby fens.

b) *Toe slope wetlands* generally occur on the concave portion of hillslopes but also on the concave portion (backswamps) or nearly level areas of terraces (riparian forests) often at the valley fringe below foot slope positions (Figure 23). As stated, toe slope wetlands are often located at the valley fringe but may also be associated with streams greater than 2nd order, often these are abandoned floodplains disconnected from the stream channel. This is generally due to historic human-induced disturbance where overbank flooding is usually no longer an important water source or influence on the wetland (Pruitt and Rheinhardt 2023). For example, in some urban areas of Maryland, stream channels have become so incised that adjacent wetlands have been reduced in size or eliminated. Channel incision severely reduces the frequency and duration of wetland hydrology resulting in a change to ecosystem processes.

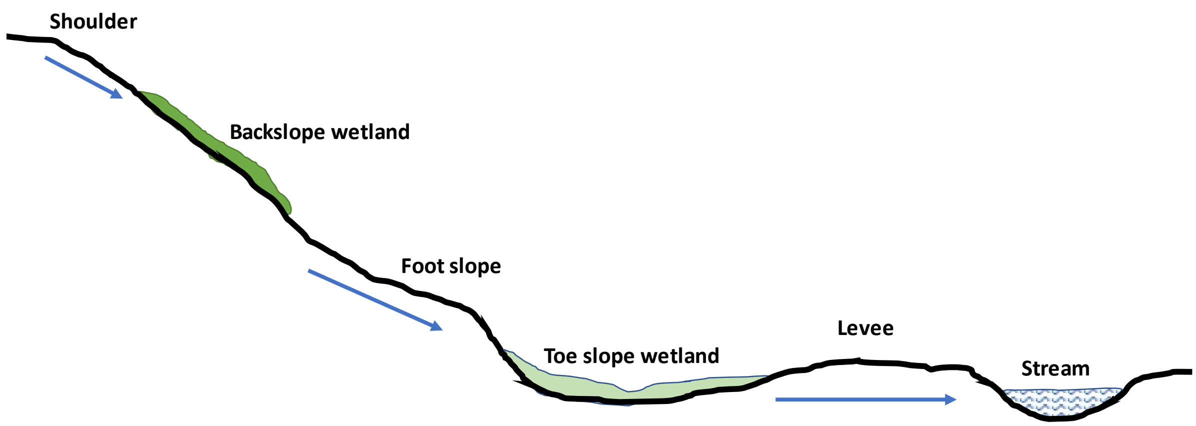

Figure 23. Cross-section view of backslope and toe slope wetland locations and general direction of water movement. See Appendix A for ground and aerial views of slope wetlands.

MINERAL FLAT WETLANDS

Mineral Flats arguably constitute the largest percentage of non tidal wetlands in Maryland. They are limited to the Coastal Plain Ecoregion and most commonly located on interfluves (interstream flats), broad flats on large floodplain terraces, and occasionally in the headwaters of coastal plain streams (Figures 24-26). Precipitation is the dominant water source to mineral flats and rarely receive groundwater inputs but may be seasonally connected to a water table. Vertical fluctuations are the dominant hydrodynamics but seasonal ephemeral discharges may occur during the wet season and as a result of extreme precipitation events. Other sources of water are groundwater, overland flow and interflow. They are distinguished from flat upland areas by their poor vertical drainage due to impermeable layers (e.g., hardpans), slow lateral drainage, and therefore, have low hydraulic gradients mainly losing water through evapotranspiration.

The hydroperiod is characterized by frequent wetting and drying making them very important for temporary water storage and nutrient cycling. The soils are primarily composed of mineral material but some shallow depressions may develop organic mantles or dark mineral surfaces, especially where high concentrations of evergreen vegetation are found. Mineral flats in Maryland occur as hardwood, pine or mixed flats. Pine flats may reflect incidents of past anthropogenic disturbance to former hardwood and mixed flats (Rheinhardt et al. 2002). Lastly, while mineral flats may have areas that are seasonally inundated, water depths are usually very shallow and of short duration. They are distinguished from depressions and slopes by their geomorphic setting, and lack of groundwater inputs.

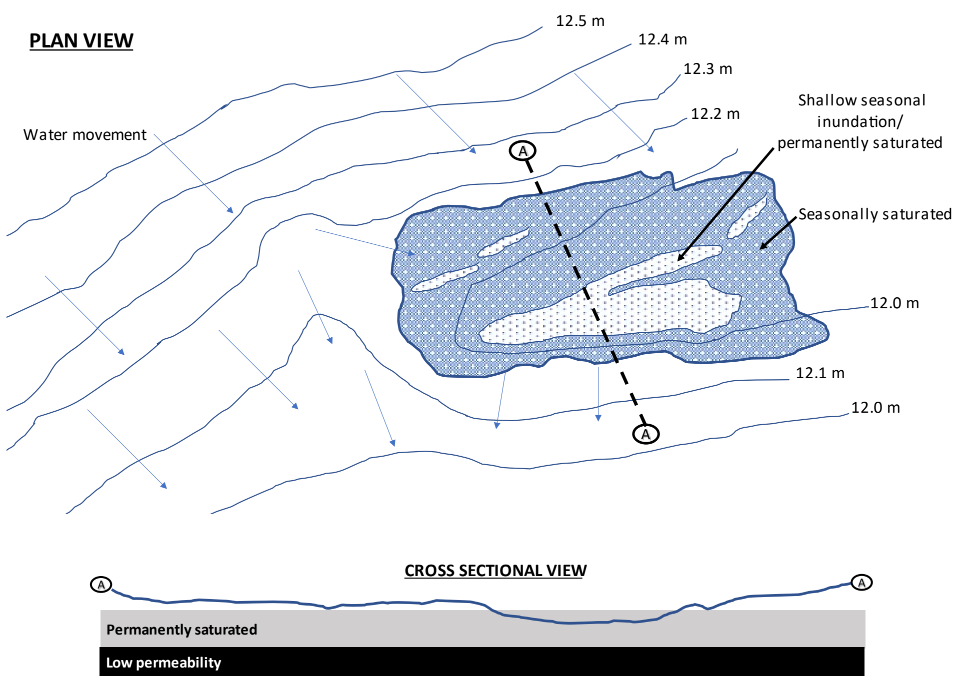

Figure 24. Mineral Flat Wetlands in plan and cross-section view (adapted from Smith et al 1995).

Figure 25. Topo and aerial view of mineral flat wetlands. *Mineral flats are potentially the most numerous non-tidal of wetlands in the Coastal Plain Ecoregion of Maryland. Mineral flats are most common on interfluves or broad flats between stream corridors but also occur at the headwaters of creeks. The broad topographic areas (left) located between stream corridors such as this area in southern Anne Arundel County often contain extensive mineral flats. This is further illustrated by the numerous dark hydrology signatures on the right highlighting flats fragmented from historic agricultural use and residential development (Source: Watershed Resource Registry). Mineral Flat Wetlands are precipitation driven, low energy, and have vertical hydrodynamics losing water primarily through evapotranspiration.*

Figure 26. Ground view of a seasonally saturated/inundated, mineral flat wetland at Franklin Point State Park, Anne Arundel County. *Note the historic logging trail commonly observed in mineral flat wetlands in the coastal plain ecoregion often appearing as seasonally inundated swales. Many mineral flats are bisected by miles of historic ditching throughout Maryland. However, most have minimal ongoing impact to wetland hydroperiods.*

Table 7. *Common hydric soil series and hydric soil indicators (Version 8.2) by ecoregion and wetland subclass.* *These series are common but not exclusive to ecoregion or subclass.*

Regional Subclass	Common Soil Series Eastern Mountains & Piedmont Ecoregion	Common Soil Series Coastal Plain Ecoregion	Common Hydric Soil Indicators (Version 8.2)
Active Floodplain	Atkins, Bowmansville, Dunning, Elkins, Fairplay, Hatboro, Melvin, Purdy	Hatboro, Potobac, Widewater, Zekiah	F3, F8, F12, F19, F21
Floodplain Features	Atkins, Bowmansville, Dunning, Elkins, Hatboro, Melvin, Purdy	Hatboro, Potobac, Widewater, Zekiah	F3, F8
Riverine Swamp Forest	Not included	Chicone, Indiantown, Lenape, Longmarsh, Manahawkin, Potobac, Puckum, Zekiah	A1, A2, A3, A9, A11, A12, F13
Lacustrine Fringe	Atkins, Bowmansville, Elkins, Hatboro, Melvin	Hatboro, Lenape, Potobac, Puckum, Widewater, Zekiah	A1, A2, A3, F3, A11, A12, F19, F21
Backslope	Andover, Baile, Brinkerton, Croton, Fairplay, Lantz, Markes **Many backslope wetlands are hydric inclusions in non-hydric major units*	Lenni, Leonardtown, Potobac, Fallsington	F2, F3, F6, F7, A11
Toe Slope			A11, A12, F3, F6, F7
Depressions	Baile, Croton, Elkins, Lantz, Melvin, Watchung	Berryland, Carmichael, Corsica, Fallsington, Hurlock, Kentuck, Lenni, Mullica, Othello, Pone, Colemantown	A7, A9, A11, A12, F3, F7, F8, F13, F21 S5, S7
Mineral Flat	Not included	Berryland, Carmichael, Othello, Fallsington, Hurlock, Lenni, Kentuck, Leonardtown, Mullica, Pone, Shadyoak, Whitemarsh, Quindocqua, Askecksy, Colemantown	A7, A9, A11, F3, F20, S5, S7

2.2.4 Wetland Assessment Area

As discussed in Section 1.4, the WAA may be determined by project type and by following guidelines for the hydrology, setting, and disturbance (stress) to the wetland. The boundaries of the WAA should be delineated after the delineation wetlands and accurately mapped for subsequent verification. The WAA must be determined and set before beginning evaluation of the metrics as described in Section 2.3. Additional information regarding calculating and inferring scores for multiple WAAs is provided in Sections 2.2.7.1 and 2.2.7.2.

2.2.5 Field Assessment

2.2.5.1 Preliminary Data Collection

It is highly recommended that preliminary data gathering and review of supporting information for the wetland to be assessed be performed prior to conducting MDWAM in the field. This generally includes current and historic aerial photography, as well as other available mapping and reports (e.g., USGS quad, LiDAR, soil survey, GIS data layers). Aerial photography is available from a variety of sources (e.g., WRR, Google Earth Pro, MERLIN, etc.), both as hard copies and electronic. Geo-rectified imagery is available from numerous sources such as the National Agriculture Imagery Program and can be used in most GIS programs. For consistency, USACE recommends that users employ the WRR for all GIS mapping used in performing MDWAM, although other sources may be acceptable. The wetland assessment should generally be based on the most recent two years of aerials and confirmation of conditions during the on-site field evaluation. However, other sources and dates of aerial photography may provide useful information. For instance, historical photography may provide valuable insight into the nature of past disturbance (land use practice) and stressors but also inform the potential level of recovery. The preliminary data is critical in determining the WAA, the landscape context, and the likely wetland characteristics to be encountered. Collecting the preliminary data for the assessment will be like preparing for a wetland delineation. It is recommended to have a copy of the most recent aerial photo for the site during the field assessment. Lastly, investigators should revisit supporting information upon completion of field work to update preliminary mapping and conclusions.

2.2.5.2 Utilizing Delineation Data

MDWAM has been developed to maximize the use of data collected from routine wetland delineations. Several metric scores are dependent upon the data recorded on the wetland determination data forms (see examples in Appendix D). As assessments may be performed separately after the completion of a wetland delineation, the wetland determination data form(s) must be available to accurately complete the assessment. The data should be verified for consistency with the current site characteristics as seasonal changes can have a significant impact on scoring some metrics.

If the wetland assessment is being performed concurrently with the wetland delineation, the wetland determination data form should be completed first, and then the MDWAM wetland data sheet should be completed using the appropriate data from the wetland determination data form. Even though delineation data may be utilized, it should be noted that additional data (as described below) may need to be collected for the vegetation community during the MDWAM field assessment based on the characteristics (e.g., diversity) of the WAA. In addition, many of the MDWAM metrics will require evaluation during the field assessment that is not related to data collected during a delineation.

Version 2.0 of both Regional Supplements used to delineate wetlands in Maryland include the rapid test indictor for hydrophytic vegetation (USACE 2012). If the indicator is met, the Regional Supplements do not require quantification of the vegetation. However, quantitative data must still be collected which is based on the percentage of absolute cover for each vegetation species as described in the regional supplements to accurately complete the species richness and non-native/invasive infestation metrics of MDWAM. For wetland delineations performed prior to the application of MDWAM, where quantitative data on vegetation was not recorded, then the data must be collected during the wetland assessment.

An adequate number of vegetation sample plots (each with a wetland determination data form) should be performed to accurately characterize the representative diversity and variability in the WAA. As required by the 1987 Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987) and pertinent regional supplement, a wetland determination data form should be completed for each vegetation community (e.g., forested, scrub/shrub, or emergent).

Additional sampling and wetland determination data forms may also be warranted for a single vegetation community that is heterogeneous, diverse, or large. Consequently, at least one sample plot with wetland determination data form should be performed for <u>each</u> vegetation community in the WAA, and two or more sample plots with wetland determination data forms should be performed for each vegetation community in the WAA that is heterogeneous, diverse, or greater than five acres in size. Thus, a WAA may have more than one wetland determination data form to provide data. In this case, the strata, and species from all wetland determination data forms in a WAA area should be used; however, a strata or species should not be counted more than once if it is present on multiple data forms.

The geographic scope of MDWAM (i.e., the Baltimore District in Maryland) is covered by the Eastern Mountains and Piedmont, and Atlantic and Gulf Coastal Plain Regional Supplements to the 1987 Corps wetland delineation manual. These two regional supplements have slight variations regarding some of their methods, strata definitions, and data forms. As a result, MDWAM has been developed so that these supplements (and their corresponding data forms) can be used with the assessment. Determine which regional supplement is appropriate for a site (based on the site characteristics and guidance in the supplements) and apply it for the wetland delineation and MDWAM evaluation. Additional details on how to use these regional supplements is provided in the discussion for each metric to which it is applicable in Section 2.3.

2.2.5.3 General Instructions

After reviewing supporting information and collecting or verifying information on the wetland determination data form(s), the next step in the field assessment for MDWAM is to examine the WAA. If the WAA has not been set during the current field visit, the WAA boundary should be verified for consistency with the guidance in Section 1.4. Specifically, the WAA should only contain one wetland class or subclass and should remain consistent regarding hydrologic processes and disturbance/stressor levels. Next, evaluate all MDWAM metrics (as appropriate) in the WAA using the information on measuring and scoring the metrics in Section 2.3. Score the best fit for each metric by observations and/or measurements and by applying the alternate graphic, numeric, or narrative descriptions. Observations (including presence of unique or limited habitats), measurements, scores, and any necessary notes about modifications or concerns due to abnormal circumstances should be recorded on the MDWAM wetland data sheet (see Appendix D). The completion of the data sheet and calculation of the final score will be performed following the additional analysis during the office review. For projects or wetlands with multiple WAAs (as described in Section 1.4), these procedures for the field assessment should be repeated at each WAA.

When performing the field assessment for MDWAM, the time of year and seasonal variations should be considered in the evaluation to keep scoring consistent. Some metrics (e.g., water source, hydroperiod, hydrologic flow) will be easier to evaluate in the wetter periods of the growing season (i.e., early, and late season). Seasonal variation and recent (i.e., previous one to two years) climatic conditions are important considerations for both wetland delineation and MDWAM. Evaluations in the winter, summer, or in times of prolonged drought must be considered and compared to the average for that area. Users should document sources of climatic data to justify their conclusions. It is recommended that MDWAM be performed during the growing season to ensure consistency. However, if performed at another time, or if climatic conditions are abnormal, the evaluation of some metrics (e.g., plant strata, species richness, non-native/invasive infestation, herbaceous cover) may need to be delayed or derived from other sources (e.g., aerial photos, reference sites, etc.). When these circumstances are encountered, they should be described on the MDWAM wetland data form and reported on the MDWAM wetland final scoring form. For consistency, seasonal variations and abnormal climatic conditions may also require additional justification and data documentation for the evaluation and scoring of affected metrics. Again, the user should provide documentation regarding sources and subsequent conclusions they generate.

2.2.6 Office Review

Following the field assessment using MDWAM, a follow up office analysis should be conducted to review several of the metrics. A subsequent review using aerial photography of the WAA boundary (as verified in the field assessment) should be performed for confirmation. Some metrics can be scored or evaluated based on a review of the most recent, high-quality aerial photos (e.g., aquatic context, buffer, edge complexity). It is recommended that available historic aerial photography should be reviewed to evaluate historic characteristics for metrics such as soil modification and vegetation alterations. Additional information on the measurements and observations to make in the office review for each metric is included in Section 2.3. In general, the landscape and buffer surrounding the WAA are important to review in the office to determine their potential relationships to other aquatic resources, adjacent land-use, and other outside influences on wetland condition (e.g., potential stressors). The metrics with some consideration in the office review include aquatic context, buffer, water source, hydroperiod, sedimentation, soil modification, edge complexity, interspersion, and vegetation alterations.

2.2.7 Calculating and Reviewing Scores

2.2.7.1 Calculating MDWAM *Scores*

The procedure for calculating the overall MDWAM score for a WAA has been developed to be as transparent and streamlined as possible. The overall MDWAM score is completed by summing the core element scores and rounding to the nearest whole number, with a maximum of 100. The score for each core element can be calculated by adding the metric scores for that core element and dividing by the total maximum possible score for those metrics, then multiplying by a specified number (core element weight, see Table 8) and rounding to the nearest tenth (i.e., one decimal place). The number used to multiply the metric percentage scores varies by core element. That is, each core element makes up a certain percentage (weight) of the overall score. Core element percentages are weighted as follows: 15% for landscape; 30% for hydrology; 15% for soils; 20% for physical structure; and 20% for biotic structure. Thus, the core element scores equal the metric score as a percentage multiplied by the respective whole number for that core element. This method of calculation is based on the concepts discussed in Section 2.1.2 so that core element weighting is relative to the influence of hydrology and structure on wetlands condition. The individual core element scores are also important for understanding the basic wetland characteristics that are influencing the overall score, especially when comparing wetlands with similar overall scores. However, the individual metric scores are not intended to be sufficiently robust to score condition, since MDWAM is a class of multi-metric index where each metric contributes information to the scoring of ecological condition. See Appendix C: Wetland Data Sheets and Final Scoring Sheets and Appendix D: Example Wetland Assessments and Completed Forms.

Table 8. Wetland core element scoring calculation.

Core Elements	Metrics	Core Element Score Calculation
Landscape	Aquatic context	Sum of metric scores / 8 x 15
	Buffer	
Hydrology	Water source	Sum of metric scores / 16 x 30
	Hydroperiod	
	Hydrologic flow	
	Surface drainage features	
Soils	Organic carbon storage	Sum of metric scores / 23 x 15
	Biogeochemical cycling	
	Sedimentation	
	Soil modification	
Physical Structure	Topographic complexity	Sum of metric scores / 12 x 20
	Edge complexity	
	Physical habitat richness	
Biotic Structure	Plant strata	Sum of metric scores / 28 x 20
	Species richness	
	Non-native/invasive infestation	
	Interspersion	
	Herbaceous cover	
	Vegetation alterations	
	Plant life forms	

A MDWAM wetland final scoring sheet for reporting the individual metric scores and calculating the overall MDWAM score is included in Appendix C. Once the core element scores have been summed, additional points to the overall score may be added for unique or limited resources. Additional points up to 10% for unique resources and up to 5% for limited habitats, may be added to the overall score. These additional points have been included to account for the ecological complexity of certain systems that may be difficult to quantify in a rapid assessment method such as MDWAM.

Unique resources include individual wetlands that fall into one or more of the following:

1. Non-tidal wetlands of Special State Concern as designated by Maryland Department of the Environment

2. Areas with populations (>20%) of the following species: bald cypress (Taxodium distichum), Atlantic White Cedar (Chamaecyparis thyoides), Red Spruce (Picea rubens), Balsam Fir (Abies balsamea), or American Larch (Larix laricina)

3. Delmarva Bay wetlands

4. Vernal Pools that are wetlands

5. Peatlands (histosol, histic epipedon or black histic hydic soil indicators present)

Limited habitats include individual wetlands that one or more of the following designations:

1. Areas dominated (i.e., greater than 50%) by native trees greater than 24-inch diameter at breast height.

2. Areas dominated (i.e., greater than 50%) by hard mast (i.e., acorns and nuts) producing native species (e.g., oaks, hickories, walnuts) in the tree strata.

3. Large unfragmented wetland tracts and continuous riparian wetland corridors greater than 20 acres in size.

Additional points for unique resources and limited habitats are added to the overall score after summing the core element scores on the final scoring sheet. Rationale (e.g., photographs, data forms, measurements, maps, etc.) is required to support the additional points for unique resources and limited habitats. Only one addition for a unique resource and one addition for a limited habitat are permitted. Based on the potential maximum score for the combined core elements and maximum additional points, a theoretical overall MDWAM score greater than 100 is possible. The USACE will determine the need for the reduction or addition of points for other situations on a case-by-case basis such as additional points for a WAA that serves as endangered or threatened species habitat. Many of these resources may be covered under the Maryland Nontidal Wetlands of Special State Concern designation.

Similar MDWAM scores for wetlands of the same class and in the same ecoregion are expected to represent wetlands with similar overall condition and potentially similar functional capacity; however, different wetlands (e.g., a slope wetland versus riverine wetland) with the same MDWAM score may have different functions or levels of functions due to differences in wetland class, structure, climatic regime, or other factors. In addition, wetlands with similar overall scores may have different core element scores that indicate differences in basic wetland characteristics and possibly functional capacity.

Example wetland assessment areas are included in Appendix D. These examples include maps, descriptions, wetland determination data forms, data sheets, and scoring sheets.

2.2.7.2 Inferring Scores

In some instances, it may be preferred to infer the MDWAM score for a set of wetlands of the same class and with very similar characteristics (i.e., similar scores for all core elements). For example, on a project that covers a large area with many wetlands (e.g., linear projects), the user could perform MDWAM on a representative wetland or subset of wetlands within the project area. The MDWAM score for the representative wetland or subset of wetlands can then be used to infer the scores for similar wetlands of the same class in the project area. This approach may be useful for projects where property access has not been obtained for some portions of a site and is comparable to a Level 3 delineation (Environmental Laboratory, 1987) which may be performed through a combination of aerial photo interpretation and field verification (on-site inspection). It is recommended that this method of representative sampling and inferring scores be confirmed with the USACE prior to commencing the assessment if it is associated with an anticipated permitting action with permanent impacts.

When inferring the MDWAM score for a set of wetlands, the similarity of the wetlands (i.e., characteristics and condition) as well as the wetland class should be confirmed through on-site (i.e., field) reconnaissance (if possible) in addition to office review of aerial photography. During the on-site reconnaissance, photographic documentation of the similarity of the wetlands to which scores are inferred is <u>required</u>. If on-site reconnaissance is not possible due to property access, the inferred score should be verified later when access is obtained. Although the inference of scores should consider the similarity of vegetation in the wetlands (e.g., vegetation community, species richness), other indicators such as the likeness of the hydrology and level of stressors should be considered as well. When deciding on a set of wetlands with similar characteristics, particular attention should be given to the comparability of all the MDWAM metrics in the landscape, hydrology, soils, physical structure, and biotic structure core elements. A separate assessment should be performed if even a single core element or metric score appears to be different for a particular wetland as compared to the rest of the set or it may be included with the inferred score for a different set of wetlands. If a wetland delineation has been performed, and wetland determination data forms are available for each wetland, these can also be compared to help determine wetland similarity and which wetlands should be grouped into sets.

The representative wetland or subset of wetlands should be selected for evaluation using MDWAM based on the similarity of conditions and characteristics of the wetlands in the set to which the representative score will be inferred (i.e., similarity of metric and core element scores). A subset of representative wetlands is preferred over a single representative wetland to account for minor variation in wetland characteristics within a set of similar wetlands. MDWAM should be performed on the representative wetland or subset of wetlands using the procedures and methods in this manual. Any wetland on the site considered representative or unique by class or condition should have a separate assessment performed with a corresponding MDWAM wetland data sheet.

If a subset of wetlands is used for determining a representative MDWAM score, the score inferred for the other wetlands in the set should be the average of the scores for the representative subset of wetlands. However, if a wetland within the representative subset differs from any of the others by more than two (2) points for any core element score or by more than five (5) points for the overall score, then that wetland should be removed from the subset and scored separately (i.e., have a unique MDWAM score and wetland data sheet). The average MDWAM score of the representative subset without this unique wetland should then be used to infer the score for the rest of the set. If the representative subset assessed only two wetlands and the scores of these wetlands differed by more than two (2) points for any core element score or by more than five (5) points for the overall score, additional wetlands in the set should be evaluated using MDWAM to determine which score should be used to determine the average representative score inferred for the rest of the set. If a representative subset has a variety of scores and more than one score differs from another by more than two (2) points for any core element score or by more than five (5) points for the overall score, the set may need to be divided into separate groups for receiving different inferred scores based on one or more characteristics (i.e., core elements).

2.2.7.3 Quality Control Review

Quality control procedures should be used when performing MDWAM to ensure that data collection and evaluation are consistent with the guidelines and procedures outlined in this manual. MDWAM was developed to be consistent and repeatable between users, so an independent or peer review of the scores resulting from MDWAM is both feasible and desirable.

First, a reviewer should check that the correct boundary for a WAA has been set according to the guidelines found in Section 1.4. A reviewer should also check that the appropriate wetland class and ecoregion have been used in the assessment and that any appropriate metric and scoring adjustments have been made for these factors. For wetlands with multiple vegetation communities or a single heterogeneous, diverse, or large community, a reviewer should check that an adequate number of vegetation sample plots (each with a wetland determination data form) have been performed to accurately characterize the representative diversity and variability in the WAA. In each WAA, a reviewer should examine the map, site photos (if available), wetland determination data form(s), and MDWAM wetland data sheet to analyze the appropriateness and accuracy of each metric score. In addition, a reviewer should check that the overall MDWAM score has been correctly calculated on the final scoring sheet. If MDWAM scores have been inferred for a set of wetlands, a reviewer should examine the available information (e.g., aerial photos, site photos, wetland determination data forms) to determine if scores have been inferred correctly.

The USACE may deem it necessary (e.g., for large and/or complex projects) to re-visit and re-assess a WAA to compare the MDWAM score with the score of the original assessment of the same WAA. As a rule, the re-assessed score should not differ from the original score by more than two (2) points for any core element score and more than five (5) points for the overall score. In cases where a MDWAM score has been inferred for a wetland, the USACE may require that MDWAM be performed in the field for that wetland to confirm the accuracy of the inferred score, especially when permanent impacts are anticipated.

2.3 Metric Evaluation Methods and Scoring Guidelines

Description of the methods for evaluating each metric and the guidelines for scoring using narrative descriptions, numeric ranges, or graphics of alternate conditions are outlined in the following sections. Wetland classes and/or ecoregions may include descriptions of special considerations and adjustments that may be required concerning certain metrics. Metrics are grouped by the core elements of landscape, hydrology, soils, physical structure, and biotic structure. See Appendix B for example photos of the following metrics.

2.3.1 Landscape Core Element

2.3.1.1 Aquatic Context

2.3.1.1.1 Description:

The aquatic context metric is a measure of the spatial relationship of the WAA to other aquatic resources (e.g., other wetlands, streams, ponds, lakes). MDWAM uses this metric to evaluate the proximity and abundance of aquatic resources to which the WAA may be connected (e.g., through hydrology or movement of wildlife). Aquatic resources which are separated from the WAA by physical, hydrologic, or ecologic barriers are not considered in this evaluation. Wetlands that are inter-connected by the flow of water and/or the movements of wildlife generally have higher function of ecosystem processes (Collins et al. 2008). In addition, a wetland's proximity to other wetlands and the wetland density (number) in the surrounding area are positively correlated with wetland condition (Fennessy et al. 1998). Note that this metric measures the influence of wetland condition from an ecological perspective and is not related to regulatory jurisdiction, since the proximity to other aquatic resources influences the sustainability of aquatic organism communities as well as the potential for restoration and conservation activities.

2.3.1.1.2 Aquatic Context Metric Method of Evaluation

The aquatic context metric is evaluated based on a review of aerial photography during the office review portion of the assessment. However, field observations of aquatic resources in the landscape surrounding the WAA are also important to consider when evaluating this metric. When the area of evaluation extends beyond the project and/or delineated area (i.e., for linear and small projects), then the evaluation may rely more heavily on aerial photo interpretation and other supporting information (e.g., USGS topographic maps or soil surveys) to identify aquatic resources if off-site access is not practicable.

On a recent aerial photo, the user should draw a 1000-foot polygon extending outward from the WAA boundary as illustrated in (Figures 27-28), then identify and count all aquatic resources (e.g., other wetlands, streams, ponds, lakes) that are located at least partially within the polygon. Aquatic resources that are separated from the WAA by potential physical, hydrologic, or ecologic barriers are excluded from the count. Connection of the wetland to another resource is defined as the flow of water and/or the movement of wildlife. MDWAM considers 1,000 feet a reasonable distance to allow even small terrestrial wildlife (e.g., mammals, birds, amphibians, or reptiles) to move regularly between a wetland and other aquatic resources in the absence of barriers. Physical alterations in a landscape that prevent the movement of wildlife or hydrologic connections between the WAA and other aquatic resources will be determined to be a break in connection. For constructed aquatic features within the 1000-foot threshold, investigators should consider the timing, purpose, and management of the potential resource (e.g., stormwater and other basins, excavation, and or filling activities, etc.). For example, basins and ditches that are regularly mowed or graded should not be considered aquatic resources. In contrast, many basins and historic ditches are not managed often presenting favorable conditions for wildlife use which should be counted.

Potential barriers may include, but are not limited to habitat modifications, construction/development, or physical obstructions (e.g., walls). Barriers to connection may be ecologic or hydrologic but are not considered a barrier if wildlife could still manage to cross an area without imminent danger (e.g., frequently traveled road). Generally, most hard surfaced roads will be considered barriers, but circumstances may dictate differently (e.g., driveways, light duty rural roads). Dirt and gravel roads on public lands, single rail lines, levees, and diversions are generally not considered barriers to name a few.

Any aquatic resource at least 1000 square feet (0.02 acres) in size that is located completely or partially within the 1000-foot polygon which connects to the WAA should be counted. However, in the case of wetland and non-wetland mosaics that function as a single resource, these should be counted only once. These are habitat patches that are usually delineated within a single wetland boundary as described in the Regional Supplements to the 1987 Corps of Engineers Wetland Delineation Manual (Chapter 5 for Wetland Mosaics). The number of aquatic resources is used to score this metric based on the narrative descriptions below.

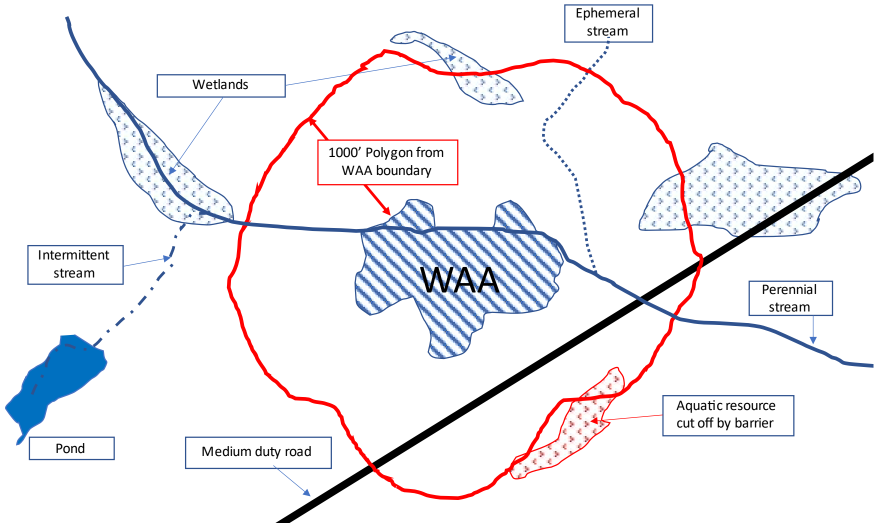

Figure 27. Example of measuring aquatic context for a riverine wetland. *This 1000' polygon contains all or a portion of four aquatic resources (two wetlands and two streams) which potentially connect to the WAA. The road is a barrier which disconnects the red wetland polygon and is not included. In this case, the aquatic context score is two for both ecoregions.*

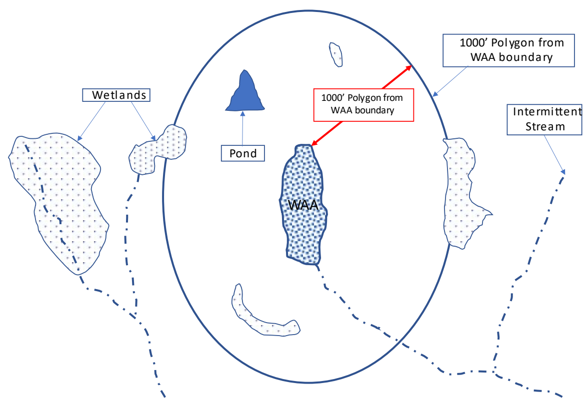

Figure 28. Example of measuring the aquatic context is measured as follows for a slope wetland. *The polygon 1,000 feet from the WAA boundary contains a portion of six aquatic resources (4 wetlands, 1 pond and 1stream) within the 1000' barrier to which the WAA connects. The aquatic context metric score is three for both ecoregions.*

2.3.1.1.3 Wetland Class and Ecoregion Considerations

For a WAA such as a lacustrine fringe wetland, where the 1,000-foot polygon around the WAA encompasses an abutting open water body that is equal to or greater than 30% of the polygon area, the number of aquatic resources should be increased by one as in Figure 29A. For riverine wetlands that occur within an active floodplain (i.e., floods after storm events with a 1-2 return interval) based on empirical evidence (e.g., drift deposits, flood gauges), the number of aquatic resources should be increased by one (Figure 29B).

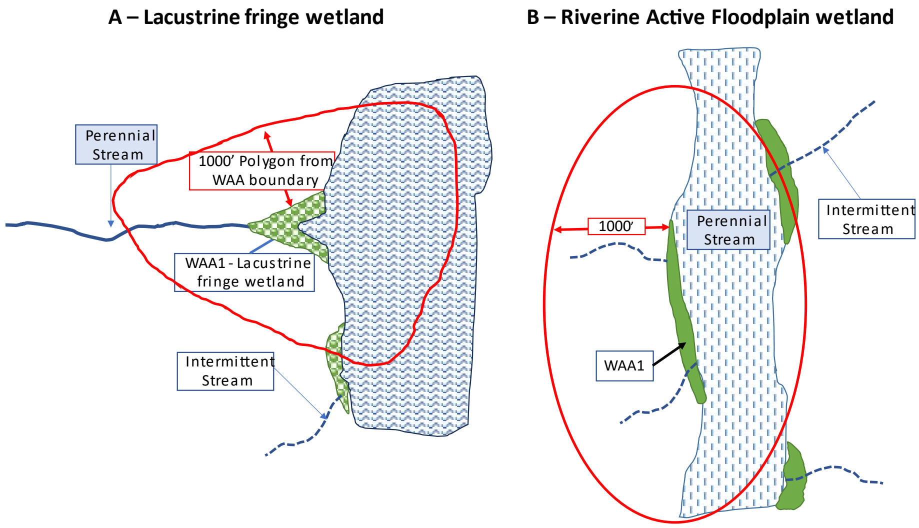

Figure 29. Examples of measuring aquatic context where additional points are added. *Example A provides an illustration of a lacustrine fringe wetland with three aquatic resources (1 wetland, 1 stream, and 1 open waterbody) located within the 1000’ aquatic context polygon. However, because the open water comprises >30% of the 1000’ aquatic context polygon, the wetland receives an additional point for aquatic context. In example B, the WAA is a riverine wetland that would have five aquatic resources (1 wetland and four streams) in the 1000’ polygon. If the WAA is an active floodplain subclass, an additional aquatic resource will be added to the total.*

In addition, for a WAA that is surrounded by and connected to one or a few large wetlands, the scoring for this metric should consider the percentage of the 1,000-foot polygon that is wetland. For each 10% of aquatic resource within the 1,000-foot polygon, the number counted for use in the scoring narratives should be one. In the example presented in Figure 30, the WAA for a depression wetland is surrounded by a single large wetland comprising 50% of the 1,000-foot polygon. The WAA would count 8 total aquatic resources (5 for the large wetland, 2 small wetlands and 1 pond) and score a “4” for this metric.

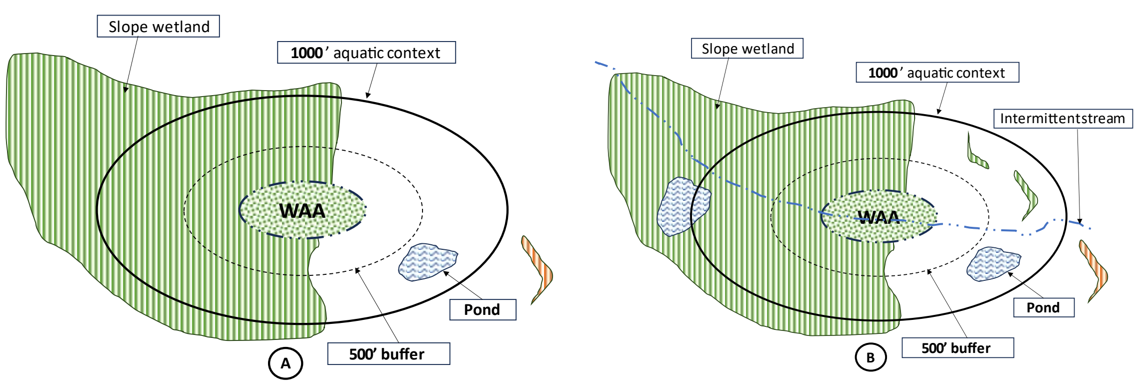

Figure 30. Examples of measuring aquatic context where 50% of the WAA consists of a single large wetland. *Example A has <u>six</u> aquatic resources (5 for the large wetland and a pond) and scores 3 for both ecoregions. Example B has <u>ten</u> aquatic resources (5 for the large wetland, 2 small wetlands, 1 stream and 2 small ponds) and scores 4 for both ecoregions. The orange polygon is located outside the 1000’ polygon in both examples and is not counted in the totals.*

The scoring narratives below (Table 9) have been adjusted to compensate for the landform and climatic difference between ecoregions. Because wetlands in the Coastal Plain Ecoregion are located on typically broader, flatter landscapes and they are generally larger in acreage (mineral flats and riverine) or occur in large clusters (e.g., Delmarva Bay depressions). Thus, a slightly higher threshold is required for the Coastal Plain Ecoregion.

2.3.1.1.4 Scoring Narratives - Use Table 9 to score this metric.

Table 9. Aquatic context scoring by ecoregion.

	Coastal Plain Ecoregion	Eastern Mountains and Piedmont Ecoregion
Score	*Number of Aquatic Resources*	*Number of Aquatic Resources*
4	8 or more	7 or more
3	6-7	5-6
2	3-5	3-4
1	1-2	1-2
0	0	0

2.3.1.2 Buffer

2.3.1.2.1 Description:

The buffer metric measures the acreage and composition of the area adjacent to the WAA related to its ability to reduce or eliminate the effects of stressors and disturbance on the wetland. This metric evaluates the percentage of different buffer types within a set distance of the WAA boundary as well as the characteristics of each type.

The effect of stressors and disturbance on a wetlands condition can greatly be reduced depending on the amount and quality of the surrounding vegetation. For an area to qualify as a buffer, human or domestic animals must not inhibit the area’s ability to serve as a buffer. Metric scoring is based on the characteristics and percentage of each buffer type. This metric uses percentage of a buffer types within a set distance of the WAA to reduce the complication associated with calculating average widths of various buffer types.

Disturbances and stresses located in adjacent uplands can have a profound impact on the biological, chemical, and physical processes in a wetland (Castelle et al. 1994). Wetland functions have been shown to be impaired from adjacent land use and not just the physical modification of the wetland (Burbridge 1994, Detenbach et al.1996). Plant species richness and sedimentation have been shown to be influenced by buffers surrounding wetlands (Houlahan et al. 2006). Wetland buffers reduce adverse impacts to wetland functions from adjacent development by moderating stormwater runoff, stabilizing soil to prevent erosion, providing habitat for wetland-associated species, reducing direct human impact/access to a wetland, and by filtering suspended solids, nutrients, and toxic substances (Castelle et al. 1992, Semlitsch and Jensen 2001). Semlitsch and Jensen (2001) reported that surrounding breeding sites are critical for feeding, growth, maturation, and maintenance of salamander populations. In addition, Babbitt (2005) emphasized the importance of wetland size and hydroperiod for amphibians.

Estimates of buffer widths necessary to offset stressors and protect wetland condition varies considerably in the literature depending on what wetland processes require protection, the intensity of adjacent land use, buffer characteristics, and specific buffer functions required

(Castelle et al. 1994). Depending upon site characteristics, buffers as narrow as 10 feet can be effective in some cases, but in most cases, many agree that a buffer of at least 45–100 feet may be necessary to protect wetlands (Castelle et al. 1994). Houlahan et al. (2006) found that adjacent land use within 825 feet can have a negative effect on wetland plant communities, particularly species richness. Furthermore, they determined that adjacent forested communities may be instrumental in deterring the spread of invasive species. Therefore, in consideration of different site characteristics and for protection of multiple ecosystem processes, the buffer metric should be assessed at 500 feet from the WAA boundary. This distance is not based on regulatory jurisdiction but rather, potential influence on wetland condition from an ecological perspective.

2.3.1.2.2 Method of Evaluation

An accurate determination of the buffer metric requires both field evaluation of the types of buffers and their individual characteristics which are combined with an office review of pertinent supporting information (e.g., aerial photography, LiDAR, thematic maps, etc.) to confirm the percentage of each buffer type within a set distance beyond the WAA boundary. Using the "buffer" tool options available in many GIS will aid in the measurement of this metric to determine the area within the set distance from the WAA. MDWAM directs users to the Maryland WRR for all mapping, especially for landscape core element metrics such as the buffer. However, other publicly available aerial photography may be used to augment those resources contained in the Maryland WRR.

As in preparing for a wetland delineation, MDWAM users are encouraged to review pertinent supporting information prior to the field investigation. This is especially true when investigating large tracts or extensive linear projects. Subsequently, each different buffer type should be recorded and scored during a field investigation using the scoring narratives described below. When scoring buffer types, note impacts or circumstances that could affect the overall condition of the buffer and ultimately the wetland. The scoring narratives present the most probable buffer conditions. However, some impacts or circumstances may warrant selecting the best fit from the scoring narratives based on the buffer's ability to reduce the effects of stressors and disturbance on the wetland. As in this case, deviation from any MDWAM protocol should be provided with supporting documentation (i.e., comments and photographs) that rationalize the scoring of the buffer type in this case.

Using recent aerial photography during the office review, draw a polygon 500 feet outward from the WAA boundary (Figures 31-33) and identify all buffer types, percentage of each, and the percentage those not qualifying as a buffer (see scoring narratives below which describes those non-buffers which score a zero for quality). Users are directed to use the mapping capabilities in the WRR. The WRR provides numerous tools to inform all mapping efforts including the ability to present 500- and 1000-foot polygons used in both landscape metrics. Multiply the percentage of each buffer type by the score for that buffer type, and then sum the resulting subtotals to get the score for the buffer metric (see examples in Tables 10-12). The final metric score is rounded to the first decimal point.

When determining the percentage of each buffer type, the evaluation should also consider non-buffer areas that act as a severance to potential buffers. Areas within the 500-foot buffer threshold that are located beyond an area of non-buffer will be scored zero as that potential buffer habitat no longer would function to reduce or eliminate the effects of stressors on the

WAA, regardless of the quality of the potential buffer (0-4). For example, a mid to late successional forest located within the 500-foot polygon usually receives a quality score of “4”. However, if it is separated from the WAA by a medium duty road or other non-buffer, it would no longer function as a buffer and is scored a zero. On the other hand, narrow linear land covers would not necessarily inhibit an adjacent area from serving as a buffer. These include, but are not limited to vegetated levees, trails, ditches, and low volume roads (e.g., dirt or gravel access maintenance roads such as on Wildlife Management Areas and driveways).

Pastureland can range in quality depending on the intensity of grazing and type of vegetation that are present. Some pastures are highly managed and intensively grazed or they can be unmanaged areas where large amounts of native vegetation remain. Scores for this buffer type can range from “0” to “2” (see narratives below). Additionally, when evaluating a buffer area of pasture (i.e., an area grazed by domestic livestock), characteristics may change over time so scoring should reflect the current situation and professional judgment should be used in evaluating recent and observable characteristics. For example, stocking rates as well as observations of vegetation and soil conditions may help to determine the intensity of grazing, whether it is moderate or heavy use. The vegetation in pastures often contain a mixture of desirable native species (Eastern gamagrass, *Tripsacum dactyloides*; big bluestem, *Andropogon gerardii*; and switchgrass, *Panicum virgatum*), to undesirable native species (e.g., reed canary grass, *Phalaris arundinacea*), or non-native species (e.g., sweet vernal grass, *Anthoxanthum odoratum* or velvet grass, *Holcus lanatus*).

For buffer types where management to improve ecological conditions are evident (e.g., prescribed burning, invasive species control, native wildlife plantings) scoring should be based on the degree of recovery or subsequent improvement to the natural vegetation community. Therefore, when selecting a scoring narrative in Section 2.3.1.2.4 below for buffer types, the score may be higher than the specified level of human and domestic animal use, provided soil disturbance is minimal. Appendix D provides some additional examples of buffer calculations.

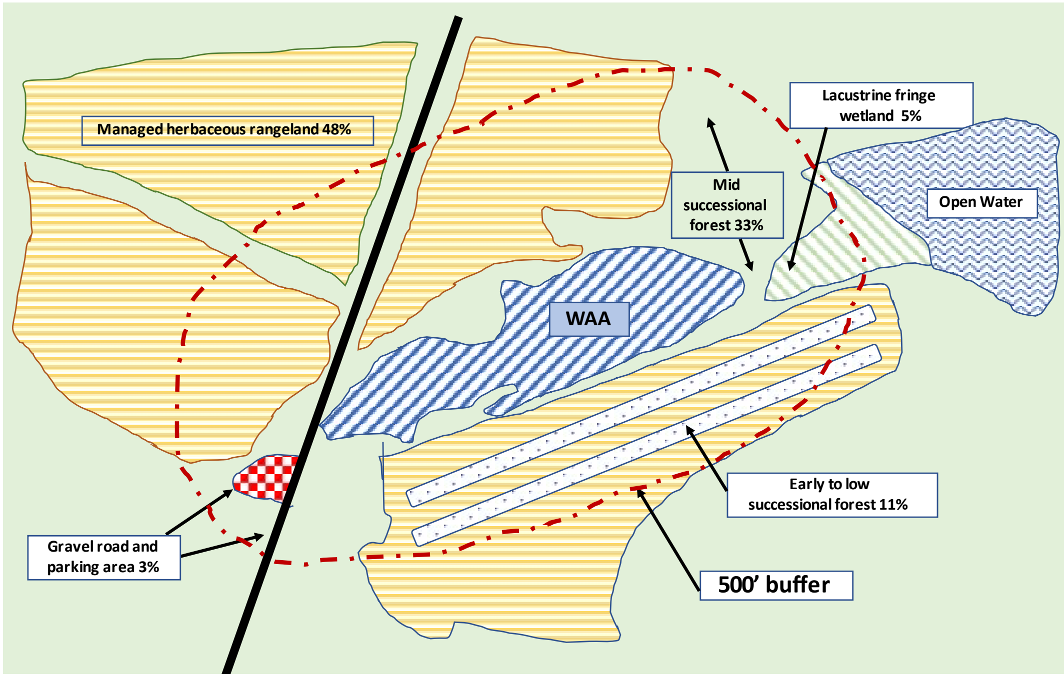

Figure 31. Example 1 of measuring the buffer metric for a slope wetland. *The 500-foot polygon radiating out from the WAA boundary is used to determine the percentage of each buffer type. The buffer metric score is calculated from the sum of the subtotals of the percentage of each buffer type times the score for that buffer type as demonstrated in Table 10 below.*

Table 10. *Example 1 calculation of buffer metric for Figure 31.*

Buffer type/Description	***Score (See Narratives)***	***Percentage***	***Subtotal***
1. Low to mid successional forest with invasives	3	33	0.99
2. Early to low successional forest with invasives	2	11	0.22
3. Primarily herbaceous grassland (regularly managed) with some trees and shrubs	1	48	0.48
4. PEM Wetland (lacustrine fringe)	3	5	0.2
5. Gravel road and parking area	0	3	0
			Score: 1.9

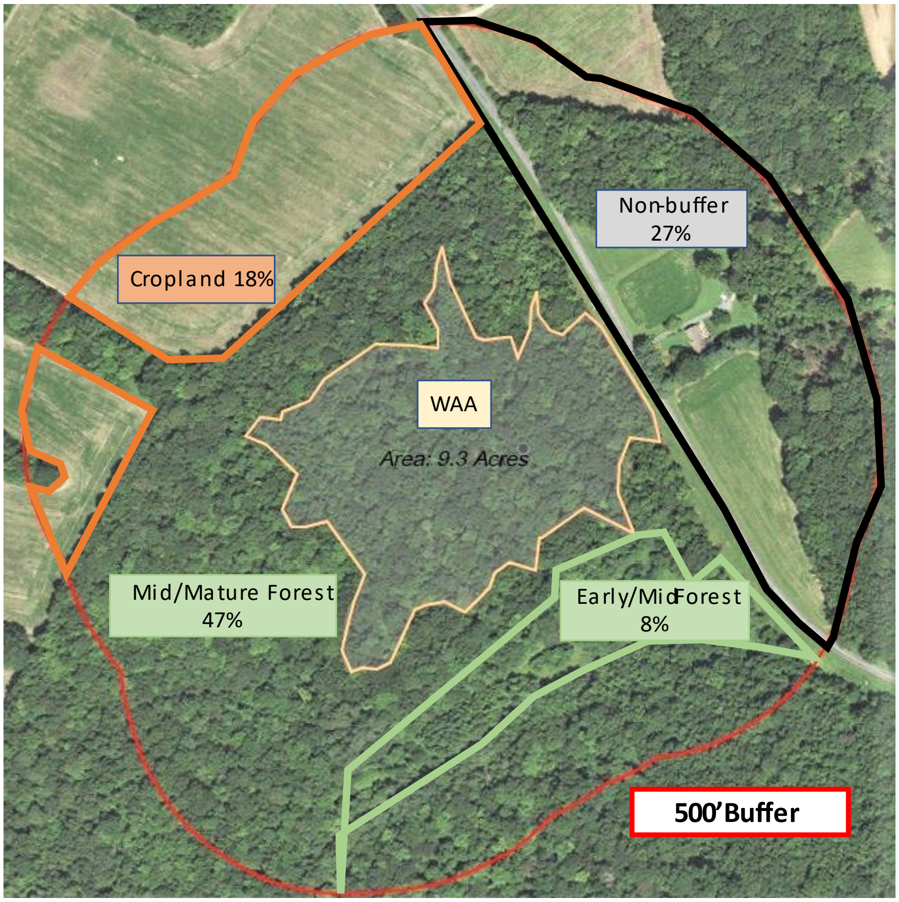

Figure 32. Example 2 of measuring the buffer metric for a mineral flat wetland. *The 500-foot polygon radiating out from the WAA boundary is used to determine the percentage of each buffer* type*. The buffer metric score is calculated from the sum of the subtotals of the percentage of each buffer* type *times the score for that buffer* type *as demonstrated in Table 11 below.*

Table 11. ***Example 2 calculation of buffer metric for Figure 32.***

Buffer Type/Description	*Score (See Narratives)*	*Percentage*	*Subtotal*
1. Mid to mature successional forest	4	47	1.88
2. Early to low successional forest with invasives	2	8	0.16
3. Non-buffer	0	27	0
4. Cropland	0	18	0
			Score: 2.0

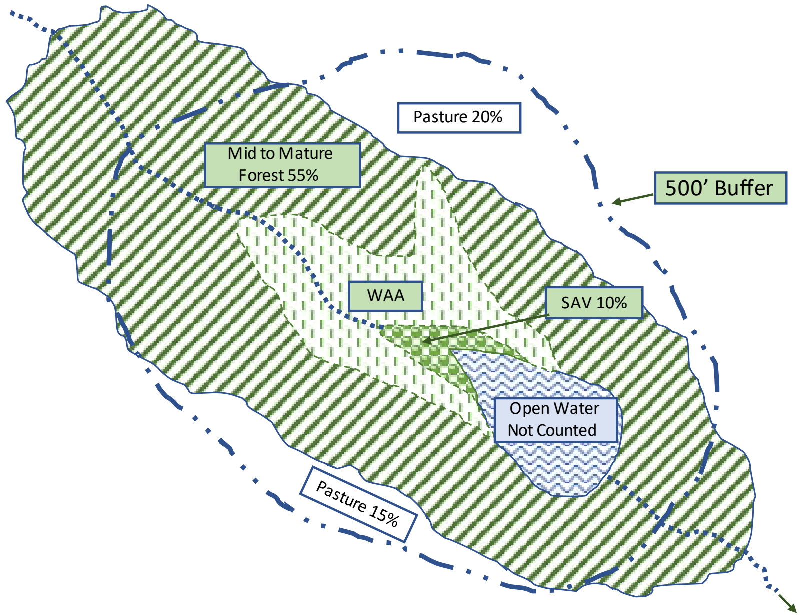

Figure 33. Example 3 of measuring the buffer metric for a lacustrine fringe wetland (revised from USACE 2015). *The 500-foot polygon radiating out from the WAA boundary is used to determine the percentage of each buffer* type*. Open water areas are presumed neutral and are excluded from the evaluation as discussed below. However, vegetated shallows (e.g., floating and SAV) are included as a buffer type. The buffer metric score is calculated from the sum of the subtotals of the percentage of each buffer* type *times the score for that buffer* type *as demonstrated in Table 12 below.*

Table 12. Example 3 calculation of buffer metric for Figure 33.

Buffer Type/Description	***Score (See Narratives)***	***Percentage***	***Subtotal***
1. Mid/mature successional forest	4	55	2.2
2. Managed Pasture	1	35	0.35
3. Vegetated shallows (floating and SAV)	3	10	0.3
4. Open water*	Neutral	NA	NA
**Note: The acreage of open water is not included in the 500' buffer acreage total.*			**Score: 2.9**

2.3.1.2.3 Wetland Class and Ecoregion Considerations

For all wetland classes, but particularly lacustrine fringe wetlands, open water areas that are within the buffer area should be recorded on the data sheet, but not included in the percentage determinations (i.e., the sum of the percentages of all other buffer types should equal 100) as in Table 12 above. Open water is considered neutral in the buffer metric as it may inflate the score or be either a source of stress or benefits. This is beyond the scope of this assessment due to the time required to obtain water quality measurements and analyze the results. However, vegetated shallows with native floating or SAV should be included in the buffer evaluation (and scored based on the narratives below) due to the habitat and the water quality benefits they provide. Because buffer areas generally affect the condition of wetlands equally in all ecoregions, there are no modifications to the buffer metric.

2.3.1.2.4 Scoring Narratives

The condition or composition of the buffer, in addition to its width and extent around a wetland generally reflects the overall capacity of the buffer to perform its critical functions. The most important consideration here is: "does the buffer present the ability to reduce stress on the WAA?" Evaluate the characteristics and score each buffer type using the narratives below with the information in Section 2.3.1.2.2. Invasive and or aggressive species often reflect buffer quality and their presence usually indicate stressors are impacting WAA condition. Additionally, elevated roads impair or reduce wildlife movement and roadside ditching can significantly impact flow and circulation to the WAA. *Because access to all or part of the buffer may be limited or restricted, documentation of invasive species is highly recommended, but not mandated.*

Where possible, users are encouraged to obtain access and provide documentation of vegetated buffers. Determining the type, severity, and proximity of stressors is essential in determining overall wetland condition and supporting rationale should be provided. Most late or mature naturally occurring non-tidal communities in Maryland are forested and often represent the reference buffer condition. MDWAM measures the degree of forest succession as diameter breast height (DBH) and generally defined as follows*:*

- Low successional stage = <3" DBH
- Early or pole stage = 3-6" DBH
- Mid-successional = 6-12" DBH
- Late or mature = >12" DBH

Due to historic alterations across Maryland, mixed aged forests are common so users should score the buffer community based on the dominant type. The scoring below refers to individual buffer types and not the entire buffer area which may consist of multiple types. Choose the best fit for each buffer type.

4 = This buffer type is largely (≥ 75%) a naturally occurring vegetative community which can range from mid to late-successional stage forested community expected for the ecoregion based on natural environmental conditions and with little or no evidence of recent (< 5 years) human alterations or domestic animal use. If past alterations have occurred, recovery is generally very high. *Some naturally occurring non-forested communities may also qualify for the maximum score (e.g., vegetated wetlands associated with beaver impoundments, other wetlands such as PSS, tidal marsh, etc.).*

3 = This buffer type is largely a naturally or semi-naturally occurring mid to late-successional stage forested community expected for the ecoregion based on natural environmental conditions but has evidence of recent (< 5 years), but not ongoing human or domestic animal use **OR** buffers characterized as early to mid-successional stage communities often with a mixture of native and invasive species regenerating from or responding to a historic disturbance/stress but with no evidence of recent human or domestic animal use. *These often include but are not limited to areas recovering from historic agricultural use or logging and generally have a large contingent of mixed woody cover.*

2 = This buffer type is comprised of an early to mid-successional stage community that is regenerating or responding to a disturbance/stress and or has evidence of on-going, but not intense, human, or domestic animal use. *Examples include timber harvest areas, unmanaged pastureland, abandoned treatment ponds, and various stages of idle or mixed rangeland (old-field habitat, clear-cuts, etc*.).

1 = A buffer type characterized by an early or low-successional stage community regenerating from or responding to a disturbance/stress and with evidence of on-going moderate to high intensity human or domestic animal use or management. *These are managed lands such as pasture, hay land, orchards, nurseries, "active" stormwater, or treatment basins etc. and often have large contingent of introduced and or undesirable species.*

0.5 = A buffer type characterized by intense human or domestic animal use that has a natural substrate (i.e., not impervious cover) and is intensely managed vegetation through mechanical and or chemical means (e.g., mowed fields, sports fields, golf courses, urbanized parks, utility line right of ways, no till cropping, etc.). *These are highly managed lands and often dominated by introduced and or undesirable species.*

0 = NON-BUFFER AREAS - Areas within 500 feet of the wetland boundary that do not qualify as a buffer because it is not vegetated, has recent highly modified soil, and/or is subject to intense human or domestic animal use which inhibits its ability to reduce the effects of stressors and disturbance on wetland condition. *Examples of areas that score "0" may include industrial, commercial, and residential developments (particularly high density) and all associated hard surface infrastructure such parking lots, secondary roads, and highways; intensive agriculture that lacks ground cover at least part of the year during the production cycle (e.g., traditional row cropping, feed-lots., etc.).*

*Areas that would be considered buffers but are separated from the wetland by a **non-buffer area** (as described in Section 2.3.1.2.2 above) also receive a score of "0" as they are presumed to no longer present a buffer to stressors.*

2.3.2 Hydrology Core Element

2.3.2.1 Water Source

2.3.2.1.1 Description:

The water source metric measures the degree to which the wetland's water source is controlled by natural or unnatural/artificial (human-influenced) means. While wetlands generally have multiple sources of hydrology, this metric identifies the dominant source of hydrology to the wetland and determines if natural processes or human influences control the inputs of water.

Hydrology is the most important factor in wetland formation and the maintenance of wetland processes (Mitsch and Gosselink 2000). Natural inflows of water to a wetland affect the wetland's ability to perform and maintain its typical functions (Collins et al. 2008). Therefore, if a wetland's natural water sources are affected because of human influences or control, wetland condition will likely be reduced.

Brinson (1993) described the variation in dominant water sources associated with HGM wetland classes. Natural sources of hydrology may include any or all the following: precipitation, overland flow, groundwater discharge, interflow and overbank or backwater flooding. Whereas unnatural sources are defined as artificial, unsustainable, controlled, or modified. These may include but are not limited to storm-drain and other outfalls/point sources, as well as irrigation/pumping. Manipulated water sources occur where an unnatural/artificial influence or control is present on a natural water source such as human impoundments that capture and artificially control surface water inflows (e.g., Agri-drains, etc.). Situations where wetlands have become established because of past human alteration of a natural water source are also considered a manipulated water source regardless of if the water source is not directly controlled. Wetlands with manipulated water sources also include unnatural changes to original contours because of grading, excavation or discharge of fill materials have resulted in wetland formation (e.g., subsurface interflow may have been artificially captured by excavation and expressed on the ground surface). Lastly, intentionally created, restored, or enhanced wetlands may have a manipulated water source that is sustainable and replicates natural processes.

2.3.2.1.2 Method of Evaluation

Determining direct sources of water to a wetland should be accomplished by direct field observation as well as office review of aerial photography for the watershed. The dominant natural water sources for each wetland subclass are discussed in Section 2.2.3 and may be more recognizable than unnatural water sources. A thorough examination should be made in the field and in the office to identify any unnatural water sources to the wetland as well as any artificial influence/control to natural water sources.

In the field, examine the WAA and make note of the immediate vicinity for evidence of outfalls, pumping, impoundment, and other unnatural/artificial controls of the wetland's water source. In the office, review supporting information (aerial photography, LiDAR, etc.) of the wetland's watershed or catchment area within one mile of the WAA.

Development, irrigated agriculture, wastewater treatment, and impoundments are influences or controls that are watershed indicators of unnatural water sources. Watershed and topographic maps are additional sources of supporting information that may assist in determining the influence of unnatural sources to a WAA. It is also useful to review historic aerial photos to determine any modifications to a wetland's water source, particularly if the current vegetation obscures visual observation in the field.

When scoring this metric, the proximity and influence of unnatural water sources should also be considered and the degree to which the water source is controlled artificially. Artificial control consists of human influences, so the degree of control depends on how actively the water source is managed or changed by human actions. See Appendix B for examples of artificial influence or control of a wetland's water source. For created or restored wetlands, the water source is scored based on the degree the water source is sustainable and replicates natural processes.

2.3.2.1.3 Wetland type and Ecoregion Considerations

The water source metric is scored using the same methods to evaluate the predominance of natural or artificial sources even though these sources may vary somewhat by type. Lacustrine fringe wetlands may score lower since they are often due to human influenced water sources (impoundments). Wetlands with water sources including human impoundments should be scored on this metric based on the proximity/influence of the impoundment and the degree to which it is controlled. For example, Frostburg Reservoir and countless other smaller impoundments and ponds are not regularly controlled or have fixed outlets where discharges are only controlled once a certain elevation is reached. On the other hand, Jennings Randolph Lake has highly controlled releases as it is used for flood control.

Beaver impoundments are considered natural and should be scored in the highest category for water source unless other unnatural/artificial controls are present. For created, restored, or enhanced wetlands that use berms or other structures such as Agri-drains to develop a water source, consider the degree to which the water source replicates sustainable natural processes or is artificially controlled and choose the best fit.

There are no modifications for ecoregions as water sources of wetlands may be natural or unnatural in either ecoregion.

2.3.2.1.4 Scoring Narratives

The water source metric is a qualitative determination of the type of water source and the degree of control exerted by natural (i.e., climate) and or unnatural (i.e., human alterations) factors. Identify the *dominant source* and evaluate how water sources directly affect the extent, duration, and frequency of saturated or ponded conditions within a WAA. Some important parameters to consider are precipitation rates and effects of historic alterations that may now represent a new normal circumstance. Manipulated water sources may include, but are not limited to dams, culverts, ditches, impervious surfaces, and stormwater control structures. Choose the best fit from the following narrative descriptions.

4 = A wetland with *all-natural* water sources that are *neither altered nor artificially influenced/controlled*; Also consider created/restored/enhanced wetlands with sustainable water sources that replicate natural processes.

3 = A wetland with *predominantly natural* water sources that are only *slightly altered or influenced/controlled*; **OR** wetlands with *manipulated* water sources that are *not under highly artificial control*; **Also** consider created/restored/enhanced wetlands where sustainable water sources may not totally replicate natural processes and are *not under highly artificial control.*

2 = A wetland with predominantly unnatural water sources or water sources that are under *highly artificial control*; **Also**, created/restored/enhanced wetlands that do not replicate natural processes or that are *under highly artificial control.*

1 = A wetland or created/restored/enhanced wetland with all *unnatural* water sources and/or water sources that are *completely artificially controlled*.

2.3.2.2 Hydroperiod

2.3.2.2.1 Description:

Hydroperiod is the duration, frequency, and magnitude of inundation and/or saturation in a wetland and this metric measures the natural variability and any alteration (i.e., increase or decrease) to the hydroperiod of a wetland. Tarr and Babbitt (2005) defined hydroperiod and its importance to wetland ecology. Wetlands with natural patterns in the amount of time, number of times, and depth that they are inundated and/or saturated have higher condition (and likely function) than wetlands in which these characteristics have been influenced by human activities.

High variation of the hydroperiod generally translates to having higher function (Mitsch and Gosselink 2000). Higher plant species diversity is typically associated with wetlands that have seasonal hydroperiods dominated by facultative and facultative wetland species where wetlands with semi-permanent to permanent hydroperiods are generally dominated by a few obligate species. Keddy (2000) categorized wetlands into types based on hydrology with respect to variation of the hydroperiod because of elevational changes within the wetland. Correspondingly, this resulted in higher species richness in those areas that were seasonally flooded compared to those where flooding is continuous. In general, the indicator status of groundcover species often represents contemporary hydrologic conditions.

This metric also evaluates any deviation from a natural, variable hydroperiod in a wetland. The alteration of hydroperiod evaluated by this metric could be either an increase in the hydroperiod that causes a transition of the wetland to more open water habitat or a decrease in the hydroperiod which would cause the wetland to transition from hydric to more mesic or xeric upland habitat. Intermediate changes to hydroperiod, including reduced variation, may be evident as shifts in biotic structure such as changes in plant species richness, strata, or productivity may be evident (Mitsch and Gosselink 2000).

2.3.2.2.2 Method of Evaluation

The hydroperiod metric is initially evaluated based on field observations and indicators of the hydroperiod and evidence of recent (i.e., within the previous five years) or historic changes in the duration, frequency, and magnitude of inundation and/or saturation in a wetland. The duration (e.g., permanent, seasonal, temporary), frequency (e.g., number of times per year), and magnitude (e.g., depth) are evaluated and then the associated natural variation (e.g., high, low) of the hydroperiod in the WAA. The variability of the hydroperiod should be determined based on how much the inundation and/or saturation in a wetland naturally changes over time. For example, a seasonally flooded riverine wetland that has different water levels throughout the year and between years has high variability, whereas a permanently saturated backslope wetland often has low variability. In addition, observe and record alterations of the hydroperiod including both direct evidence of diversions, ditches, levees, or impoundments and indirect evidence such as wetland plant stress, encroachment by upland species, and other plant morphology, plant community structure, and soil indicators. The 1987 Corps of Engineers Wetland Delineation Manual (atypical situations) and associated Regional Supplements (Chapter 5) contain some information on potential indicators of altered hydroperiod (e.g., difficult, or problematic situations). Photographs in Appendices A and B provide examples of wetlands with different levels of variability and alteration of the hydroperiods.

Evaluation of the hydroperiod metric should include an office review of aerial photography for the wetland's watershed or catchment area to determine if any direct modifications (e.g., diversions, ditches, levees, or impoundments) are present and have likely altered the hydroperiod. For example, an impoundment constructed directly upstream of a riverine wetland would likely reduce the magnitude of flooding and the natural variability of the hydroperiod. In addition, the scoring of the hydroperiod metric should consider the degree to which modifications within the watershed influence a wetland's hydroperiod (i.e., the relative influence compared to the overall condition).

Alterations due to natural events, defined as anything other than human activity (e.g., logjam, channel migration, etc.) should be noted separately from human alterations. However, beaver activity is considered dynamic and an important natural process that should score in the highest category for this metric (i.e., not considered an alteration). In addition, the hydroperiod for a created/restored/enhanced wetland should be scored based on the degree to which it replicates a natural and variable hydroperiod. That is, replicating the targeted wetland class or subclass.

2.3.2.2.3 Wetland Class and Ecoregion Considerations

With one exception, wetland classes are evaluated the same for the hydroperiod metric. The evaluation of lacustrine fringe wetlands adjacent to a human impoundment must consider the extent to which the wetland has adapted to a "normal" hydrologic regime. Consequently, for wetlands that have developed adjacent to a human impoundment, the metric scoring should be based on whether any recent changes have occurred to the normal hydroperiod resulting from the impoundment. Thus, for lacustrine fringe wetlands the impoundment should not be considered an alteration unless it has recently changed; additionally, the evaluation should consider the normal variability of the hydroperiod associated with the impoundment. The variability of the hydroperiod generally depends on the control of water levels in an impoundment and the elevation of the wetland relative to the normal water elevation in the impoundment. The hydroperiod metric for lacustrine fringe wetlands adjacent to a human impoundment should be evaluated using the specified narratives in Section 2.3.2.2.4 below.

In riverine wetlands, the evaluation of hydroperiod requires consideration of the condition of the channel from which the wetland receives overbank flow. If the channel is (or has been recently) degrading or aggrading, this may change the duration and frequency of inundation (i.e., its hydroperiod) in the wetland. Wetlands that have become disconnected from the channel (i.e., no longer flood at 1–2-year intervals) and its floodplain are included in other non-riverine subclasses. In addition, the evaluation of the hydroperiod in riverine wetlands should consider any upstream influences (e.g., impoundment, diversion, urban development) which have altered the natural variability of the hydroperiod.

Mineral flat wetlands have high natural variability of the hydroperiod and generally score higher in contrast to closed depressions that typically have low variability.

No modifications to this metric for different ecoregions are warranted since the wetland's ecoregion does not directly influence the alteration and variation of the hydroperiod.

2.3.2.2.4 Scoring Narratives

The hydroperiod metric identifies the frequency, duration, and magnitude of the inundation and or saturation in a typical year. Hydroperiod is scored using the narratives below except for lacustrine fringe wetlands adjacent to a human impoundment.

4 = A hydroperiod characterized by *natural patterns* (i.e., no alterations) and *high variation* of inundation/saturation and drying; **OR** recent or historic alterations have minimal effect to hydroperiod or impact a small fraction of the WAA; **Also**, the hydroperiod of a created/restored/enhanced wetland that *replicates* natural patterns and high variation. Example wetland classes are seasonal depressions and most mineral flats.

3 = A hydroperiod characterized by *natural patterns and low variation* (e.g., lack of understory due to extended inundation such as perennial depressions); **OR** a hydroperiod that has *changed* (increased, decreased, or reduced variability [i.e., seasonal fluctuation or pulsing]) due to natural events; **Also**, the hydroperiod of a created/restored/enhanced wetland that *replicates most* natural patterns with low variation. Examples include perennial depressions and backslope wetlands.

2 = A hydroperiod that is *somewhat altered/manipulated* [slightly increased, decreased, or reduced variability (i.e., seasonal fluctuation or pulsing)] due to human influences; **Also**, hydroperiod of a created/restored/enhanced wetland that *replicates some* natural patterns with little variation.

1 = A hydroperiod that is *highly altered/manipulated* (increased, decreased, or variability eliminated) from the natural condition by human influences; **Also**, the hydroperiod of a created/restored/enhanced wetland that *does not replicate* natural patterns or variation.

For **lacustrine fringe wetlands adjacent to a human and beaver impoundment, the hydroperiod metric is scored using the narratives below*.

3 = A wetland adapted to *high variability* of the normal hydroperiod resulting from the impoundment.

2 = A wetland adapted to *low variability* of the normal hydroperiod resulting from the impoundment.

1 = A wetland where the normal hydroperiod resulting from the impoundment has *recently changed* (increased or decreased).

2.3.2.3 Hydrologic Flow

2.3.2.3.1 Description:

The hydrologic flow metric is a measure of the movement of water to and from the wetland and the surrounding area. That is, a measure of the flow and circulation of waters within the wetland which often dictates how the wetland functions and performs various ecosystem processes. This metric also evaluates how the wetland is hydrologically linked to adjacent aquatic and non-wetland (terrestrial) habitats regarding how water, sediment, nutrients, and organic matter are exchanged and the movement of fauna at all levels. According to Hammer (1992), hydrology can modify or determine the structure and functioning of wetlands. This is accomplished by controlling the composition of the plant community and thereby the animal community. He also concluded that hydrology also directly influences productivity by controlling nutrient cycling and availability, import and export of nutrients, and fixed energy supplies in the form of organic particulates and decomposition rates. Collins et al. (2006) proposed that higher hydrologic flow positively influences ecosystem functions, food webs, nutrient cycling, plant diversity, and wildlife habitat.

In addition, this metric qualitatively evaluates the openness to flow through a wetland. Mitsch and Gosselink (2000) found that wetlands with higher “flowthrough” or openness to hydrologic fluxes generally have higher productivity, export of organic carbon, and nutrient cycling. Cook and Hauer (2007) found that temporary surface and near-surface hydrologic connections between intermontane depression wetlands strongly influenced surface water chemistry and vegetation structure, diversity, and productivity. Therefore, it is apparent that wetland structure, function, and condition are all affected by hydrologic flow.

2.3.2.3.2 Method of Evaluation

The hydrologic flow metric is evaluated in the field by indicators of flow to and from the wetland as well as the presence of restrictions to the movement of water (such as levees, berms, roads, and diversions). Identify the presence of inlets and outlets, signs of water movement to and from the WAA and adjacent habitats, and indicators of high flowthrough such as drift deposits, drainage patterns, and sediment deposits (these can be extracted from wetland determination data forms). Inlets and outlets include defined locations of surface flow within the WAA as well as where waters enter and exit. Restrictions that impair the movement of waters should be recorded such as levees, berms, roads, diversions, ditches, etc., as well as indicators of low flowthrough such as stagnant water conditions, topography, or the lack of inlets and outlets.

Based on observations of indicators as discussed above, score the hydrologic flow metric using the narrative descriptions. The hydrologic flow metric defines flowthrough is as the openness to hydrologic fluxes or simply, the openness of the WAA to water flowing through the wetland. This may be best observed in the early growing season as vegetative growth later in the season may conceal flow indicators. Photographs in Appendix B provide examples of wetlands with different scores for the hydrologic flow metric.

2.3.2.3.3 Wetland Class and Ecoregion Considerations

No modifications are proposed despite the variability of scoring between wetland classes for hydrologic flow. Variability is best illustrated between mineral flats and depressions that generally score low when compared to riverine wetlands which generally score on the higher end because of their hydrogeomorphic setting, hydrodynamics and water sources.

Lacustrine fringe wetlands typically have high movement of water between the wetland and adjacent aquatic and terrestrial habitat at least seasonally. However, because most lacustrine fringe wetlands in Maryland exist as human impoundments, evaluation of this metric must consider that hydrologic flows to downstream areas have been restricted. Therefore, lacustrine fringe wetlands resulting from a human-made structure which impedes the movement of water should not score in the highest category for this metric.

Similar wetlands resulting from the construction of a human-made berm or dam (i.e., small ponds and other berms) restrict water movement and often create or enhance hydrology also have restricted hydrologic flow. While the restriction of water movement has potentially created the wetland, it should receive a lower score for this metric since it lacks the level of water movement of some other wetlands.

As indicated above, riverine wetlands without human-made restrictions to water movement typically have high flowthrough due to their geomorphic setting (e.g., floodplain), receiving overbank flow from a channel, and have inlets and outlets that allow water movement to and from other areas. Apply caution when evaluating flowthrough in some concave floodplain features in the riverine class. *Caution*, observations in the dry season may not provide an accurate depiction of the rate of flowthrough as vegetation densities may conceal indicators of flooding or observations of stagnant water may suggest low flowthrough. Conversely, wet season observations may present the opposite determination of high flowthrough and water movement.

Because depression wetlands typically occur in closed elevation contours, they have low flowthrough and are primarily dominated by vertical hydrodynamics which limit movement of water (i.e., water accumulates rather than moving out of the wetland). Even depression wetlands with inlets, outlets, and/or other surface and near-surface hydrologic flow paths do not have high openness or flowthrough. Slope wetlands generally have moderate movement of water and hydrologic openness as they are generally dominated by groundwater discharge and downslope movement of water. Frequently, numerous springs or groundwater seeps occur as braided flow paths that eventually may form a surface channel (outlet) conducting water downslope.

The movement of water into and from the wetland, or the restrictions to water movement, are not directly dependent on ecoregion so modifications for ecoregion are not required.

2.3.2.3.4 Scoring Narratives - The hydrologic flow metric is scored using the narratives below.

4 = Wetlands with <u>high movement</u> of water to and from the wetland and the surrounding area (e.g., lack of human-made restrictions to the movement of water), as well as <u>high openness</u> to hydrologic fluxes (i.e., high flowthrough – e.g., floodplains).

3 = Wetlands with <u>high movement</u> of water to and from the wetland and the surrounding area (e.g., lack human-made restrictions to the movement of water), but with <u>low openness</u> to hydrologic fluxes (i.e., low flowthrough); **OR**, wetlands with <u>moderate</u> movement of water to or from the wetland and the surrounding area (e.g., have minor influences from human-made restrictions to the movement of water or have some naturally limited water movement), as well as <u>high openness</u> to hydrologic fluxes (i.e., high flowthrough).

2 = Wetlands with moderate movement of water to or from the wetland and the surrounding area (e.g., have minor influences from human-made restrictions to the movement of water or have some naturally limited water movement), but with low openness to hydrologic fluxes (i.e., low flowthrough).

1 = Wetlands with low movement of water to and from the wetland and the surrounding area (e.g., have major influences from human-made restrictions to the movement of water or have a natural lack of water movement) with low openness to hydrologic fluxes (i.e., low flowthrough).

2.3.2.4 Surface Drainage Features

2.3.2.4.1 Description:

This metric was developed to evaluate the potential negative effects of natural and unnatural surface drainage features (SDFs) on wetland hydrology and its functions within the wetland. Human-altered streams, ditches, and swales (diversions) can have a profound negative effect on the wetland hydroperiod and / or may disrupt the flow and circulation of waters moving through the wetland. Examples of surface drainage features with ongoing negative effects include signs of channel instability, such as head cuts, channel incision (lowering the water table), sedimentation (excessive deposition), which result in excess drainage or increased volumes of water. Conversely, side cast dredged materials from excavation or discharges of fill materials may enhance hydrology in a wetland by blocking flow and circulation. In these situations, if the effect is significant enough to change the hydrologic processes in a wetland, the user may consider separate WAAs.

2.3.2.4.2 Method of Evaluation

Using aerial photography identify all SDFs within the WAA and confirm during field investigation and determine the potential negative effect on wetland hydrology of each SDF present if applicable. Use field observations to further document the number and condition of surface drainage features and their potential effects on wetland hydrology and its ability to perform ecosystem processes.

2.3.2.4.3 Wetland Class and Ecoregion Considerations

There are no considerations for this metric for ecoregions or wetland class. However, it should be noted that mineral flats and depressions rarely have natural SDFs present and will generally score high for this metric as a result.

2.3.2.4.4 Scoring Narratives

After identifying all natural or human-altered streams, human created (ditches, swales) and or other SDFs present within or adjacent to the WAA, determine the best fit using the following narratives to score this metric.

4 = SDFs are not present, are unaltered, or in the case of historic alterations (typically greater than 5 years), are unlikely to have an ongoing negative effect on surface water flow, groundwater levels, or the frequency and or duration of hydrology to the WAA.

3 = SDFs are present but appear to have a minimal ongoing negative effect on surface water flow, groundwater levels, or the frequency and / or duration of hydrology to the WAA.

2 = SDFs are present and likely have a moderate ongoing negative effect on surface water flow, groundwater levels, or the frequency and / or duration of hydrology to the WAA. Historic alterations exhibit some degree of recovery of hydrology in the WAA and potential associated functions.

1 = SDFs are present and likely have a severe ongoing negative effect to surface water flow, groundwater levels, or the frequency and or duration of hydrology to the WAA as evidenced by the factors listed above.

2.2.3 Soils Core Element

2.3.3.1 Organic Carbon Storage

2.3.3.1.1 Description:

Soil organic matter is made up of living and non-living plant and animal residues that accumulate in the soil. As organic materials are broken down in the soil, they provide sources of energy and/or nutrients for soil microbial communities and macrofauna. Stabilized organic matter (humus) serves as a long-term reserve of organic carbon and nutrient sources. Soil organic carbon is the carbon contained within the soil organic matter. Wetland soils tend to accumulate more soil organic carbon than upland soils because they form under saturated and anerobic conditions, which slows decomposition and oxidation of organic carbon. In addition, wetlands often have high levels of primary productivity, increasing organic inputs to the soil. The accumulation of organic matter in mineral soils will pigment the soil, making it darker in color (low value and chroma). Mineral horizons with an accumulation of organic matter tend to occur at or near the soil surface and are described as A horizons. In some cases, organic matter will accumulate at such a rate that distinct horizons comprised solely of organic material will form. These are called O horizons.

The soil organic carbon storage metric is a measure of the organic carbon stored in surface and near surface layers of the soil in a wetland. This metric is scored based on the presence and thickness of organic soils and/or organic enriched mineral soils in the upper 16” of the soil. Organic and mineral soil materials are distinguished by their organic carbon. In the field, this distinction can be made by feel. The relative concentrations of organic carbon in mineral soils are evaluated by color. Mineral soils high in organic matter tend to be darker in color.

2.3.3.1.2 Method of Evaluation

The Soil Organic Carbon Storage Metric is evaluated in the field when a small soil pit is dug and described as part of completing the wetland determination data form. The procedures for sampling, observing, and documenting the soil should follow the applicable regional supplement and Field Indicators of Hydric Soils in the United States (USDA-NRCS, 2018).

Soil organic matter is evaluated for the surface and near surface horizons, in the upper 16" and below any leaf litter, duff, or root mats. The relative amount of organic carbon stored in the soil is assessed based on the presence, thickness, and color of O and A horizons. O horizons are layers of organic soil materials. Organic soil materials have organic carbon contents (by weight) of 12% or more (approximately equal to 20% organic matter). Organic soil materials include muck (sapric soil material), mucky peat (hemic soil material), and peat (fibric soil material).
A- horizons are mineral soils that have an accumulation of organic matter, typically occurring at or near the soil surface. They tend to be darker in color than underlying subsoil horizons, reflecting higher levels of organic matter.

The amount of organic carbon in the soil can be estimated by gently rubbing wet soil between the fingers. If the material feels gritty, plastic, or sticky after the first or second rub, it is mineral soil material. Organic soil material will feel greasy after rubbing. Mucky modified mineral soil material (containing 5-12% organic carbon by weight) may initially feel greasy, but after rubbing will begin to feel gritty, plastic, or sticky. The texture, color, and thickness of surface horizon(s) should be documented on the wetland determination data form. Horizons may be combined to determine the total thickness of organic or mineral layers. All horizons within the upper 16" of the soil should be considered when assessing this metric.

As specific in Section 2.2.5.2, multiple samples (i.e., wetland determination data forms) may be warranted for each vegetation community in the WAA (that are heterogeneous, diverse, or greater than 5 acres). Therefore, a WAA may have more than one wetland determination data form containing several soil characterizations to provide data. In this case, the scores for each sample should be recorded on the MDWAM data form, averaged, and rounded to one decimal point.

2.3.3.1.3 Wetland Class and Ecoregion Considerations

Organic carbon accumulates in the soil when organic inputs are greater than decomposition. Plant biomass is the predominant source of carbon inputs in soils. Plant biomass production (primary productivity) is affected by the plant species, site hydrology, and climate, among other factors. Similarly, decomposition rates are a function of hydrology, climate, and organic substrates. While all wetland soils can accumulate soil organic carbon, their capacity for carbon accumulation (potential total storage) is expected to vary by wetland class and by ecoregion. Therefore, the same metric score for different classes of wetlands may not reflect the same condition, and a lower metric score for a different wetland class does not imply that it is in poorer condition. Comparisons or interpretations of the soil organic carbon storage metric should only be made between wetlands of the same class and ecoregion.

Some wetland classes (e.g., seasonally saturated mineral flats) do not typically develop organic horizons, and therefore would never have a soil organic carbon storage metric score greater than 3. When evaluating condition, the metric score for a wetland should be compared to that of a high condition reference wetland of the same class and ecoregion and not the theoretical maximum score.

Scoring Narratives

After describing the soil (from wetland data forms), determine the total thickness of organic soil layers (O horizons) and mineral soil layers that have accumulated organic matter (A horizons) within 16” of the soil surface. For the purposes of this metric, start observations at the actual soil surface, below any duff or leaf litter layers. When measuring the thickness of organic soil layers, the thickness of all organic soil layers within the top 16” of the soil surface should be combined, even if they are separated by mineral soil horizons.

5 = Total thickness of organic soil layer(s) is ≥2”

4 = Total thickness of organic soil layer(s) is <2”, OR a Dark* mineral surface layer(s) that is ≥10” thick

3 = No organic soil layer(s) and Dark* mineral surface layer(s) ≥4” and <10” thick

2 = No organic soil layer(s) and Dark* mineral surface layer(s) ≥1” and <4” thick

1 = No organic soil layer(s) and mineral surface layer(s) (any thickness) have matrix value >3 and ≤4 or chroma >2 and ≤3

0 = No organic soil layer(s), and mineral surface layer(s) (any thickness) have matrix chroma >3, OR situations where the surface layer(s) have been removed

**Dark mineral surface layers have matrix value ≤3 and chroma ≤2*

As specific in Section 2.2.5.2, multiple samples (i.e., wetland determination data forms) may be warranted for each vegetation community in the WAA (that are heterogeneous, diverse, or greater than 5 acres). Therefore, a WAA may have more than one wetland determination data form containing several soil characterizations to provide data for organic carbon storage. In this case, final metric scores for each sample should be recorded on the MDWAM data form, averaged, and rounded to one decimal point.

2.3.3.2 Biogeochemical Cycling

2.3.3.2.1 Description:

Biogeochemical cycling is promoted by a combination of aerobic and anaerobic conditions (dynamic redox conditions) and labile carbon. Labile carbon is the portion of organic carbon that is readily available to microbial communities. It becomes available as plant biomass is broken down through decomposition. Plant roots are an important source of labile carbon because they essentially leak carbon compounds into the soil in the form of root exudates. In addition, epidermal cells are continuously sloughed off plant roots, further contributing to the pool of labile carbon. An abundance of labile carbon enhances microbial activity, which is critical for the chemical transformations occurring in wetland soils (e.g., denitrification, sulfate reduction, methanogenesis).

Redox conditions can vary spatially with microtopography or temporally with a dynamic water table. Redox concentrations (bodies of apparent accumulation of Fe-Mn oxides) form because of fluctuating redox conditions in the soil, reflecting a dynamic water table. Redox concentrations located close to the soil surface indicates the water table fluctuates within the rooting zone and A horizon where the concentration of labile carbon is likely to be greatest.

Wetlands with greater topographic complexity, dynamic redox conditions (reflecting a fluctuating water table), and readily available organic carbon are likely to have the highest rates of biogeochemical cycling.

2.3.3.2.2 Method of Evaluation:

This metric uses four sub-metrics: redox concentrations, microtopography, soil organic matter, and herbaceous surface cover. The sub-metrics for redox concentrations and microtopography evaluate the fluctuation in redox conditions over time and space, respectively. The sub-metrics for soil organic matter and herbaceous surface cover evaluate labile carbon sources. The sub-metric scores are combined to evaluate the potential for biogeochemical cycling within the wetland.

The redox concentrations and soil organic matter sub-metrics are evaluated in the field when a soil pit is dug and described as part of completing the wetland determination data form. The procedures for sampling, observing, and documenting the soil should follow the applicable regional supplement and Field Indicators of Hydric Soils in the United States (USDA-NRCS, 2018).

Depth to redox concentrations should be measured below leaf litter, duff, or a living root mat. Redox concentrations must be distinct or prominent, and ≥2% surface area. The presence and abundance of redox concentrations should be documented on the wetland determination data form.

Soil organic matter is evaluated for the surface layer, within the rooting zone. Soil color is used as a proxy to evaluate soil organic matter in mineral soils. The surface layer starts below any leaf litter, duff, or living root mats. Organic soil materials have organic carbon contents (by weight) of 12% or more. Organic soil materials include muck (sapric soil material), mucky peat (hemic soil material), and peat (fibric soil material). The amount of organic carbon in the soil can be estimated by gently rubbing wet soil between the fingers. If the material feels gritty, plastic, or sticky after the first or second rub, it is mineral soil material. Organic soil material will feel greasy after rubbing. Mucky modified mineral soil material may initially feel greasy, but after rubbing will begin to feel gritty, plastic, or sticky. The texture, color, and thickness of surface horizon(s) should be documented on the wetland determination data form. Horizons may be combined to make up the surface layer. For example, in the profile description below the surface layer would include the first two horizons, from 0 to 5 inches:

Depth	Horizon	Matrix Color	Redox Features
0-3	A1	10YR 2/1	-
3-5	A2	10YR 3/1	-
5-12	Btg	10YR 5/1	5% conc. 10YR 5/6

Microtopography – use text from metric.
Herbaceous stratum – use text from metric.

2.3.3.2.3 Wetland Class and Ecoregion Considerations

The potential for biogeochemical cycling in a wetland is a function of the wetland type and ecoregion in addition to site condition. For example, wetlands with a highly variable natural hydroperiod (i.e., high variation of inundation/saturation and drying) will likely have increased rates of denitrification and nitrification because of the fluctuating redox conditions relative to a wetland that has near continuous inundation/saturation. Additionally, rates of soil microbial activity vary seasonally in response to soil temperatures. Therefore, equal metric scores of different wetland types may not represent similar levels of condition and equal metric scores in different ecoregions may not represent similar levels of condition. A wetland’s metric score should be compared against high condition reference sites of the same wetland type and ecoregion as opposed to the theoretical maximum score (which may not be attainable in some wetland types).

2.3.3.2.4 Scoring Narratives

Each of the four sub-metrics are scored using the narratives below. The equation at the bottom of the narratives table is used to calculate the overall score for the Biogeochemical Cycling Metric. Scores range from 1 to 10, with higher scores corresponding to increased biogeochemical cycling potential (for wetlands of the same class and ecoregion).

<u>Sub-metric 1: Redoximorphic Concentrations</u>

Concentrations must be distinct or prominent, and ≥2% surface area

4 = Redox concentrations starting 0 to 6” from the soil surface and are >10% surface area

3 = Redox concentrations starting 0 to 6” from the soil surface and are ≤10% surface area, OR redox concentrations starting >6 to 12” from the soil surface and are >10% surface area

2 = Redox concentrations starting >6 to 12” from the soil surface and are ≤10% surface area, OR redox concentrations starting >12 to 18” from the soil surface and are >10% surface area

1 = Redox concentrations starting >12 to 18” from the soil surface and are ≤10% surface area

0 = No redox concentrations within 18” of the soil surface

<u>Sub-metric 2: Microtopography</u>

4 = ≥50% of WAA

3 = 30 to 49% of WAA

2 = 10 to 29% of WAA

1 = <10% of WAA

Sub-metric 3: Soil Organic Matter

4 = Organic surface layer(s) present (any thickness)

3 = Mineral surface layer(s) ≥4" thick with matrix ≤3 and chroma ≤2

2 = Mineral surface layer(s) <4" thick with matrix ≤3 and chroma ≤2

1 = Mineral surface layer(s) of any thickness with matrix >3 or chroma >2

Sub-metric 4: Surface Cover of Herbaceous Stratum (herbaceous plants only)

4 = >75% ground cover

3 = >50 to 75% ground cover

2 = >25 to 50% ground cover

1 = ≤25% ground cover

Biogeochemical
Cycling Metric = $[0.75 \times (Submetric\ 1 + Submetric\ 2 + Submetric\ 3 + Submetric\ 4)] - 2$

As specific in Section 2.2.5.2, multiple samples (i.e., wetland determination data forms) may be warranted for each vegetation community in the WAA (that are heterogeneous, diverse, or greater than 5 acres). Therefore, a WAA may have more than one wetland determination data form producing multiple scores for each sub metric for biogeochemical cycling. All sub metric scores for each sample location are recorded on the MDWAM data form as instructed in the scoring narratives in Section 2.3.3.2.4 above. Total scores from the equation of each sample are averaged and rounded to the first decimal.

2.3.3.3 Sedimentation

2.3.3.3.1 Description

This metric measures recent deposition of sediments that may occur beyond natural amounts generally because of human activities both within and outside of a wetland. While the deposition of sediment is important to many wetland processes (Mitsch and Gosselink 2000), excessive inputs will likely result in reduced condition and function of the wetland over time as biotic and abiotic processes will be interrupted or eliminated. Examples include decreased plant species richness, reduced microtopography, change in hydrologic flow (i.e., impaired flow and circulation of surface waters), encroachment of upland species and a higher degree of non-native/invasive infestation. These changes often result in changes to the physical, chemical, and/or biological integrity of a wetland (Werner and Zedler 2002).

Excessive sedimentation will also result in a reduction to plant species recruitment and potential elimination of terrestrial and aquatic invertebrates when substrates are buried by excessive sedimentation (Gleason et al. 2003). For instance, breeding habitat for amphibians and other aquatic species is reduced when excessive sediments bury seasonal pools. Additionally, when surfaces are buried by thick accumulations of sediment, tree seedlings and other vegetation may be stressed or eliminated (Pierce and King 2007).

2.3.3.3.2 Method of Evaluation

This metric is a qualitative estimate of recent sediment deposition based on field observations within the WAA and the surrounding area. An office review of supporting information is important to identify sources of stress outside the WAA that could lead to additional excessive sedimentation.

For the analysis of this metric, excess sediment deposition is defined as those amounts beyond natural quantities and generally expressed as more than just coatings of the substrate and vegetation. Measurable amounts of sediment deposits suggest that human alterations are the cause and often result in changes to the hydrologic, biotic, and abiotic processes within the wetland.

When evaluating the effects of sedimentation in a WAA, the wetland class and landscape position should be considered. For the most part, wetlands occurring in larger watersheds and those located in low lying landscape positions will be more likely to have natural sedimentation processes. Determine the general landscape position from the relative topographic location of the WAA using aerial photography, LiDAR, or other supporting information in addition to field observations. These tools are also helpful in determining landform variability (e.g., concave, convex, flat, etc.) within and adjacent to the WAA. In addition, the magnitude of recent flooding or runoff events should be considered (e.g., using a host of potential sources of precipitation data) to determine if sedimentation is excessive. The higher the magnitude of a flood or runoff event, the more likely that sedimentation has occurred because of natural processes.

As indicated above, normal amounts of sediment generally occur as thin coatings of fine-grained mineral material (e.g., silt or clay) that cover the ground surface. In contrast, excessive amounts occur as thick accumulations of bare mineral material (e.g., sand) and often mixed with leaf litter or other debris. Record observations of the location, frequency, and depth of deposits within the WAA and evaluate this metric based on the narrative descriptions below. See Appendix B for examples of a wetland with high sediment deposition.

2.3.3.3.3 Wetland Class and Ecoregion Considerations

Wetland class is a significant factor to consider when evaluating the sedimentation metric to determine if the deposition of sediment in a WAA is beyond a natural amount. Because water movement in different wetland classes varies greatly, so does the potential for sediment movement and deposition. Groundwater discharge is the dominant source of water to slope wetlands, so natural sedimentation in these wetlands would typically be low while riverine wetlands dominated by overbank flooding from a channel will be more likely to receive varying amounts of waterborne sediments that is deposited in the wetland. Therefore, abiotic processes in riverine wetlands are dependent on overbank sources of sediment deposition. Closed depression wetlands have very low sources of sediment while human-made impoundments often form fringe wetlands due to the large amounts of deposited sediments from incoming tributaries. Dependent upon the amounts and frequency of the deposits, this may either degrade or contribute to the expansion of the fringe wetlands. The effect of sedimentation on the biotic and abiotic processes of a lacustrine fringe wetland should be considered when evaluating this metric.

Lastly, beaver impoundments will often act as huge sediment traps often accumulating significant amounts of sediment depending on the condition of the catchment area. These shallow impoundments eventually become vegetated for this reason and due to varied rates of sediment deposition.

While the potential rates of sediment erosion and deposition may differ somewhat between ecoregions, the scoring narratives for this metric were developed general enough to apply to both ecoregions.

Evaluate this metric and the natural sediment processes using the scoring narratives below. The user is interpreting recent alluvium (often unvegetated) only and not historic deposits that have become the normal circumstance. For instance, situations with legacy sediments that have accumulated over time and become part of the current soil profile which supports a naturalized hydrophytic plant community would not necessarily be scored down (i.e., Piedmont floodplain soils – F19 or Stratified Layers – A5). Natural deposition is generally limited to sediment coatings or minimal small deposits.

2.3.3.3.4 Scoring Narratives (Physical changes induced by human activities)

The sedimentation metric is scored using the narratives below. The user is interpreting recent alluvium (often unvegetated) only and not historic deposits that have become a permanent change. For instance, situations with legacy sediments that have accumulated historically and or over time and developed as the current soil profile (i.e., normal circumstance) and which supports a naturalized hydrophytic plant community would not be scored down (i.e., Piedmont floodplain soils – F19 or Stratified Layers – A5). Natural deposition is generally limited to sediment coatings or minimal small deposits.

4 = Wetlands without sediment deposition beyond the quantity that is natural and necessary to maintain wetland condition through ecosystem processes. This is often expressed as uniformly distributed coatings resulting from overbank or backwater flooding.

3 = Excessive sediment deposition is infrequent (i.e., beyond the natural quantity), observed in less than 25% of the WAA, with substantial deposits often concentrated immediately abutting the stream or drainage feature. Impacts to wetland processes are localized and or minimal.

2 = Excessive sediment deposition is frequently observed (26-50%) within the WAA. Deposits are common and much thicker than coatings. Impacts to wetland processes are likely.

1 = Excessive sediment deposition is predominant and observed in greater than 50% of the WAA. Deposits are substantial, severe, and frequent. Impacts to wetland processes are usually severe.

2.3.3.4 Soil Modification

2.3.3.4.1 Description

The soil modification metric measures the extent and severity of physical modification to the wetland substrate by recent or past human activities. This includes disturbances resulting from agriculture, forestry, mining, and off-road traffic as well as other activities that modify the soil profile such as filling, land clearing and grading and dredging. This metric does not evaluate soil morphological changes such as the development of hydric soil indicators resulting from increasing periods of saturation and or inundation. It is well documented that soil modification alters physical soil properties such as compaction and therefore, disrupts various biotic and abiotic soil processes which can often lead to increased erosion or sediment transport. Consequently, wetlands with increased soil modification will exhibit lower condition.

Modification to the physical, chemical, and textural soil properties of naturally occurring wetland soils often results in decreased performance of important biological and chemical processes such as in restored/created wetlands (Bantilan-Smith et al. 2009) where physical disturbance may be significant. Johns et al. (2004) found differences in soil characteristics such as pH, organic matter, total nitrogen, and carbon to nitrogen ratios between natural wetlands and created wetlands (i.e., with previous soil modification) in east Texas. However, denitrification rates were similar within created wetlands and between created wetlands and natural wetlands, demonstrating that the development or recovery of some chemical processes is possible in 5–10 years. However, it is important to remember that numerous factors must play into potential recovery of chemical processes in created wetland soils thus reducing predictability.

2.3.3.4.2 Method of Evaluation

The soil modification metric is a qualitative evaluation of the extent and level of human caused soil modification. General field observations, in addition to soil profile characterizations recorded from wetland delineation sampling will provide insight to the degree of recent soil modification. It is imperative that the soil characterizations on the wetland data forms be accurate and complete to facilitate scoring of this and the other soil metrics.

Note that the soil modification metric may not consider other changes to the wetland substrate from human or domestic animal activities (e.g., grazing, off road vehicle travel, mowing, etc.) but they may receive consideration in other metrics (see vegetation alterations in Section 2.3.5.7). The evaluation should include the percentage of the WAA with recent (i.e., current/observable) soil modification and the degree of the soil modification.

To evaluate the impact of recent soil modification, the user should consider the severity of the activity regarding the alteration of soil physical properties and the potential disruption of abiotic processes. For example, areas that have been excavated, land leveled, and or filled will have a higher degree of soil modification due to changes to soil organic matter, structure, texture, and chemical properties than from grazing which generally causes a low degree of compaction.

A review of supporting information (historic aerial photography) in addition to data from the soil profile description on wetland determination forms should be reviewed to identify and describe the percentage of the WAA with past soil modification. Indicators of past soil modification may include high bulk density, low organic matter, lack of soil structure, lack of horizons, a human-induced hardpan (i.e., a hardened subsurface soil layer), dramatic change in texture or color (that is not a natural soil horizon change), a heterogeneous mixture of soil textures and/or aggregates (e.g., rocks) and other atypical characteristics of the soil profile. Users should determine if soil observations vary from official soil series descriptions.

The degree of recovery from past soil modifications should also be considered when evaluating this metric. Organic matter content, structural development, horizons, redoximorphic features, and other natural properties are important in determining the degree of recovery as opposed to the indicators of modification described above. Where excavation, grading, and soil amendments (additions) are required modifications for wetland mitigation, creation or restoration, soil recovery should be based on these soil properties as well as the development of redoximorphic features (hydric soil indicators).

Observe and record the percentage within the WAA that has recent and or past soil modification (i.e., physical human alterations) the degree of recent modification (e.g., high, or low) and the degree of recovery from past soil modification by using the indicators identified above. Score the soil modification metric based on the narrative descriptions below. See Appendix B for examples of wetlands exhibiting soil modification.

2.3.3.4.3 Wetland Class and Ecoregion Considerations

No calibration is warranted to this metric as soil modification may apply to any wetland class in either ecoregion.

2.3.3.4.4 Scoring Narratives

The soil modification metric is scored based on the following narratives. Note that if the WAA contains multiple degrees (e.g., high, and low) of recent soil modification the narrative for the lowest applicable score should be chosen. However, if the WAA does not contain recent soil modification but contains multiple degrees (e.g., high, moderate, or low) of recovery from past soil modification, the narrative for the highest applicable score should be chosen. If the wetland contains both recent and past soil modification, the most prevalent type should be used to choose the most appropriate score.

While recent soil modifications are generally very clear when characterizing a soil profile, indicators of recovery from past modifications are often more difficult (e.g., historic land clearing and agricultural uses such as cropping, pasturing, etc., may only modify the upper soil profile). Redoximorphic features may develop quickly but organic accumulation, structure, and horizon development generally require longer periods to develop and are more difficult to accurately characterize especially for the non-soil scientist (Vepraskas, 2001; Collins and Kuehl, 2001; Vasilas and Vasilas, 2003; Vasilas et al. 2003; SSSA, 2023).

Prior to scoring, consider the following:

- *Use supporting information in conjunction with on-site observations (i.e., soil profile characterizations, vegetative community composition and structure, indicators of disturbance, invasive or aggressive native species, etc.) to identify potential soil modifications to determine the "best fit" narrative score. Consider how these potential sources of modification may have impacted the soils in the WAA.*

- *Additionally, use supporting information to identify the percentage of the WAA with soil modifications, the intensity level of modifications, and the timeframe where recovery initiated. For example, areas with large contingents of woody vegetation (especially large trees) suggest low intensity modifications, small areas of modification, or longer recovery periods resulting in more advanced soil morphological development.*

- *As stated above, because redoximorphic features can develop quickly, they are not always a good indicator of recovery from past modifications. In contrast, indicators such as organic accumulation, development of structure, horizons, etc., are more difficult to accurately assess the rate and amount of development or recovery. <u>Therefore, soil modification is scored based primarily on evidence of modification to soil development indicators.</u> For example, soil profiles that have low intensity modifications will often exhibit many of the indicators discussed above. When evaluating indicators of soil modification, consider what would be expected for the wetland class and site hydrology (e.g., a seasonally saturated mineral flat would have low organic matter relative to permanently saturated depression).*

- *In situations where the WAA contains multiple degrees (e.g., high to low) of past soil modifications, score the <u>most prevalent</u> type or best fit. If warranted, delineate separate WAAs.*

4 = Wetlands with minimal or no signs of soil modification, have well developed soil profiles and no indicators of past disturbance (see data form). **<u>OR</u>** areas with past disturbances of low-level intensity (cropping, logging, etc.) or comprise only a small portion of the WAA. Examples are historically cropped areas that have reverted to advanced stages of forest (complete or high recovery) and restored, rehabilitated, or enhanced wetlands that have predominantly original hydric soil profiles, are supported by strong hydrophytic plant communities, and confirmed wetland hydrology.

3 = Wetlands with some level of soil modification (i.e., generally of low intensity) is evidenced by having one indicator of past soil modifications (see data form). Much of the WAA may contain original hydric soil profiles and no indicators of past disturbance. Examples include but are not limited to abandoned cropland that have reverted to varying stages of woody vegetation, restored/rehabilitated/enhanced wetlands with large areas of original hydric soil profiles, or well established created/restored/enhanced wetlands that exhibit multiple indicators of hydric soil development and are supported by a hydrophytic plant community and verified wetland hydrology.

2 = Wetlands with moderate amounts of soil modification of varying intensities evidenced by two indicators of past disturbance (some original hydric soil profiles may exist). Examples include abandoned silviculture and agricultural lands (e.g., mixed rangeland, old-field) and established created/restored/enhanced wetlands with some original soil profiles, evidence of hydric soil development, and or are supported by other verified wetland parameters.

1 = Wetlands with large areas of soil modification often of higher intensity evidenced by three or more indicators of past disturbance listed on the data form. These areas include recently abandoned cropland, pasture, hay land, lawns, etc., that are often compacted due to regular ongoing manipulation by machinery (examples include) and have sparse or no woody vegetation or herbaceous perennials. For example, recently completed created/restored/enhanced wetlands (<5 years in the ground) that appear to be developing wetland parameters.

0 = Wetlands where a significant portion of the WAA (>50%) has high intensity soil modifications and no signs of recovery or areas with past soil modification exhibiting most or all the indicators of past disturbance listed on the data form. For the most part, the soil modification is ongoing, and examples include cropping, land clearing/leveling, stumping, and most grading associated with land development.

2.3.4 Physical Structure Core Element

2.3.4.1 Topographic Complexity

2.3.4.1.1 Description

The topographic complexity metric is a measure of the variability in surface elevations in the wetland as well as physical features that create micro-highs and micro-lows. This increase in surface roughness facilitates the opportunity for various functions to be performed in the wetland such as increased water retention time (Mack 2001, Adamus et al. 2010). Increased complexity of microtopographic features create small scale vertical relief which increases surface area enabling processes such as biogeochemical cycling of nutrients and providing wildlife habitat for a variety of wildlife and specialized plants (Byers 2019). This diversity of habitats and organisms associated with increased topographic complexity also improves the conditional response of a wetland to periods with water levels higher or lower than average. In addition, topographic complexity creates variability in nutrient cycling, organic carbon accumulation, and sediment storage which lead to enhanced ecological complexity (Collins et al. 2008).

2.3.4.1.2 Evaluation of the Topographic Complexity Metric

The topographic complexity metric is evaluated based on field observations of the abundance of micro-topographic features (surface roughness) and elevation gradients within the WAA. Characterization of topographic relief is important because the slope of the water table often parallels the topography of the land surface (Fetter 1980). Within the WAA, identify and record the number of elevation gradients that affect the level of saturation/inundation or the path of water flow.

Elevation gradients typically have greater than six inches of difference with a corresponding change in saturation/inundation, soil condition, and/or vegetation (Figure 34). The presence of elevation gradients produce variation of hydroperiods and accompanying moisture gradients, often reflected as variable plant assemblages or patches resulting from this variation of frequency and duration in saturation/inundation. An elevation gradient must comprise at least 10% of the WAA to be considered in the evaluation of this metric. Excessive elevation gradients within the WAA (e.g., > 36”) may not meet wetland conditions (i.e., non-wetlands) but may provide many of the same processes and different plant zones.

Figure 34. Example of elevation gradients. *This depression wetland in Dorchester County illustrates a wetland with two elevation gradients (> 6"), each with microtopography. Elevation gradients must represent at least 10% of the WAA.*

Additionally, observe and record the abundance (i.e., percentage) of micro-topographic relief within the WAA (Figure 35). If more than one elevation gradient is present in the WAA, estimate the percentage of micro-topography for each elevation gradient, as well as the percentage of the WAA made up by each elevation gradient, to determine the overall percentage of micro-topography in the WAA. That is, multiply the percentage of micro-topography by the percentage of the WAA for each gradient and sum the results to find the overall percentage of micro-topography in the WAA. Micro-topography includes micro-highs and micro-lows that are generally interspersed, local in extent, and typically have 3–6 inches of elevation difference from the surrounding area with a corresponding change in saturation/inundation, soil condition, and/or vegetation.

Figure 35. Example of microtopography. *This photo of a mineral flat wetland in Anne Arundel County demonstrates high topographic complexity as over 50% of the WAA has 3-6 inches of variation in elevation.*

To be effective in permanently inundated areas, micro-topography should result in habitat variation in one of the characteristics above to be counted. If the WAA is flooded at the time of assessment, and micro-topography is difficult to measure (i.e., not practical to estimate based on walking in the WAA), then micro-topography should be assumed to be moderate and scored based on professional judgment using the number of elevation gradients. Examples of features that may be present and indicate micro-topographic relief include depressions, pools, burrows, swales, wind-thrown tree holes, mounds, islands, variable shorelines, partially buried debris, debris jams, and plant hummocks/roots. Additionally, rotting logs in advanced stages of decomposition are considered as they have become an organic component of the soil.

Based on the observations of elevation gradients and micro-topography, score this metric using Table 13 in Section 2.3.4.1.4 below. In general, most wetlands with topographic complexity either have multiple elevation gradients with low micro-topography or have a single elevation gradient with abundant micro-topography. Some wetlands with topographic complexity may have multiple elevation gradients but only one elevation gradient that contains micro-topography. Figures 36-38 illustrate examples of topographic complexity. Appendix A provides examples of wetlands with different levels of topographic complexity.

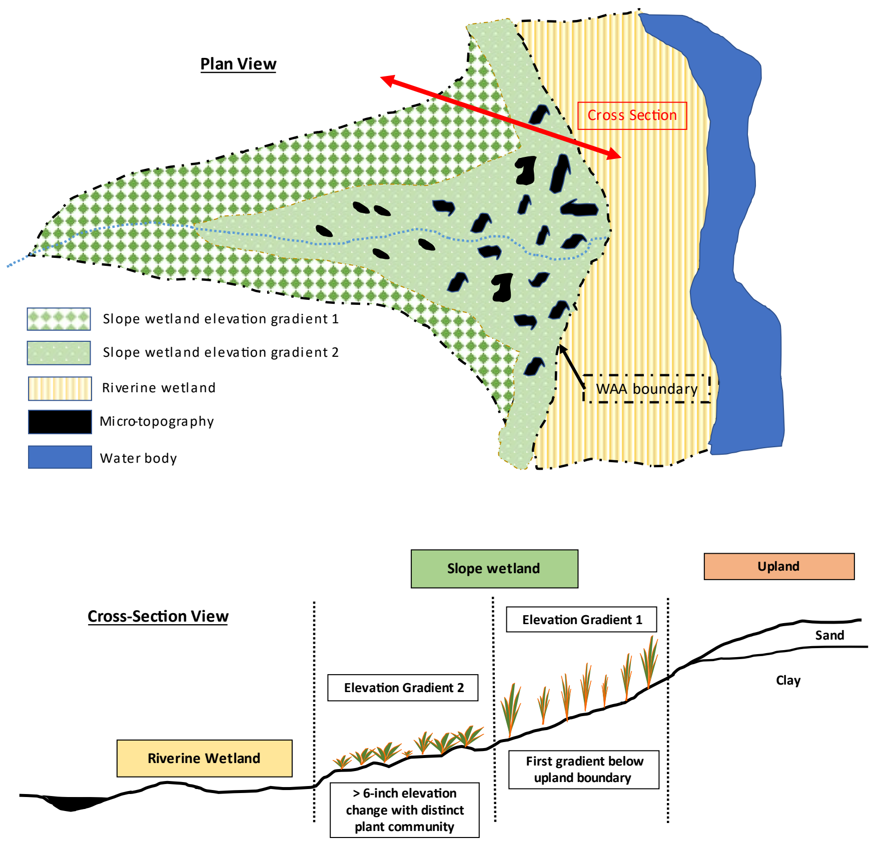

Figure 36. Example of topographic complexity in a slope wetland. Gradients are signified by > 6-inch elevation change and often a corresponding change in vegetation composition. In this example, the WAA has two elevation gradients and greater than 50% micro- topographic features, and thus would score a "4" for the topographic complexity metric.

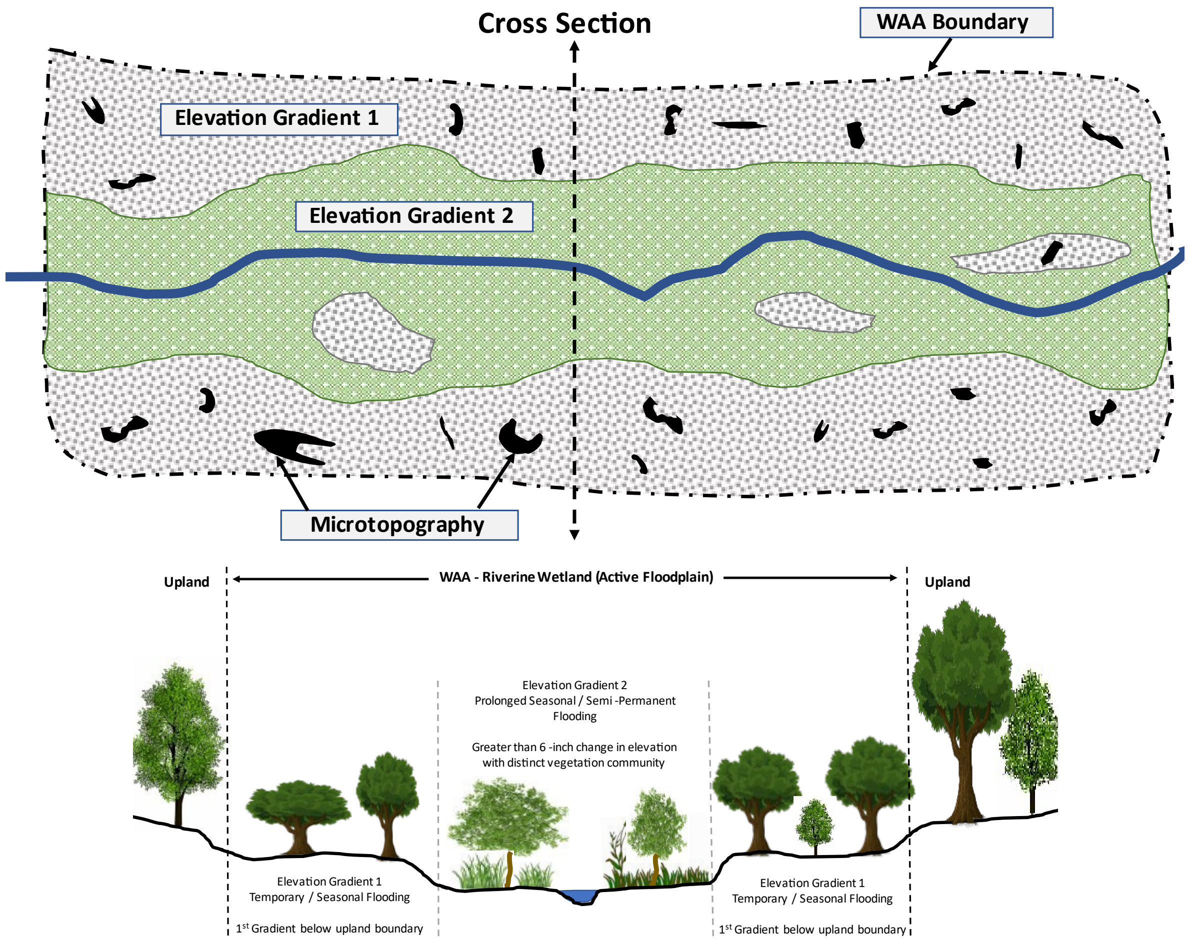

Figure 37*. *Example of topographic complexity in a riverine wetland. In this example, the WAA has two elevation gradients and 10–29% micro- topographic features, and thus would score a “3” for the topographic complexity metric.

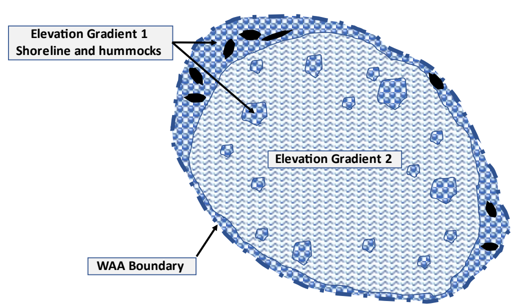

Figure 38*. *Example of topographic complexity in a depression (Delmarva Bay) wetland. In this example, the WAA has two elevation gradients and 10-29% micro- topographic features, and thus would score a “3” for the topographic complexity metric.

2.3.4.1.3 Topographic Complexity Metric Wetland Class and Ecoregion Considerations

The topographic complexity metric is evaluated and scored the same for all wetland classes regardless of the types of topographic features that may occur in a different wetland class or ecoregion. In addition, topographic complexity should be distinguished from changes in geomorphic position that indicate a change in wetland class. As each WAA contains a single wetland class, topographic features that confirm a change of hydrogeomorphic classification should be evaluated separately for each wetland class. Since each WAA should only contain a single wetland class, topographic features that indicate a change in hydrogeomorphic classification, and thus wetland class, should not be considered in the evaluation of this metric. For example, a slope wetland that abuts a riverine wetland can be distinguished by the topographic break from a hillside to a floodplain. In this case, each wetland would have a separate WAA, and the evaluator would consider topographic complexity separately without crossing the topographic break.

2.3.4.1.4 Topographic Complexity Metric Scoring

The topographic complexity metric is scored using Table 13 below to locate the overall percentage of micro-topography in the WAA (using the methods described in Section 2.3.4.1.2) for the applicable number of elevation gradients observed in the WAA. Figure 39 provides an illustration of scoring the topographic complexity metric by elevation gradients and percentage of micro-topography.

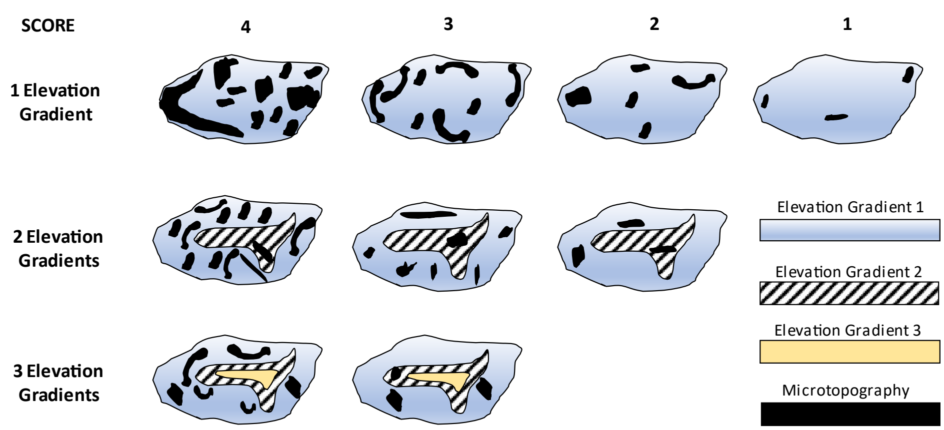

Figure 39. Examples of different scores for the topographic complexity metric. *The threshold for microtopography decreases with additional gradients.*

Table 13. Scoring topographic complexity metric by elevation gradients and percentage of micro-topography

Score	*1 Elevation Gradient*	*2 Elevation Gradients*	*≥ 3 Elevation Gradients*
4	≥ 50% Micro-topography	≥ 30% Micro-topography	≥ 15% Micro-topography
3	30–49% Micro-topography	10–29% Micro-topography	< 15% Micro-topography
2	10–29% Micro-topography	< 10% Micro-topography	–
1	< 10% Micro-topography	–	–

2.3.4.2 Edge Complexity

2.3.4.2.1 Description

The edge complexity metric measures the horizontal irregularity and vertical structure of the wetland boundary. Wetland boundaries with a high degree of edge complexity increases the interface between the wetland and surrounding habitats as well as the structural variation with micro-habitats.

This “edge effect” or ecotone presents more physical habitat complexity resulting in a beneficial effect to the diversity and abundance of species that utilize wetlands. An irregular wetland edge can augment habitat structure and provide shelter, thus enhancing diversity and abundance of fish and invertebrates, particularly in narrow fringe wetlands (Adamus et al. 1991). Wetlands with an irregular shape are also more likely to have greater interspersion of cover classes and more edge which supports the diversity and abundance of wetland dependent birds (Adamus et al. 1991).

2.3.4.2.2 Method of Evaluation

The edge complexity metric is evaluated through a combination of qualitative field observations and review of pertinent supporting information (GIS and or other mapping tools). This information presents the degree of horizontal variability in the wetland edge or boundary (e.g., convolution, sinuosity, or irregularity) and the vertical structure variability of habitat surrounding the WAA (Figure 40). Vertical structure variability is generally defined as the WAA edge surrounded by a different, vegetated habitat class which results in edge complexity related to increased availability of micro-habitats at the interface.

The addition, distribution, and or density of one or more plant strata may indicate vertical structure variability, or a change in the density of a particular stratum (e.g., tree canopy or shrub stems), often presents a distinct change to the vertical structure of the adjacent plant community when viewed along the edge of the WAA. Shifts in species composition in an adjacent plant community along the WAA edge (e.g., apart from strata variation), may not alone be sufficient to confirm a change in vertical structure variability, unless there is a distinct and significant change in plant height or density that results in an increase in habitat complexity at the WAA edge. While many different forms or types of vertical structure variability may exist at the WAA edge, scoring is dependent on whether it is present or absent when considering this metric. Information should be documented based on the characteristics that led to the determination that vertical structure variability exists (Figure 41 and the data sheet in Appendix C). Additionally, changes in vertical structure variability of the edge are considered for natural conditions, and not the result of human disturbance associated with vegetative alterations. The habitat type surrounding the WAA must abut a reasonable amount (at least 30%) of the WAA perimeter to be considered as vertical structure variability.

Investigators should record qualitative observations of WAA setting and surrounding habitat conditions, vertical structure variability (type, characteristics, and amount of habitat surrounding the WAA which creates vertical structure variation/complexity with micro-habitats, as discussed in the sections below), as well as horizontal edge variability. Using the qualitative observations, score the edge complexity metric using Figures 40-41 and the narratives below. Appendix B provide examples of wetlands with different edge complexity.

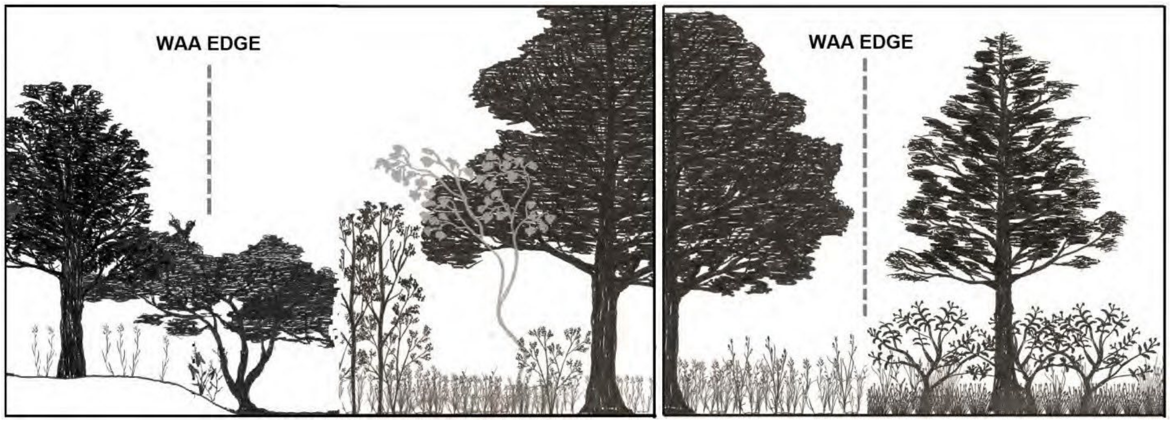

Figure 40. Examples of vertical structure variability (adapted from USACE 2015)

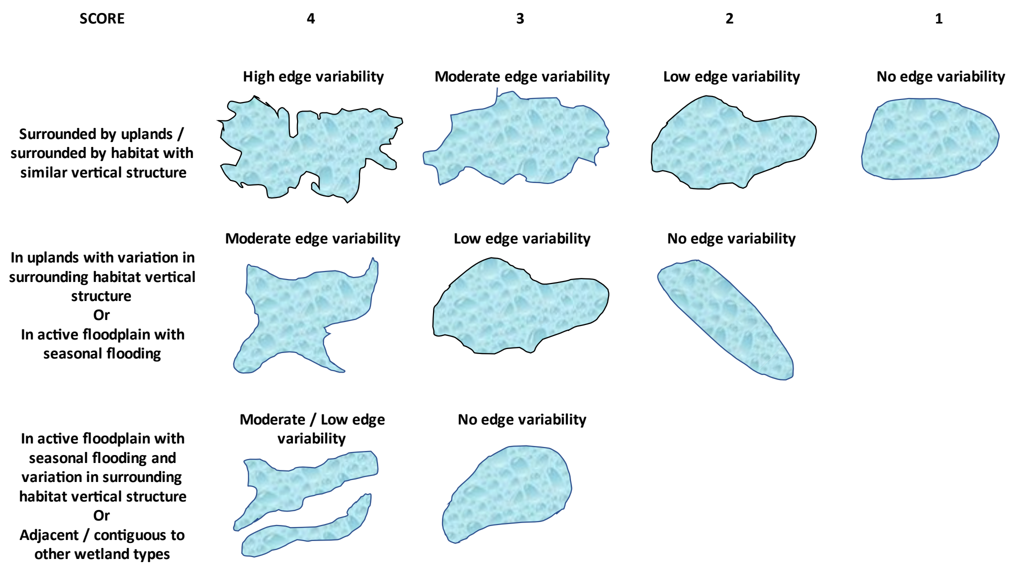

Figure 41. Examples of variability in the wetland boundary for use in qualitative evaluation of the edge complexity metric (revised from USACE 2015).

2.3.4.2.3 Wetland Class and Ecoregion Considerations

The edge complexity metric is evaluated and scored the same for all wetland types. Since the wetland boundary with open water can potentially fluctuate based on climatic and other conditions, and since open water is not present in all wetlands, the wetland-to-open water edge is not considered in this metric. For wetlands abutting open water (e.g., lacustrine fringe and depression wetlands), only the wetland-upland and wetland-wetland edge should be evaluated in this metric. Therefore, wetland-open water boundaries are not considered with this metric.

When the WAA is in a seasonal floodplain or those that abut or are surrounded by other wetland classes scores should be based on the horizontal complexity of the edge and the vertical structure variability using the second or third lines in Figure 41. In this case, an explanation of the scoring rationale should be provided on the data sheet and final scoring sheet. These areas are afforded additional value to account for the edge complexity related to increased quality of micro-habitats at the interaction of seasonally flooded communities. The habitat type abutting the WAA should make up a reasonable amount (at least 30%) of the WAA perimeter to be considered.

2.3.4.2.4 Scoring Narratives

The edge complexity metric is evaluated using a combination of the horizontal and vertical edge variability with consideration for the hydrologic setting/surrounding habitat conditions, as shown in Figure 39 and following the scoring narratives below.

4 = Wetlands with high edge complexity.

3 = Wetlands with moderate edge complexity.

2 = Wetlands with low edge complexity.

1 = Wetlands with no edge complexity.

2.3.4.3 Physical Habitat Richness

2.3.4.3.1 Description

The physical habitat richness metric is a measure of the number of different physical habitat types that occur in a wetland. Physical habitat types are different structural surfaces and features that support the living requirements of flora and fauna. The richness of physical habitat types in a wetland reflects the diversity of physical processes in a wetland (e.g., energy dissipation and water storage). These processes promote natural ecological complexity (e.g., biological diversity, bio-chemical activity) and provide an indication of the overall condition and ecological functions of a wetland (Collins et al. 2008).

2.3.4.3.2 Physical Habitat Richness Metric Method of Evaluation

The physical habitat richness metric is evaluated in the field based on observations of the presence (at a sufficient size) of a habitat type. Examine the entire WAA for the presence of physical habitat types and record the physical habitat types present (based on size requirement below) using the check boxes on the data forms and which are defined below. In addition, areas within 25 feet of the WAA boundary are also included as they are reasonably available to wildlife using the wetland and its boundary. The 25-foot area mirrors MDEs current non tidal wetland buffer requirement. To qualify as a habitat type, the size of the feature should generally support the living requirements of characteristic flora and fauna. For the consistency of this assessment, the minimum habitat size is defined as 36 square feet for aquatic (e.g., pools) and vegetation (e.g., thick herbaceous cover) habitat types, whereas no minimum size applies to other structural habitat types (e.g., snags). Physical habitat types should be reasonably common within the WAA and therefore, magnifies the need for the investigator to examine as much of the WAA as possible. The physical habitat types potentially present for each wetland class are discussed in the section below. Score the metric using the information in Section 2.3.4.3.4 below.

The physical habitat types are defined as follows (adapted from Collins et al. 2008, USACE 2015).

A. ***Concentric high-water marks***: these are concentric marks in wetlands that are frequently inundated for long to very long duration. Common examples include staining on tree trunks, woody debris, and moss trim lines. Higher variation of inundation/saturation in a wetland often results in higher variation of vegetation types thereby increasing ecological diversity by providing alternate habitats for wildlife.

B. ***Secondary channel***: are surface drainage features (bed and banks) that confine and convey flood flows that overflow from a primary channel. A tributary that originates in a wetland and conveys flow between the wetland and a primary channel is also considered a secondary channel. These are often a collection of multiple groundwater discharges.

C. ***Seasonally inundated swale***: these surface features are broad, elongated, and often vegetated depressions that entrap and often convey water at least seasonally. They serve as a continuous surface connection to a primary channel occasionally conveying flood flows in larger events but generally lack channel morphological characteristics. Note, these can include seasonally inundated ditches.

D. ***Un-vegetated pool***: Shallow depressions lacking vegetation but retain water longer than surrounding areas during dry periods. Shallow concave surface hydrology indicator. Common in mineral flats.

E. ***Un-vegetated flat***: an area of sediment or rock that lacks vegetation and is a potential resting and feeding area for shore birds, wading birds, and other water birds. Exposed shorelines along impoundments or streams during natural or manipulated drawdown.

F. ***Vegetated island***: an area of land above the normal high-water level that is usually surrounded by water and supports macro phytic vegetation. Root wads of trees or shrubs in depressions are examples.

G. ***Slope with undercut, slump, or overhang***: a slope (as on a stream bank or shoreline) with a portion of the soil that has broken away or been excavated by water to form a hollow or void which provides habitat for fish or wildlife. Overhanging roots of trees are an example.

H. ***Rock or rock piles with voids***: a rock or pile of rocks of sufficient size and with sufficient space underneath or in-between to provide shelter for fish or wildlife such as amphibians, reptiles, and small mammals. These are most common in the Eastern Mountains and Piedmont ecoregion.

I. ***Plant hummocks/sediment mounds***: areas higher than the surrounding elevation created by decomposing wind-thrown trees, plants (e.g., sedges, rushes), elevated root wads of woody species, and accumulated sediment.

J. ***Submerged/floating vegetation***: true aquatic macrophytes that occur below or on the water surface and provide habitat for macro-invertebrates, fish, and other organisms.

K. ***Thick herbaceous cover***: a dense layer of the stems, leaves, and litter of herbaceous plant species that create a canopy that shades the soil surface and serves as cover for wildlife.

L. ***Brambles/thickets***: a dense clump, patch, or layer of the stems/branches of woody plants (e.g., vines, shrubs, and saplings) that provide cover for wildlife. Thickets surrounding open depressions are an example.

M. ***Mature/late-successional stage of plant community***: a community that has reached a state of maturity or equilibrium with natural environmental conditions (including disturbance such as fire) and that provides unique and/or highly valuable habitat for wildlife (e.g., mature timber bottomland, fens). Maturity or successional stage of a plant community is often determined by the amount of time since a disturbance or stress based on the species composition and/or age (e.g., trees >24" diameter breast height).

N. ***Drift deposits/organic debris/brush piles/fallen logs***: an accumulation of woody or leafy debris, heaps of remnant vegetation, or dead tree trunks laying on the ground surface which provide cover for wildlife.

O. ***Standing snags/stumps***: any dead woody vegetation that remains standing and provides habitat for birds or small mammals.

P. ***Wind-thrown trees***: trees uprooted and blown over by wind that may leave depressions and exposed roots for wildlife habitat as well as patches for plant regeneration and increased diversity.

Q. ***Tree root cavities/pneumatophores***: aboveground or aerial roots of woody plant species, such as bald cypress knees, that provide micro-habitats for other plants to grow on or for wildlife to use as cover. Trees that are not completely wind thrown may produce cavities for wildlife cover.

R. ***Nesting cavity/den***: a hole or hollow in a tree that provides cover for wildlife.

S. ***Other***: a type of physical surface or feature, different from those listed and defined, that supports the living requirements of flora or fauna. They may be natural, or may include constructed features (e.g., nest boxes, amphibian shelter, etc.) but are subject to the USACEs discretion and approval.

2.3.4.3.3 Physical Habitat Richness Metric Wetland Class and Ecoregion Considerations

Not all physical habitat types are present in every wetland class, so this metric evaluates the number of physical habitat types present in a wetland based on the total expected for that wetland class. The lacustrine fringe subclass is included separately from other riverine subclasses in Table 14 due to its unique characteristics because of impoundment.

Even though the characteristics and abundance of each physical habitat type may vary by ecoregion, this metric has been developed so that the different habitat types apply throughout the two ecoregions. Since this metric evaluates the number of different types present, no modifications to the metric are necessary for different ecoregions.

2.3.4.3.4 Physical Habitat Richness Metric Scoring

The physical habitat richness metric is scored by using Table 14 below and the number of physical habitat types present in the WAA for the appropriate wetland class.

Table 14. Scoring by wetland class for the physical habitat richness metric.

Score	Riverine	Lacustrine Fringe (subclass)	Depression	Slope	Mineral Flat
4	≥ 10	≥ 7	≥ 7	≥ 7	≥ 8
3	8-9	5-6	5-6	5-6	6-7
2	6-7	3-4	3-4	3-4	4-5
1	≤ 5	≤ 2	≤ 2	≤ 2	≤ 3

2.3.5 Biotic Structure Core Element

2.3.5.1 Plant Strata

2.3.4.5.1 Plant Strata Metric Description

The plant strata metric is a measure of the number of different plant strata that are present in a wetland. A stratum is a grouping of plants based on growth form, height, and other characteristics. The number of plant strata present influences the richness of the plant community and the diversity/complexity of the biotic structure. The greater the complexity of the biotic structure is correlated to increased wetland condition (Collins et al. 2008).

2.3.4.5.2 Plant Strata Metric Method of Evaluation

The plant strata metric is evaluated in the field using the information recorded on wetland determination data form(s) for the appropriate Regional Supplement (e.g., Eastern Mountains and Piedmont or Atlantic and Gulf Coastal Plain) or by confirming submitted data collected for plant strata (using adequate sampling as described below). Strata used in this evaluation include tree, sapling, shrub, herbaceous (including emergent, submergent, and non-rooted floating plants), and woody vine. Both Regional Supplements that are currently used in Maryland provide a 4 or 5 strata approach, while either are appropriate for wetland delineation, the 4 strata approach, which combines shrub and sapling strata, will be used to score this metric.

Individual strata must have at least 5% or more total plant cover to qualify as a stratum in the WAA (or within a particular vegetation community type, if more than one occurs in a WAA). An adequate number of vegetation sample plots should be performed to accurately characterize the representative plant community diversity in the WAA. As described in Section 2.2.5.2, a wetland determination data form should be completed for each vegetation community within the WAA.

Additional sampling and wetland determination data forms may also be warranted for a single vegetation community that is heterogeneous, diverse, or large. If a WAA has more than one wetland determination data form, the strata from all the forms should be counted. However, a stratum should not be counted more than once if it is present on more than one wetland determination data form.

The strata from a vegetation community should only be counted if the community itself is 10% or more of the WAA. The cover of submergent and floating (non-rooted) macrophyte species shall be included in the evaluation of the herbaceous stratum as these plants are important substrate for algae involved in nutrient uptake and a food source for vertebrates and habitat for detritivores. Then determine the number of plant strata that are present in the WAA and score the metric using the narratives below. Appendix B provides examples of wetlands with different numbers of plant strata.

2.3.4.5.3 Plant Strata Metric Wetland Class and Ecoregion Considerations

Except for wetlands in the lacustrine fringe regional subclass, wetland classes and subclasses in both ecoregions usually have similar plant strata so modifications to this metric are not warranted. Lacustrine wetlands generally are limited to one stratum, herbaceous cover. However, there are some wetlands in this subclass that may support other strata but are generally uncommon.

2.3.4.5.4 Plant Strata Metric Scoring Narratives

The plant strata metric is scored using the narratives below. *Note, it is common that some wetland types will naturally lack one or more strata particularly if the hydrologic regime is perennial (i.e., fringe wetlands, perennially flooded or saturated Delmarva Bays and fens).*

4 = Wetlands with four or more plant strata.

3 = Wetlands with three plant strata.

2 = Wetlands with two plant strata.

1 = Wetlands with one plant strata.

0 = Wetlands with no plant strata (e.g., abnormal circumstances such as an impacted, cleared, or recently created wetland, etc.).

2.3.5.2 Species Richness

2.3.5.2.1 Description

This metric evaluates an aspect of the plant species diversity of a wetland and is measured by the number of species present in a wetland. Healthy condition and optimal function in a wetland are usually reflected by the presence of a rich assemblage of native plants. A rich plant community will generally exhibit a seed bank that can maintain vegetative productivity and stability even when environmental conditions fluctuate.

2.3.5.2.2 Method of Evaluation

The species richness metric is evaluated in the field from information collected and recorded on the wetland determination data form(s) or by confirming the data collected on vegetation (using adequate sampling as described in Section 2.2.5.2 and the procedures below). The total number of species counted in this metric are determined by estimating and recording the absolute percent cover of each species as in the “Procedure for Selecting Dominant Species by the 50/20 Rule” in the regional supplements. However, once the absolute percent cover of each species is estimated, this evaluation will differ from the regional supplements by counting any species that constitutes 5% or more relative cover in a stratum using the following steps.

1. After recording absolute cover for each species in a stratum, calculate the total coverage of all species in a stratum by summing the individual absolute percent cover values. The total of the absolute cover estimates will not necessarily equal 100%.

2. Calculate relative percent cover for each species in a stratum by dividing the individual absolute percent cover for that species by the total absolute cover for the stratum.

3. Repeat these steps for other stratum present, noting that a stratum is defined as having 5% or more total plant cover.

4. Count the number of unique species that constitute 5% or more relative cover in a stratum.

The absolute percent cover of submergent and floating (non-rooted) macrophyte species in the herbaceous stratum are to be included. Species that occur in multiple strata or multiple forms should be counted only once. Thus, a species is only counted once no matter how many strata it occurs in with 5% or more relative cover. See examples in Table 15 and Appendix D.

Lastly, because some species may not be captured in the sampling plots, but are obviously common within the WAA, they should be added to the total if they constitute at least 5% relative cover within the WAA. Supporting rationale on the MDWAM data form is required.

Table 15. Example of calculations for species richness metric using a 4 strata approach.

Strata	Absolute Cover (%)	Relative Cover (%)	Count in Species Richness
Tree stratum			
Acer rubrum	30	50	Yes
Quercus phellos	20	33	Yes
Nyssa sylvatica	10	17	Yes
Total	**60**	**100**	**-**
Sapling/shrub stratum			
Liquidambar styraciflua	20	67	Yes
Acer rubrum	10	33	No (Duplicate)
Total	**30**	**100**	**-**
Herbaceous stratum			
Carex lupulina	70	61	Yes
Cinna arundinacea	40	35	Yes
Leersia virginica	5	4	No
Total	**115**	**100**	**-**
Vine stratum			
Smilax rotundifolia	4	-	No
Total	**4**	**-**	
Number of unique species for richness (not counting a species more than once):		**6**	

An adequate number of vegetation sample plots should be completed to adequately characterize the species richness in the WAA. As described in the procedures, a wetland determination data form should be completed for each vegetation community within the WAA. Large, diverse, or heterogeneous vegetation communities may require multiple data forms to adequately characterize species richness.

However, for a WAA that has species present on multiple forms, they will be counted only once (those that constitute 5% or more relative cover in a stratum on a single form). If a WAA has multiple vegetative communities within it, the species from a vegetation community should only be counted if that community makes up 10% or more of the WAA. Determine the number of species in the WAA using the methods described herein and score this metric using the tables below.

2.3.5.2.3 Wetland Class and Ecoregion Considerations

Wetland class influences the number of species expected for a particular condition due to variations in plant species richness with different hydrogeomorphic characteristics. For example, wetlands with low variation of the hydroperiod will often have low species richness. For this reason, the lacustrine fringe subclass is called out separately from other riverine subclasses as the expectation for the number of species is lower. On the other hand, plant species richness increases with high variation of the hydroperiod or with increased flowthrough in a wetland (Mitsch and Gosselink 2000). Therefore, when evaluating the number of species, the scoring for this metric considers the typical flowthrough and hydroperiod variability for each wetland class.

There are no considerations for ecoregion for this metric as climatic conditions are similar.

Area, disturbance, stress, competition, and management are other factors that influence plant species richness, but these factors are expected to accompany variations in condition and are not accounted for separately in this metric.

2.3.5.2.4 Scoring Narratives

The species richness metric is scored using Table 16 using the column for the applicable wetland class and number of species counted in the wetland using the methods described above.

Table 16. Scoring species richness metric

Score	Riverine	Lacustrine Fringe (riverine subclass)	Depression	Slope	Flat
4	≥ 11	≥ 9	≥ 8	≥ 7	≥ 10
3	9-10	7–8	6–7	5–6	8-9
2	6-8	5–6	4–5	3–4	6-7
1	≤ 5	≤ 4	≤ 3	≤ 2	≤ 5

2.3.5.3 Non-native/Invasive Infestation

2.3.5.3.1 Description

The non-native/invasive infestation metric is a measure of the presence and abundance of non-native and invasive species in a wetland. It estimates the level of colonization of a wetland community by non-native and invasive (native and non-native) plants. An infestation or invasion by non-native plant species can degrade the form, structure, and function of a wetland ecosystem (Collins et al. 2008 and Ervin et al. 2006). For instance, reed canary grass (*Phalaris arundinacea)* is believed to be indigenous to North America and can grow in a wide range of environmental conditions. It can transform an emergent wetland from diverse native species to a monotypic stand, especially in agricultural areas with nitrate inputs. It has been documented to colonize preferentially post-disturbance moist denuded sites achieving rapid and near total dominance over other native wetland plant communities (Galatowitsch, S.M. & E.K. Green). Aggressive invasive species such as this limits native plant recruitment, productivity, and function for wildlife habitat especially when human-induced alterations (e.g., nutrient input, hydrology manipulations, etc.) present favorable conditions to become overwhelmingly dominant (e.g., greater than 80% cover). This is common in wetland restoration and mitigation efforts and the means for increasing species richness is through hydrological, chemical, or mechanical management.

Table 17. List of common native and nonnative invasive species encountered from field testing of MDWAM in Maryland. This is a short list of invasives, an expanded list is available by consulting the list of Invasive Species of Concern in Maryland at https://mdinvasives.org/species-of-concern/.

Native Invasives	Species	Nonnative Invasive	Species
Reed canary grass	*Phalaris arundinacea*	Bush Honeysuckles	*Lonicera species*
Broadleaf cattail	*Typha latifolia*	Japanese Honeysuckle	*Lonicera japonica*
		Multiflora Rose	*Rosa multiflora*
		Narrow Leaf Cattail	*Typha angustifolia*
		Wild Or European Privet	*Ligustrum vulgare*
		Creeping Jenny	*Lysimachia nummilaria*
		Marsh Dewflower	*Murdannia keisak*
		Japanese Stilt Grass	*Microstegium viminea*
		Carp Grass	*Arthraxon hispidus*
		Autumn Olive	*Eleaganus*
		European Barberry	*Berberis vulgaris*
		Common reed	*Phragmites australis*
		Bradford Pear	*Pyrus calleryana*

2.3.5.3.2 Method of Evaluation

The non-native/invasive infestation metric is evaluated based on quantitative data collected in the field during completion of the wetland determination data form or by confirming the data collected on vegetation (see note on collecting quantitative data in Section 2.2.5.2). Although the vegetation sampling should follow the applicable regional supplement, as noted in Section 2.2.5.2 and the previous section on vegetation sampling for the species richness metric, the WAA may contain multiple vegetation communities or a single vegetation community that is heterogeneous, diverse, or large, and thus require multiple sample plots and wetland determination data forms to adequately quantify the percent cover of non-native/invasive species. Calculate the average total relative percent cover of non-native/invasive species using the following steps.

1. After the vegetation in a WAA has been sampled, the native or non-native (i.e., introduced) status of each species can be determined using the following sources:

Species of Concern in Maryland (https://mdinvasives.org/species-of-concern/, Maryland Invasive Species Council https://mdinvasives.org/, the USDA-NRCS plants database (http://plants.usda.gov/) or other pertinent source. Native species considered invasive include but are not limited to cattail (*Typha spp.*) and reed canary grass *Phalaris arundinacea*). Other native species acting as invasive may be considered on a case-by-case basis in coordination with the USACE.

2. For each stratum present, divide the absolute cover of each non-native/invasive species by the total absolute cover for that stratum to find the relative percent cover of the species in that stratum.

3. For each stratum individually, sum the relative percent cover of each non- native/invasive species in that stratum to find the total relative percent cover for each stratum.

4. Finally, take the average of the total relative percent cover of non-native/invasive species for each stratum present (see examples in Tables 18-19 below).

5. For a WAA with multiple sample plots and wetland determination data forms, the average total relative percent cover for each form should further be averaged together for the entire WAA.

6. Some species of invasive plants may not be adequately captured or omitted due to plot location. Therefore, additional sampling plots may be added to accommodate this situation or species are added from observations during the data collection provided the species comprise at least 5% relative cover within the WAA. Rationale for including non-plot-based additions should be provided on the MDWAM data form.

Examples of a wetland exhibiting non-native/invasive infestation are provided in Appendix B.

Table 18. Example 1 of calculations for non-native/invasive infestation metric (4 strata)

Vegetative Strata	*Non- Native/Invasive*	*Absolute Cover (%)*	*Relative Cover of NN/I (%)*
Tree Stratum			
Ulmus americana	No	40	-
Plantanus occidentalis	No	20	-
Salix nigra	No	10	-
Total		70	***0***
Sapling/Shrub Stratum			
Acer negundo	No	20	-
Cornus amomum	No	15	-
Lonicera morrowii	Yes	5	13
Total		40	***13***
Herbaceous Stratum			
Microstegium viminea	Yes	60	67
Poa trivialis	No	30	-
Total		90	***67***
Woody Vine Stratum			
Toxicodendron radicans	No	10	**-**
Total		10	***0***
Average of total relative percent cover for non-native/invasive species for tree, shrub, herbaceous, and woody vine strata (%):			**20**

Table 19. Example 2 of calculations for non-native/invasive infestation metric (5 strata)

Vegetative Strata	*Non- Native/Invasive*	*Absolute Cover (%)*	*Relative Cover of NN/I (%)*
Tree Stratum			
Acer rubrum	No	45	-
Quercus phellos	No	25	-
Liquidambar styraciflua	No	10	-
Total		**80**	***0***
Sapling Stratum			
Nyssa sylvatica	No	20	-
Acer rubrum	No	15	-
Quercus phellos	No	5	-
Total		**40**	
Shrub Stratum			
Vaccinium corymbosum	No	25	
Rosa multiflora	Yes	15	30
Liquidambar styraciflua	No	10	
Total		**50**	***30***
Herbaceous Stratum			
Murdannia kiesak	Yes	60	57
Cinna arundinaria	Yes	45	-
Total		105	***57***
Woody Vine Stratum			
Toxicodendron radicans	No	15	-
Lonicera japonica	Yes	10	*40*
Total		**25**	***40***
Average of total relative percent cover for non-native/invasive species for tree, sapling, shrub, herbaceous, and woody vine strata (%):			***27***

2.3.5.3.3 Wetland Class and Ecoregion Considerations

Some wetland classes (e.g., riverine) are inherently more susceptible to non- native/invasive plant infestation due to their generally high connectivity to other ecosystems. However, because all wetland classes are susceptible to and degraded by non-native/invasive plant infestation this metric is measured and scored the same for all wetland classes. No modifications to this metric for different ecoregions are warranted as non-native/invasive plant species are ubiquitous and degrade wetlands in all ecoregions.

2.3.5.3.4 Scoring Narratives

The non-native/invasive infestation metric is scored using the narratives below.

4 = Wetlands with less than 1% average total relative percent cover of non-native/invasive species.

3 = Wetlands with 1–10% average total relative percent cover of non-native/invasive species.

2 = Wetlands with 11–25% average total relative percent cover of non-native/invasive species.

1 = Wetlands with 26–100% average total relative percent cover of non-native/invasive species.

2.3.5.4 Interspersion

2.3.5.4.1 Description

This metric is a measure of the internal complexity of the plant community within a wetland. It is a qualitative measure of the variety of distinct plant zones or patches and the amount of edge produced between them. These zones or patches may occur as monocultures or obvious multi-species associations of plants which often correspond to variations in surface elevations (i.e., gradients or benches) and thus, variable moisture gradients within the wetland (Collins et al 2008). The numerous elevated root masses or bases of trees in depression wetlands such as Delmarva Bays is a prime example. While the number of zones can be significant, this metric should not be scored based on numbers alone, rather, it should also consider their arrangement and the degree of edge they produce. Increased spatial complexity of plant zones in a wetland normally translates to healthy ecosystem processes and a well-developed plant community. Furthermore, wetlands with a higher degree of interspersion generally will have richer biotic diversity.

2.3.5.4.2 Method of Evaluation

The interspersion metric is best evaluated in the field but may be supported using aerial photography and LiDAR. However, the size of plant zones or canopy closure often distort or prevent detection using supporting information and therefore, should be evaluated on the ground. The abundance and distribution of plant zones should be evaluated in plan view; that is, as viewed from above the wetland or seen in an aerial photograph. A plant zone (i.e., different associations of plants resulting from elevation and/or hydrologic gradients) may be comprised of one or more plant species which may be discontinuous from similar plant zones, vary in size, shape, and number within the WAA. Plant associations evaluated in this metric must comprise <u>at least 5% total cover</u> in the WAA to be considered and may consist of a single or multiple strata. Use the diagrams in Figure 42 in combination with the scoring narratives below to determine the different degrees of interspersion.

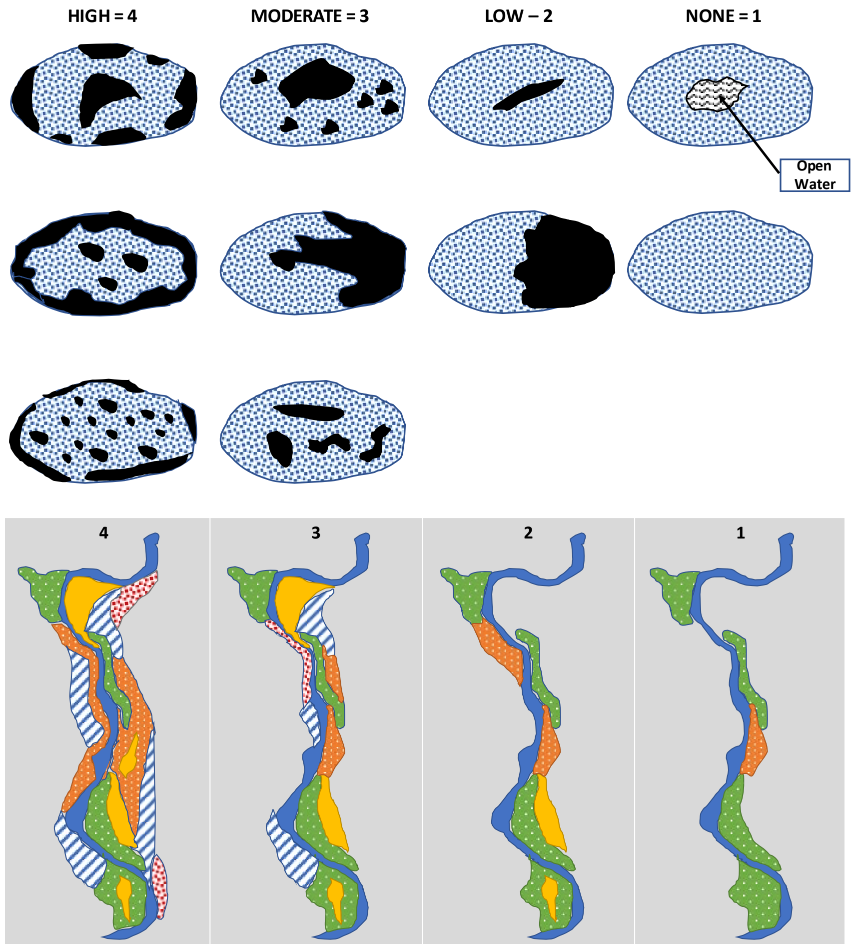

Figure 42. Examples of different degrees of interspersion for use in evaluating the interspersion metric (from *USACE 2015*)***.*** *Each pattern or color represents a different plant zone which constitutes at least 5% cover in the WAA.*

In general, high interspersion is characterized as three or more plant zones, with one or more of the plant zones in multiple patches/locations in the WAA, and high variability of the boundaries between the plant zones. Moderate interspersion is characterized as three concentric plant zones with low boundary variability or as two plant zones with high boundary variability and/or with multiple patches of a single plant zone. Low interspersion is characterized as two plant zones with low boundary variability and does not typically contain multiple patches of a single plant zone. No interspersion is characterized as a single plant zone, with or without open water within the WAA. Appendix B provide examples of wetlands with different interspersion.

2.3.5.4.3 Wetland Class and Ecoregion Considerations

Wetland classes are generally evaluated and scored similarly for the degree of interspersion. Wetland classes such as Lacustrine Fringe, beaver impoundments and depressions are often associated or integrated with varying degrees of open water and/or SAV components. SAV is an important part of the biotic structure of wetlands and should be considered as a plant zone if it comprises at 5% or more cover in the WAA. Open water lacking rooted vegetation (e.g., submergent, emergent, or woody vegetation) are not considered a plant zone and not evaluated for this metric (floating vegetation such as *Lemna, Wolfia, and Spiradela,* are not considered). Timing of observation is paramount when viewing open water particularly on aerial photography as many species of SAV, floating and emergent vegetation may be absent or undetectable.

Modifications to this metric for different ecoregions are not warranted as interspersion of the plant community in a wetland is associated with richer biotic diversity and higher condition regardless of ecoregion.

2.3.5.4.4 Scoring Narratives

The interspersion metric is scored using the narratives below.

4 = Wetlands with a high degree of horizontal interspersion. Vegetation patches are large and intertwined or numerous and scattered throughout the WAA.

3 = Wetlands with a moderate degree of horizontal interspersion. A small step down from the above.

2 = Wetlands with a low degree of horizontal interspersion. Patches are localized and not intertwined with other types presenting much less diversity.

1 = Wetlands with no horizontal interspersion. Very little diversity present favors specialized species.

2.3.5.5 Herbaceous Cover

2.3.5.5.1 Description

The herbaceous cover metric is a measure of the abundance of emergent annual and perennial herbaceous plants in a wetland. Wetland plants and their associated algal and microbial communities remove and transform nutrients from water and sediment. Herbaceous plants are more efficient at nutrient removal and transformation than woody plants, and typically provide more surface area for the attachment of algae and microbes which remove and transform nutrients. Dense herbaceous vegetation can also create frictional resistance to water flow which increases water retention time and sediment retention which also enhances nutrient removal and transformation (Adamus et al. 1991). Wetlands in urban landscapes that score low in many of the other metrics may still perform important nutrient cycling functions. Hence the herbaceous cover metric is important for assessing the condition of nutrient cycling in these wetlands.

Wetlands occurring in urban and agricultural landscapes often score low in many of the other metrics but may still perform important nutrient cycling functions. Therefore, the herbaceous cover metric remains essential for assessing the condition of nutrient cycling in these wetlands. For instance, dense stands of *Phalaris arundinacea* and *Typha latifolia* occur in many Maryland wetlands suggesting high probability to perform nutrient cycling functions despite a degraded overall condition.

2.3.5.4.2 Method of Evaluation

The herbaceous cover metric is evaluated using the total cover of herbaceous (i.e., emergent and submergent) plants in a WAA. The total cover is a qualitative estimate of percentage of all herbaceous cover observed in the entire WAA including emergent and submergent plant species. “Covered” is defined as the presence of the above-ground portions of plants (e.g., stems and leaves) covering the ground surface when viewed from above, and all submergent rooted floating plants below the water surface but above the substrate. The evaluation of this metric differs from the wetland delineation manual and regional supplements by only measuring the total cover of all herbaceous plants, and thus not considering the cover of individual species and plant foliage that overlaps. Additionally, small woody plants normally included in the delineation data form (< 1 meter) are also excluded. Therefore, the cover estimate in this metric corresponds to the percentage of the WAA that is vegetated with emergent and submergent species. Record the total herbaceous cover and score this metric based on the narratives below. Appendix B provide examples of wetlands with different herbaceous cover.

2.3.5.4.3 Wetland Class and Ecoregion Considerations

Wetland classes such as mineral flat and some depression wetlands (i.e., perennially inundated Delmarva Bays) notoriously lack herbaceous cover, mostly due to canopy closure and or long-term inundation. However, while this characteristic often results in a low score for this metric and a lower overall score, this is accepted as the norm for these wetland classes and no modifications are made.

Modifications to this metric are not warranted for different wetland classes and/or ecoregions since the herbaceous cover is assumed to influence the condition of nutrient cycling regardless of wetland class and/or ecoregion.

2.3.5.4.4 Scoring Narratives

The herbaceous cover metric is scored using the narratives below.

4 = Wetlands with greater than 75% herbaceous plant cover.

3 = Wetlands with 51–75% herbaceous plant cover.

2 = Wetlands with 26–50% herbaceous plant cover.

1 = Wetlands with 25% or less herbaceous plant cover.

2.3.5.6 Vegetation Alterations

2.3.5.6.1 Description

This metric evaluates and measures the presence of man-made or unnatural physical, chemical, and biological modifications or stressors to native vegetation within the WAA. Modifications usually range in severity from partial impacts to complete vegetation removal. Alterations can include, but are not limited to, physical impacts such as mowing/shredding, cutting, timber harvest, woody debris removal, and trampling or herbivory by domestic animals.

Additionally, disking, plowing, grading, and excavation increase severity potentially delaying or eliminating recovery. Lastly, the application of herbicides, chemical spills, and other unnatural stressors (organic and inorganic pollution) can have a long-lasting effect on plant communities which usually degrade wetland condition and degrade the form, structure, and function of a wetland ecosystem.

The presence of aggressive invasive plant species (i.e., *Phalaris arundinacea* and *Murdannia kiesak*) that may prevent natural volunteer vegetation from establishing, as well as introduced pests and disease (i.e., emerald ash borer, gypsy moth, Dutch elm disease, etc.), present challenges to scoring this metric as many are now naturalized in Maryland. For example, green ash (*Fraxinus pennsylvanica)* is a common dominant species that has been devastated by the ash borer in many Maryland wetlands. Consequently, the expectation for recovery is extremely low and these forests will likely experience a permanent change in species composition and structure potentially resulting in a lower score for this metric. Furthermore, these types of alterations perpetuate colonization by invasive species such as Japanese stilt grass (*Microstegium viminea*).

2.3.5.6.2 Method of Evaluation

The vegetation alterations metric is evaluated based on field observations of the extent and severity of alterations which were presented in the previous section. Natural disturbances are not evaluated for this metric but may include herbivory and other disturbances caused by domestic animals. Mitigated wetlands (created, restored, enhanced) should be evaluated based on unnatural vegetation alterations (e.g., mowing, herbicides, plantings, etc.,) occurring after the development of a hydrophytic vegetation community. This may include wetlands that have developed adjacent to a human-made or beaver impoundments.

Vegetative alterations will vary in the degree of severity, which is paramount in determining how long it will take a vegetative community to recover and more importantly, the degree of recovery (e.g., complete, or partial). For example, the vegetation community in an emergent wetland altered by mowing will generally recover more rapidly and completely than in a wetland polluted by a chemical spill. In addition, the severity of an alteration may depend on the type of vegetation community affected. For example, the temporal severity of clearcutting a mid to late successional forested wetland dominated by loblolly pine (*Pinus taeda*) is substantially less than clearing in a mature hardwood forest dominated by red maple (*Acer rubrum*) and pin oak (*Quercus palustris*).

MDWAM considers recent alterations as the current condition having occurred within the past five years and past alterations as those from which the vegetation community has begun to recover. Historic aerial photography should be reviewed to estimate the percentage of the WAA with any past vegetation alterations. Determine the percentage of the WAA that has past alteration from historic aerial photos. The current condition of the vegetative community may also provide insight into the type and severity of past alterations that may have occurred (e.g., lower rate of succession in comparison to surrounding areas or other wetlands of the same class).

However, when evaluating past vegetation alterations, consider other factors such as normal climatic conditions (e.g., drought) that may have influenced the vegetation community. While speculative at this point, climate change will likely influence recovery of vegetative communities. Where past vegetation alterations can be documented, the degree of recovery should be evaluated when scoring this metric. Assess the degree of recovery similarly to the severity of alteration described above. Evaluate the degree of recovery by considering the expectation that full recovery of the vegetation community will occur and the time frame for this to occur. In addition, a determination of the level of recovery is made by comparing the existing vegetation community with the mature, natural vegetation community (i.e., mature, or late-successional stage) expected for that wetland class and ecoregion.

Alterations that are designed to improve wetland condition, should be evaluated in accordance with the degree to which recovery of the natural vegetation community has been successful. For example, shredding to reduce competition for tree seedlings, prescribed burning to reduce shrub competition, or herbicide treatment to control invasive species and increase species richness. Evaluate the extent and severity (e.g., high, or low) of recent vegetation alterations in the WAA, as well as the degree of recovery from past alterations (e.g., complete, high, moderate, low), and score this metric using the narratives below. While a particular WAA may have both recent and past vegetation alterations, the total usually should not exceed 100%. However, there are circumstances where an entire WAA recovering from a past severe alteration (i.e., land clearing and cropping) may also include recent, low severity alterations. Examples of wetlands exhibiting vegetation alterations are provided in Appendix B.

2.3.5.6.3 Wetland Class and Ecoregion Considerations

As vegetation alterations may occur in any wetland classes or ecoregions, no modifications for this metric are warranted.

2.3.5.6.4 Scoring Narratives

The vegetation alteration metric is evaluated using the following narratives. Note that if the WAA plant communities were recently altered and contain multiple levels of severity (e.g., high, and low), the narrative for the lowest applicable score should be chosen. However, if the WAA does not contain recent vegetation alteration but contains multiple degrees (e.g., high, moderate, or low) of recovery from past vegetation alteration, the narrative for the highest applicable score should be chosen. Additionally, if the WAA contains both recent and past vegetation alterations which fit different scoring narratives, then the narrative and score for the most prevalent vegetation alternation class should be used to choose the appropriate score. Furthermore, alterations that are the result of management to improve ecological conditions should be scored based on degree of recovery or resulting improvement to the natural vegetation community. Lastly, where plant communities have permanently changed due to past alterations and represent the new normal circumstance, score based on the current condition. For example, as discussed in Section 2.3.5.6.1, introduced parasites (e.g., emerald ash borer, etc.) and various diseases (Dutch elm, etc.) can result in a permanent change in species composition.

4 = Wetland vegetative communities with no record of past alterations or with past alterations exhibiting complete recovery (late/mature successional stage). For wetland vegetative communities with recent alterations, the alterations are minimal (< 5% of WAA - low severity) and / or localized.

3 = Wetland vegetative communities with past alterations that exhibit a high degree of recovery (mid-successional stage generally dominated by a mixture of woody canopies). For wetland vegetative communities with recent alterations, the alterations are minor (~5-25% of WAA with low severity).

2 = Wetland vegetative communities with past alterations that exhibit a moderate degree of recovery (various stages of Oldfield or early successional forest habitat). For wetland vegetative communities with recent alterations, the alterations are moderate (~25-50% of WAA - low severity and/or < 25% of WAA - high severity).

1 = Wetland vegetative communities with past alterations that exhibit a low degree of recovery (low-successional stage). For wetland vegetative communities with recent alterations, the alterations are major (> 50% of WAA - low severity and/or ~25-50% of WAA - high severity).
0 = Wetlands with more than 50% of the WAA with high severity of recent vegetation alterations without recovery (activities are ongoing or recovery is restricted). Examples may include farmed wetlands, managed pastureland, hay land, utility corridors and right of way corridors.

Definitions:

- *<u>Recent vegetative alterations</u> are defined as occurring within the past 5 years.*

- *<u>Low severity</u> = the nature of the alteration is temporary from activities such as selective logging or spraying, mowing, bush hogging, etc. Adequate living stock such as smaller woody stems, stumps, rooted perennials, and seed bank are present to promote subsequent regeneration.*

- *<u>High severity</u> = the physical and or chemical alteration is severe and generally long lasting. Activities such as clearcutting, stumping, grubbing, land leveling, fill, inundation, non-selective herbicide application, disease, continuous agricultural practices, or other similar management/conversion that effectively prevent or delay recovery of the native vegetation.*

- *<u>Creation</u> = mitigation areas should be scored based on the degree of success toward the targeted wetland class being replaced.*

- *<u>Restored or enhanced</u> = wetlands are scored based on the degree the mitigation replicates the natural condition. As multiple degrees of success or recovery may be present – choose the most prevalent condition.*

2.3.5.7 Plant Life Forms

2.3.5.7.1 Description

The Plant Life Forms metric identifies the number of different plant structure classes that are present within the WAA. Each plant life form provides unique functions for animal habitat as well as influencing hydrologic and physical processes. Wetlands with multiple life forms provide a greater diversity and complexity of biotic structure, which in turn provides the complexity of habitat for all forms of native fauna (Collins et al 2008). Each life form must have at least 5% relative cover in the WAA to be considered.

Life Form Definitions (adapted from Collins et al 2008):

Bryophytes*:* Non-vascular land plants, consisting of a large group of seedless, flowerless, fruitless green plants including the mosses, liverworts, and hornworts. Bryophytes lack the specialized tissues xylem and phloem that circulate water and dissolved nutrients in the vascular plants. Bryophytes generally live on land but are mostly found in moist environments, for they have free-swimming sperm that require water for transport. Mosses and most liverworts have clearly recognizable leaves on stems, but totally lack a root system, while hornworts and some liverworts lack a leaf-stem differentiation. Examples in Maryland include *Sphagnum spp., Rhizomnium glabrescens, Climacium americanum,*

Coniferous trees*:* Gymnosperms that have reproductive structures in cones. They are typically evergreen and have drought-resistant leaves that are needle-shaped or scalelike. This group generally includes pines, spruces, hemlocks, cypresses, junipers, and cedars. Examples include *Pinus taeda*, *Pinus virginiana*, *Tsuga canadensis*, *Chamaecyparis thyoides*, and *Taxodium distichum*.

Deciduous Broadleaf trees*:* Trees with leaves that fall seasonally. Examples include *Acer rubrum, Nyssa sylvatica, Liquidambar styraciflua, Quercus bicolor, and Quercus palustris*.

Evergreen Broadleaf trees*:* Evergreen trees that are never leafless; usually pertaining to leaves that remain green and on the plant for more than one season, and that do not fall seasonally, or to plants that are never leafless. Broadleaf trees are angiosperms that have flat leaves and produce seeds inside of fruits. Examples include *Ilex opaca*, *Rhododendron maximum*, *Kalmia latifolia*.

Ferns*:* A vascular plant that reproduces via spores. Ferns do not have seeds or flowers. Examples include *Onoclea sensibilis, Thelypteris palustris, Osmundastrum cinnamomeum, and Osmunda regalis*.

Grasses*:* Monocotyledonous plants of the family Poaceae, which can be perennial or annual. Characterized by narrow, blade shaped leaves with sheaths, and jointed stems. Examples include *Poa trivialis, Glyceria striata, Cinna arundinacea, Calamogrostis canadensis, and Andropogon virginicus*.

Herbs*:* Plants that, at least above ground, are generally non-woody and of less than one year or growing season in duration. Examples include *Boehmeria cylindrica, Saururus cernuum, Persicaria sagitatum.*

Lichens or fungi*:* Lichen is a symbiosis of algae or cyanobacteria living among fungi. Fungi is a eukaryotic organism that does not photosynthesize. They are the principal decomposers of organic matter. Examples include *Ischnoderma resinosum, Trametes versicolor, Cladonia cristatella*.

Sedges/Rushes*:* Sedges are graminoid flowering plants that have stems with triangular cross sections. Rushes are graminoid flowering plants that have round stems. For example, *Carex typhina, Carex lupulina, Juncus effusus, Juncus subcaudatus and Scirpus cyperinus*.

Shrubs*:* Woody plant of relatively short maximum height, with generally many branches from the base (Jepson e-flora). Examples include *Cornus amomum, Cephalanthus occidentalis, Clethra alnifolia and Vaccinium corymbosum*.

Vines*:* Trailing, twining, or climbing plant, usually attached to its support by the twisting or coiling of stems, tendrils, or other structures (Jepson e-flora). For example, *Toxicodendron radicans, Parthenocissus quinquefolia and Smilax rotundifolia.*

Special Notes: *Dead vegetation does not count towards life forms present.*

2.3.5.7.2 Method of Evaluation

This metric is evaluated by performing a visual estimate of the plant life forms that commonly occur within the WAA. This qualitative estimate may be informed by consulting the wetland data forms for several of the types. However, because some life forms bryophytes, lichens or fungi are not considered in the wetland data forms, an estimate must be performed during the field investigation. Identify and record those plant life forms that comprise at least 5% total relative cover within the entire WAA.

2.3.5.7.3 Wetland Class and Ecoregion Considerations

Because the listed Plant Life Forms may occur in all wetland classes and ecoregions, no modifications are warranted.

2.3.5.7.4 Scoring Narratives

This is a qualitative estimate of all plant life forms from delineation data forms and routine observations within the WAA. Note: several groups are not generally recorded on wetland delineation forms (e.g., bryophytes, fungi, etc.). Plant life forms must occur in at least 5% of the WAA (adapted from Collins et al 2008). Use the following table to score this metric.

Table 20. Scoring the plant life forms metric.

Total Number of Plant Life Forms	Score
≥ 6	4
4 or 5	3
3	2
1or 2	1
0	0

3.4 References

Adamus, P.R., L.T. Stockwell, E.J. Clairain, M.E. Morrow, L.D. Rozas, and R.D. Smith. 1991. *Wetland Evaluation Technique (WET); Volume I: Literature Review and Evaluation Rationale*. Technical Report WRP-DE-2, United States Army Engineer Waterways Experiment Station, Vicksburg, MS.

Babbitt, K.J. 2005. The relative importance of wetland size and hydroperiod for amphibians in southern New Hampshire,USA. *Wetlands Ecology and Management* **13**: 269-279.

Bergstrom, D. (1985) *Beavers: Biologists 'Rediscover' a Natural Resource*. Forestry Research West, United States Department of Agriculture, Forest Service.

Berkowitz, J. F., G. C. L. David, and K. Gordon. 2023. *Technical Guide for the Development, Evaluation, and Modification of Wetland Rapid Assessment Methods for the Corps Regulatory Program*. ERDC SR-23-3. Vicksburg, MS: US Army Engineer Research and Development Center.

Brewer, Gwenda L., Jason Harrison, and Peter Stango. 2023. *Field Manual for Rapid Ecological Integrity Assessments of Wetlands in Riparian Areas of Maryland. Coastal Plain Version 1.0* Prepared by Maryland Department of Natural Resources for Maryland Department of the Environment. 122 pp.

Brewer, Gwenda L., and Jason Harrison. 2023. *Field Manual for Rapid Ecological Integrity Assessments of Wetlands in Riparian Areas of Maryland. Piedmont Version 1.0* Maryland Prepared by Department of Natural Resources for Maryland Department of the Environment. 120 pp.

Brinson, M.M. 1990. *"Riverine forests." Forested wetlands*. A. E. Lugo, M. M. Brinson, and S. Brown, ed., Elsevier Scientific Publishers, Amsterdam, 87-141.

Brinson, M.M. 1993. *A Hydrogeomorphic Classification for Wetlands*. Technical Report WRP-DE-4, United States Army Engineer Waterways Experiment Station, Vicksburg, MS.

Byers, Elizabeth A. 2019. *User Manual for the West Virginia Wetland Rapid Assessment Method (WVWRAM). Version 0.52.* Watershed Assessment Branch, Division of Water and Wastewater Management, West Virginia Department of Environmental Protection, Charleston, WV.

Castelle, A.J., C. Conolly, M. Emers, E.D. Metz, S. Meyer, M. Witter, S. Mauermann, T. Erickson, and S.S. Cooke. 1992. *Wetland Buffers: Use and Effectiveness*. Adolfson Associates, Inc., Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Pub. No. 92-10. Olympia, WA.

Castelle, A.J., A.W. Johnson, and C. Conolly, 1994. *Wetland and Stream Buffer Size Requirements—A Review*. Journal of Environmental Quality, Vol. 23, No. 5, pp. 878– 882, Madison, WI.

Code of Federal Regulations, Title 33, Part 328, Section (§) 328.3 Definitions.

Collins, J.N., E.D. Stein, M. Sutula, R. Clark, A.E. Fetscher, L. Grenier, C. Grosso, and A. Wiskind. 2008. *California Rapid Assessment Method (CRAM) for Wetlands*, v. 5.0.2.

Collins, M. and R. Kuehl. 2001. *Organic Matter Accumulation and Organic Soils*. In J.L. Richardson and M.J. Vepraskas (eds.). Wetland Soils; Genesis, Hydrology, Landscapes and Classification. P. 137-162. Lewis Publishers, N.Y.

Cook, B.J., and F.R. Hauer. 2007. *Effects of Hydrologic Connectivity on Water Chemistry, Soils, and Vegetation Structure and Function in an Intermontane Depressional Wetland Landscape*. Wetlands, Vol. 27, No. 3, pp. 719–738. McLean, VA.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States* United States Fish and Wildlife Service, Washington, D.C.

Correll, D.L., Jordan, T.E. & Weller, D.E. (2000) *Beaver Pond Biogeochemical Effects in the Maryland Coastal Plain*. Biogeochemistry, **49**, 217–239.

Jacobs, A.D., D.F. Whigham, D.Fillis, E.Rehm, and A. Howard. 2009. *Delaware Comprehensive Assessment Procedure Version 5.2.* Delaware Department of Natural Resources and Environmental Control, Dover, DE 72pp.

Environmental Laboratory. 1987. *Corps of Engineers Wetlands Delineation Manual*. Technical Report Y-87-1, United States Army Engineer Waterways Experiment Station, Vicksburg, MS.
Ervin, G.N., B.D. Herman, J.T. Bried, and D.C. Holly. 2006. *Evaluating Non-native Species and Wetland Indicator Status as Components of Wetlands Floristic Assessment*. Wetlands, Vol. 26, No. 4, pp. 1114–1129. McLean, VA.

Fennessy, M.S., M.A. Gray, and R.D. Lopez. 1998. *An Ecological Assessment of Wetlands Using Reference Sites Volume 1: Final Report*. Final Report to USEPA. Ohio EPA, Wetlands Unit, Division of Surface Water.

Fennessy, M.S., A.D. Jacobs, and M.E. Kentula. 2007. *An Evaluation of Rapid Methods for Assessing the Ecological Condition of Wetlands*. Wetlands, Vol. 27, No. 3, pp. 543–560. McLean, VA.

Fetter, C. W., Jr. 1980. *Applied Hydrogeology*. Bell and Howell Co., Columbus, Floyd, K. P., R. D. Hoyt, and S. Timbrook. OH. 488 p.

Gleason, R.A., N.H. Euliss, Jr., D.E. Hubbard, and W.G. Duffy. 2003. *Effects of Sediment Load on Emergence of Aquatic Invertebrates and Plants from Wetland Soil Egg and Seed Banks.* Wetlands, Vol. 23, No. 1, pp. 26–34. McLean, VA.

Grasse, J.E. (1951) *Beaver Ecology and Management in the Rockies.* Journal of Forestry, **49**, 3–6.

Green, E. K. & S. M. Galatowitsch, 2002. *Effects of Phalaris arundinacea and Nitrate-N Addition on the Establishment of Wetland Plant Communities.* Journal of Applied Ecology, 39:134–144.

Griffith, G. E., J. M. Omernik, C. M. Rohm, and S. M. Pierson. 1994. *Florida Regionalization Project*. Corvallis, OR: USEPA, Environmental Research Laboratory.
Hammer, Donald A. (1992). *Creating Freshwater Wetlands*. Lewis Publishers.

Harthun, M. (2000) *Influence of the Damming-up by Beavers (Castor fiber albicus) on Physical and Chemical Parameters of Highland Brooks (Hesse, Germany).* Limnologica, **30**, 21–35.

Houlahan, J.E., P.A. Keddy, K. Makkay, and C.S. Findlay. 2006. *The Effects of Adjacent Land Use on Wetland Species Richness and Community Composition*. Wetlands, Vol. 26, No. 1, pp. 79–96, McLean, VA.

Huntly, N. (1995). How important are consumer species to ecosystem functioning? In: *Linking Species and Ecosystem* (Ed. by C.G. Jones & J.H. Lawton), pp. 72–83. Chapman & Hall, New York.

Iannone, B.V., III, S.M. Galatowitsch and C.J. Rosen. (2008). *Evaluation of Resource-Limiting Strategies Intended to Prevent Phalaris Arundinacea Invasions in Restored Sedge Meadows*. Ecoscience 15:508–518.

Keddy, Paul A. (2000). *Wetland Ecology Principles and Conservation*. Cambridge University Press.
Lowrance, R., R. Todd, J. Fail, Jr., 0. Hendrickson, Jr., R. Leonard, and L. Asmussen. 1984. *Riparian forests as nutrient filters in agricultural watersheds*. Bioscience 34:374-377.

Johns, D., H. Williams, K. Farrish, and S. Wagner. 2004. *Denitrification and Soil Characteristics of Wetlands Created on Two Mine Soils in East Texas, USA*. Wetlands, Vol. 24, No. 1, pp. 57–67. McLean, VA.

Mack, J.J. 2001. *Ohio Rapid Assessment Method for Wetlands v. 5.0, User's Manual and Scoring Forms*. Ohio EPA Technical Report WET/2001-1. Ohio Environmental Protection Agency, Division of Surface Water, 401/Wetland Ecology Unit, Columbus, OH.

Mitsch, W. J., C. L. Dorge, and J. R. Wiemhoff. 1977. *Forested wetlands for water resources management in southern Illinois.* Ill. Univ. Water Resour. Cent., Urbana-Champaign.

Mitsch W. J. and J.G. Gosselink. 2000. *Wetlands*. Third Edition. John Wiley & Sons, Inc. New York, NY.

Patrick, W. H., R. DeLaune, R. M. Engler, and S. Gotoh. 1976. *Nitrate removal Nutrient dynamics in an agricultural from water at the water-mud interface in watershed*: EPA 600/3-76-042. US Environmental Protection Agency, Corvallis, OR. 79 p.

Pollock, M.M., Naiman, R.J., Erickson, H.E., Johnston, C.A., Pastor, J. & Pinay, G. (1995) Beaver as engineers: influences on biotic and abiotic characteristics of drainage basins. In: *Linking Species and Ecosystem* (Ed. by C.G. Jones & J.H. Lawton), pp. 117–126. Chapman & Hall, New York.

Pruitt, B.A., Rheinhardt, R.D. 2023. *A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Riverine Wetlands in Alluvial Valleys of the Piedmont United States* ERDC/EL TR-16-__. Vicksburg, MS: United States Army Engineer Research and Development Center.

Pruitt, B.A. and F.R. Plewa 2024. *Identification of Best Attainable Reference Conditions: A Case Study.* ERDC/TN WRAP-xx-x. Vicksburg, MS: US Army Engineer Research and Development Center.

Richard D. Rheinhardt, Martha Craig Rheinhardt, Mark M. Brinson. 2002*. A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Wet Pine Flats on Mineral Soils in the Atlantic and Gulf Coastal Plains.* ERDC/EL TR-02-9. Engineer Research and Development Center, USACE, Vicksburg, MS.

Rokosch, A.E., V. Bouchard, S. Fennessy, and R. Dick. 2009. *The Use of Soil Parameters as Indicators of Quality in Forested Depressional Wetlands*. Wetlands, Vol. 29, No. 2, pp. 666–677. McLean, VA.

Semlitsch, R. D., and J. B. Jensen. 2001. *Core habitat, not buffer zone*. National Wetlands Newsletter 23 (4):5-6.

Skagen, S.K., C.P. Melcher, and D.A. Haukos. 2008. *Reducing Sedimentation of Depressional Wetlands in Agricultural Landscapes*. Wetlands, Vol. 28, No. 3, pp. 594–604. McLean, VA.

Smith, D. R., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. *An Approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices*. Technical Report WRP-DE-9, United States Army Engineer Waterways Experiment Station, Vicksburg, MS.

Stein, E.D., M.M. Brinson, M.C. Rains, W. Kleindl, and F.R. Hauer. 2009. *Wetland Assessment Debate*. Wetland Science and Practice, Vol. 26, No. 4, pp. 20–25. McLean, VA. SSSA. 2023. *Soil Basics* - Soil Science Society of America. https://www.soils.org › about-soils › basics

Stolt, M.H., and M.C. Rabenhorst. 1987. *Carolina Bays on the Eastern Shore of Maryland: I. Soil characterization and Classification.* Soil Sci. Soc. Am. J. 51:394-398.

Stolt, M.H., and M.C. Rabenhorst. 1987. *Carolina Bays on the Eastern Shore of Maryland: II. Distribution and Origin*. Soil Sci. Soc. Am. J. 51:399-405.
Strahler, A. N. (1952). *"Dynamic basis of geomorphology". Geological Society of America Bulletin* **63**: 923–938

Stolt, M.H., M.H. Genthner, W.L. Daniels, V.A. Groover, S.M. Nagle, and K.C. Haering. 2000. *Comparison of Soil and Other Environmental Conditions in Constructed and Adjacent Palustrine Reference Wetlands*. Wetlands 20 (4):671-683.

Sutula, M.A., E.D. Stein, J.N. Collins, A.E. Fetscher, and R. Clark. 2006. *A Practical Guide for the Development of a Wetland Assessment Method: The California Experience*. Journal of the American Water Resources Association, Vol. 42, No. 1, pp. 157–175. Middleburg, VA.

USACE and USEPA. 2008. *Compensatory Mitigation for Losses of Aquatic Resources*; Final Rule. 33 CFR Parts 325 and 332. 40 CFR Part 230. Federal Register / Vol. 73, No. 70 / Thursday, April 10, 2008 / Rules and Regulations.

United States Army Corps of Engineers. 2010. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Version 2.0)*. Ed. J.S. Wakeley, R.W. Lichvar, and C.V. Noble. ERDC/EL TR 10-20. Vicksburg, MS: United States Army Engineer Research and Development Center.

United States Army Corps of Engineers. 2012. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Eastern Mountains and Piedmont Region Version 2.0*, ed. J. F. Berkowitz, J. S. Wakeley, R. W. Lichvar, C. V. Noble. ERDC/EL TR-12-9. Vicksburg, MS: United States Army Engineer Research and Development Center.

United States Army Corps of Engineers. 2015a. *The TXRAM. Wetland and Streams Modules, Version 2.0. Final*

USACE (2015b). *Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions – Water Resources Region 02,* Mid-Atlantic. Civil Works Technical Report, CWTS-2015-09, USACE, Washington, DC.

United States Department of Agriculture, Natural Resources Conservation Service. 2018. *Field Indicators of Hydric Soils in the United States,* Version 8.2. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.). USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

United States Department of Agriculture, Natural Resources Conservation Service. 2022. *Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin*. United States Department of Agriculture, Agriculture Handbook 296.

United States Army Corps of Engineers, Baltimore District. *The Maryland Stream Mitigation Framework, Version 1 Final.* Published 20 September 2023.
Vasilas, L., and B. Vasilas. 2003. *Hydric Soil Identification Techniques*. In J.T. Anderson and C.A. Davis (eds.), Wetland Techniques: Volume 1: Foundations, P. 227-272. DOI 10.1007/978-94-007-6860-4_4, © Springer Science Business Media Dordrecht

Vasilas, B.; M. Rabenhorst; J. Fuhrmann; A. Chirnside, and S. Inamdar. 2003*. Wetland Biogeochemistry Techniques*. In J.T. Anderson and C.A. Davis (eds.), Wetland Techniques: Volume 1: Foundations, P. 355-442. DOI 10.1007/978-94-007-6860-4_4, © Springer Science+Business Media Dordrecht

Vepraskas, M. 2001. *Morphological Features of Seasonally Reduced Soils*. In J.L. Richardson and M.J. Vepraskas (eds.). Wetland Soils; Genesis, Hydrology, Landscapes and Classification. P. 163-182. Lewis Publishers, N.Y.

Werner, K.J., and J.B. Zedler. 2002. *How Sedge Meadow Soils, Microtopography, and Vegetation Respond to Sedimentation*. Wetlands, Vol. 22, No. 3, pp. 451–466. McLean, VA.