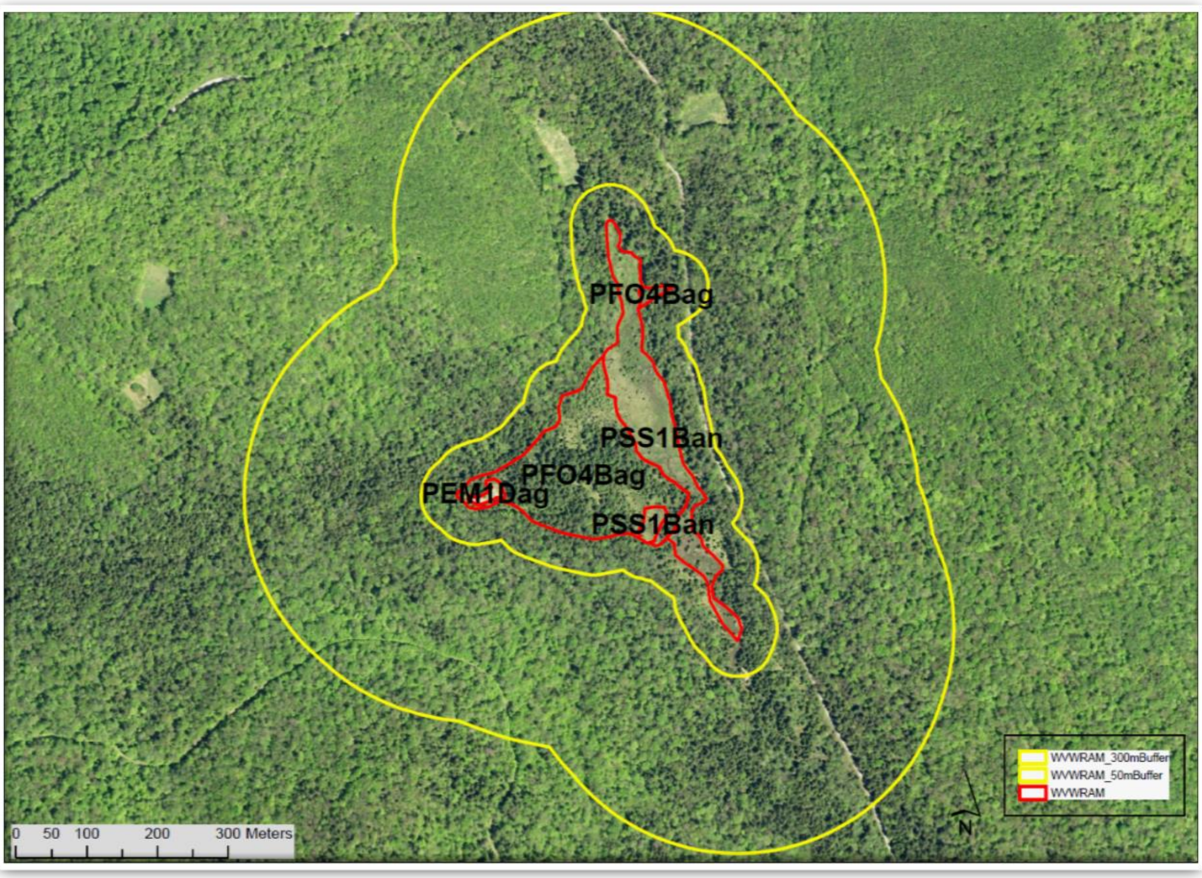
Reference Manual for theWest Virginia Wetland Rapid Assessment Method (WVWRAM)

May 1, 2020 Version 1.0

Watershed Assessment Branch
Division of Water and Wastewater Management
WV Department of Environmental Protection



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Contents

1.0 INTRODUCTION

1.1 Purpose

The West Virginia Wetland Rapid Assessment Method (WVWRAM) is a standardized protocol for rapidly assessing the functions, services, values, and condition of wetlands. The West Virginia Department of Environmental Protection (WVDEP) has developed this method in coordination with the West Virginia Division of Natural Resources (WVDNR), with funding from the U.S. Environmental Protection Agency's Wetland Program Development program. This document describes the data analysis and formulas behind the two-part wetland assessment method, which consists of a rapid field assessment and GIS assessment. The field and GIS protocol for users is described in the separate WVWRAM User Manual. The combined field and GIS assessment produces a broad palette of metrics that can be rolled up into composite scores for specific purposes. The regulatory wetland function score is designed to be used for actions related to the Clean Water Act, including permitting, compensatory mitigation and the in-lieu fee program. The WVDNR land acquisition score supports decision-making regarding state lands. The wetland condition score supports wetland monitoring activities at WVDEP. Additional roll-ups are possible depending on the particular needs of agencies and organizations for planning purposes and for conservation, restoration, enhancement, and protection of wetlands in West Virginia.

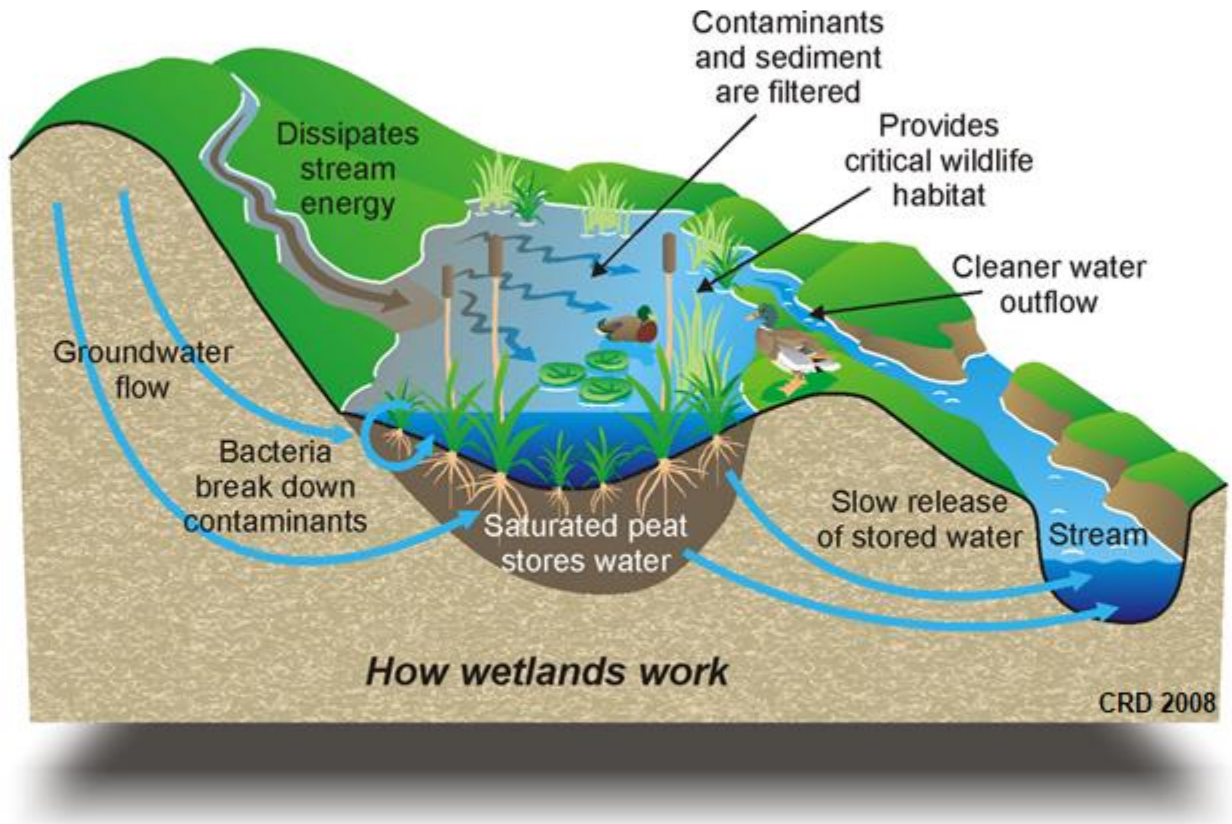
WVWRAM is applicable to wetlands of any type anywhere in West Virginia. After the field assessment is completed and the GIS assessment is run, metrics are generated which answer the following questions:

- How effective is the wetland in improving water quality downstream, including sediment retention, nutrient processing, and pollutant removal?
- How effective is the wetland in slowing and storing flood waters and providing base flow to streams?
- How effective is the wetland in providing wildlife habitat and maintaining biodiversity and ecological integrity?
- What is the current quality or condition of the wetland?

The field portion of WVWRAM is designed to be completed in 4 hours or less by a 2-person team. At least one person on the assessment team must have the skill level of a wetland delineator, i.e., the ability to identify dominant wetland plants, classify soils, understand hydrology, recognize stressors, and perform general field survey work. Assessors are strongly encouraged to attend WVDEP-approved training prior to implementation of the rapid assessment protocol. The GIS portion of the assessment requires a basic knowledge of ArcGIS mapping and shapefile creation. Data entry and final scoring is done in an MS-Access database.

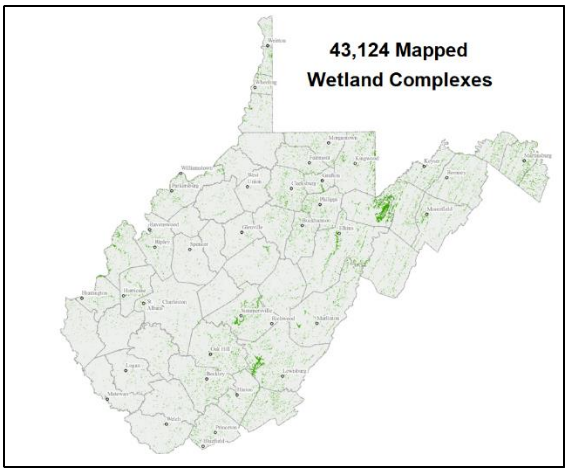
1.2 Background

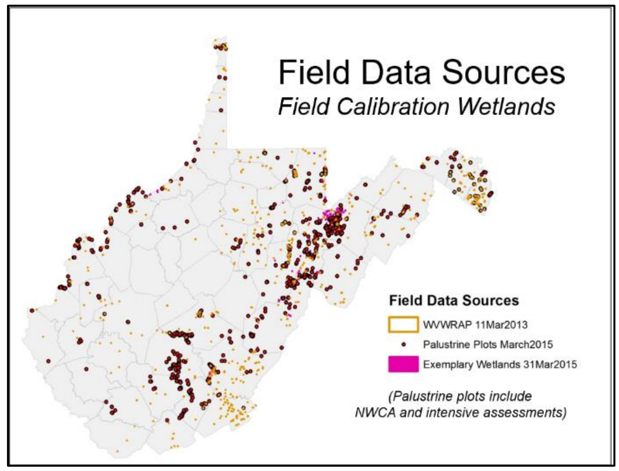
West Virginia and federal goals for "no net loss" of wetlands refer not only to acreage but also to the beneficial functions and services that wetlands provide in terms of filtering water, reducing sedimentation and flood flows, providing wildlife habitat, and maintaining ecological integrity. The primary drivers for developing WVWRAM were the need to (a) quantify functions and values of wetlands for regulatory programs and (b) provide information to state agencies and to the public to assist in avoidance of impacts and promote conservation of wetlands (Federal Register 2008, West Virginia Code 2012, WVDEP 2014).



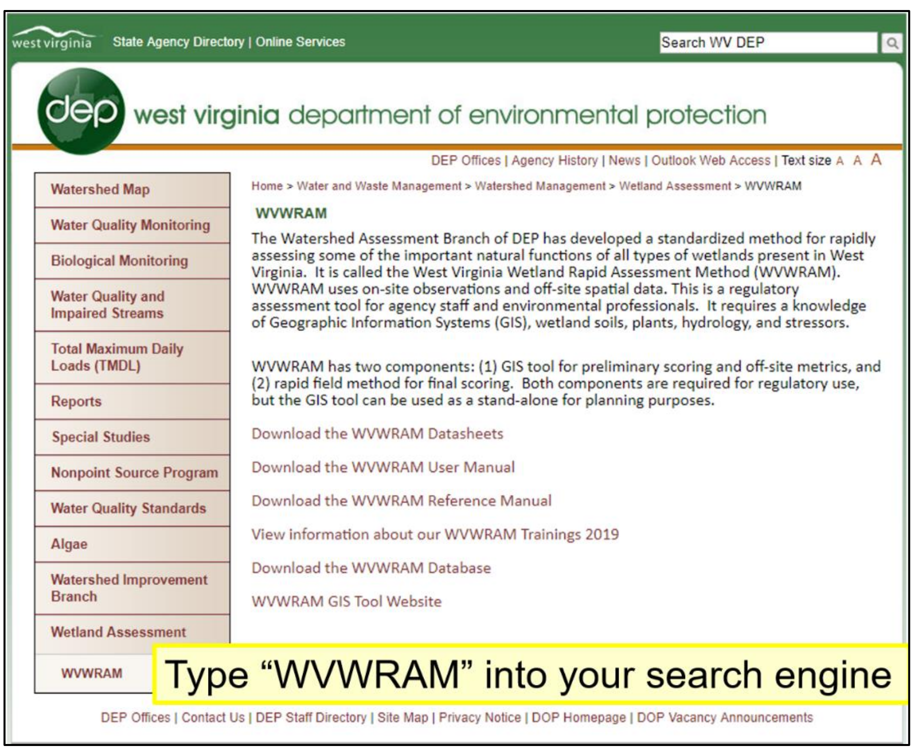
The functional assessment metrics that make up WVWRAM are based on validated approaches currently in use by other states and organizations, in particular those of Washington (Hruby 2012), Oregon (Adamus et al. 2010), California (CWMW 2013), Ohio (Mack 2001), Minnesota (Bourdaghs 2014), Wisconsin (Miller et al. 2017), and NatureServe (Faber-Langendoen et al. 2016). Washington, Oregon, California, Ohio, and NatureServe have performed specific validation and repeatability testing on their wetland functional assessments. The involvement of literally hundreds of wetland scientists in the testing processes, and the similarity of the final metrics, gives us confidence that the approaches are robust. The groundwork done for 605 wetland sites by West Virginia University (Veselka and Anderson 2011), and the 1667 wetland plots of the West Virginia Natural Heritage Program (WVDNR 2016) provided important data for adapting these validated functional assessment methods to the West Virginia context.

The GIS component of WVWRAM was developed based on data for 43,124 wetland complexes mapped in the state. The field component of WVWRAM was developed based on 2,273 wetlands with existing field data and 70 sites that were directly surveyed during method development. These sites are shown on the maps below.





Additional information and updates to WVWRAM are available on the WVDEP website: type "WVWRAM" into your search engine.



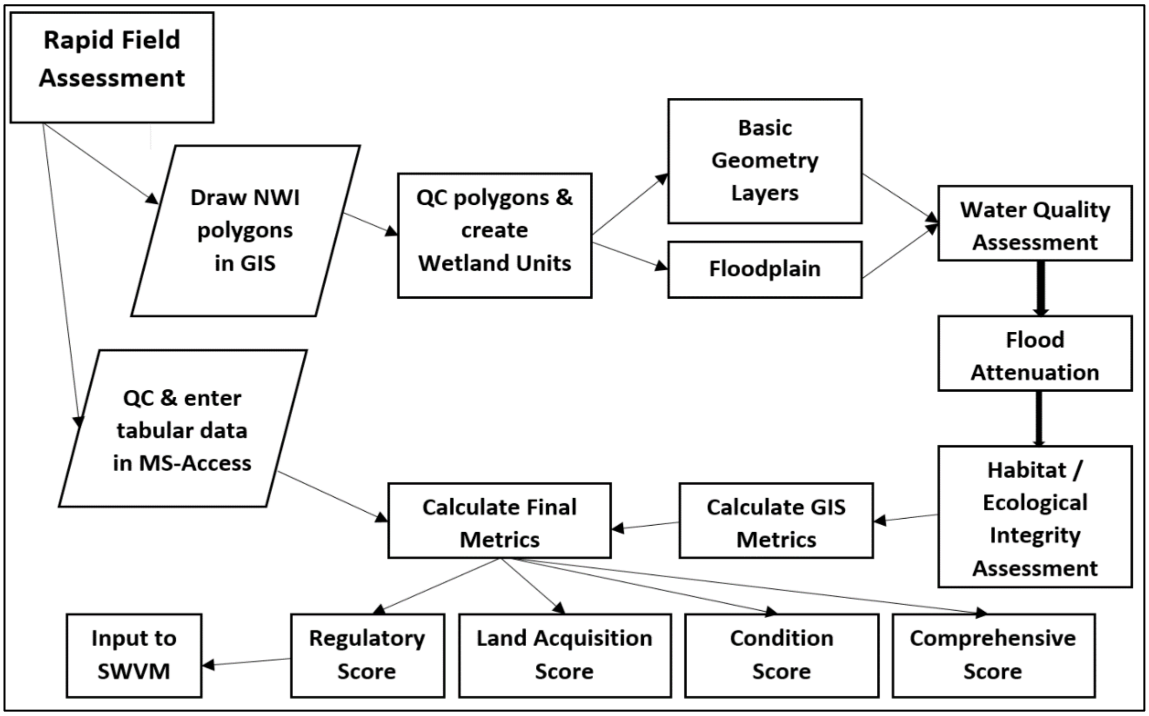
1.3 Limitations

WVWRAM, including both GIS and rapid field assessment of wetland functions, is not intended to answer all questions about wetlands. The following are important limitations:

- WVWRAM does not change any current procedures for determining wetland jurisdictional status or delineating wetland boundaries.
- WVWRAM does not assess all possible functions, values, and services that a wetland might support, but rather focuses on water quality, flood attenuation, and habitat/ecological integrity.
- WVWRAM does not assess the viability of a particular site for restoration, although it may be used in conjunction with WVDEP's restorable wetlands model to determine promising and potentially high-functioning restoration sites.

1.4 Flow chart of field and GIS components of WVWRAM

The field and GIS components of WVWRAM are designed to complement one another to produce a robust set of metrics that consider watershed- and landscape-level processes in addition to on-the-ground processes within the wetland itself. It is possible to run desktop scenarios using only the GIS portion of the assessment, for example to evaluate potential mitigation sites or land acquisitions. Both field and GIS components are required for regulatory or monitoring purposes. Field components and user instructions are contained in the companion document "User Manual for the West Virginia Wetland Rapid Assessment Method".

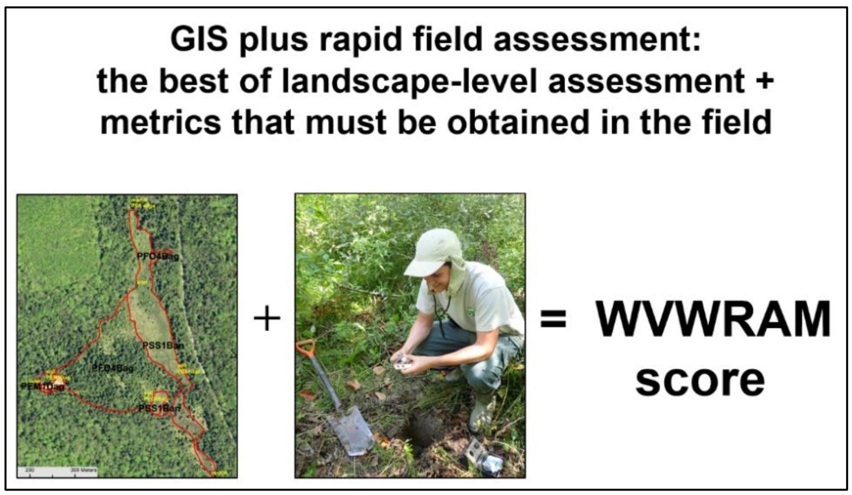


Documents describing the components of WVWRAM are:

- User Manual for the West Virginia Wetland Rapid Assessment Method (2020).
- Reference Manual for the West Virginia Wetland Rapid Assessment Method (2020).
- Field Work Quality Assurance Project Plant (QAPP) for the Wetland Program Development Project: Operationalizing Wetland Functional Assessments in West Virginia (2017).
- Secondary Data Quality Assurance Project Plant (QAPP) for the Wetland Program Development Project: Operationalizing Wetland Functional Assessments in West Virginia (2017).

1.5 Overview of Metrics and Weights

Specific metrics and scores are calculated based on GIS and field data. The rationale and strategy for calculating each metric, including source data and submetrics, are described in this document. The field assessment complements and improves the GIS assessment score, with the two assessment levels supporting a final score that blends the best of landscape-level assessment with metrics that must be obtained in the field.



The GIS portion draws on 62 statewide GIS datasets to calculate a preliminary score for the wetland.

62 statewide GIS datasets

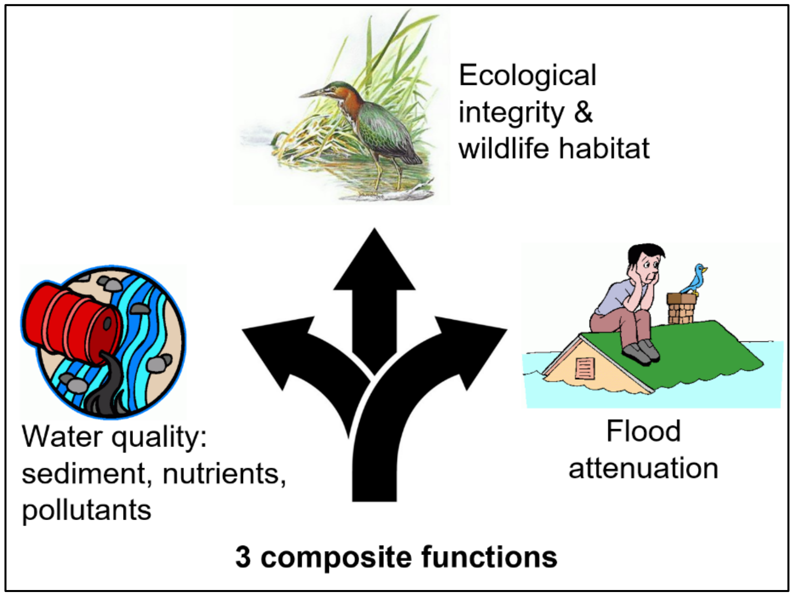
- Biodiversity
- Ecosystems
- Elevation
- Geology
- Hydrology
- Imagery
- Infrastructure
- Jurisdiction
- Landcover
- Landform
- Soils
- Stressors

The final WVWRAM score requires a field assessment, which is done by technicians with the skill level of a wetland delineator, and typically takes 1-4 hours to complete.

Field assessment

- Level of effort: 2 technicians x 1-4 hours
- Skill level required: wetland delineator plus 2-day WVWRAM training

The many possible functions of a wetland are combined into three composite functions that are particularly important in West Virginia: (a) water quality, including sediment retention, nutrient transformation, and pollutant removal, (b) flood attenuation, including slowing and storing flood water and stream baseflow augmentation, and (c) ecological integrity and wildlife habitat.



The field metrics are combined with the preliminary GIS score to calculate the final WVWRAM score. Sixty-five metrics are used for the regulatory score. Note that the "Value to Society" metrics are not included in the regulatory score. "Value to Society" metrics are, however, included in the comprehensive functional score, since they are important for land acquisition and other conservation decisions.

65 metrics in 6 categories (regulatory)

	Intrinsic Potential	Landscape Opportunity	Value to Society
Water Quality	vegetation, soil, hydrology	50 m buffer, contributing watershed	public use, planning
Flood Attenuation	vegetation, soil, hydrology	50 m buffer, contributing watershed	economic risk
Habitat/ Ecological Integrity	vegetation, soil, hydrology	perimeter, 300 m / 1 km buffer, contrib. watershed	investment, public use, access

WVWRAM Framework for GIS and Field Assessment Metrics

<u>Water Quality</u> (25 points)	(floodplain/non-floodplain wetlands)
Intrinsic potential to provide function	16/16 points max
1. Headwater location	1/1
2. Vegetation	10/5
3. Surface depressions	5/0
4. Surface water outflow	0/4
5. Organic soil material	0/3
6. Seasonal ponding, slope, wetland/upland interface	0/3
Landscape opportunity	5/4 points max
1. Discharges to the wetland	
2. Land use disturbance within buffer	
3. Land use disturbance in contributing watershed	
4. Roads and railroads	
5. Impaired waters, algal blooms, powerboat use	
Value to society	4/4 points max
1. Wetland discharges to impaired waters	
2. Water quality issues present in 12-digit HUC watershed	
3. Watershed or water quality plan exists	
4. Public use of water quality (water supply, fisheries, recreation)	
<u>Flood Attenuation</u> (25 points)	(floodplain/non-floodplain wetlands)
Intrinsic potential to provide function	17/14 points max
1. Headwater location	1/1
2. Median percent slope	2/2
3. Vegetation	9/5
4. Runoff and Storage	5/4
5. Surface Water Outflow	0/2
Landscape opportunity	4/2 points max
1. Overland flow delivered to wetland	2/2
2. Connectivity to historic floodplain	2/0
Value to society	4/4 points max
1. Location in FEMA floodway	
2. Economically valuable flood risk areas nearby	
<u>Habitat and Ecological Integrity</u> (50 points + special concern adjustment 1-100 pts*)	
Intrinsic potential to provide function	30 points max
1. Vegetation (structure and floristic quality)	15
2. Hydrology (intact regime, floodplain connectivity)	9
3. Soils and structural patches	6
Landscape opportunity	13 points max
1. Buffer and landscape integrity	7
2. Landscape-level hydrologic connectivity	3
3. Landscape-level ecological connectivity	3
Value to society	7 points max
1. Societal investment	3
2. Public use and access	4
Wetlands of Special Conservation Concern, including Exemplary Wetlands	
1. Documented rare species or high-quality natural communities	1-100 points

**Note that 100% of open water wetlands and > 98% of vegetated wetlands score < 100. Exemplary Wetlands with total scores > 100 comprise less than 2% of vegetated wetlands.*

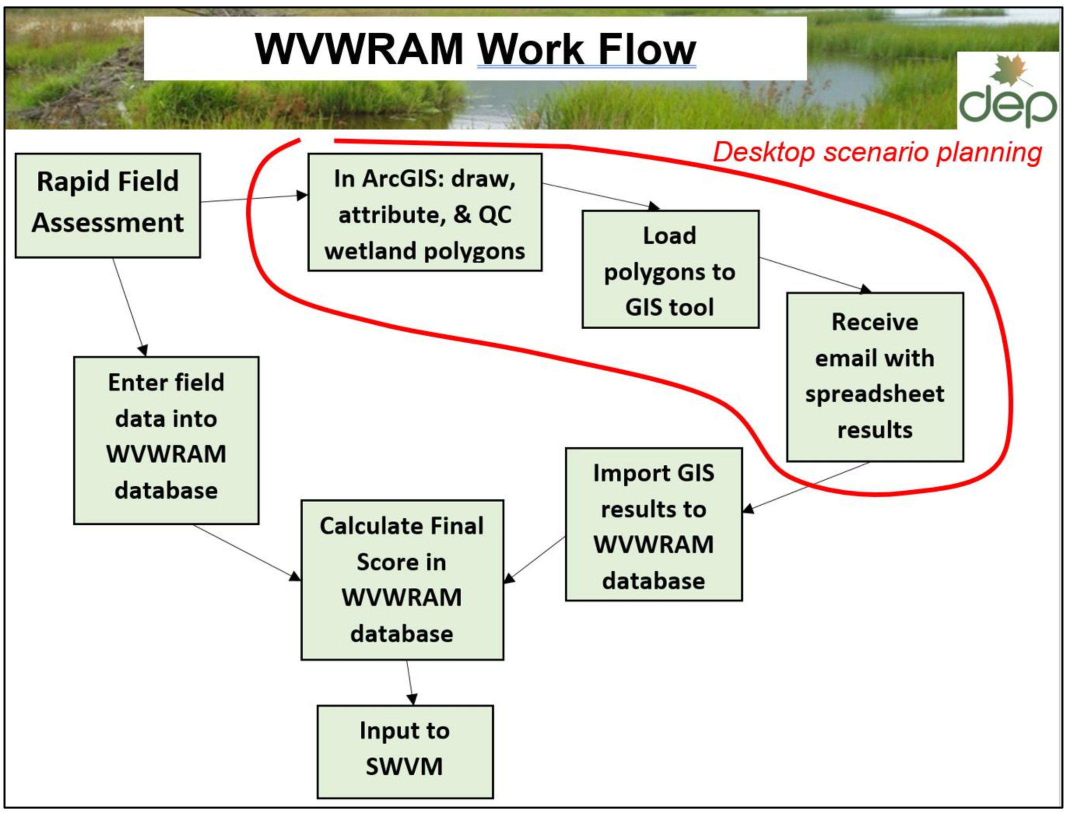
1.6 Regulatory Use

WVWRAM scores are intended to inform compensatory mitigation requirements pertaining to the Clean Water Act, as detailed in the Federal Register (2008).

1.6.1 Regulatory score

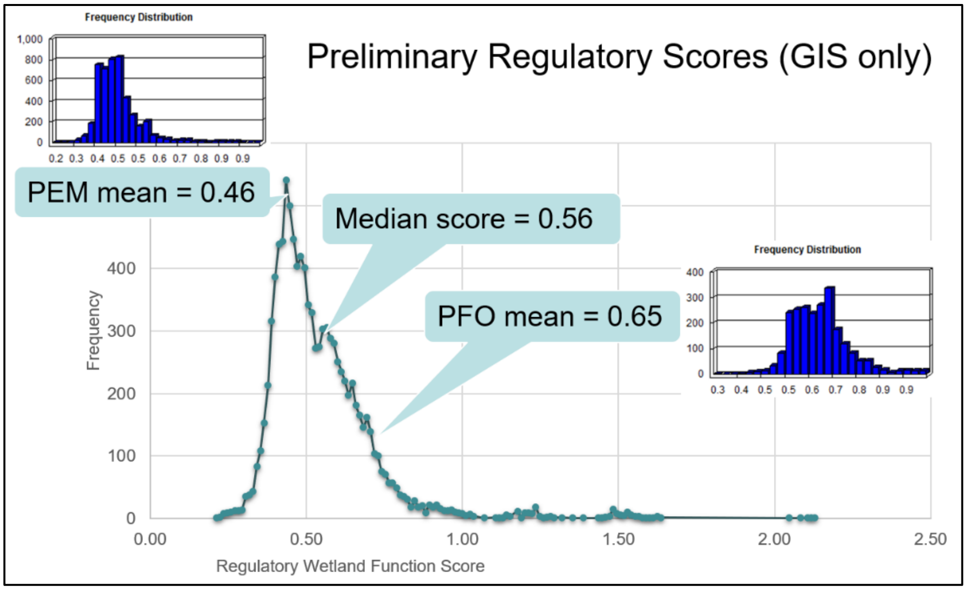
The regulatory score is based on metrics that assess the chemical, physical, and biological integrity of jurisdictional wetlands in West Virginia. The regulatory score does not include WVWRAM's "Value to Society" metrics, which are assessed for other purposes such as conservation land acquisition. The non-regulatory metrics are in the light gray panel on the first page of the field form. All other sections of the field form are required for regulatory assessments.

The preliminary GIS assessment may be used as a stand-alone for desktop scenario planning.

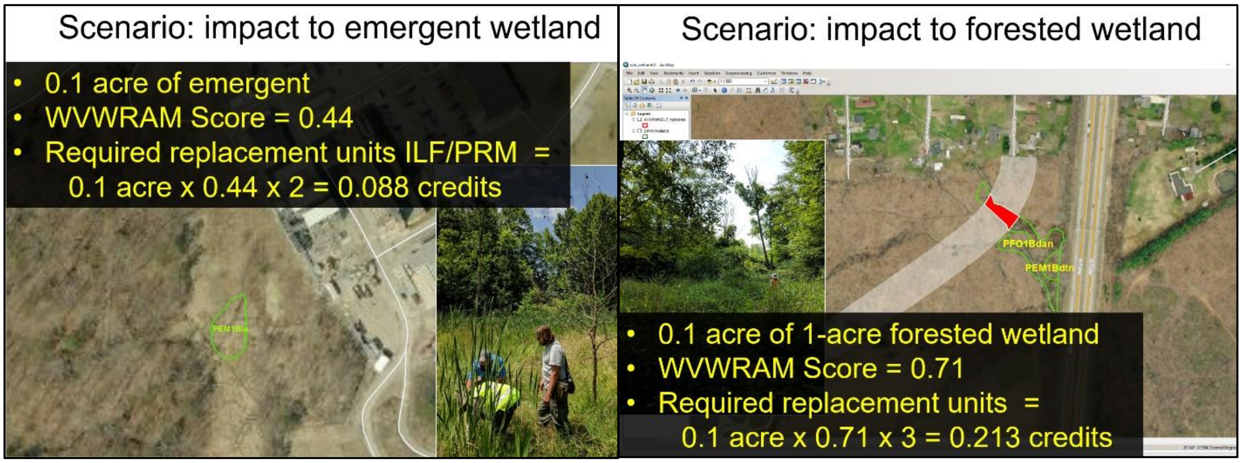


The regulatory score is an input to the Stream and Wetland Valuation Metric (SWVM) spreadsheet, which is used in West Virginia to calculate mitigation debits and credits for wetlands.

The regulatory score is based on a 0-1 index for 98% of wetlands in the state. Exemplary wetlands of special conservation concern (2% of wetlands) have scores above 1.0.

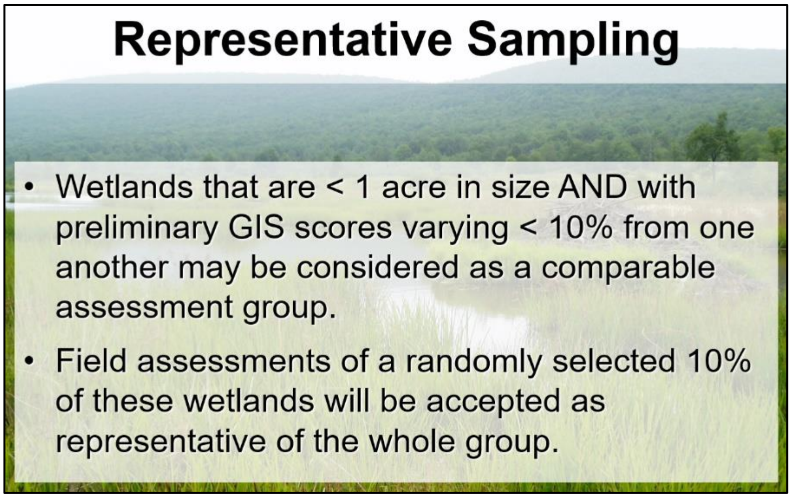


Example scoring for an emergent and forested wetland, with the mitigation provider as in-lieu fee or permittee-responsible, are shown below. These examples do not include the calculations for additional factors in the Stream and Wetland Valuation Metric (SWVM) including temporal loss-construction, temporal loss-maturity, and long-term protection.



1.6.2 Representative sampling of certain sites

When a single regulated site includes many similar small wetlands, representative sampling may be conducted under certain conditions. All wetlands must be mapped and run through the preliminary GIS assessment. Wetlands that are less than one acre in size AND with preliminary GIS scores varying less than 10% from one another may be considered as a comparable assessment group. Field assessments of a randomly selected 10% of these wetlands will be accepted as representative of the whole group.



1.6.3 Year-round assessment

WVWRAM is designed to produce robust, repeatable results during the growing season.

Assessors are strongly encouraged to perform the assessment during the index period of May 1 - September 30 (June 1 - September 30 for elevations above 3000 feet). If the assessment is performed outside the growing season, then a vegetation adjustment of 0.10 units is added to the regulatory score for impacts to wetlands.

Permittees may avoid the vegetation adjustment by providing an update to the WVWRAM field form during the next growing season and prior to final approval of their mitigation obligations.

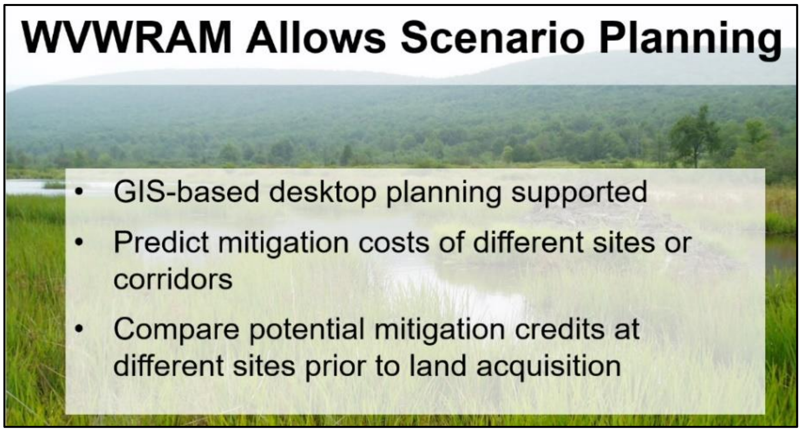
Permittees may choose to skip the Rapid Floristic Quality portion of the assessment even during the index period. This will result in the 0.10 vegetation adjustment being applied to the WVWRAM score.

The out-of-season vegetation adjustment represents 77% of the maximum score that could be attained during the growing season for rapid floristic quality (0.1058) and the herbaceous portion of vegetative structure (up to 0.0235).

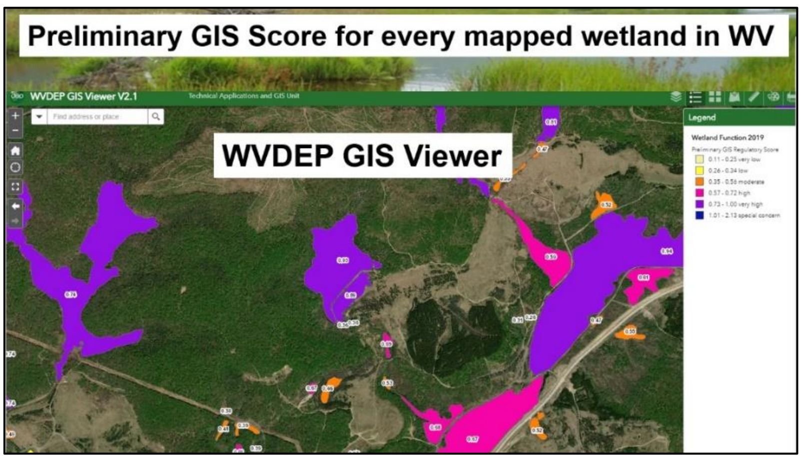
For WVWRAM assessments done outside the index period, surveyors must fill out most of the field form including woody vegetation structure, presence of tall emergent marsh, vegetation fringing open water, and all stressors. The only parts of the field form that are not filled out during out-of-season assessments are the height strata of emergent NWI types (top right of page 2 of the field form) and the rapid floristic quality (vegetation species and cover, pages 5&6 of the field form).

1.6.4 Scenario planning

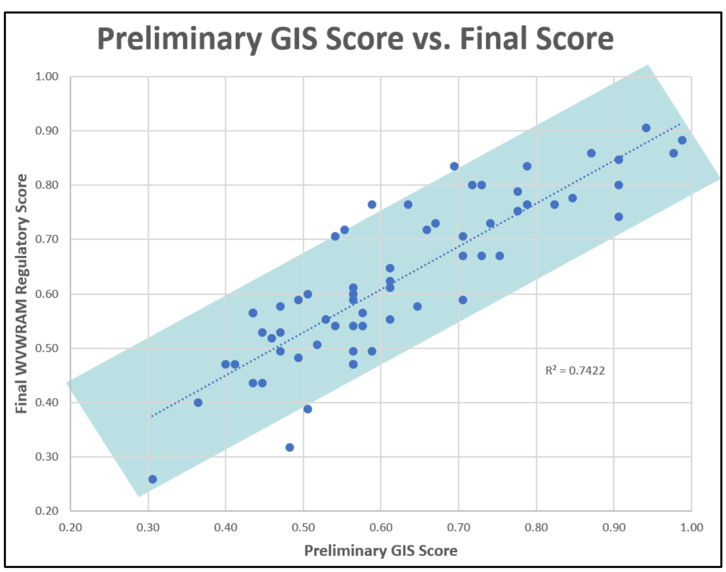
The WVWRAM GIS tool allows for scenario planning to minimize impacts to high-functioning wetlands.



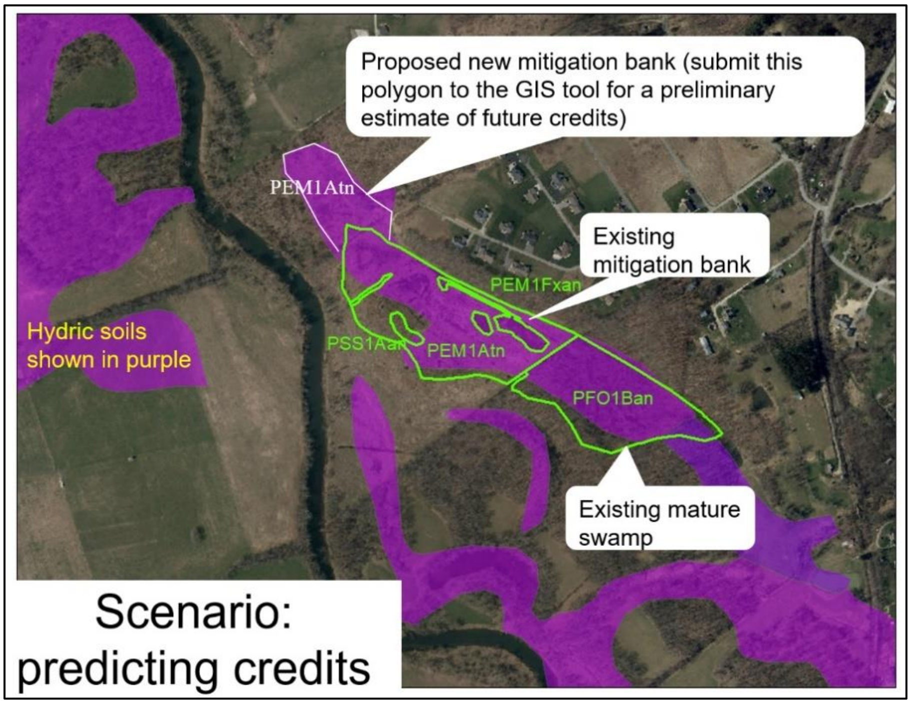
Preliminary GIS scores of all mapped wetlands in West Virginia are posted on the DEP Data Viewer (https://tagis.dep.wv.gov/wvdep_gis_viewer/). Click the "Layer List" icon in the upper right corner and look in the "Watershed Assessment" section.



Generally, the preliminary GIS score will be within about 30% of the final regulatory score.



If wetlands in the project footprint have been delineated or roughly mapped from air photos, then custom GIS assessments can be run. Each wetland must have an NWI code, but complete codes with all modifiers are not required for preliminary GIS assessment. For example, wetlands may be labeled PEM rather than PEM1Ban, although codes with more modifiers will give a more accurate preliminary score. The mapped wetlands must be saved as a shapefile for submittal to the WVWRAM GIS tool.



1.6.5 Linear projects

Linear projects are likely to impact portions of a large number of wetlands. Scenario planning (discussed above) along the proposed linear project route and alternative routes is strongly recommended to minimize impacts to high-functioning wetlands. Representative sampling, also discussed above, allows many similar sites to be efficiently assessed.

Impacts to portions of wetlands are discussed in the User Manual under "Field Measurement Protocols/Assessment area". When part of a wetland is impacted, its score depends on the score of the entire wetland that contains it. Often it will not be possible to access the non-impacted portion of the wetland, and in this case the wetland must be mapped from air photos. See the section in the User Manual under "Field Measurement Protocols/Wetland mapping" for more details.

1.6.6 Cumulative impacts

Cumulative impacts may be quantified by summing the pre-impact regulatory scores across a watershed and comparing them to the sum of the post-impact regulatory scores for the same watershed.

1.6.7 Exemplary Wetlands

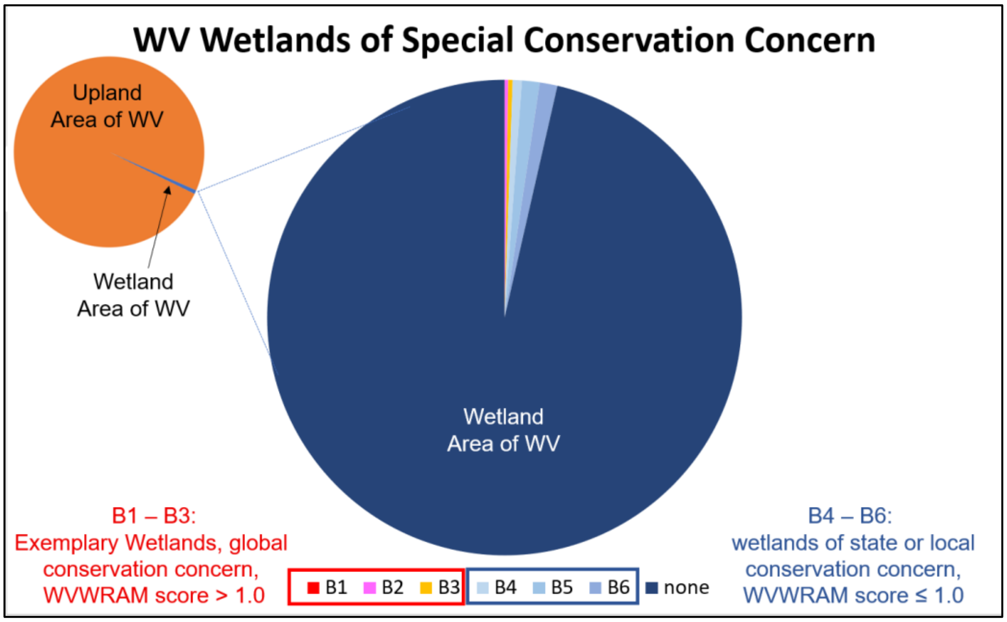
Exemplary Wetlands are defined as wetlands that support globally rare, threatened, or endangered species or exceptionally high-quality natural communities, as documented in the WVDEP Exemplary Wetlands Database (WVDEP 2019) and the WVDNR Natural Heritage Database (WVDNR 2020). Exemplary Wetlands have a Site Biodiversity Rank of B1, B2, or B3 following criteria developed by WVDNR in cooperation with the national NatureServe network (WVDNR 2014). These criteria have been in use since 2012 by the West Virginia Outdoor Heritage Conservation Fund established by the West Virginia Legislature (West Virginia Legislature 1985, WVOHCF 2019). Site Biodiversity Ranks for West Virginia wetlands may be summarized as:

Site Biodiversity Rank	Significance	Associated Threat Level	Number of WV Wetlands	Exemplary Wetlands
B1	Outstanding global biodiversity significance	Globally critically imperiled	6	yes
B2	High global biodiversity significance	Globally imperiled	100	yes
B3	Global biodiversity significance	Globally vulnerable	129	yes
B4	Outstanding state biodiversity significance	Globally stable but critically imperiled at the state level	270	no
B5	State biodiversity significance	Globally stable but imperiled at the state level	518	no
B6	Local biodiversity significance	Globally stable but vulnerable at the state level	519	no
none	General habitat value	Presumed stable	41,582	no

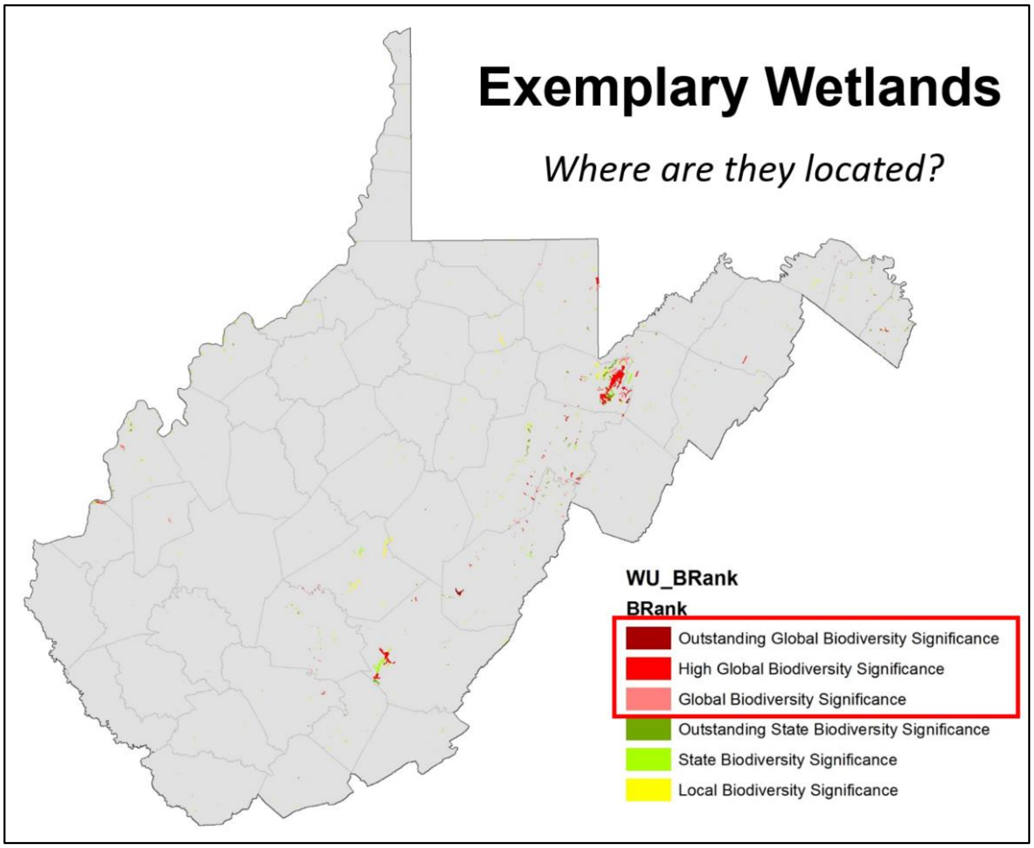
It is extremely difficult to mitigate for Exemplary Wetlands since they contain highly specialized habitats and rare species. A multiplier of 3 will be applied to the required replacement units for Exemplary Wetlands within the Stream and Wetland Valuation Metric. Potential impacts to Exemplary Wetlands may also receive additional scrutiny from the Inter-Agency Review Team.

This multiplier is comparable to the multipliers of 3-5 that are currently in use by other states (National Research Council 2001, Maryland Department of the Environment 2020, Michigan Department of Environment, Great Lakes, and Energy 1994, Ohio EPA 2015, Society of Conservation Biology 2012) for impacts to wetlands with rare, threatened, or endangered species.

Exemplary Wetlands make up less than 2% of vegetated wetlands, and less than 0.5% of all wetlands in West Virginia.



Exemplary Wetlands are concentrated in the Allegheny Mountains and eastern panhandle regions of West Virginia, with a smaller number occurring along the Ohio River or elsewhere.



1.6.8 Cost-neutral credits/debits

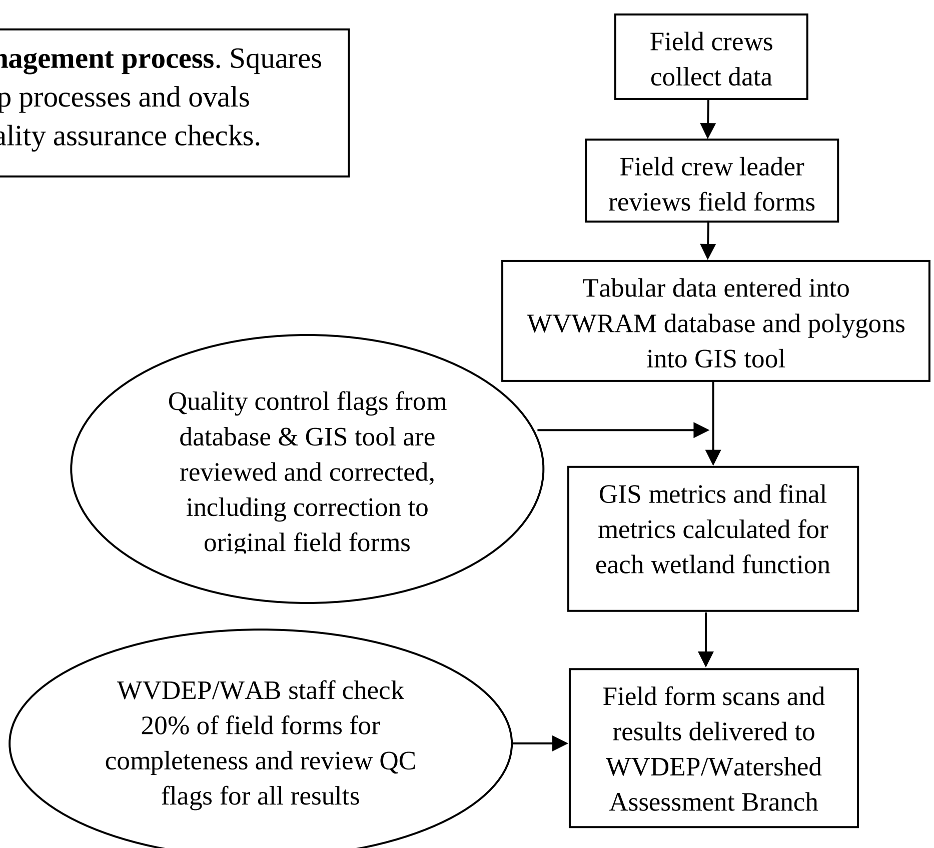
The average amount of mitigation required statewide will not change as a result of WVWRAM implementation. However, the cost of individual projects will change. Low-functioning wetlands will require less mitigation than previously, and high-functioning wetlands will require more mitigation than previously.

1.6.9 When is WVWRAM required?

WVWRAM scores are a required input to the Stream and Wetland Valuation Metric (SWVM) when Section 404/401 permitting is triggered, in other words, when there will be permanent impacts to wetlands including conversion from PSS/PFO to PEM. WVWRAM is not required for projects when wetlands are avoided or temporarily impacted (less than one year) and Section 404/401 is not triggered.

1.7 Data Management and Review

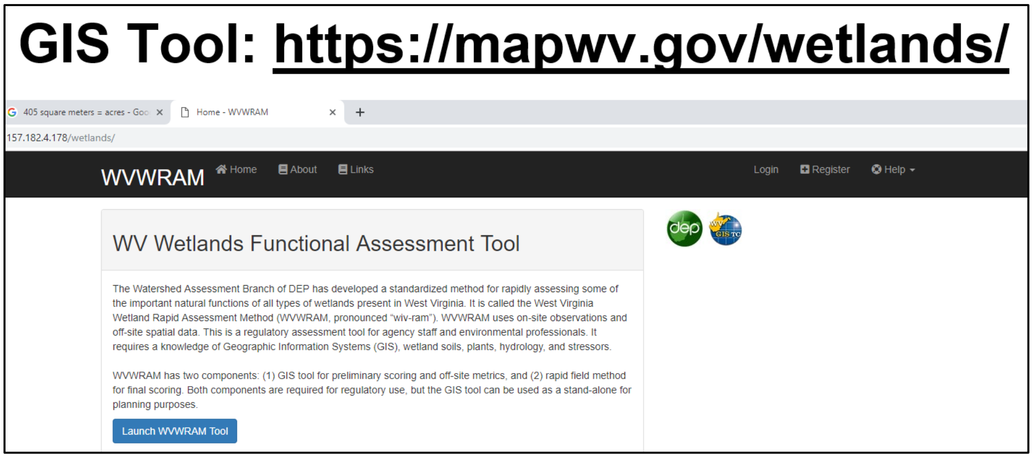
Data management includes review of field data forms, data entry into the database, and review of the final electronic records. At each step of the process, checks of the data are performed to ensure that high quality and accurate data are transmitted to the next level of the process. If during any step of the process, errors are found in >5% of the sites or appear to follow a systematic pattern, more extensive checks of the data will be employed.



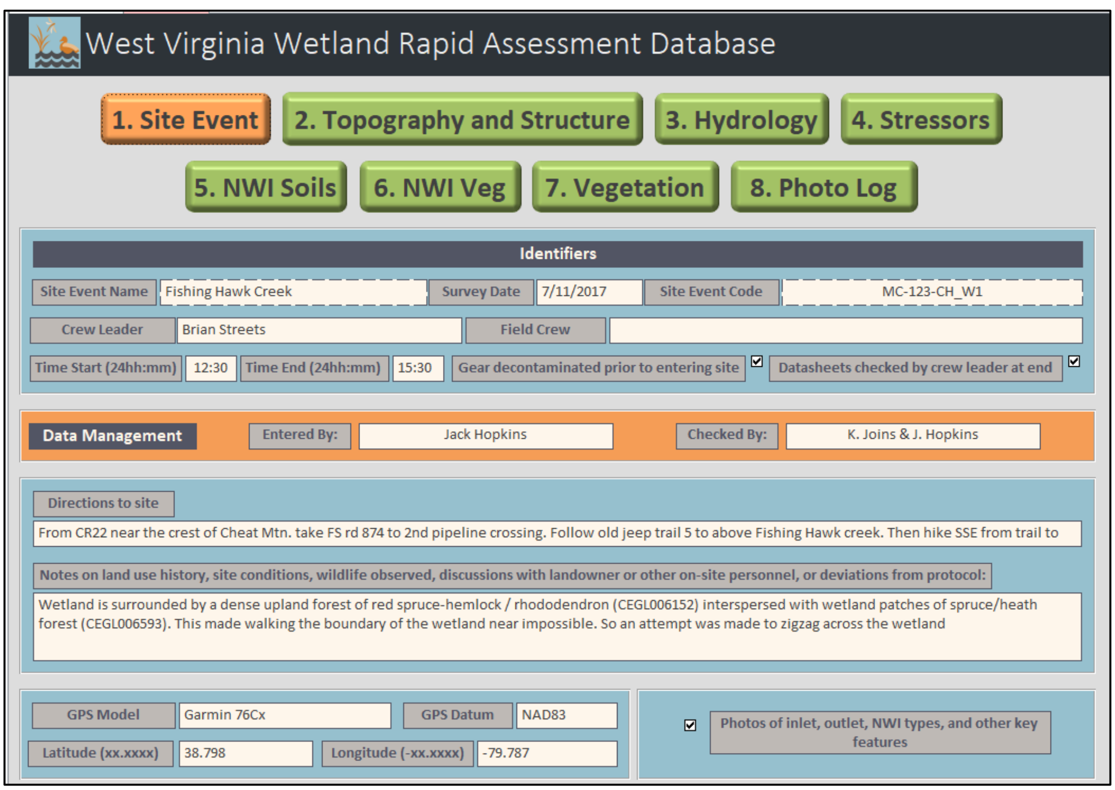
Data management process. Squares depict step processes and ovals depict quality assurance checks.

1.7.1 GIS and tabular data entry

Each data point collected in the field is designed to contribute directly to the WVWRAM functional assessment equations. Field-delineated spatial data (mapped wetland polygons according to the National Wetlands Inventory standard) are input to the GIS tool of WVWRAM.



Tabular field data are input to the WVWRAM MS-Access wetland database. After the data is entered, a printout (or computer display) will be compared back to the original field form. Data entry and checking will be done by different individuals. After the data quality checks are complete, then the GIS results are imported to the WVWRAM database and merged with field tabular data to result in final metrics and scores.



1.7.2 Data transfer and review by WVDEP

All field data, including field form scans, photographs, GIS files, and WVWRAM database results will be transferred from the assessors to the WVDEP Watershed Assessment Branch. WVDEP/WAB staff will review a subsample of the results. At least 20% of the total field forms will be reviewed for completeness. Quality control flags generated by the WVWRAM database or GIS tool will be reviewed for all sites. More thorough review of field forms and results, including comparison of air photos with mapping and data fields, will be performed for 5% of sites and as requested for unusual or high-impact sites.

1.7.3 Data tracking and archival

WVDEP/WAB will be responsible for tracking and archiving all WVWRAM data, including internally generated assessments and assessments submitted by external assessors. The tracking system is part of the wetland database and will include target sites, sampling date, field crew leader, QC of data entry, GIS results, and final scoring of wetland.

Original field forms will be scanned and stored in the WVDEP Watershed Assessment Branch archival system. Electronic data, photos, GIS data layers, progress reports, final reports and publications will be stored on the WVDEP computer server with regular backup to external hard drive.

2.0 WHAT'S BEHIND THE USER INTERFACE

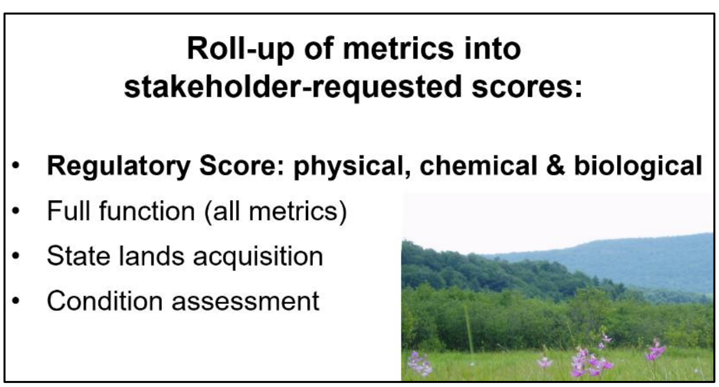
Most users will not need to delve beyond the user interface. Those interested in the inner workings of the assessment tool can read on for details on the metrics and scoring formulas used in WVWRAM.

2.1 Scoring

There are two sets of functional equations used to calculate metrics and scores. The first is entirely GIS-based and provides a preliminary estimate of functional scores. The second is a final score based on merged GIS and field data, combining the best of landscape-level assessment with measurements that must be made in the field. Common abbreviations used in variable names in the formulas in this section include:

A	combined GIS and tabular field data (suffix)
BR…	Site Biodiversity Rank
FA	flood attenuation
FQ	floristic quality
H	habitat/ecological integrity
Opport…	landcape opportunity
Potent…	intrinsic potential
Reg	regulatory
Societ…	value to society
SW	surface water
T	tabular field data (suffix)
Veg	vegetation
WQ	water quality

Variables and metrics are described in the sections below. A summary table is included in Appendix 5.3 and detailed methods for each calculating metric and compiling each source layer are included in Appendices 5.5-5.7. Metrics are rolled up into total scores for several distinct purposes that require different sets of metrics, including regulatory use, state lands acquisition, condition assessment, and full function (all metrics).



2.1.1 RegScore: Final Regulatory Score

The final regulatory score is an input to the Stream and Wetland Valuation Metric (SWVM) used for calculating debits and credits. It is calculated as the raw regulatory function divided by 85 (the total maximum raw points). Ninety-eight percent of scores for vegetated wetlands fall in the range of 0 – 1.0. Two percent of scores are above 1.0 and represent Exemplary Wetlands of special conservation concern. Scores for Exemplary Wetlands can reach a maximum of 2.18.

RegScore = RegFunctiA/85

2.1.2 RegPrelim: Preliminary GIS Regulatory Score

The preliminary GIS regulatory score is used for planning purposes only. It is calculated as the raw regulatory function from the WVWRAM GIS tool divided by 85. Ninety-eight percent of scores for vegetated wetlands fall in the range of 0 – 1.0. Two percent of scores are above 1.0 and represent Exemplary Wetlands of special conservation concern. Scores for Exemplary Wetlands can reach a maximum of 2.18.

RegPrelim = RegFunction/85

2.1.3 RegFunction: Raw Regulatory Function

The raw regulatory function is a roll-up of the Intrinsic Potential and Landscape Opportunity metrics for water quality (WQ), flood attenuation (FA), and habitat/ecological integrity (H), plus the Site Biodiversity Rank (Brank) adjustment to the habitat/ecological integrity function. The maximum score is 185. Note that 98% of scores for vegetated wetlands fall in the range 0-85; scores above 85 represent Exemplary Wetlands of special conservation concern. The 0-85 score is converted to a 0-1 scale for input to the Stream and Wetland Valuation Metric (SWVM) used for calculating debits and credits.

Preliminary GIS score (for planning purposes only):

RegFunction = WQPotential + WQOpportun + FAPotential + FAOpportun + (HPotential including BRank + HOpportun)

Raw regulatory function, including tabular field data:

RegFunctiA = WQPotentiA + WQOpportuA + FAPotentiA + FAOpportuA + HConditionA

MS Access SQL expression:

RegFunctiA: [WQPotentiA]+[WQOpportuA]+[FAPotentiA]+[FAOpportuA]+[HConditioA]

2.1.4 Function: Comprehensive Functional Score

The comprehensive functional score is a roll-up of water quality (WQ), flood attenuation (FA), and habitat/ecological integrity (H) scores. The maximum score is 200. Note that >99% of all wetlands and 98% of vegetated wetlands fall in the range 0-100; scores above 100 represent Exemplary Wetlands. The median score for vegetated wetlands is 50.

Preliminary GIS score:

Function = WQFunction + FAFunction + HFunction

Final score, including tabular field data:

FunctionA = WQFunctioA + FAFunctioA + HFunctionA

MS Access SQL expression: FunctionA: [WQFunctioA]+[FAFunctioA]+[HFunctionA]

2.1.5 Condition: Wetland Condition Score

Wetland condition is different from wetland function. Wetland condition is a measure of healthy ecological conditions in a wetland, including the absence of stressors. Wetland quality is a commonly used synonym for wetland condition (USEPA 2016). In contrast to wetland condition or quality, wetland function measures the specific processes that take place within a wetland, such as the storage of water, transformation of nutrients, growth of living matter, and diversity of species (Novitski et al 1996). These processes are closely related to and include ecological health, but also include factors that relate to whether the wetland is actually performing a specific function such as water quality improvement and reducing flood flows. In a functional assessment, stressors may provide a "need" for wetland functions, which allow the wetland to perform the function at a higher level. Wetland condition assessment addresses the intrinsic potential of a wetland to perform many services in terms of its overall ecological health but does not consider whether the wetland is actually performing a particular function.

An example of a wetland type which scores quite differently for condition and function would be an emergent wetland covered by dense growth of invasive cattails in the active floodplain of an impaired stream within an urban area. This wetland would be actively filtering pollutants and reducing flood flows, although it would provide extremely poor habitat and have very low ecological integrity. The condition of the wetland would be poor, but its functional score would be moderate since it is providing some important functions.

Another example is a headwater fen in a wilderness area that has few or no stressors. It would have a high intrinsic potential to filter pollutants but would not be performing this function. This wetland would score very high for condition but would have a somewhat lower score for function.

The condition score is calculated from the intrinsic potential portion of the water quality (WQ), flood attenuation (FA), and habitat/ecological integrity (H) metrics, plus the landscape opportunity portion of the habitat/ecological integrity metrics. The habitat landscape opportunity metrics are included as good indicators hydrologic and ecological connectivity and the absence of stressors. The maximum score is 176. Note that >99% of all wetlands and 98% of vegetated wetlands fall in the range 0-76; scores above 76 represent Exemplary Wetlands.

Preliminary GIS score:

Condition = WQPotential + FAPotential + HPotential (including BRank) + HOpportun

Final score, including tabular field data:

ConditionA = WQPotentiA + FAPotentiA + HConditioA

MS Access SQL expression: ConditionA: [WQPotentiA]+[FAPotentiA]+[HConditioA]

2.1.6 LandAcquire: WVDNR Land Acquisition Score

The mission of the WVDNR is to "provide and administer a long-range comprehensive program for the exploration, conservation, development, protection, enjoyment and use of the natural resources of the State of West Virginia." This includes acquisition of public land. WVWRAM metrics can be used to help determine the value of wetlands in terms of "conservation, development, protection, enjoyment and use". This score is based on the condition of the wetland (see condition score above) plus the "Value to Society" metrics for all functions. The maximum score is 191. Note that >99% of all wetlands and 98% of vegetated wetlands fall in the range 0-91; scores above 91 represent Exemplary Wetlands.

Preliminary GIS score:

LandAcquire = Condition + WQSociety + FASociety + HSociety

Final score, including tabular field data:

DNRLandAcA = ConditionA + WQSocietyA + FASociety + HSocietyA

MS Access SQL expression:

DNRLandAcA: [ConditionA]+[WQSocietyA]+[FASocietyA]+[HSocietyA]

2.2 Upper-level Roll-up Metrics

Upper-level metrics are roll-ups of the basic metrics. They include the values for Intrinsic Potential, Landscape Opportunity, and Value to Society for each function.

2.2.1 WQFunction: Water Quality

Water Quality Function (WQFunction) is a roll-up of Water Quality Intrinsic Potential, Water Quality Landscape Opportunity, and Water Quality Value to Society. The maximum score is 25.

Preliminary GIS score:

WQFunction = WQPotential + WQOpportun + WQSociety

Final score, including tabular field data:

WQFunctioA = WQPotentiA + WQOpportuA + WQSocietyA

MS Access SQL expression:

WQFunctioA: [WQPotentiA]+[WQOpportuA]+[WQSocietyA]

2.2.2 WQPotential: Water Quality Intrinsic Potential

Wetlands have an intrinsic potential to improve water quality, through filtering of contaminants, capture of sediment, absorption of nutrients, and chemical reactions that convert noxious compounds to benign ones (e.g., nitrates to nitrogen gas). This intrinsic capability is related to landscape position, vegetation, microtopography, drainage patterns, soils, wetland shape, and slope of the wetland.

Water Quality Intrinsic Potential (WQPotential) is a roll-up of headwater location, vegetation (woody vegetation, persistent ungrazed vegetation, and fringing vegetation), surface water depressions, surface water outflow, organic soils near surface, and time/place for chemical reactions to occur (seasonal ponding, slope, wetland/upland interface). The maximum score is 16.

Preliminary GIS score:

WQPotential = Headwater + VegWQ + Depressions + SWOutflow + ClayOrganic + ChemTime

Final score, including tabular field data:

WQPotentiA = HeadwaterA + VegWQA + DepressionsT + SWOutflowT + ClayOrganA + ChemTimeA

MS Access SQL expression:

WQPotentiA: [HeadwaterA]+[VegWQA]+[DepressioT]+[SWOutflowT]+ [ClayOrganA]+[ChemTimeA]

2.2.3 WQOpportun: Water Quality Landscape Opportunity

The landscape surrounding a wetland helps determine its capacity to improve water quality. Wetlands receiving sediment, nutrients, or pollutants from the surrounding landscape will function to retain or remove these elements before they reach downstream waters. If the wetland does not receive any pollutants, then it cannot remove them, even if it has the necessary physical, chemical, and biological characteristics. The level of incoming pollutants can be correlated with known discharges, land use disturbance, development, intensity of agriculture, and recent logging in the landscape. Relatively undisturbed watersheds will carry much lower sediment, nutrient, and pollutant loads than those that have been impacted by development, agriculture, or logging practices (Hruby 2012, Sundareshwar et al. 2009, Reinelt and Horner 1995).

Water Quality Landscape Opportunity (WQOpportun) is a roll-up of discharges to the wetland, impaired waters impacting wetland, roads or railroads impacting wetland, disturbed land in the 50m buffer, and disturbed land in the contributing watershed. The maximum score is capped at 5 for floodplain wetlands and 4 for non-floodplain wetlands.

Preliminary GIS score:

> *WQOpportun = Discharges + ImpairedIn + RoadRail + Disturb50m + DisturbWshd (cap maximum score at 5 for floodplain wetlands and 4 for non-floodplain wetlands)*

Final score, including tabular field data:

> *WQOpportuA = DischargeA + ImpairedIn + RoadRailT + Disturb50mT + DisturbWsh*
>
> *(cap maximum score at 5 for floodplain wetlands and 4 for non-floodplain wetlands)*
>
> *MS Access SQL expression:*
>
> *WQOpportuA: IIf([DischargeA]+[ImpairedIn]+[RoadRailT]+[Disturb50mT]+ [DisturbWsh] > 5 And [4_Metrics_tabular]![FloodplainT]=(-1),5, IIf([DischargeA]+ [ImpairedIn]+ [RoadRailT] + [Disturb50mT] + [DisturbWsh] > 5 And [4_Metrics_tabular]![FloodplainT] = 0, 4, [DischargeA] + [ImpairedIn] + [RoadRailT] + [Disturb50mT]+[DisturbWsh]))*

2.2.4 WQSociety: Water Quality Value to Society

The retention or removal of sediment, nutrients, and pollutants by wetlands is a valuable function for society (Hruby 2012). Wetlands that improve water quality above critical water resources such as water supply intakes, economic fisheries, or public swimming areas are particularly valued. Wetlands that discharge directly to impaired waters are judged to be more valuable than those that discharge to unpolluted bodies of water because their role at cleaning up the pollution is critical for reducing further degradation of water quality. Community or state investment in a water quality plan for the wetland's watershed is another indicator of public valuing of wetland functions.

Water Quality Value to Society (WQSociety) is a roll-up of water quality issues in the HUC12 watershed, wetland discharges to impaired waters, TMDL or other water quality plan exists, and public use of water quality (public water supply, fisheries, swimming areas). The maximum score is capped at 4.

Preliminary GIS score:

> *WQSociety = HUC12WQ + ImpairedOut + WQPlan + WQUse (cap at 4 for all wetlands)*

Final score, including tabular field data:

> *WQSocietyA = HUC12WQ + ImpairedOu + WQPlanA + WQUseA (cap at 4 for all wetlands)*

MS Access SQL expression:

WQSocietyA: IIf([HUC12WQ] + [ImpairedOu] + [WQPlanA] + [WQUseA] >4, 4, [HUC12WQ]+[ImpairedOu]+[WQPlanA]+[WQUseA])

2.2.5 FAFunction: Flood Attenuation

The flood attenuation function is a measure of the effectiveness of a wetland in storing water or delaying the downgradient movement of water, thus potentially influencing the height, timing, duration, and frequency of flooding in downstream areas. Many wetlands are capable of slowing the downslope movement of water, regardless of whether they have significant storage capacity. Water that is slowed, or stored, in a wetland becomes potentially available for stream baseflow augmentation, groundwater recharge, and supporting local food webs.

Flood Attenuation Function (FAFunction) is a roll-up of Flood Attenuation Intrinsic Potential, Flood Attenuation Landscape Opportunity, and Flood Attenuation Value to Society. The maximum score is 25 for floodplain wetlands and 20 for non-floodplain wetlands.

Preliminary GIS score:

FAFunction = FAPotential + FAOpportun + FASociety

Final score, including tabular field data:

FAFunctioA = FAPotentiA + FAOpportuA + FASociety

MS Access SQL expression: FAFunctioA: [FAPotentiA]+[FAOpportuA]+[FASociety]

2.2.6 FAPotential: Flood Attenuation Intrinsic Potential

The intrinsic potential of a wetland to reduce flooding depends on a number of factors, including its location in the watershed, slope, the structure and density of vegetation (especially woody vegetation but also persistent ungrazed vegetation and to a lesser degree, all vegetation types), water storage capacity, microtopography, and the type of surface water outlet.

Flood Attenuation Intrinsic Potential (FAPotential) is a roll-up of headwater location, median percent slope, vegetation, runoff and storage, and surface water outflow. These metrics serve as proxies to estimate the floodwater detention potential of a wetland. The maximum score is 17 for floodplain wetlands and 14 for non-floodplain wetlands.

Preliminary GIS score:

FAPotential = Headwater + LowSlope + VegFA + Runoff + SWOutflow2

Final score, including tabular field data:

FAPotentiA = HeadwaterA + LowSlope + VegFAA + RunoffA + SWOutflw2T

MS Access SQL expression:

FAPotentiA: [HeadwaterA]+[LowSlope]+[VegFAA]+[RunoffA]+[SWOutflw2T]

2.2.7 FAOpportun: Flood Attenuation Landscape Opportunity

The landscape surrounding a wetland helps determine its capacity to reduce flooding. Wetlands that are well-connected to their historic floodplains, are surrounded by runoff-producing areas, or have catchments with steep slopes, all tend to receive flood waters and have high opportunity to attenuate floods.

Flood Attenuation Landscape Opportunity (FAOpportun) is a roll-up of overland flow, overbank flow delivered to wetland and connectivity to the historic floodplain. The maximum score is 4 for floodplain wetlands and capped at 2 for non-floodplain wetlands.

Preliminary GIS score:

> *FAOpportun = FloodIn + ConnectFL (non-floodplain wetlands capped at 2)*

Final score, including tabular field data:

> *FAOpportuA = FloodInA + ConnectFLT (non-floodplain wetlands capped at 2)*
>
> *MS Access SQL expression:*
>
> *FAOpportuA: IIf([FloodInA]+[ConnectFLT]>2 And [4_Metrics_tabular]![FloodplainT] =0,2,[FloodInA]+[ConnectFLT])*

2.2.8 FASociety: Flood Attenuation Value to Society

Wetlands in regulatory floodways or upstream of economically valuable flood-prone areas can reduce the costs and negative impacts of flood damages to society.

Flood Attenuation Value to Society (FASociety) is a roll-up of location in FEMA regulatory floodway and economically valuable flood risk areas nearby. The maximum score is 4.

GIS score and final score:

> *FASociety = Floodway + Econrisk*

2.2.9 HFunction: Habitat & Ecological Integrity

Habitat & Ecological Integrity Function (HFunction) is a roll-up of Habitat & Ecological Integrity Function without BRank and Site Biodiversity Rank. The maximum score is 150. Note that >99% of all wetlands and 98% of vegetated wetlands fall in the range 0-50; scores above 50 represent Exemplary Wetlands.

Preliminary GIS score:

> *HFunction = HPotential + HOpportun + HSociety + points assigned based on BRank as follows: B1= HFunction set to 150; B2= HFunction set to 100; B3= HFunction set to 75; B4= HFunction set to 50; B5 = HPotential set to max of 30; B6 = 5 points added to HPotential (but cannot exceed 30).*

Final score, including tabular field data:

HFunctionA = HPotentiA + HOpportunA + HSocietyA + points assigned based on BRankA as follows: B1=HFunctionA set to max of 150; B2=HFunctionA set to 100; B3= HFunctionA set to 75; B4= HFunction set to 50; B5 = HPotentiaA set to 30; B6 = 5 points added to HPotentiaA (but cannot exceed 30).

MS Access SQL expression:

HFunctionA: IIf([BRankA]="none",[HPotentiA]+[HOpportunA]+[HSocietyA], IIf([BRankA]="B6" And [HPotentiA]<25,[HPotentiA]+[HOpportunA]+[HSocietyA]+5, IIf([BRankA]="B6" And [HPotentiA]>=25,30+[HOpportunA]+[HSocietyA], IIf([BRankA]="B5",30+[HOpportunA]+[HSocietyA],IIf([BRankA]="B4",50, IIf([BRankA]="B3",75,IIf([BRankA]="B2",100,IIf([BRankA]="B1",150,999))))))))

2.2.10 HFuncNoBR: Habitat & Ecological Integrity without BRank

Habitat & Ecological Integrity Function without BRank (HFuncNoBR) is a roll-up of Habitat & Ecological Integrity Intrinsic Potential, Habitat & Ecological Integrity Landscape Opportunity, and Habitat & Ecological Integrity Value to Society. The maximum score is 50.

Preliminary GIS score:

HFuncNoBR = HPotential + HOpportun + HSociety

Final score, including tabular field data:

HFunctNBRA = HPotentiaA + HOpportunA + HSocietyA

MS Access SQL expression: HFunctNBRA: [HPotentiA]+[HOpportunA]+[HSocietyA]

2.2.11 HCondition: Habitat & Ecological Integrity Condition

Habitat & Ecological Integrity Condition is a roll-up metric of Habitat & Ecological Integrity Intrinsic Potential, Habitat & Ecological Integrity Landscape Opportunity, and Site Biodiversity Rank. This intermediate metric is not used on its own, but rather is used to calculate the RegFunction and Condition scores, which specifically exclude the "Value to Society" metrics. The maximum score is 143. Note that >99% of all wetlands and 98% of vegetated wetlands fall in the range 0-43; scores above 43 represent Exemplary Wetlands.

HConditioA = HOpportunA + HPotentiaA + points assigned based on BRankA: B1=HConditioA set to max of 43, plus 100 extra; B2=HConditioA set to max of 43, plus 50 extra; B3= HConditioA set to max of 43 + 25 extra; B4= HConditioA set to max of 43; B5 = HPotentiaA set to max of 30; B6 = 5 points added to HPotentiaA (but cannot exceed 30).

MS Access SQL expression:

HConditioA: IIf([BRankA]="none",[HPotentiA]+[HOpportunA], IIf([BRankA]="B6" And [HPotentiA]<25,[HPotentiA]+[HOpportunA]+5, IIf([BRankA]="B6" And [HPotentiA]>=25,30 +[HOpportunA], *IIf([BRankA]="B5",30 +[HOpportunA],IIf([BRankA]="B4",43, IIf([BRankA]="B3",68,IIf([BRankA]="B2",93,IIf([BRankA]="B1",143,999)))))))*

2.2.12 HPotential: Habitat & Ecological Integrity Intrinsic Potential

Wetlands occur on less than 1% of West Virginia's total area but provide critical habitat for a remarkable 23% of its species and 44% of its rare species. The abundance of water, lush vegetation, large number of habitat niches, and naturalness of wetlands account for their high biodiversity value. Wetlands have an intrinsic potential to provide habitat for species, and wetlands benefit from high ecological integrity. This intrinsic capability is related to their vegetation, hydrology, soils, and physical structure.

Habitat & Ecological Integrity Intrinsic Potential (HPotential) is a roll-up of vegetation, soils, and hydrology. The maximum score is 30.

Preliminary GIS score:

HPotential = VegH + HydroH + SoilH

Final score, including tabular field data:

HPotentiaA = VegHA + HydroHA + SoilHA

MS Access SQL expression: HPotentiA: [VegHA]+[HydroHA]+[SoilHA]

2.2.13 HOpportun: Habitat & Ecological Integrity Landscape Opportunity

The landscape around a wetland, including its perimeter, buffer, and the connectivity of the hydrologic and ecologic setting, have important influences on habitat value and ecological integrity of the wetland.

Habitat & Ecological Integrity Landscape Opportunity (HOpportun) is a roll-up of buffer and landscape integrity, hydrologic connectivity, and ecological connectivity. The maximum score is 13.

Preliminary GIS score:

HOpportun = BufferLand + LandHydro + LandEco

Final score, including tabular field data:

HOpportunA = BufferLanA + LandHydro + LandEco

MS Access SQL expression: HOpportunA: [BufferLanA]+[LandHydro]+[LandEco]

2.2.14 HSociety: Habitat & Ecological Integrity Value to Society

Societal investments in habitat and ecological integrity, along with public use and accessibility infrastructure, reflect the value to society of specific wetlands.

Habitat & Ecological Integrity Value to Society (HSociety) is a roll-up of mitigation or conservation investment, public ownership, accessibility, public use, infrastructure, and long-term monitoring. The maximum score is 7.

Preliminary GIS score:

HSociety = HInvest + HUse

Final score, including tabular field data:

HSocietyA = HInvestA + HUse

MS Access SQL expression: HSocietyA: [HInvestA]+[HUse]

2.3 Vegetation and Biodiversity Metrics

2.3.1 BRank: Site Biodiversity Rank

Impacts to wetlands that are difficult or impossible to restore should be avoided (Gardner et al. 2009). Bogs, fens, old growth, and wetlands providing critical habitat to rare, threatened, or endangered species are examples of wetland types that are difficult or impossible to restore. Certain wetlands are recognized as being of special conservation concern for their outstanding biodiversity value or threatened status (Adamus et al. 2010, Berglund and McEldowney 2008, and Mack 2001). Wetlands of Special Conservation Concern in West Virginia are identified by their calculated Site Biodiversity Rank (B-rank), which is based on the presence, quality and abundance of rare species populations and high-quality natural communities (WVDNR 2014, Faber-Langendoen et al 2009, Tomaino et al 2008, CONHP 2005, TNC 1991). B-rank methodology is implemented by WVDNR's Natural Heritage staff. Surveying for rare species is not part of the rapid field assessment protocol; however, if survey data have already been documented by the state, then they will be included in the GIS assessment. Certain types of wetlands are known to be rare or of particularly high conservation concern in the state. Detailed surveys are not necessary to recognize these wetlands; therefore, noting these wetland types is a required part of the rapid field assessment. These include old growth swamp, large bogs or fens, large patches of mature forest swamp, and Ridge & Valley summit sinkhole wetlands. Many of these have already been mapped by the state in the Exemplary Wetlands database (WVDEP 2019). Definitions of these wetland types are:

<u>Large Bog or Fen</u>: Wetland > 0.5 hectare (1.2 acres) in size with seasonally or permanently saturated organic soils covering at least 0.1 hectare (0.25 acre) or 10% of the wetland. Vegetation is often characterized by extensive cover of mosses and sedges. Rainfall and groundwater are important water sources. This category includes both acidic bogs and fens, typically found in the mountain counties, and calcareous fens, found on marl deposits in the eastern panhandle. Site Biodiversity Rank = B4 minimum.

<u>Mature Forested Swamp</u>: Wetland > 0.5 hectare (1.2 acres) in size in which mean diameter at breast height (dbh) of canopy trees (FACW and FAC species only) exceeds

30 centimeters (12 icnhes), and/or the average age of trees exceeds 80 years, and/or there are > 5 trees/acre with diameter > 50 centimeters (20 inches). The canopy must be dominated by one or more of the following trees: oak, ash, maple (red or silver), elm, sweetgum, birch, spruce, hemlock, fir, larch, pitch pine, or blackgum. Site Biodiversity Rank = B5 minimum.

Old Growth Swamp: Must meet all criteria for "Mature Forested Swamp", plus the wetland must be a remnant old-growth patch, with its older canopy trees >130 years old, i.e., stand dates to before the logging boom in WV 1880-1915. Site Biodiversity Rank = B3 minimum.

Summit Sinkhole Wetland: Sandstone-over-karst acidic sinkhole wetlands on the summits of the Ridge & Valley (Pendleton, Hardy, Hampshire, Morgan, Berkeley Counties only). No size requirement. Site Biodiversity Rank = B5 minimum.

Site Biodiversity Ranks (B-ranks) are designated as:

- B1 Outstanding Global Biodiversity Significance
- B2 High Global Biodiversity Significance
- B3 Global Biodiversity Significance
- B4 Outstanding State Biodiversity Significance
- B5 State Biodiversity Significance
- B6 Local Biodiversity Significance

B-ranks are calculated by screening the WVDNR Natural Heritage geodatabase of element occurrences for wetland species to create the BRankInput layer. Then the Wetland Unit boundary is overlain on BRankInput. B-rank is assigned based on the quality and abundance of single unique elements (BSing) and concentrations of four or more unique elements (BConc) documented within the wetland boundary.

Technical criteria for assigning B-ranks are maintained by the WVDNR Natural Heritage staff and summarized in the table below.

Site Biodiversity Rank Technical Criteria.

Single Occurrences

					Flags with Occurrence Quality Rank in parentheses					
	A	B	C	D	Disjunct	OnlyRange	Best5Range	Best5Ecoregion	BestState	OnlyState (EOCount=1)
G1	B1	B2	B2			B1(D)			B1(BC), B3(D)	B1(BC), B3(D)
G2	B2	B2	B3						B4(D)	B4(D)
G3	B3	B3	B4				B2(AB)		B5(D)	B5(D)
G4-G5					B4(ABC)					
G4-G5 comm	B4	B4	B5					B3(AB)		
S1	B4	B4	B5		B3(AB)				B4(C)	B4(C)
S2	B4	B5	B5							
S3	B5	B6	B6							

Concentrations (4 or more occurrences)

	A	B	C	D
G1		B1		
G2	B1	B1	B2	
G3	B2	B2	B3	
G4-G5 comm			B4	
S1	B3	B3	B4	
S2		B4	B4	
S3	B4	B5	B5	

B1	Outstanding Global Biodiversity Significance
B2	High Global Biodiversity Significance
B3	Global Biodiversity Significance
B4	Outstanding State Biodiversity Significance
B5	State Biodiversity Significance
B6	Local Biodiversity Significance

GIS rank:

BRank

Tabular field rank:

BrankT

Final rank is the highest of the GIS or tabular field scores:

BRankA = IIf(Right([BRank],2)<Right([BRankT],2),[BRank],[BRankT])

Input to: *Habitat & Ecological Integrity / HPotential / HFunction, HFunctionT*

2.3.2 MarlPEM: Emergent Wetlands on Marl Substrate

Emergent wetlands on marl substrates provide habitat for a large number of rare species and comprise a globally rare and imperiled habitat (WVDNR 2016). Not all emergent marl wetlands are captured in the Natural Heritage database. This metric is used in the GIS estimate of Floristic Quality. It is not used in the rapid field assessment, where it is replaced by direct assessment of Floristic Quality. The maximum score is 3.

Preliminary GIS score:

Overlay emergent wetland (PEM) on marl soils and calculate area and ratio of area to total wetland area.

3 points: PEM on marl > 1 hectare (2.5 acres) in extent
2 points: PEM on marl comprises > 50% of wetland
1 point: PEM on marl > 200 m^2 (2,150 ft^2) in extent
0 points: none of the above criteria are met

Field and Final Scores: not used (replaced by VegFQT)

Input to: *Habitat & Ecological Integrity / HPotential / VegFQ*

2.3.3 VegAll: All Vegetation Types

All vegetation, even grazed pastures and aquatic bed vegetation, plays at least a minor role in slowing and desynchronizing flood flows (Hruby 2012).

The score is calculated in GIS, and field data are incorporated through field-mapping of NWI polygons. The maximum score is 1.

GIS score & final score:

Assign 1 point to wetlands with at least 50% areal cover by vegetation of any type.

Input to: *Flood Attenuation / FAPotential / VegFA*

2.3.4 VegByLP: Vegetation Fringing Open Water

Vegetation fringing the banks of open water, including lakes, reservoirs, ponds or streams, provides vertical structure to filter out pollutants or absorb them, enhancing sediment retention and stabilization, phosphorus retention, and nitrate removal (Adamus et al. 2010, Hruby 2012). Wetlands in which the average width of shoreline vegetation is large are more likely to retain sediment and toxic compounds than where shoreline vegetation is narrow (Adamus et al. 1991). Aquatic bed species that die back every year play a role in improving water quality. These plants take up nutrients in the spring and summer that would otherwise be available to stimulate algal blooms in the water body (Reynolds and Davies 2001). In addition, aquatic bed species change the chemistry of the lake/pond bottom to facilitate the binding of phosphorus (Moore et al. 1994). Vegetated shorelines provide physical protection from erosion, including shoreline anchoring and the dissipation of erosive forces. Fringing wetlands that have extensive, persistent (especially woody) plants provide protection from overbank flows or waves associated with large storms (Adamus et al 1991). Deeply rooted shoreline vegetation is resistant to change and recovers quickly, improving the structural integrity of the shoreline and protecting against erosion (NY DEC 2010).

GIS estimation of this metric is replaced during the field assessment. Maximum score is 1.

Preliminary GIS score:

Assign 1 point to vegetated wetlands that

- *intersect a river, lake, or reservoir*
- *contain pond(s)*
- *contain a through-flowing perennial stream*

Final score, including tabular field data:

VegByLPT = 1 if at least 90% of open water (stream, lake, reservoir, or pond > 0.1 acre) boundaries with the wetland are fringed by a band of vegetation at least 10 m (33 ft) wide.

Input to: *Water Quality / WQPotential / VegWQ*

2.3.5 VegFA roll-up: Vegetation for Flood Attenuation

Plants enhance flood attenuation by physically impeding flows, creating microtopographic depressions to store water, and by actively taking up water through their root systems. Plants that persist throughout the year and provide a complex vertical structure to slow overland or overbank flows (live or dead trees, shrubs, and persistent herbs) enhance flood attenuation. However, their effectiveness is reduced if the plants are grazed or mowed to less than 6 inches in height, since their low stature offers little resistance to flood flows. Aquatic bed plants play a smaller role in slowing floods. Forest vegetation provides high interception and evapotranspiration during rainfall events. In floodplains, forest vegetation is particularly effective at slowing flows and providing temporary storage due to the structural complexity of tree trunks and branches, coarse woody debris and microtopographically complex root structures.

The score is calculated in GIS, and field data are incorporated through field-mapping of NWI polygons. Maximum score is 9 for floodplain wetlands and 5 for non-floodplain wetlands.

Preliminary GIS score:

VegFA = VegAll + VegPerUng4 + VegWoody4; reduce to maximum of 5 points for non-floodplain wetlands

Final score, including field tabular data:

VegFAA = VegAll + VegPerUn4A + VegWoody4; reduce to maximum of 5 points for non-floodplain wetlands:

MS Access SQL expression:

VegFAA: IIf(([VegAll]+[VegWoody4]+[VegPerUn4A])>5 And [4_Metrics_tabular]![FloodplainT]=0,5,[VegAll]+[VegWoody4]+[VegPerUn4A])

Input to: *Flood Attenuation / FAPotential*

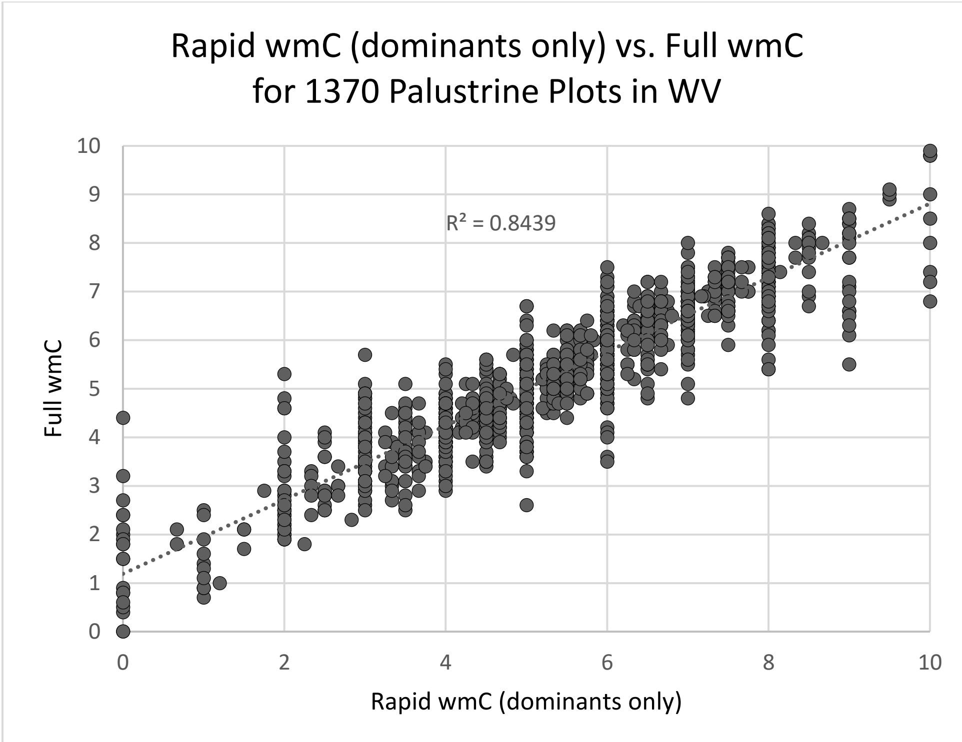
2.3.6 VegFQ: Floristic Quality Assessment

Floristic quality assessment (FQA) evaluates the ecological condition and integrity of natural habitats based on the plant species that grow in them. Each species is characterized by a Coefficient of Conservatism (CoC) based on its tolerance of disturbance and its fidelity to intact natural habitats (Swink and Wilhelm 1994, Wilhelm and Masters 1999). CoC values have been assigned to all species in the West Virginia flora (Rentch and Anderson 2006, WVDNR 2015). The assemblages of plant species present in a wetland reflects the potential number of niches available for invertebrates, birds, and mammals (Bourdaghs 2014, Hruby et al. 2000, Knops et al.

1999). Plant biodiversity affects fundamental ecosystem processes such as nutrient dynamics, autotrophic production, susceptibility to invasive species and fungal disease, richness and structure of insect communities, and the overall integrity and functioning of ecosystems (Knops et al. 1999, Fennessy et al. 1998). Excessive nutrients, particularly total P and NO_3-NO_2-N, have been significantly correlated with lower floristic quality (Fennessy et al. 1998).

Floristic quality assessment in its original design requires a high degree of botanical skill and effort and has not generally been included in rapid field assessment methodologies. However, new studies in Minnesota, North Carolina, Pennsylvania, and Oklahoma indicate that FQA can be successfully adapted to the constraints of rapid field assessment (Gianopulos 2018, Spyreas 2016, Bourdaghs 2014, Chamberlain and Brooks 2016). A significant limitation of the Rapid FQA method is that is does not account for species richness. Therefore, only the "cover-weighted mean CoC" (wmC) value, which does not depend on species richness, is measured. Bourdaghs (2014) and Spyreas (2016) have correlated wmC with wetland condition independent of wetland size. A second metric often used in FQA, called the Floristic Quality Index (FQI), is impacted by wetland size and total species richness, and is not measured during Rapid FQA. The West Virginia Rapid FQA method has been adapted from the Minnesota Rapid FQA checklist method by Bourdaghs (2014) and the Rapid FQA method for dominant species in Pennsylvania Chamberlain and Brooks (2016). Gara (2016) has also validated a simplified VIBI-Floristic Quality for wetland assessment and mitigation monitoring in Ohio; however, this method requires a higher degree of botanical skill, including full species inventory of plots, and uses both wmC and FQI metrics.

Recording only the small number of dominant species greatly decreases the botanical knowledge and time investment required to conduct floristic quality assessment. The level of botanical skill required to perform Rapid FQA using the dominant species approach is the same as that required for wetland delineation. A comparison of wmC (dominant species only) to full wmC (all species) for 1370 wetland plots in West Virginia shows very high correlations.



Comparison of rapid vs. full floristic quality scores in WV based on palustrine plots (WVDNR 2016).

2.3.6.1 Highly Invasive Wetland Species

Invasive species are non-native species that can spread into natural ecosystems, and displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes (CWMW 2013, Hruby 2012, Adamus et al. 2010, Faber-Langendoen et al. 2016, Miller et al. 2017, Mack 2001). Invasive species may disrupt ecosystem processes and cause major alterations in plant community composition and structure. They establish readily in natural systems and spread rapidly. Their ecological impacts include loss of habitat, loss of native biodiversity, decreased nutrition for herbivores, impaired hydrologic function, and alteration of biomass, energy cycling, productivity, and nutrient cycling (Dukes and Mooney 1999, Faber-Langendoen et al 2016). WVDNR maintains rankings of invasive plant species for West Virginia (WVDNR 2009). Rapid FQA includes the negative impacts of invasive plant species by applying negative CoC values of -1, -3, and -5 to occasionally, moderately, and highly invasive species, respectively (DeBerry et al. 2015).

Highly invasive wetland species are recorded on the same field form as other species during the Rapid FQA.

Highly invasive wetland plants of West Virginia

<u>Top three</u>
Phalaris arundinacea (Reed Canarygrass) FACW
Lythrum salicaria (Purple Loosestrife) FACW

Phragmites australis (Common Reed) FACW

…and the rest of the dirty dozen
Arthraxon hispidus (Small Carpetgrass) FAC
Iris pseudacorus (Yellow Iris) OBL
Lonicera japonica (Japanese Honeysuckle) FAC
Microstegium vimineum (Japanese Stiltgrass) FAC
Myriophyllum aquaticum, M. spicatum (Parrotfeather, Eurasian water-milfoil) OBL
Polygonum cuspidatum/Fallopia japonica (Japanese Knotweed) FAC
Polygonum perfoliatum (Asiatic Tearthumb, Mile-a-minute) FAC
Rosa multiflora (Multiflora Rose) FAC
Typha x glauca, T. latifolia, T. angustifolia (Cattail) OBL

Source: WVDNR 2009

2.3.6.2 Lab identification of unknown species

Unknown species may be keyed out in the field or collected for later study. Standard flora references that surveyors should refer to are:

1. Flora of Virginia (Weakley et al 2015). This is the best single reference for West Virginia, including all but a handful of West Virginia species. It is available in book form and as a user-friendly Android/iOS app with graphical and text keys and some line drawings.
2. Flora of West Virginia (Strausbaugh and Core 1978). Book: outdated and incomplete but a good secondary reference, with West Virginia habitats and line drawings of most species.
3. Aquatic and Wetland Plants of Northeastern North America Vols I-II. (Crow and Hellquist 2000 & 2006). Book: easy-to-use keys and detailed line drawings. Does not include all WV wetland species.
4. Flora of North America (FNA 1993+). Book: excellent but not all families have been completed. Volumes 22-25 (grasses, sedges, rushes) are particularly helpful.
5. Flora of the Southern and Mid-Atlantic States (Weakley 2015). Available as an electronic book (free pdf download) or iOS "FloraQuest" app. Includes the entire flora of WV, with excellent technical keys, which can be filtered by state.
6. In areas with Internet connections, or for office use, the "GoBotany" website has excellent, well-illustrated keys covering many, but not all, West Virginia species.

2.3.6.3 Calculating wmC

Abundance-weighted mean coefficient of conservatism (wmC) is calculated from the species name and cover values. Each species name corresponds to a coefficient of conservatism value, ranging from 0-10 for non-invasive plants, with negative values of -5 to -1 for invasive plants. This value is multiplied by the abundance value (range from 0-1 representing 0-100% cover) for each species. The products are summed, and the sum is divided by the summed abundance for all species:

$$wmC = \frac{\sum_{i=0}^{n} C_i a_i}{\sum_{i=0}^{n} a_i}$$

Where wmC = abundance-weighted mean coefficient of conservatism
C = coefficient of conservatism
a = abundance

The percent of the wetland occupied by each NWI wetland type is multiplied by its calculated wmC to obtain the components of the final wmC value for the wetland. The component values are then summed, as in the example below.

NWI wetland type	Percent of AA	wmC	PercentAA * wmC
PEM1Fhtn	16	-2.095	-0.335
PAB3Hhtn	75	3.979	2.984
PEM1Cin	9	2.011	0.181
Total (wmC for wetland)			**2.830**

2.3.6.4 Scoring the Rapid FQA

Floristic quality is inherently a field metric; however, there are documented correlations between floristic quality and several GIS parameters that can be used to estimate a preliminary score using GIS. Buffer disturbance is known to be correlated with floristic quality (Fennessy et al 1998).

The GIS score is overwritten by the field score. Scores range from a minimum of (-2) to a maximum of 9.

Preliminary GIS score:

VegFQ = VegPerUng1 + VegWoodyFor + MarlPEM + Histosol +Karst + Dist50mFQ + LandInteg (score capped at 9)

Final score, including tabular field data:

The interim variable VegSum is scored based on wmC categories for floodplain and non-floodplain wetlands. The categories are derived from analysis of 1370 palustrine plots in West Virginia.

Score	wmC range (floodplain wetland)	wmC range (non-floodplain wetland)
9	>5	>6
8	4.67 < *wmC* ≤ 5	5.67 < *wmC* ≤ 6
7	4.33 < *wmC* ≤ 4.67	5.33 < *wmC* ≤ 5.67
6	4 < *wmC* ≤ 4.33	5 < *wmC* ≤ 5.33
5	3.5 < *wmC* ≤ 4	4.67 < *wmC* ≤ 5
4	3 < *wmC* ≤ 3.5	4.33 < *wmC* ≤ 4.67
3	2 < *wmC* ≤ 3	4 < *wmC* ≤ 4.33

2	1 < *wmC* ≤ 2	2 < *wmC* ≤ 4
1	0 < *wmC* ≤ 1	0 < *wmC* ≤ 2
0	≤ 0	≤ 0

The vegetation stressor score (VegStress, with values ranging from 0 for minimal or no stressors to -2 for high stressors) is added to VegSum to obtain the final score:

VegFQT = VegSum + VegStress

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential / VegH*

2.3.7 VegH roll-up: Vegetation Structure and Quality

Vegetation is an outstanding proxy for overall ecological integrity, biodiversity potential, and habitat quality. This roll-up metric sums the values for vertical structure of vegetation, horizontal interspersion of vegetation types, and floristic quality. Maximum score is 15.

Preliminary GIS score:

VegH = VegVerStr + VegHorInt + VegFQ

Final score, including field tabular data:

VegHA = VegVerStrT + VegHorIntA + VegFQT

MS Access SQL expression:

VegHA: [4_Metrics_tabular]![VegVerStrT]+[VegHorIntA]+[VegFQT]

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential*

2.3.8 VegHorInt: Horizontal Interspersion of Vegetation

Interspersion of different habitat types provides multiple niches for species and is important in supporting biodiversity (Adamus et al. 2010a, Mack 2001). Complex vegetation structure optimizes potential breeding areas, escape, cover, food production, and native species richness (CWMW 2013, Hruby et al. 2000, Hruby 2012, and Faber-Langendoen et al. 2016). It also provides surface roughness, which reduces flow velocities and increases the contact time between water and vegetation to support biogeochemical cycling functions and water quality services (USEPA 2002, Järvelä 2003).

Interspersion tends to be greater in larger wetlands and serves as a partial proxy for wetland size.

Horizontal interspersion of vegetation is estimated in GIS from the complexity of the NWI polygons, which are based on vegetation classes classified by Cowardin et al. (1979). These are supplemented by field observations of several size ranges within the emergent class of vegetation to address important bird habitats. Tall graminoid marsh is included as a special structural type that benefits birds of conservation concern in WV.

Preliminary GIS score:

Divide the perimeter of summed NWI (all) polygon perimeters by the square root of the wetland area. Then, compare this ratio to the number of NWI polygons in the wetland.

- *3 points: ratio > 10 AND at least 5 NWI polygons present*
- *2 points: ratio > 6 AND at least 3 NWI polygons present*
- *1 point: ratio > 4 AND at least 2 NWI polygons present*
- *0 points: ratio <= 4 OR only 1 NWI polygon present*

Field tabular score:

For emergent vegetation, note the number of vegetation types based on height classes. Add an extra point if tall emergent marsh is present.

- *2 points: 2 or more emergent types present plus tall emergent marsh present*
- *1 point: 2 or more emergent types present or tall emergent marsh present*
- *0 points: less than 2 emergent types present; no tall emergent marsh*

MS Access SQL expression:

IIf(([PEM_030]+[PEM_30100]+[PEM_gt100])<(-1) And [TallMarsh]<0,2,IIf(([PEM_030]+[PEM_30100]+[PEM_gt100])<(-1) Or [TallMarsh]<0,1,0))

Final score:

Sum of GIS plus field score, capped at 3 maximum.

MS Access SQL expression:

VegHorIntA: IIf([VegHorInt]+[VegHorIntT]>3, 3, [VegHorInt]+[VegHorIntT])

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential / VegH*

2.3.9 VegPerUng: Persistent Ungrazed Vegetation

Persistent, ungrazed vegetation improves water quality by acting as a filter to trap sediment, nutrients, and pollutants. When vegetation is grazed or mowed to heights below 15 centimeters (6 inches), this function is reduced (Sheldon et al. 2005, Adamus et al. 1991, Adamus et al. 2010, Hruby 2012).

Note that this variable could be improved by a better estimation of grazed areas. These are currently available for only a few parts of the state. James Summers (WVDEP) has provided the mapped watersheds used in the “[Grazed] Pastures Not Hayfields” layer. He has also provided estimates of the percentage of NLCD grassland that is probably grazed pasture statewide. This latter data has not yet been incorporated into the VegPerUng variable but could be used in the future.

The GIS metric sums the persistent vegetation types within the wetland, excluding ponds, non-persistent emergent areas, and grazed pastures. The field metric modifies this value based on the observed condition of vegetation. The final score is based on the minimum value. Maximum score is 5.

2.3.9.1 VegPerUng: Persistent Ungrazed Vegetation for Water Quality

Persistent, ungrazed vegetation improves water quality by acting as a filter to trap sediment, nutrients, and pollutants. Maximum score is 5.

Preliminary GIS score:

> *Sum the persistent ungrazed vegetation based on the NWI attribute. Erase the mapped grazed pastures. Calculate the percentage of persistent ungrazed vegetation for the wetland, and assign points as follows:*
>
> - *5 points: persistent ungrazed vegetation >2/3 of wetland area*
> - *3 points: persistent ungrazed vegetation = 1/3 to 2/3 of wetland area*
> - *1 point: persistent ungrazed vegetation = 1/10 to 1/3 of wetland area*
> - *0 points: persistent ungrazed vegetation <1/10 of wetland area*

Field tabular score:

> *Mowed (< 15 cm tall or < 6 in tall) or livestock-grazed portion of wetland: None = 5, trace-33% = 4, 33-67% = 2, >67% = 0.*
>
> *IIf([MowGraze]="none",5,IIf([MowGraze]="trace - 33%",4,IIf([MowGraze]="33 - 67%",2,IIf([MowGraze]="> 67%",0,999))))*

Final Score is the minimum value of either the GIS or field tabular score.

> *VegPerUngA = Min(VegPerUng, VegPerUngT)*
>
> *MS Access SQL expression:*
>
> *VegPerUngA: IIf([VegPerUng]<[VegPerUngT], [VegPerUng],[VegPerUngT])*

Input to: *Water Quality / WQPotential / VegWQ*

2.3.9.2 VegPerUng4: Persistent Ungrazed Vegetation for Flood Attenuation

Persistent, ungrazed vegetation enhances flood attenuation by physically impeding flows, creating microtopographic depressions to store water, and by actively taking up water through root systems. Maximum score is 4.

Preliminary GIS score:

Sum the persistent ungrazed vegetation based on the NWI attribute. Erase the mapped grazed pastures. Calculate the percentage of persistent ungrazed vegetation for the wetland, and assign points as follows:

- *4 points: persistent ungrazed vegetation >2/3 of wetland area*
- *3 points: persistent ungrazed vegetation = 1/2 to 2/3 of wetland area*
- *2 points: persistent ungrazed vegetation = 1/3 to 1/2 of wetland area*
- *1 point: persistent ungrazed vegetation = 1/10 to 1/3 of wetland area*
- *0 points: persistent ungrazed vegetation <1/10 of wetland area*

Field tabular Score:

Mowed (< 15 cm tall or < 6 in tall) or livestock-grazed portion of wetland: None = 4, trace-33% = 3, 33-67% = 2, >67% = 0.

MS Access SQL expression:

IIf([MowGraze]="none",4,IIf([MowGraze]="trace - 33%",3,IIf([MowGraze]="33 - 67%",2,IIf([MowGraze]="> 67%",0,999))))

Final Score is the minimum value of either the GIS or field tabular score.

VegPerUn4A = Min(VegPerUng4, VegPerUng4T)

MS Access SQL expression:

VegPerUn4A: IIf([VegPerUng4]<[VegPerUng4T], [VegPerUng4],[VegPerUng4T])

Input to: *Flood Attenuation / FAPotential / VegFA*

2.3.9.3 VegPerUng1: Persistent Ungrazed Vegetation for GIS Floristic Quality

Persistent, ungrazed vegetation uses carbon from the atmosphere and stores carbon in above- and below-ground biomass. This biomass provides important habitat and energy to organisms, creating a setting where biodiversity can potentially flourish. Maximum score is 1.

Preliminary GIS score (not used for field or final score):

Sum the persistent ungrazed vegetation based on the NWI attribute. Erase the mapped grazed pastures. Calculate the percentage of persistent ungrazed vegetation for the wetland, and assign points as follows:

- *1 point: persistent ungrazed vegetation 1/2 or more of wetland area*
- *0 points: persistent ungrazed vegetation <1/2 of wetland area*

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential / VegH / VegFQ*

2.3.10 VegVerStr: Vertical Structure of Vegetation

Plant communities with complex vertical structure offer enhanced habitat niches for a variety of plants and animals. Complex vegetation structure optimizes potential animal breeding areas, escape, cover, food production, and native species richness (CWMW 2013, Hruby et al. 2000, Hruby 2012, and Faber-Langendoen et al. 2016). It also provides surface roughness, which reduces flow velocities and increases the contact time between water and vegetation to support biogeochemical cycling functions and water quality services (USEPA 2002, Järvelä 2003).

Vertical structure of vegetation is measured by the number of strata present, e.g., tree canopy, understory, shrub, herbaceous, and moss layers. GIS structural components are estimated from the NWI attributes, which are based on vegetation classes classified by Cowardin et al. (1979). These are supplemented by field observations of strata and regeneration characteristics of a stand. Maximum score is 3.

Preliminary GIS score:

Assign points based on the ratio of forest and vegetated classes to total area; minimum polygon size 0.1 acre (only count those codes whose aggregated area >= 0.05 ha).

- *3 points: PFO > 50% of wetland AND PFO ≥ 0.05 ha*
- *2 points: (PFO >5% of wetland AND PFO >=0.05 ha) AND vegetated classes (PFO+PSS+PEM+PAB+PML) > 50% of wetland*
- *1 point: vegetated classes (PFO+PSS+PEM+PAB+PML) > 5% of wetland AND vegetated classes >=0.05 ha*
- *0 point: none of the above criteria are met*

Field tabular score:

3 points: > 3 forest strata present with canopy regeneration
2 points: > 3 forest strata present OR > 2 forest strata with canopy regeneration
1 point: > 2 forest strata present OR canopy regeneration
0 points: none of the above criteria are met

MS Access SQL expression:

IIf([PFOSum]>3 And [ForestRegen]<0,3,IIf([PFOSum]>3 Or ([PFOSum]>2 And [ForestRegen]<0),2,IIf([PFOSum]>2 Or [ForestRegen]<0,1,0)))

Final score:

Increase GIS score up to max (3) based on field tabular data.

MS Access SQL expression:

VegVerStrA: IIf([VegVerStr]+[VegVerStrT]>3,3,[VegVerStr]+[VegVerStrT])

Input to: *Habitat & Ecological Integrity / HFuncNoBR / Potential / VegH*
Habitat & Ecological Integrity / HFuncNoBR / Potential / SoilH / StrucPatch (preliminary GIS score only)

2.3.11 VegWoody: Woody Vegetation

Woody vegetation is important for multiple wetland functions. Maximum score is 5.

2.3.11.1 VegWoody: Woody Vegetation for Water Quality

Plants improve water quality by acting as a filter to trap sediments and associated pollutants. They also slow the velocity of water which results in the deposition of sediments. Persistent, multi-stemmed plants enhance sedimentation by offering frictional resistance to water flow (Adamus et al. 1991). Woody vegetation takes up and provides long-term storage of phosphorus (Reddy et al 2019).

The score is calculated in GIS, and field data are incorporated through field-mapping of NWI polygons. Maximum score is 5.

GIS score & final score:

Assign points based on the ratio of forest and shrub cover to total area.

- *5 points: forested wetlands cover more than 2/3 of the wetland*
- *4 points: forest > 1/3 AND shrub/forest > 90%*
- *3 points: shrub/forest > 2/3*
- *2 points: shrub/forest > 1/3*
- *1 point: shrub/forest > 1/10*
- *0 point: shrub/forest < 1/10*

Input to: *Water Quality / WQPotential / VegWQ*

2.3.11.2 VegWoody4: Woody Vegetation for Flood Attenuation

Woody vegetation provides high interception and evapotranspiration during rainfall events. Woody vegetation in a floodplain slows the velocity of water and offers frictional resistance to water flow (Adamus et al. 1991). Shrubs and trees are considered to be better at resisting water velocities than emergent plants during flooding. Aquatic bed species or grazed, herbaceous (non-woody) plants provide little resistance to water flows.

The score is calculated in GIS, and field data are incorporated through field-mapping of NWI polygons. Maximum score is 4.

GIS score & final score:

Assign points based on the ratio of forest and shrub cover to total area.

- *4 points: forested wetlands cover more than 2/3 of the wetland*
- *3 points: forest > 1/3 AND shrub/forest > 90%*
- *2 points: shrub/forest > 1/2*
- *1 point: shrub/forest > 1/10*

- *0 point: shrub/forest < 1/10*

Input to: *Flood Attenuation / FAPotential / VegFA*

2.3.11.3 VegWoody2: Woody Vegetation for Structural Patches

Woody vegetation provides multiple layers for habitat niches to develop. It is one indicator of structural patch richness.

This preliminary GIS metric is replaced by rapid field assessment of structural patches. Maximum score is 2.

Preliminary GIS score (not used in field and final scores):

Assign points based on the ratio of forest and woody shrub cover to total wetland area.

- *2 points: forested wetlands cover more than 2/3 of the wetland*
- *1 point: forested or shrub wetlands cover at least 10% of the wetland*
- *0 point: shrub/forest < 1/10*

Input to: *Habitat & Ecological Integrity / HFuncNoBR / Potential / SoilH / StrucPatch (preliminary GIS score only)*

2.3.11.4 VegWoodyFor: Woody Vegetation for Floristic Quality

Forested wetlands include many of the highest-quality wetlands in the state, such as conifer peatlands, pin oak swamps, and blackgum swamps. Forested wetlands have many layers of habitat to support a large diversity of organisms. Forested wetlands take decades or centuries to develop and are not easily replaced. Woody vegetation in forested wetlands provides long-term carbon storage in roots, branches, and trunks. Large intact patches of forested wetland have greater habitat value than smaller or fragmented patches.

This preliminary GIS metric is replaced by rapid field assessment of floristic quality. Maximum score is 3.

Preliminary GIS score (not used in field and final scores):

Assign points based on the ratio of forest cover to total wetland area, and size of forest patch.

- *3 points: forested wetlands cover more than 2/3 of the wetland AND forested wetlands total > 0.5 hectare (1.2 acre); OR forested wetlands comprise > 5 hectares (12 acres) within the wetland*
- *2 points: forested wetlands cover 1/3 to 2/3 of the wetland AND forested wetlands total > 0.2 hectare (0.5 acre); OR forested wetlands comprise 2-5 hectares (5-12 acres)*
- *1 point: forested wetlands cover 1/10 to 1/3 of the wetland OR forested wetlands comprise > 1 hectare (2.5 acres)*

Input to: *Habitat & Ecological Integrity / HFuncNoBR / Potential / VegH / VegFQ (preliminary GIS score only)*

2.3.12 VegWQ roll-up: Vegetation for Water Quality

Vegetation slows the flow of water, causing deposition of mineral and organic particles with their adsorbed nutrients, including nitrogen and phosphorus (Tiner 2003). Plants enhance sedimentation by acting as a filter, and cause sediment particles to drop to the wetland surface. Plants are most effective when they persist throughout the year and provide a vertical structure to trap or filter out pollutants (live or dead trees, shrubs, and persistent herbs). The effectiveness at trapping sediments and pollutants is severely reduced if the plants are grazed by livestock or mowed to a height of less than 15 centimeters (6 inches). Aquatic bed plants are not considered important in sequestering toxic compounds because the toxics will be released in the fall when the plants decompose (Adamus et al 1991).

This roll-up metric sums the scores for persistent ungrazed vegetation, woody vegetation, and vegetation fringing open water. Maximum score is 10 for floodplain wetlands and 5 for non-floodplain wetlands.

Preliminary GIS score:

VegWQ = VegPerUng + VegWoody + VegByLP; reduce to maximum of 10 (floodplain wetlands) or 5 (non-floodplain wetlands)

Final score, including field tabular data:

VegWQA = VegPerUngA + VegWoody + VegByLPT; reduce to maximum of 10 (floodplain wetlands) or 5 (non-floodplain wetlands)

MS Access SQL expression:

VegWQA: IIf([VegPerUngA]+[VegWoody]+[VegByLPT]>10 And [4_Metrics_tabular]![FloodplainT] = (-1), 10, IIf([VegPerUngA]+[VegWoody]+[VegByLPT] > 5 And [4_Metrics_tabular]![FloodplainT]=(0),5,[VegPerUngA]+[VegWoody]+[VegByLPT]))

Input to: *Water Quality / WQPotential*

2.4 Soil and Structure Metrics

2.4.1 ChemTime roll-up: Time and Space for Chemical Reactions to Occur

The time and space for chemical reactions to occur and provide water quality improvements within a wetland is linked to its area of seasonal ponding, slope, the complexity of its upland-wetland interface, and its location relative to a floodplain. The area of the wetland that is seasonally ponded is an important characteristic in understanding how well it will remove nutrients, specifically nitrogen. The highest levels of nitrogen transformation occur in areas of the wetland that undergo a cyclic change between oxic (oxygen present) and anoxic (oxygen absent) conditions. The oxic regime (oxygen present) is needed so certain types of bacteria will change nitrogen that is in the form of ammonium ion (NH4+) to nitrate, and the anoxic regime is needed for denitrification (changing nitrate to nitrogen gas) (Mitsch and Gosselink 1993). The area that is seasonally ponded is used as an indicator of the area in the wetland that undergoes this seasonal cycling. The soils are oxygenated when dry but become anoxic during the time they are flooded. Wetlands with a highly irregular upland-wetland boundary have a large linear area where chemical reactions are likely to occur.

Water velocity increases with increasing slope. This decreases the retention time of surface water in the wetland and the potential for retaining sediments and associated toxic pollutants. The potential for sediment deposition and retention of toxics by burial decreases as the slope increases (Adamus et al. 1991).

Select wetlands that are not in a floodplain and have seasonal ponding. Then, filter the points so that wetlands with slope >5% do not receive any points, and wetlands with slopes 2-5% get a maximum of 2 points. Finally, wetlands can gain 1 additional point (regardless of slope) if they have a highly irregular upland/wetland boundary. This roll-up metric is calculated based on the values of Floodplain, SeasonPond, Slope, and IrrEdge. Maximum score is 3.

Preliminary GIS score:

> *Calculate "ChemTime" = "SeasonPond" except in the cases below where "ChemTime" =*
> *0 WHERE "SLOPE" > 5 OR "Floodplain" = 'Y';*
> *2 WHERE: "SLOPE" > 2 AND "SLOPE" < 6 AND "Floodplain" = 'N' AND "SeasonPond" > 2;*
> *"SeasonPond" + 1 WHERE: "IrrEdge" = 1 AND "Floodplain" = 'N' AND "SLOPE" < 6 AND "SeasonPond" < 3.*

Final score, including tabular field data:

> *Same as GIS score, except that "Floodplain" is replaced with the field metric"FloodplainT".*
>
> *MS-Access SQL Expression:*
>
> *[ChemTimeA] = IIf([SLOPE]>5 Or [FloodplainT]=(-1),0,IIf([SLOPE]>2 And [SeasonPond]>2,2,IIf([IrrEdge]=1 And [SeasonPond]<3, [SeasonPond]+1, [SeasonPond])))*

Input to: *Water Quality / WQPotential*

2.4.2 ClayOrganic roll-up: Organic Soil near Surface

Note that the metric name "ClayOrganic" is a holdover from earlier versions of WVWRAM which included clayey soils near the soil surface. The metric name was not changed (to avoid introducing errors into the formulas) but it no longer includes clayey soils.

Organic material near the soil surface is a good indicator that a wetland can remove a wide range of nutrients and pollutants from surface and ground water. The uptake of dissolved phosphorus and toxic compounds through adsorption to soil particles is highest when soils are high in organic content (Mitsch and Gosselink 2007, Rosenblatt et al. 2001, NRC 2002). The top 8 centimeters (3 inches) of the soil profile is where the soil is likely to have maximum alternating wet and dry contact with nutrients or pollutants, and where many of the chemical and biological reactions occur (Hruby 2012).

Soils must be outside the area of permanent ponding. Assign points based on seasonal area of ponding to wetlands that have organic material near the surface and are not in a floodplain. Maximum score is 3 (non-floodplain wetlands only).

Preliminary GIS score:

ClayOrganic = wetlands where Floodplain = N AND Organic = Y AND wetland contains areas that are not permanently ponded, as follows:

- *SeaPondRatio = 90-100% cover: 3 points*
- *SeaPondRatio = 50-90% cover: 2 points*
- *SeaPondRatio = 10-50% cover: 1 point*
- *SeaPondRatio < 10% cover: 0 point*

Final score, including tabular field data:

ClayOrganA = wetlands where FloodplainT = N AND OrganicT > 0 AND wetland contains areas that are not permanently ponded, as follows:

- *SeaPondRatio = 90-100% cover AND (OrganicT >2): 3 points*
- *SeaPondRatio = 50-100% cover AND (OrganicT = (1,2)): 2 points*
- *SeaPondRatio < 90% cover AND (OrganicT >2): 2 points*
- *SeaPondRatio < 50% cover AND (OrganicT = (1,2)): 1 point*

MS-Access SQL expression:

ClayOrganA: IIf([FloodplainT]=(-1) Or ([OrganicT]=0) Or [SeaPondRat]=0,0,
IIf([OrganicT] in (1,2) And [SeaPondRat]=0.5,1,
IIf([OrganicT] in (1,2) And [SeaPondRat]>=0.5,2,
IIf(OrganicT] >2 And [SeaPondRat]<0.9,2,
IIf([OrganicT] >2 And [SeaPondRat]>=0.9,3,0)))))

Input to: *Water Quality / WQPotential*

2.4.3 Depressions: Surface Depressions

Surface depressions in a wetland that receives overland or overbank flow can trap sediments during a flood event (Hruby 2012, Adamus et al. 2010, Brinson 1993). Depressions in floodplain wetlands will tend to accumulate sediment and the pollutants associated with sediment (phosphorus and some toxins). Depressions reduce flood water velocities (Fennessey et al. 2004) while wetland vegetation takes up and stores phosphorus from nutrient-laden water (Reddy et al 1999). Wetlands where a larger part of the total area has depressions are relatively better at removing pollutants associated with sediments than those that have no such depressions. Nitrite removal is aided by upland/wetland contact (Adamus et al. 2010).

We cannot calculate surface depressions directly with available digital elevation models, although this will change as LiDAR becomes available. The GIS score is estimated based on interspersion of NWI polygons, low slope, and irregularity of the upland/wetland edge. This is a proxy for complex microtopography. During rapid field assessment, surface depressions are estimated directly. The field score replaces the preliminary GIS score. Maximum score is 5 for floodplain wetlands and 0 for non-floodplain wetlands.

Preliminary GIS score:

Depressions = Microtopo + LowSlope + IrrEdge (floodplain wetlands only)

Final score, including tabular field data:

DepressioT (floodplain wetlands only) =

- *0 points: no depressions*
- *1 point: trace-10% depressions*
- *3 points: 10-33% depressions*
- *5 points: >33% depressions*

MS Access SQL expression: DepressioT: IIf([FloodplainT]=(-1),[DepressTab],0)

Input to: *Water Quality / WQPotential*

2.4.4 Histosol: Deep Organic Soil

Deep organic soils (histosols) provide important habitat to specialist plants and animals, including bog and fen species (WVDNR 2015). Peatlands are the most vulnerable of all freshwater habitats for threatened dragonfly and damselfly species in the northeastern USA (White et al. 2014). Wetlands with deep organic soils store more carbon per hectare than any other terrestrial ecosystem type (Amthor et al. 1998). Peatlands are considered Wetlands of Special Conservation Concern in West Virginia. The larger peatlands have been mapped and are included in the Exemplary Wetlands database (WVDEP 2019). Some smaller peatlands have not been mapped and therefore field assessment includes a metric for deep organic soil. Ohio (Mack 2001) also considers peatlands as wetlands of special conservation concern.

Histosols and histic epipedons are defined as follows (NRCS 2014, NRCS 2018):

Histosol (Field Indicator of Hydric Soil = A1): Peat, mucky peat, or muck soil with at least 12-18% organic matter by weight and ≥ 40 cm (16 in) thick within the upper 80 cm (32 in) of soil profile; note that the 40 cm (16 in) of organic matter is cumulative and can occur anywhere in the top 80 cm (32 in), even in stratified layering; alternatively, organic soil material of any thickness resting on rock or on fragmental material having interstices filled with organic materials.

Histic epipedon (Field Indicator of Hydric Soil = A2): A surface horizon of peat, mucky peat, or muck soil with at least 12-18% organic matter by weight and ≥ 20 cm (8 in) thick, but < 40 cm (16 in) thick. Aquic conditions or artificial drainage is required.

At the GIS level, histosols and histic epipedons are identified based on organic soil mapping by NRCS (SSURGO), WVNHP palustrine plots, NWI organic soil modifiers, or the WV Peatlands layer. The rapid field assessment of soil organic material replaces the preliminary GIS score. Maximum score is 3.

Preliminary GIS score:

Assign values to Histosol based on the criteria below.

3 points (histosol present in wetland): select all wetlands that intersect with:

- *WVNHP palustrine plots containing organic soils at least 40 cm (16 in) thick OR*
- *SSURGO soils with organic material > 15% by weight with a thickness of at least 40 cm (16 in) in the upper 80 cm (32 in) of the soil profile OR*
- *Mapped WV peatlands OR*
- *NWI attribute soil modifier "n" for organic soil (histosol)*

2 points (histic epipedon present in wetland): select all wetlands that intersect with:

- *WVNHP palustrine plots containing soil textures described as peat, mucky peat, or muck (conservative assumption that these are histic epipedons) AND plots containing organic soils 20-39 cm (8-15 in) thick.*
- *SSURGO soils with organic material > 15% by weight with a thickness of at least 20 cm (8 in) in the upper 80 centimeters (32 in) of the soil profile OR*
- *Mapped WV peatlands OR*

0 points: none of the above criteria are met

Final score, including tabular field data:

Histosols and histic epipedons are documented during field soil sampling. If any histosols are present, 3 points are assigned. If no histosols are present but histic epipedons are present, 2 points are assigned. If neither are present, 0 points are assigned.

MS Access SQL expression:

[HistosolT]: IIf([SumOfHistosol]<0,3,IIf([SumOfHisticEpipedon]<0,2,0))

Input to: *Habitat & Ecological Integrity / HPotential / SoilOrgCalc*
Habitat & Ecological Integrity / HPotential / VegFQ (preliminary GIS score only)

2.4.5 IrrEdge: Complex Upland/Wetland Boundary

Nitrite removal is aided by upland/wetland contact (Adamus et al. 2010). An irregular or complex upland/wetland boundary helps to maximize the area where nitrate removal takes places.

The score is calculated in GIS, and field data are incorporated through field-mapping of NWI polygons. Calculate the perimeter of the wetland that is NOT adjacent to open water (*DryPerim*) divided by the square root of the area of the wetland. Assign 1 point if this ratio is greater than 6. The maximum score is 1.

GIS score & final score:

IrrEdge = 1 if [DryPerim] / ([Shape_Area] ^ 0.5) > 6

Input to: *Water Quality / WQPotential / ChemTime*
Water Quality / WQPotential / Depressions (preliminary GIS score only)

2.4.6 Karst: Karst and Limestone-influenced Wetlands

Karst areas have a uniquely sensitive underground ecology and provide calcium-rich water to above-ground ecosystems. Karst systems lack natural filtering capacity and are vulnerable to pollution wherever they occur in the state (Gutiérrez et al. 2014). Wetlands in karst areas may buffer streams and caves that are particularly vulnerable to nutrient pollution. Water inputs to wetlands from limestone, dolomite, or marl deposits and contain elevated levels of calcium or magnesium. A rich and diverse flora and fauna are characteristic of calcareous wetlands (WVDNR 2015). We have multiple ways to identify wetlands in karst areas (mapped geology, mapped soils, soil pH). The visual evidence of karst topography (springs, sinking streams, sinkholes, caves, and/or limestone/dolomite outcrops is one more way to capture this, particularly where soils or geology are not well-mapped or pH is in the middle range, as sometimes occurs in WV. Perhaps because other states have more abundant calcareous substrates than West Virginia, the karst metric is not commonly used in rapid assessment by other states. It is, however, of clear importance in our state, as presented in the WV State Wildlife Action Plan (WVDNR 2015).

At the GIS level, karst and limestone-influenced wetlands are identified based on overlap with the "KarstComposite" layer created for the assessment tool. This layer is built from WVGES 250k geologic map of limestone and dolostone bedrock geology, NRCS (SSURGO) soil mapping with "karst" in the geomorphic description, and calcareous soil map units identified by Jared Beard, State Soil Scientist, in 2017. The calcareous soil map units are Fairplay, Lappans, and Massanetta, and are located in primarily in Jefferson and Berkeley Counties, with a few additional polygons in Pendleton, Hardy, and Grant Counties. Both rapid field assessment and GIS scores are used to calculate the final score, with full points for the field score and pro-rated points for the GIS score. Maximum score is 3.

Preliminary GIS score:

> *Karst > 67% of total wetland area = 3 points; 33-67% = 2 points; 10-33% = 1 point; <10% 0 points.*

Tabular field data score:

> *KarstT = 3 if any karst indicators are noted in the field. Otherwise KarstT = 0.*
>
> *KarstT = IIf([Kar_spring]<0 Or [Kar_sinkhole]<0 Or [Kar_sinkstr]<0 Or [Kar_limest]<0 Or [Kar_cave]<0,3,0)*

Final score:

> *KarstA = KarstT; if KarstT = 0 and Karst > 1, then KarstA = 1.*
>
> *MS Access expression:*
>
> *KarstA: IIf([KarstT]=0 And [Karst]>1,1,[KarstT])*

Input to: *Habitat & Ecological Integrity / HPotential / SoilOrgCalc*
Habitat & Ecological Integrity / HPotential / VegFQ (preliminary GIS score only)
Habitat & Ecological Integrity / HOpportun / WshdPos (field only, max 1 point)

2.4.7 LowSlope: Low Slope within Wetland

Flat-lying wetlands are more effective at storing and slowing the velocity of flood waters and trapping sediments than sloping wetlands (Brinson 1993).

Slope is calculated as the median value of percent slope 3-meter pixels within a wetland. *LowSlope* is derived from the slope value. The maximum score is 2.

GIS score & final score:

> *LowSlope =*
>
> - *Slope < 2% (2 points)*

- *Slope = 2-5% (1 point)*
- *Slope > 5% (0 points)*

Input to: *Flood Attenuation / FAPotential*
Water Quality / WQPotential / Depressions (preliminary GIS score only)

2.4.8 Microtopo: Microtopographic Complexity

Microtopography, or topographic variability on the scale of individual plants, describes soil surface variation within an elevation range from about 1 cm (0.4 in) to as much as 1 meter (3.3 feet) (Moser et al 2007). It encompasses both vertical relief and surface roughness, and for this assessment should include the soil surface and objects embedded in the soil such as boulders or spreading tree roots (but not tree trunks or standing vegetation). Microtopographic complexity serves to slow and hold water during a flood event (Tweedy and Evans 2001, Mack 2001, Adamus et al. 2010, and MI DNRE 2010). Microtopographic features create small-scale vertical relief that is important for chemical reactions, which tend to occur at the upland-wetland interface (Hruby 2012). Small-scale features such as animal burrows, mounds, hummocks, tussocks, above-ground tree roots, boulders, upturned tree root wads, pit and mound structure, islands, natural levees, dry channels, pits, and wide soil cracks provide habitat for amphibians, birds, and specialized plants (WVDNR 2015b).

We cannot calculate complex microtopography directly with available digital elevation models, although this will change as LiDAR becomes available. The GIS score is coarsely estimated based on interspersion of NWI polygons. During rapid field assessment, microtopography is assessed directly. The field score replaces the preliminary GIS score. Maximum score is 2.

Preliminary GIS score:

Microtopo = Ratio of summed perimeters of all NWI polygons contained in the wetland to the square root of the area of the wetland, with points assigned as follows:

- *0 points: MicroRatio* ≤ 8
- *1 point: 8 < MicroRatio* ≤ 15
- *2 points: MicroRatio* > 15

Final score, including tabular field data:

MicrotopoT =

- *0 points: microtopographic complexity covers < 3% of site*
- *1 point: microtopographic complexity covers 3-40% of site*
- *2 points: microtopographic complexity covers > 40% of site*

Input to: *Flood Attenuation / FAPotential / Runoff*
Water Quality / WQPotential / Depressions (preliminary GIS score only)

2.4.9 Organic: Organic Soil near Surface

Organic soil material near the soil surface is a good indicator that a wetland can remove a wide range of nutrients and pollutants from surface and ground water. Denitrification is high in all soils with anaerobic conditions. Occurrence of redoximorphic features and/or accumulation of organic matter in the soil surface horizon is usually indicative of anaerobic conditions caused by saturated soil conditions. The uptake of dissolved phosphorus and toxic compounds through adsorption to soil particles is high when soils are high in organic content (Mitsch and Gosselink 2007, Rosenblatt et al. 2001, NRC 2002, Fisher and Acreman 2004). Microbial action in the soil is the driving force behind chemical transformations in wetlands. Organic matter is a key food source for microbes, and wetlands with high amounts of organic matter tend to have an abundance of microflora to perform nutrient cycling (Tiner 2003). Soils mapped by NRCS and WVNHP palustrine plots provide documentation of organic soils; however, many of the smaller wetlands in West Virginia have not been mapped due to the scale at which the soil survey maps were produced. Small areas of hydric soils are often recognized in the soil survey as minor components of mapped soils. Therefore, field assessment of organic soil material at or near the soil surface is required. The top 8 centimeters (3 inches) of the soil profile is where the soil is likely to have maximum alternating wet and dry contact with nutrients or pollutants, and where many of the chemical and biological reactions occur (Hruby 2012). Soils must be outside the area of permanent ponding.

The field assessment of soil organic material replaces the preliminary GIS score. Maximum score is "Yes" for the preliminary GIS score and 3 for the field/final score.

Preliminary GIS score:

Organic (Y/N): select all wetlands that intersect with:

- *WVNHP palustrine plots containing peat, mucky peat, muck, or mucky modified mineral soil in the top 8 cm (3 in) of the soil profile OR*
- *SSURGO soils with a surface O horizon or with organic matter >30% in the top 8 cm (3 in) of the soil profile OR*
- *Mapped WV peatlands OR*
- *NWI attribute soil modifier "n" for organic soil (histosol)*

Note that SSURGO mapping is very uneven, with some counties heavily mapped with organic soils and other counties with few or no organic soils mapped.

Final score, including tabular field data:

Assign points to OrganicT based on the number of soil samples in NWI communities with at least 2 cm (0.8 in) of organic or mucky modified mineral soil in the top 8 cm (3 in) of the soil profile:

0 points: none or < 2 cm (0.8 in) thickness of organic soil/mucky modified mineral soil in top 8 cm (3 in) of soil profile
2 points: at least one soil sample includes organic soil near surface
3 points: more than half of soil samples include organic soil near surface

MS Access SQL expression:

[OrganicT] = IIf([OrgPercent]>0.5,3,IIf([OrgPercent]>0,2,0))

Input to: *Water Quality / WQPotential / ClayOrganic*

2.4.10 pH: Soil pH

Soil pH is a key element in classifying the NWI wetland type. Soil pH has a strong impact on the plant and animal life that lives in a wetland. It also has a strong impact on the ability of the wetland to filter and absorb certain nutrients and pollutants. Soil pH is a clue to identifying wetlands impacted by acid or alkaline mine drainage. Soil pH is measured at 10 centimeters (4 inches) depth in order to maximize the correlation with the plant root zone and to provide compatibility with existing pH measurements from 1,667 palustrine wetlands in West Virginia.

Soil pH is recorded on the field sheet and used to determine the pH modifier for the NWI attribute code. Soil pH may also be used in future assessment scenarios to identify highly alkaline or acidic sites.

Tabular field method:

Measure pH at 10 cm (4 in) depth at each soil sampling site. Assign NWI pH modifier as follows:

- *pH < 5.5 = acid (a)*
- *pH 5.5-7.4 = circumneutral (t)*
- *pH > 7.4 = alkaline (i)*

Input to: *Field-mapped NWI polygons*

2.4.11 Slope: Median Percent Slope

Slope is calculated in the GIS tool as the median value of percent slope 3-meter (10-foot) pixels within a wetland. *Slope* is used to filter the values for other metrics. The metric *LowSlope* is derived from the slope value.

GIS score & final score:

Slope = median percent slope of wetland

Input to: *Water Quality / WQPotential / ChemTime*
Water Quality / WQPotential / Depressions / LowSlope (preliminary GIS score only)
Flood Attenuation / FAPotential / LowSlope

2.4.12 SoilH roll-up: Soil and Structural Patches for Habitat

Undisturbed soils, organic or calcareous soils, and structural patches all contribute important physical habitat characteristics to wetlands. This roll-up metric sums the values for intact soils, deep organic soils, calcareous or limestone-influenced soils, and structural patches. Maximum score is 6.

Preliminary GIS score:

SoilH = SoilIntact + SoilOrgCalc + StrucPatch

Final score, including field tabular data:

SoilHA = SoilIntactT + SoilOrgCaA + StrucPatchT

MS Access SQL expression:

SoilHA: [SoilIntactT] + [SoilOrgCaA] + [StrucPatchT]

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential*

2.4.13 SoilIntact: Lack of Soil Disturbance

Soil disturbance or compaction reduces the habitat value and ecological integrity of a wetland. This metric is best observed in the field. The preliminary GIS score is estimated based on disturbed land uses in the 50 meter (164 foot) buffer, including NLCD developed areas, urbanized areas, recent timber harvests, and grazed pastures. Maximum score is 2.

Preliminary GIS score:

SoilIntact =

- *2 points: No disturbed land uses within 50 m (164 ft) buffer*
- *1 point: Trace to 50% of 50 m (164 ft) buffer is covered by disturbed land uses*
- *0 points: > 50% of 50 m (164 foot) buffer is covered by disturbed land uses*

Final score, including field tabular data:

SoilIntactT = [1d_Site_stressors]![SoilStress]

- *2 points: intact*
- *1 point: moderate stressors*
- *0 points: substantial stressors*

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential / SoilH*

2.4.14 SoilOrgCalc roll-up: Deep Organic or Limestone-influenced Soil

Peatlands, characterized by deep organic soils, provide habitat for uniquely adapted flora and fauna. Soils developed on limestone, dolomite, or marl deposits contain elevated levels of calcium or magnesium. A rich and diverse flora and fauna are characteristic of calcareous wetlands. Maximum score is 1.

Preliminary GIS score:

SoilOrgCalc = Histosol + Karst (capped at 1)

Final score, including field tabular data:

SoilOrgCaA = HistosolT + KarstA (capped at 1)

MS Access SQL expression:

SoilOrgCaA: IIf([HistosolT] + [KarstA] >1, 1, [HistosolT] + [KarstA])

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential / SoilH*

2.4.15 StrucPatch: Structural Patches

Structural patch richness is a count of the number of different types of features that may provide habitat for plant or animal species. This metric is different from microtopographic complexity in that it addresses the number of different patch types. Structural patch richness is related to key wetland services including short- or long-term surface water storage, dissipation of energy, cycling of nutrients, retention of particulates, and maintenance of plant and animal communities (CWMW 2013, Mack 2001, Adamus et al 2010, Hruby 2012).

This metric is best assessed in the field. The preliminary GIS score is estimated using the proxies of interspersion of NWI polygons, complexity of the upland-wetland interface, stream channel complexity within the wetland, and the amount of woody vegetation in the wetland.

Preliminary GIS score:

StrucPatch = (VegHorInt + VegVerStr + StreamEdge3), pro-rated as follows

- *3 points: sum > 5*
- *2 points: sum = 4-5*
- *1 point: sum = 2-3*
- *0 points: sum = 0-1*

Final score, including field tabular data:

Count of structural patches observed:

- *3 points: > 6 patches*

- *2 points: 4-5 patches*
- *1 point: 1-3 patches*
- *0 points: no patches*

StrucPatchT = [1b_Site_structure]![StrucPatch]
[1b_Site_structure]![StrucPatch] = IIf([Str_CalcCount]>6,3, IIf([Str_CalcCount]>3,2, IIf([Str_CalcCount]>0,1,0)))
[1b_Site_structure]![Str_CalcCount] = ([Str_water] + [Str_oxbow]+[Str_pool] + [Str_spring]+[Str_mudbank]+[Str_flats]+[Str_mound]+[Str_beaver]+[Str_litter]+ [Str_humm]+[Str_humm_abun]+[Str_CWD]+[Str_CWD_abun]+[Str_snag]+ [Str_snag_abun]+[Str_tipup])(-1)*

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential / SoilH*

2.5 Hydrology Metrics

2.5.1 ConnectFL: Connectivity to the historic floodplain

Wetlands connected to the river continuum provide heightened water quality, flood attenuation, habitat, and ecological integrity functions to their watersheds (Vannote et al 1980, CWMW 2013, Faber-Langendoen et al. 2016, Berglund and McEldowney 2008, Miller et al. 2017, Mack 2001, Brinson 1993). Wetlands are more likely to receive flood waters and the accompanying rich exchange of organisms and nutrients if they are well-connected to their historic floodplain (Junk et al 1989, Acreman and Holden 2013). The degree of stream channel entrenchment or incisement are important indicators of connection to the river continuum (Rosgen 1996, Montgomery and MacDonald 2002).

Floodplain wetlands that are strongly connected to streams have a high capacity to receive overbank flow and intercept floodwaters (Miller et al. 2017). For riverine wetlands, hydrologic connectivity is assessed based on evidence of overbank flow between the stream and the wetland (USACE 2012), and observations of barriers to river flooding such as human-created levees and dikes, or impairments caused by rivershore rip-rap (Collins et al. 2006).

This metric is best assessed in the field. The GIS score is estimated based on the percentage of a wetland that falls within a mapped floodplain, and the complexity of stream path(s) through a wetland. The GIS score is replaced by the rapid field assessment score. The ConnectFL metric is an integer with range 0 – 2.

Preliminary GIS score:

ConnectFL = FloodArea + StreamEdge (capped at 2)

Final score, including field tabular data:

ConnectFLT =

2 points if only "overbank flooding and connection" boxes are checked,
1 point if boxes in both sections are checked, and
0 points if only "disconnection" boxes are checked.

MS Access SQL expression:

[ConnectFLT] = IIf([DisConnSum]=0 And [ConnectSum]<0,2,IIf([DisConnSum]<0 And [ConnectSum]<0,1,0))

Input to: *Flood Attenuation / FAOpportun*
Habitat & Ecological Integrity / HFuncNBR / HPotential / HydroH

2.5.2 FloodArea: Proportion of Wetland Area in the Floodplain

Floodplain wetlands store and slow water movement during floods and storms. The amount of flood attenuation in a wetland is related to the amount of overbank flooding it receives, which in turn is related to its position in the floodplain. Wetlands that are entirely within the floodplain have more opportunity to attenuate floods than wetlands that are only partially in a floodplain.

This metric is an input to the GIS estimation of wetland connectivity to the floodplain. During rapid field assessment, the connectivity score is replaced by the field value, and therefore this intermediate metric is not needed. Maximum score is 2.

Preliminary GIS score (not used in field or final score):

FloodArea = Ratio of wetland area that lies in the floodplain (either 100-yr FEMA or TNC Active River Area) to total wetland area. Peatlands are set to zero since they are primarily groundwater, not floodplain, wetlands.
Ratio > 0.5 = 2 points
Ratio 0.1-0.5 = 1 point
Ratio < 0.1 = 0 points

Input to: *Flood Attenuation / FAOpportun / ConnectFL (preliminary GIS score only)*
Habitat & Ecological Integrity / HFuncNBR / HPotential / HydroH / ConnectFL (preliminary GIS score only)

2.5.3 FloodIn roll-up: Floodwaters Delivered to Wetland

Wetlands are more likely to receive flood waters if there are steep slopes in their contributing watershed, and if the land surrounding the wetland has high runoff potential. This roll-up metric sums the values for median slope of the contributing watershed, runoff-producing lands in the 50 meter (164 foot) buffer, and runoff-producing lands in the contributing watershed. Maximum score is 2.

Preliminary GIS score:

FloodIn = (SlopeWshd + Runoff50m + RunoffWshd); pro-rate points as follows:

0 points: sum is (0,1,2)
1 point: sum is (3,4)
2 points: sum is (5,6)

Final score, including field tabular data:

FloodInA = (SlopeWshd + Runoff50mT + RunoffWshd); pro-rate points as follows:

0 points: sum is (0,1,2)
1 point: sum is (3,4)
2 points: sum is (5,6)

MS-Access SQL expression:

FloodInA: IIf(([SlopeWshd] + [Runoff50mT] + [RunoffWshd]) >4, 2, IIf(([SlopeWshd] + [Runoff50mT] + [RunoffWshd]) <3, 0, 1))

Input to: *Flood Attenuation / FAOpportun*

2.5.4 Floodplain: Floodplain Location

Wetlands that receive overland or overbank flood flows are subject to different stresses and nutrient inputs than primarily groundwater-fed, rainfall-fed, or other wetlands that do not receive overland flows (Brinson 1993, Brinson et al 1995). "Floodplain" and "Non-floodplain" wetlands are therefore assessed using different variables for certain water quality and flood attenuation functions. For example, surface depressions are important in holding floodwaters in a wetland, and woody vegetation physically slows flood flows and associated debris. Groundwater wetlands with slower-moving subsurface flows and wetlands not in a floodplain have water quality functions that are more dependent on the presence of organic soils or the irregularity of the upland-wetland edge.

Wetlands with 10% or greater of their area in the 100-year FEMA floodplain or Active River Area Base Zone are considered floodplain wetlands unless they have known peat deposits, in which case they are put in the non-floodplain wetland group. The GIS technique slightly over-estimates the actual number of floodplain wetlands. The floodplain status of each wetland is re-evaluated during rapid field assessment, and the field value overwrites the GIS value. Floodplain location is not associated directly with points, but rather is an input to several water quality and flood attenuation metrics. Value is "Yes" or "No".

Preliminary GIS value:

Default Floodplain value = "No". Calculate the percentage of the wetland that intersects the FloodplainARAFEMA layer and set wetlands with >10% overlap to "Yes". Then, overlay wetlands with Peatlands and set any overlapping wetlands back to Floodplain = "No".

Final value, including field tabular data:

FloodplainT = [1c_Site_hydrology]![FloodplainT]

Input to: *Water Quality / WQPotential / ChemTime, ClayOrganic, Depressions, SWOutflow, VegWQ*
Water Quality / WQOpportun
Flood Attenuation / FAPotential / Headwater, VegFA, Runoff, SWOutflow2
Flood Attenuation / FAOpportun

2.5.5 Headwater: Headwater Location

Headwater wetlands are upstream of all aquatic habitats and provide important protection to these ecosystems, including sediment retention and stabilization, phosphorus retention, and nitrate removal and retention (USEPA 2015, Adamus et al. 2010, Hruby 2012, Savage and Baker 2007). Wetlands found in the headwaters of streams often do not generally store significant surface water; however, they can help to reduce peak flows by slowing and desynchronizing the initial peak flows from a storm (Brassard et al. 2000, Hruby 2012). Their importance in hydrologic functions is often under-rated. In the words of Michael Davis, Deputy Assistant of the Army, to the U.S. Senate: "The most recent data and scientific literature indicate that isolated and headwater wetlands often play an ecological role that is as important as other types of wetlands in protecting water quality, reducing flood flows, and providing habitat for many species of fish and wildlife" (Davis 1997). The American Fisheries Society has documented the important role of headwater wetlands in providing ecological functions not only within headwater regions, but also in downstream rivers and lakes. Fishery functions of headwater wetlands include providing habitat for endemic and threatened fish species as well as species supporting economically important fisheries, and providing native or threatened fish species with critical refuge habitat from invasive aquatic species (Colvin et al. 2019). The overall biodiversity of river networks is tied to the integrity of headwater streams and wetlands, which offer refuge to animal and plant species from temperature and flow extremes, competitors, predators, and introduced species. Headwaters also serve as a source of colonizing species, provide spawning sites and rearing areas, are a rich source of food, and provide migration corridors between watersheds (Meyer at al 2007).

Surface water inlets and outlets are a basic input to the Tiner functional attributes (Tiner 2003, Tiner 2011) of a wetland, in particular Tiner's Wetland Landscape Position and Water Flow Path. These are used to determine headwater position and hydrologic connectivity. Tiner (2011) defines lotic headwater wetlands as "wetlands along first- and second-order perennial streams in hilly terrain including all intermittent streams above these perennial streams". He defines terrene headwater wetlands as "wetland is the source of a river or stream but this watercourse does not extend through the wetland". These are coded in our database as "LandPos" = 'LSh' (lotic stream headwater wetlands) and "LandPos" = 'TEh' (terrene headwater wetlands).

Assign one point if the wetland has a Tiner Landscape Position (LandPos) with a headwater modifier. Field observations of the inlet and outlet are used to add certain lotic stream and terrene wetlands that do not qualify based on the GIS Landscape Position. The maximum score is 1.

Preliminary GIS score:

Headwater = 1 IF LandPos IN (‘LSh’, ‘TEh’)

Field tabular score:

HeadFlowT =

Assign a potential headwater flow regime to the wetland if the largest inlet is a first- or second-order stream, intermittent stream, spring, groundwater AND the largest outlet is a relatively permanently flowing stream or an intermittent stream.

MS Access SQL expression: [1c_Site_hydrology]!HeadFlowT = IIf([LargestInlet] In ("perm12ord","intermittent","spring","groundwater") And [LargestOutlet] In ("perm","perm_constrict","intermittent"),1,0)

Final formula (combine field and GIS data):

HeadwaterA =

Assign 1 point to wetlands identified as headwaters in GIS. Also, assign 1 point to wetlands with GIS-identified lotic stream or terrene landscape positions that have a field-identified potential headwater flow regime.

MS Access SQL expression:

HeadwaterA: IIf([5_GIS_AllResults]![LandPos] In ("TEh","LSh") Or ([5_GIS_AllResults]![LandPos] In ("TE","LS") And [HeadFlowT]=1),1,0)

Input to: *Water Quality / WQPotential*
Flood Attenuation / FAPotential
Habitat & Ecological Integrity / HOpportun / LandHydro / WshdPos

2.5.6 HydIntact: Intactness of Hydrologic Regime

Natural hydrologic processes vary greatly among different types of wetlands. Peatlands rely on precipitation and very slow groundwater movement to create deep organic soils and unique plant communities. Seepage swamps rely primarily on groundwater movement. Floodplain wetlands receive water from overbank flooding in addition to groundwater and precipitation. Rather than specifying a particular hydrologic regime, this metric is rated based on the dominance of natural hydrologic processes and deviations from natural conditions. Hydroperiod is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. In most wetlands, plant recruitment and maintenance are dependent on hydroperiod. The interactions of hydroperiod and topography are major determinants of the distribution and abundance of native wetland plants and animals (Mitsch and Gosselink 2007, National Research Council 2001, CWMW 2013).

This metric is best assessed in the field. The GIS score is estimated based on low levels of disturbance and discharges to the wetland (inverse of the *WQOpportun* metric) plus high landscape integrity. The preliminary GIS score is replaced by the rapid field assessment score. The maximum score is 6.

Preliminary GIS score:

HydIntact =

6 points: "WQOpportun" = 0 AND "LandInteg" IN (2,3)
5 points: ("WQOpportun" = 1 AND "LandInteg" IN (2,3)) OR ("WQOpportun" = 0 AND "LandInteg" IN (0,1))
4 points: ("WQOpportun" = 2 AND "LandInteg" IN (2,3)) OR ("WQOpportun" = 1 AND "LandInteg" IN (0,1))
3 points: ("WQOpportun" = 3 AND "LandInteg" IN (2,3)) OR ("WQOpportun" = 2 AND "LandInteg" IN (0,1))
2 points: ("WQOpportun" = 4 AND "LandInteg" IN (2,3)) OR ("WQOpportun" = 3 AND "LandInteg" IN (0,1))
1 point: ("WQOpportun" = 5 AND "LandInteg" IN (2,3)) OR ("WQOpportun" = 4 AND "LandInteg" IN (0,1))
0 points: none of the above criteria are met

Final score, including field tabular data:

HydIntactT =

6 points: intact
5 points: mild stressors
3 points: moderate stressors
1 point: severe stressors
0 points: artificial hydrology

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential / HydroH*

2.5.7 HydroH roll-up: Hydrology for Habitat & Ecological Integrity

Hydrology is the most important direct determinant of wetland functions (Mitsch and Gosselink 2007); however, it is not easy to accurately assess hydroperiod remotely or during a single field visit (Stein et al 2009, Mack 2001). Wetland hydrology varies greatly under natural conditions, from rainfed bogs to groundwater wetlands to wetlands fed by overbank flooding. All of these natural hydrologic regimes create conditions under which wetland plants and animals can thrive and wetlands can perform their intrinsic ecological, hydrological, and societal functions and services (CWMW 2013). Disturbances to hydrology are one of the main sources of degradation to wetlands (Mack 2001).

This roll-up metric sums the values for intact hydrologic regime, connectivity to the floodplain, and availability of surface water. The field score overwrites the GIS estimate. The maximum score is 9.

Preliminary GIS score:

HydroH = HydIntact + ConnectFL + HydSW

Final score, including field tabular data:

HydroHA = HydIntactT + ConnectFLT + HydSWA

MS Access SQL expression:

HydroHA: [HydIntactT]+[ConnectFLT]+[HydSWA]

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential*

2.5.8 HydSW: Available Surface Water

Seasonally or permanently available open water typically supports submerged macrophytes and provides important foraging and breeding habitat for birds, bats, and amphibians. The structural complexity provided by aquatic bed species increases the number habitat niches for invertebrate and vertebrate species (Hruby 2012, Berglund and McEldowney 2008). The maximum score is 1.

Preliminary GIS score:

HydSW = 1 if wetland contains NWI polygons that are attributed as palustrine aquatic bed, unconsolidated bottom, or unconsolidated shore AND are permanently flooded or intermittently exposed AND are not spoil. Also select wetlands that are contiguous to a non-impaired lake or stream (do not include impaired stream reaches or algal lakes/streams). Do not include polygons with the special modifier for spoil.

Tabular field data:

HydSWT = 1 if open water is present as a Structural Patch Type OR vegetation fringes open water.
Access SQL expression: IIf([Str_water]<0 Or [VegLake]<0,1,0)

Final score, including field tabular data:

HydSWA = Max (HydSW, HydSWT)

MS Access expression:

HydSWA: IIf([HydSW]>[HydSWT],[HydSW],[HydSWT])

Input to: *Habitat & Ecological Integrity / HFuncNBR / HPotential / HydroH*

2.5.9 ImpairedIn: Impaired Waters Impacting Wetland

Impaired waters entering a wetland provide an opportunity for the wetland to improve water quality for areas downstream. Impaired waters also degrade the wetland itself. The GIS score for impaired waters entering and impacting the wetland is estimated based on the state impaired streams database, known algal blooms, and power boat use. Algal blooms and blooms of larger plants such as milfoil in open water are an indication of excessive nutrients (Schindler and Fee 1974, Smith et al. 1999). The increased levels of nutrients in the water body increase the amount of nutrients that the wetland plants absorb (Venterink and others 2002) and thus also increase the level of function within the wetland. The presence of power boats in adjacent reservoirs or water bodies will increase the pollutants entering a fringe wetland. Toxic chemicals, oils, cleaners, and paint scrapings from boat maintenance can make their way into the water (Asplund 2000). In addition, older two stroke engines still found on many recreational boats and jet skis were purposely designed to discharge the exhaust that contains unburned gasoline and oil into the water. The maximum score for *ImpairedIn* is 2 as input to *WQOpportun*. Note that high scores for *WQOpportun* contribute to lower scores for Habitat & Ecological Integrity.

GIS score & final score:

ImpairedIn =

2 points: all wetlands within 5 meters of impaired waters, algal blooms, or powerboat use

1 point: floodplain wetlands > 5 meters from impaired waters, algal blooms, or powerboat use but with these sources of pollutants in their contributing watershed

0 point: none of the above criteria are met

Input to: *Water Quality / WQOpportun*

2.5.10 ImpairedOut: Wetland Discharges to Impaired Waters

Wetlands that discharge to impaired waters are valuable to society because their role in cleaning up the pollution is critical for reducing further degradation of water quality. Karst systems lack natural filtering capacity and are vulnerable to pollution wherever they occur in the state; therefore wetlands discharging to karst areas receive this point whether or not degradation has been documented.

The GIS score is estimated based on proximity to impaired waters, algal blooms, lakes with power boat use, or wetland location on karst geology. The maximum score is 1.

GIS score & final score:

ImpairedOut = 1 if wetland is within 1 km (0.6 mile) of an impaired reach, algal lake, algal stream, or lake with power boat use OR wetland occurs on karst. Note that this is a coarse approximation (since it does not follow flowlines) that selects slightly over half of the state's wetlands.

Input to: *Water Quality / WQSociety*

2.5.11 Runoff roll-up: Microtopography Slows and Stores Runoff

Slowing and storing runoff is an essential aspect of flood attenuation by wetlands. Seasonal ponding, complex surface topography, complex upland edge or a close hydrologic connection with a stream contribute to the ability of a wetland to perform this function.

This roll-up metric sums the values for seasonal ponding, microtopographic complexity, and stream-wetland interface. The maximum score is capped at 5 for floodplain wetlands and 4 for non-floodplain wetlands.

Preliminary GIS score:

Runoff = (SeasonPond + Microtopo + StreamEdge); cap at 5 for floodplain wetlands and 4 for non-floodplain wetlands

Final score, including tabular field data:

RunoffA = (SeasonPond + MicrotopoT + StreamEdgeT); cap at 5 for floodplain wetlands and 4 for non-floodplain wetlands

MS Access SQL expression:

RunoffA: IIf([SeasonPond]+[MicrotopoT]+[StreamEdgeT]>5 And [FloodplainT]=(-1),5,IIf([SeasonPond]+[MicrotopoT]+[StreamEdgeT]>4 And [FloodplainT]=0,4,[SeasonPond]+[MicrotopoT]+[StreamEdgeT]))

Input to: *Flood Attenuation / FAPotential*

2.5.12 Runoff50m: Lands Producing Runoff within 50m

Wetlands that receive surface runoff from their immediate buffer have an enhanced opportunity to reduce, slow, or desynchonize flows downstream. Impervious surfaces, urban areas, agricultural areas, mining, industrial and commercial land uses contribute to increased runoff (Miller et al. 2017). Recent timber harvests and soil types with high runoff/low infiltration characteristics also produce runoff. The land use and soil type immediately adjacent to a wetland have a strong influence on the surface runoff that the wetland receives.

A "RunoffLand" layer was produced for the assessment tool, consisting of NLCD developed land, NLCD barren land, NLCD cultivated crops, WVDNR/WVDOF timber harvests within the last 5 years, and NRCS SSURGO soils in hydrologic group D (high runoff/low infiltration).

This metric is best assessed in the field. The preliminary GIS score is estimated by overlaying the wetland buffer on the RunoffLand layer. The rapid field assessment score replaces the GIS score. The maximum score is 2.

Preliminary GIS score:

Runoff50m = 50 m (164 ft) wetland buffer characterized by land uses and soil types that are likely to contribute to increased runoff. Assign points as follows:

- *2 points: >33% of area within 50 m (164 ft) is runoff-producing*
- *1 point: 10 - 33%*
- *0 points: ≤ 10%*

Final score, including tabular field data:

Runoff50mT = 50 m (164 ft) buffer around the wetland :

- *2 points: < 75%*
- *1 point: 75 – 90%*
- *0 points: > 90%*

Input to: *Flood Attenuation / FAOpportun / FloodIn*

2.5.13 RunoffWshd: Runoff from Contributing Watershed

Wetlands that receive surface runoff from their contributing watershed have an enhanced opportunity to reduce, slow, or desynchonize flows downstream. Impervious surfaces, urban areas, agricultural areas, mining, industrial and commercial land uses contribute to increased runoff in a catchment (Miller et al. 2017). Recent logging, and high runoff/low infiltration soil types also contribute to runoff. The presence of these areas in the contributing watershed of a wetland is a good indicator that surface runoff may be reaching the wetland, especially during storm events. A "RunoffLand" layer was produced for the assessment tool, consisting of NLCD developed land, NLCD barren land, NLCD cultivated crops, WVDNR/WVDOF timber harvests within the last 5 years, and NRCS SSURGO soils in hydrologic group D (high runoff/low infiltration).

The GIS score and the final score are the same for this metric (no field assessment). The maximum score is 2.

GIS score & final score:

RunoffWshd = portion of contributing watershed characterized by land uses and soil types that are likely to contribute to increased runoff. Assign points as follows:

- *2 points: > 25% of contributing watershed is runoff-producing*
- *1 point: 10 - 25%*
- *0 points: ≤ 10%*

Input to: *Flood Attenuation / FAOpportun / FloodIn*

2.5.14 SeasonPond: Seasonal Ponding

All wetlands recycle nutrients, but those having a fluctuating water table are best able to recycle nitrogen and other nutrients (Tiner 2003). The area of the wetland that is seasonally ponded is an important characteristic in understanding how well it will remove nutrients, specifically nitrogen. The highest levels of nitrogen transformation occur in areas of the wetland that undergo a cyclic change between oxic (oxygen present) and anoxic (oxygen absent) conditions. The oxic regime (oxygen present) is needed so certain types of bacteria will change nitrogen that is in the form of ammonium ion (NH_4^+) to nitrate, and the anoxic regime is needed for denitrification (changing nitrate to nitrogen gas) (Mitsch et al. 2005). The area of a wetland that is not permanently flooded undergoes this seasonal cycling. These soils are oxygenated when dry but become anoxic during the time they are flooded.

The score is calculated in GIS, and field data are incorporated through field-mapping of NWI polygons. The maximum score is 3.

GIS score & final score:

> *SeasonPond = Select NWI wetland polygons that are NOT permanently flooded. Calculate the ratio of the non-permanently flooded area to the total area of the wetland. Assign points as follows:*
>
> - *SeaPondRatio = 70-100% cover: 3 points*
> - *SeaPondRatio = 40-70% cover: 2 points*
> - *SeaPondRatio = 10-40% cover: 1 point*
> - *SeaPondRatio < 10% cover: 0 point*

Input to: *Water Quality / WQPotential / ChemTime*
Flood Attenuation / FAPotential / Runoff
Flood Attenuation / FAOpportun / ConnectFL (preliminary GIS score only)

2.5.15 StreamEdge: Complexity of Wetland/Stream Interface

Wetlands that are strongly connected to streams have a high capacity to receive overbank flow and intercept floodwaters (Miller et al. 2017). Note that we cannot determine whether a stream is disconnected or entrenched from GIS. This will be measured during rapid field assessment. The GIS metric is limited to the length/complexity of shared stream/wetland boundaries. The maximum score is 2.

Preliminary GIS score:

> *StreamEdge = Sum of shared wetland/river (polygonal stream) boundary lengths and length of NHD stream segments within wetland, divided by the square root of the wetland area. Assign points as follows:*

- *2 points to wetlands with a ratio > 3.4,*
- *1 point if the ratio is 1-3.4, and*
- *0 points if the ratio < 1.*

Note that these thresholds were set by examining the histogram of values, with the highest class (2 points) representing the upper tail of the distribution, i.e., more than one standard deviation above the median. The middle class (1 point) represents the middle of the peak to where the upper tail begins, and also has the real-world significance of being more sinuous than a straight line through a theoretical square wetland.

Final score, including tabular field data;

StreamEdgeT = ConnectFLT

Input to: *Flood Attenuation / FAPotential / Runoff*
Flood Attenuation / FAOpportun / ConnectFL (preliminary GIS score only)
Habitat & Ecological Integrity / HFuncNBR / HPotential / HydroH (preliminary GIS score only
Habitat & Ecological Integrity / HFuncNBR / HPotential / SoilH / StrucPatch (preliminary GIS score only)

2.5.16 SWOutflow: Surface Water Outflow

Pollutants that are in the form of particulates (e.g., sediment, or phosphorus that is bound to sediment) will be retained in a wetland with no outlet. An outlet that flows only seasonally is usually better at trapping particulates than one that is flowing all the time because there is no chance for a downstream release of particulates for most of the year (Adamus et al. 1991). Outlet restrictions such as culverts or dams impact the hydrologic connectivity of the wetland (Hruby 2012, Adamus et al. 2010, and Faber-Langendoen et al. 2016).

The preliminary GIS score for surface water outflow is determined from the GIS-estimated water flow path (Tiner 2011). The final score is based on field observation of the wetland outlet. This metric is used only for non-floodplain wetlands, not for floodplain wetlands.

2.5.16.1 SWOutflow: Surface Water Outflow for Water Quality

The maximum score is 4 for non-floodplain wetlands and 0 for floodplain wetlands.

Preliminary GIS score:

SWOutflow = Assign points based on WFlowPath and Floodplain values:
4 points: no surface water outlet: "Floodplain" = 'N' AND "WFlowPath" IN ('IS')
3 points: intermittent or highly constricted permanent outlet: "Floodplain" = 'N' AND "WFlowPath" IN ('OI', 'TI', 'BI', 'IB');
1 point: relatively permanently flowing surface outlet: "Floodplain = "N" AND "WFlowPath" not as above
0 points: "Floodplain = "Y"

Final score, including tabular field data:

SWOutflowT = Assign points based on observed outlet when FloodplainT = N:

4 points: no surface water outlet (non-floodplain only)

3 points: intermittent or highly constricted permanent outlet

1 point: relatively permanently flowing surface outlet

MS Access SQL expression:
[1c_Site_hydrology]![SWOutflowT] =
IIf([FloodplainT]=(-1),0,IIf([LargestOutlet]="groundwater",4,IIf([LargestOutlet]= "perm_constrict" Or [LargestOutlet]="intermittent",3,1)))

Input to: *Water Quality / WQPotential*

2.5.16.2 SWOutflow2: Surface Water Outflow for Flood Attenuation

Surface water is retained or released slowly through groundwater in a wetland with no surface outlet. Wetlands with an outlet that is highly constricted, or flows only seasonally, are more likely to retain water than those with relatively permanently flowing outlets. The maximum score is 2 for non-floodplain wetlands and 0 for floodplain wetlands.

Preliminary GIS score:

SWOutflow2 = Assign points based on WFlowPath value when Floodplain = N:

2 points: no surface water outlet; "Floodplain" = 'N' AND "WFlowPath" IN ('IS')

1 point: intermittent or highly constricted permanent outlet: "Floodplain" = 'N' AND "WFlowPath" IN ('OI', 'TI', 'BI', 'IB');

0 points: neither of the above criteria are met

Final score, including tabular field data;

SWOutflw2T = Assign points based on observed outlet when FloodplainT = N:

2 points: no surface water outlet (non-floodplain only)

1 point: intermittent or highly constricted permanent outlet

0 points: relatively permanently flowing surface outlet

MS Access SQL expression:
[1c_Site_hydrology]![SWOutflw2T] =
IIf([FloodplainT]=(-1),0,IIf([LargestOutlet]="groundwater",2,IIf([LargestOutlet]= "perm_constrict" Or [LargestOutlet]="intermittent",1,0)))

Input to: *Flood Attenuation / FAPotential*

2.5.17 WFlowPath: Water Flow Path (Tiner)

Water Flow Path is part of the Tiner (2011) wetland functional classification which describes and classifies wetlands by landscape position, landform, water flow path, and waterbody type

(LLWW). Options for water flow path in WV are: Paludified, Isolated, Throughflow, Inflow, Outflow, Bi-directional non-tidal. Modifiers are perennial, intermittent, and artificial. Not all of these can be accurately assigned via GIS, but the main codes (IS, OU, OP, OI, TH, TI, and BI) can be approximately assigned. The table below lists the Tiner (2011) Water Flow Path codes potentially found in WV.

Water Flow Path Codes in West Virginia Wetlands (Tiner 2011)

PA Paludified
IS Isolated
IT Isolated-throughflow (connected to other wetlands in an isolated complex)
IO Isolated-outflow (connected to other wetlands in an isolated complex)
II Isolated-inflow (connected to other wetlands in an isolated complex)
ITA Isolated-artificial throughflow (connected by ditches to other artificially isolated wetlands)
IOA Isolated-artificial outflow (connected by ditches to other artificially isolated wetlands)
IIA Isolated-artificial inflow (connected by ditches to other artificially isolated wetlands)
IN Inflow
OU Outflow
OA Outflow-artificial (wetland connected to stream by ditches)
OP Outflow-perennial
OI Outflow-intermittent
TH Throughflow
TA Throughflow-artificial (wetland connected to stream by ditches)
TN Throughflow-entrenched
TI Throughflow-intermittent
TP Throughflow-perennial
BI Bidirectional-nontidal
BIA Bidirectional-nontidal Artificial (e.g., diked wetland)
BO Bidirectional-nontidal/outflow (lake)
TB Bidirectional-nontidal/throughflow (lake)
IB Bidirectional-nontidal/isolated (lake)
NB Bidirectional-nontidal/inflow (lake)

Note on stream intersections: In the method below, if a wetland boundary intersects more than 1 perennial stream, then it is called throughflow perennial. Presumably one of the intersections will be an outflow, and the other(s) will be inflow. This assumption does not work for a small number of headwater wetlands on drainage divides with no inflows but two outflows. Future work might include adding the direction of flow to identify these wetlands.

Note on flow accumulation: Paybins (2003) in southern WV noted that median watershed size to initiate intermittent flow is 14.5 +-3.4 acres, and for perennial flow is 40.8 +-18.0 acres. In the method below, wetlands that are tagged as "isolated" but have maximum flow accumulation values > 2000, which corresponds to a drainage area > 0.0625 mi or 40 acres), are updated from "isolated" to "outflow". This threshold corresponds roughly to known outflow wetlands in West Virginia according to Elizabeth Byers' field knowledge. Note that the flow accumulation values from the 27m raster are not highly accurate. With more computing power in the future, we can create a new flow accumulation raster with higher resolution.

Note on karst wetlands: In the future we may be able to identify Inflow wetlands (NHD "dangles"). There will be very few, mostly in karst areas.

Note on National Hydrography Dataset (NHD): NHD data is incorrectly attributed (no ephemeral or intermittent streams) in Preston County and parts of Monongalia, Barbour, Morgan, Kanawha, Putnam, Wirt, Marshall, Tucker, and small parts of about 10 additional counties.

Preliminary GIS value:

> *WFlowPath =*
>
> *Part 1: Select wetlands that intersect intermittent or ephemeral streams and attribute as intermittent (_I). Select wetland that intersect perennial streams and attribute as perennial (_P). Count the number of wetland-stream intersections and attribute wetlands with 0 intersections to isolated (IS), 1 intersection to outflow (OU), and 2 or more intersections to throughflow (TH).*
>
> *Part 2: Update flowpath based on adjacent streams, rivers, and impoundments. Update flowpath from IS to OU for wetlands within 30m of a mapped stream and wetlands that contain an impoundment. Update IS to outflow intermittent (OI) if the contributing watershed > 40 acres. Update WFlowPath to throughflow perennial (TP) for wetlands that intersect or share a boundary with large streams, i.e. NWI riverine attribute or NHD 24k rivers*
>
> *Part 3: Combine perennial, intermittent, and flow path codes.*
>
> *Part 4: Update WFlowPath for wetlands that fringe lakes and reservoirs to bidirectional outflow (BO), bidirectional throughflow (TB), or bidirectional isolated (IB). Select wetlands in lake basins with bi-directional flow. This will over-write flowpath. Note that there are some errors generated by over-writing: some wetlands that border a lake but are primarily stream wetlands are selected. However, the number of errors is smaller than if over-writing is not done. Future refinements could include measuring the perimeter bordering the lake, and if it is a small fraction of the total perimeter, then flowpath "OU" or "TH" is not over-written.*

Tabular field data value:

> *WFlowPath (GIS value) is replaced by direct observation of surface water inflows and outflows for the metrics in this assessment. As a result, the derived WFlowPath metric is not used in the final scoring. If needed for future analyses, the WFlowPath variable can be calculated from field data. An Excel table with the requisite information is included in the "Metric Hierarchy" spreadsheet.*

Input to: *Water Quality / WQPotential / SWOutflow (preliminary GIS score only)*

Flood Attenuation / FAPotential / SWOutflow2 (preliminary GIS score only)
Flood Attenuation / FAPotential / Headwater / LandPos (preliminary GIS score only)

2.6 Buffer Condition and Extent Metrics

2.6.1 BufferContig: Contiguous 300m Wildlife Buffer

A wider buffer has a greater capacity to serve as habitat for wetland edge-dependent species and species that require both wetlands and uplands to complete their life cycle (Adamus et al. 2010, CWMW 2013, Faber-Landendoen et al. 2016, and Berglund and McEldowney 2008). The habitat must be contiguous to the wetland and accessible to wildlife species. Core habitat for many wildlife species, particularly birds and amphibians, extends to between 300-1,000 meters (1,000-3,300 feet) from the wetland edge; plant biodiversity is correlated with natural buffer extents of 60-300 meters (200-1,000 feet) from the wetland edge (Hruby 2013, Wilson and Dorcas 2003, Sheldon et al 2005, Ervin 2009, Rooney et al. 2012, Houlahan et al. 2006, Rittenhouse and Semlitsch 2007, McElfish et al. 2008, Eigenbrod et al. 2008, Semlitsch and Brodie 2003).

The preliminary GIS score is calculated based on the percentage of the contiguous 300-meter (1,000 feet) buffer that does not overlap the DisturbedLand layer. The integrity of the 300-meter (1,000 feet) wetland buffer is verified in the field with the assistance of air photographs, and the GIS metric is overwritten by the rapid field assessment score. The maximum score is 2.

Preliminary GIS score:

> *BufferContig = Calculate percent of contiguous 300 m (1,000 ft) buffer not overlapping DisturbLand: erase the DisturbedLand from the 300 m (1,000 ft) buffer, then select the remaining buffer polygons that are contiguous (approximated as "share a line segment with") with their corresponding wetland. Assign points as follows:*
>
> > *2 points: >90% of buffer is undisturbed AND is contiguous with wetland*
> > *1 point: 60-90% of buffer is undisturbed AND is contiguous with wetland*
> > *0 points: neither of the above criteria are met*

Final score, including tabular field data:

> *BufferConT =*
>
> > *2 points: >90% of 300 m (1,000 ft) buffer is natural & contiguous*
> > *1 point: 60-90% of 300 m (1,000 ft) buffer is natural & contiguous*
> > *0 points: < 60% of 300 m (1,000 ft) buffer is natural & contiguous*

Input to: *Habitat & Ecological Integrity / HOpportun / BufferLand*

2.6.2 BufferLand roll-up: Buffer Condition and Extent

Buffers are vegetated areas adjacent to wetlands that can reduce impacts to these resources from adjacent land uses or disturbances through physical, chemical, and biological processes. Buffers also provide some of the terrestrial habitats necessary for wetland-dependent species that require both aquatic and terrestrial habitats. Buffer extent and condition is important for all wetland functions (Hruby 2103, McElfish et al. 2008). Natural buffer characteristics used in this assessment are described in the table below.

Buffers: guidelines for identifying natural wetland buffers
(adapted from Collins et al. 2006, Faber-langendoen et al. 2016, Hruby 2012, Miller et al. 2001, Taylor and Knight 2003))

Natural buffer	Excluded from natural buffer
Natural upland habitats, open water, vegetated levees, old fields, naturally vegetated rights-of-way, hayfields, low-intensity hiking trails (used up to a few times a week but not daily), 2- or 3-strand fences that don't interfere with wildlife movement.	Industrial areas, residential developments, parking lots, agricultural cropland, grazed pastures, regularly mowed areas, orchards, commercial tree plantations, heavy timbering (>50% of mature trees) within last 5 years, roads (paved, gravel, dirt), railroads, bike trails, horse trails, intensively (daily) used hiking trails, bridges, hardened channels, culverts, fences that interfere with wildlife movement, areas accessible to dogs or other pets that can stress wildlife, highly compacted or disturbed soils (often found on reclaimed mine lands), large amounts of trash, intense human visitation or recreational impacts.

This roll-up metric sums the values for natural perimeter, contiguous 300-meter (1,000 feet) natural buffer, and landscape integrity index. The maximum score is 7.

Preliminary GIS score:

$$BufferLand = BufferPerim + BufferContig + LandInteg$$

Final score, including tabular field data:

$$BufferLanA = BufferPerimT + BufferContigT + LandInteg$$

Input to: *Habitat & Ecological Integrity / HOpportun*

2.6.3 BufferPerim: Undisturbed Perimeter

An intact perimeter, even with a narrow natural buffer, offers protection to the wetland habitat. The ability of a buffer to protect a wetland increases with buffer extent along the wetland perimeter. For some kinds of stress, such as predation by feral pets or disruption of plant communities by cattle, small breaks in buffers may be adequate to nullify the benefits of an existing buffer. However, for most stressors, small breaks in buffers caused by such features as trails and small, unpaved roadways probably do not significantly disrupt the buffer functions (CWMW 2013, Faber-Langendoen et al. 2016).

To qualify as undisturbed perimeter, the undisturbed land must be at least 10 meters (33 feet) wide and extend along the perimeter of the wetland for at least 10 m. Buffer characteristics are described in the “Buffers” table under the BufferLand metric.

The preliminary GIS score is calculated based on the ratio of disturbed land to undisturbed land in the 10-meter (33 feet) buffer (*Dist10mRat*) and the presence of roads or railroads within 10 meters (33 feet) of the wetland (*RoadRailType*). The integrity of the wetland perimeter is verified in the field, and the GIS metric is overwritten by the rapid field assessment score. The maximum score is 2.

Preliminary GIS score:

BufferPerim =

2 points: "Dist10mRat" = 0 AND "RoadRailType" IS NULL
1 point: 0 < "Dist10mRat" ≤ 0.25 OR "RoadRailType" IN ('Trail', 'Local', 'Other')
0 points: "Dist10mRat" > 0.25 OR "RoadRailType" IN ('Rail', 'Primary', 'Interstate')

Final score, including tabular field data:

BufferPerT =

2 points: 100% of perimeter is natural
1 point: 75-99% of perimeter is natural
0 points: < 75% of perimeter is natural

Input to: *Habitat & Ecological Integrity / HOpportun / BufferLand*

2.6.4 Discharges: Discharges to Wetlands within 100 m (328 ft)

Discharges entering a wetland provide an opportunity for the wetland to improve water quality for areas downstream. Discharges also degrade the wetland itself. Wetlands can receive polluted waters even if they have extensive well-vegetated buffers. For example, a pipe can discharge directly into a wetland, or a stream that drains areas where pollutants are released far from the unit can pass through the wetland. Silt fences often do not prevent all the sediment from reaching wetlands during nearby construction. Other sources of pollutants may be septic tanks, NPDES discharges, Hydrological Protection Units (mining impacts), Acid Mine Lands, and Acid Mine Drainage sites. Sources that we are not currently able to include are pesticide spraying on golf courses, particulates in exhausts from airplanes or motor vehicles, pesticides used in mosquito or gypsy moth control, and atmospheric deposition of mercury or other contaminants.

The GIS and rapid field assessment scores are both used to estimate the final score for this metric. The maximum score for *Discharges* is 2 as input to *WQOpportun*. Note that high scores for *WQOpportun* contribute to lower scores for Habitat & Ecological Integrity.

Preliminary GIS score:

Discharges =

2 points: wetlands within 100 m (328 ft) of NPDES outlets (excluding deep injection sites), Well pads permitted within the last 5 years, Hydrologic Protection Units, Acid Mine Lands, Acid Mine Drainage sites, Superfund sites, and National Priority List sites.

1 point: wetlands within 100 m (328 ft) of septic risk or low-certainty NPDES permit location (excluding deep injection sites).

0 points: "Dist10mRat" > 0.25 OR "RoadRailType" IN ('Rail', 'Primary', 'Interstate')

Tabular field data score:

DischargesT =

2 points: water quality stressors observed on-site
0 points: no water stressors observed on-site

Final score:

DischargeA = MAX (Discharges, DischargesT)

MS-Access SQL expression:

DischargeA: IIf([Discharges]>[DischargesT],[Discharges],[DischargesT])

Input to: *Water Quality / WQOpportun*

2.6.5 Dist50mFQ: Floristic Quality 50m (164 ft) Buffer

Buffer disturbance is known to be correlated with floristic quality (Fennessy et al 1998) and provides input to the GIS estimate of floristic quality. This preliminary GIS metric is replaced by rapid field assessment of floristic quality. Maximum score is 3.

Preliminary GIS score (not used in field and final scores):

Dist50mFQ =

3 points: no disturbance in 50 m (164 ft) buffer
2 points: 0 < 50m (164 ft) buffer disturbance ≤ 10%
1 point: 10% < 50 m (164 ft) buffer disturbance ≤ 25%
0 points: 50 m (164 ft) buffer disturbance > 25%

Input to: *Habitat & Ecological Integrity / HPotential / VegH / VegFQ (preliminary GIS score only)*

2.6.6 Disturb50m: Water Quality 50m Buffer

Disturbed land in the 50-meter (164 feet) buffer around a wetland provides an opportunity for the wetland to improve water quality for areas downstream. Disturbed land in the 50-meter (164 feet) buffer also degrades the wetland itself. Buffers reduce the inputs of non-point source contaminants, help to control erosion and runoff, and generally protect the wetland from human activities (Hruby 2013, McElfish et al. 2008). Farming, grazing, golf courses, residential areas, commercial land uses, urban areas, and developed areas in general, are major sources of pollutants (Sheldon et al. 2005). Tilled fields are a source of nutrients, pesticides, and sediment. Pastures are a source of nutrients and pathogenic bacteria, and clearcut areas are a source of sediment (Sheldon et al. 2005). A well-vegetated buffer of 50 meters (164 feet) will only remove 60-80% of some pollutants from surface runoff into a wetland. Consequently, polluting land uses within the 50 meter (164 feet) buffer are likely to be significant sources of pollution to the wetland (CWMW 2013, Hruby 2012, Faber-Landendoen et al. 2016, Miller et al. 2017, and Mack 2001).

The maximum score for *Disturb50m* is 3 as input to *WQOpportun*. Note that high scores for *WQOpportun* contribute to lower scores for Habitat & Ecological Integrity. The preliminary GIS value is replaced by the rapid field assessment value.

Preliminary GIS score:

> *Disturb50m = Calculate the ratio of disturbed area to total area within 50 m (164 ft) of the wetland. Disturbed land uses include agricultural, pasture, golf course, residential, commercial, urban, or areas that have been timbered within the last 5 years.*
>
> > *3 points: disturbance in 50 m (164 ft) buffer > 50%*
> > *2 points: 25% < 50 m (164 ft) buffer disturbance ≤ 50%*
> > *1 point: 10% < 50 m (164 ft) buffer disturbance ≤ 25%*
> > *0 points: 50 m (164 ft) buffer disturbance < 10%*

Final score, including tabular field data:

> *Disturb50T =*
>
> > *3 points: 50 m (164 ft) natural buffer ≤ 50%*
> > *2 points: 50% < 50 m (164 ft) natural buffer ≤ 75%*
> > *1 point: 75% < 50 m (164 ft) natural buffer ≤ 90%*
> > *0 points: 50 m (164 ft) natural buffer > 90%*

Input to: *Water Quality / WQOpportun*

2.6.7 LandInteg: Landscape Integrity

Landscape integrity is a good indicator of overall habitat value and ecological integrity. This metric draws on four modeled sources of landscape integrity: WVDNR Landscape Integrity Index 2008, UMass Index of Ecological Integrity 2010, TNC Resilient and Connected Lands

2016, and TNC Forest Patches 2014. Although the WVDNR and UMass Indices are older and in need of updates, they have seamless state-wide coverage and are more direct measures of landscape integrity; the other two sources have small gaps (e.g., a small percentage of null pixel values in TNC Resilient and Connected Lands 2016 and no forest patches mapped north of Cranberry Glades in TNC Forest Patches 2014).

WVDNR 2008 Landscape Integrity model: use the mean value of pixels within a wetland. For wetlands that are smaller or narrower than a single pixel (30 m x 30 m, or 98' x 98'), use the value of the (contained) centroid of the polygon.

- 3 points: > 800
- 2 points: 700-800
- 1 point: 600-700
- 0 points: < 600

UMass 2010 Index of Ecological Integrity model: This layer is very similar to the WVDNR 2008 landscape integrity layer. It has finer resolution and does a better job of capturing roads and other detailed features. However, its treatment of pipelines and powerlines as higher-integrity areas than surrounding wetlands is problematic. Use the mean value of pixels within a wetland. For wetlands that are smaller or narrower than a single pixel (30m x 30m, or 98' x 98'), use the value of the (contained) centroid of the polygon.

- 3 points: >70
- 2 points: 45-70
- 1 point: 15-45
- 0 points: < 15

TNC 2016 Resilient and Connected Landscapes model: use the most common value of pixels within a wetland. For wetlands that are smaller or narrower than a single pixel (30m x 30m, or 98' x 98'), use the value of the (contained) centroid of the polygon.

- 3 points: wetland intersects resilient land with confirmed diversity: Value IN (11,12,112)
- 2 points: wetland intersects land with connectivity but without confirmed biodiversity: Value IN (2,4,13,14,33)
- 1 point: wetland intersects resilient land only: Value = 3
- 0 points: wetland does not meet above criteria

Definition of Value codes:

  - 0 Vulnerable
  - 2 Climate Corridor (resilient)
  - 3 Resilient only (unsecured)
  - 4 Climate Corridor (vulnerable)
  - 11 Climate Corridor with confirmed diversity

  - 12 Resilient Area with confirmed diversity
  - 13 Climate Corridor
  - 14 Climate Flow Zone
  - 33 Resilient only (secured)
  - 112 Climate Flow Zone with confirmed diversity

TNC Forest Patches 2014: use forest tract proximity and extent.

- 3 points: wetland intersects forest patch ≥ 1,000 hectares (2,470 acres) in size
- 2 points: wetland intersects forest patch ≥ 100 hectares (247 acres) in size, i.e., is contiguous with a forest patch ≥ 100 hectares (247 acres) in size OR wetland itself contains ≥ 100 hectares (247 acres) of forest
- 1 point: wetland intersects a forest patch ≥ 20 hectares (50 acres) in size OR wetland is within 30 meters (98 feet) of a forest patch ≥ 100 hectares (247 acres) in size
- 0 points: wetland does not meet above criteria

This is a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 3.

GIS score and final score:

*LandInteg = ((LandIntegDNR*2) + LandResil + ForestPatch)/4; round to the nearest integer*

Input to: *Habitat & Ecological Integrity / HOpportun / BufferLand*
Habitat & Ecological Integrity / HPotential / VegH / VegFQ (preliminary GIS score only)

2.6.8 RoadRail: Roads and Railroads

Runoff, sediment, and pollutants from roads and railways near a wetland provides an opportunity for the wetland to improve water quality for areas downstream. Nearby roads and railways also degrade the wetland itself. Road and rail crossings can increase sediment and contaminant loads (especially salt and petrochemicals) to a wetland (McElfish et al. 2008).

The maximum score for *RoadRail* is 2 as input to *WQOpportun*. Note that high scores for *WQOpportun* contribute to lower scores for Habitat & Ecological Integrity. The preliminary GIS value is replaced by the rapid field assessment value.

Preliminary GIS score:

RoadRail =
2 points: wetland is within 5 m (16 ft) of a road or railroad track
1 point: wetland is 5-50 m (16-164 ft) from a road or railroad track
0 points: wetland is > 50 m (164 ft) from a road or railroad track

Final score, including tabular field data:

RoadRailT =

2 points: Road or Rail are checked in Hydrology Stressors AND Hydrology stress is "Moderate" or "Severe"

1 point: Road or Rail are checked in Hydrology Stressors AND Hydrology stress is "Intact" or "Mild"

0 points: Road or Rail are NOT checked in Hydrology Stressors

Access SQL expression: [1d_Site_stressors]![RoadRailT] = IIf([HS_road]=0 And [HS_rail]=0,0,IIf(([HS_road]<0 Or [HS_rail]<0) And [HydIntactT]>4,1,2))

Input to: *Water Quality / WQOpportun*

2.7 Landscape or Watershed Scale Metrics

2.7.1 AquaAbund: Aquatic Area Abundance

The aquatic area abundance of a wetland is a measure of its spatial association with other aquatic resources, e.g., other wetlands, lakes, ponds, or streams. Wetlands close to other aquatic resources have a potential to interact ecologically and hydrologically, and such interactions are generally beneficial (CWMW 2013). The functional capacity of a wetland is determined not only by its intrinsic properties, but by its relationship to other habitats across the landscape. Landscape-scale variables are important predictors of stream and wetland integrity (Roth et al. 1996, Scott et al. 2002). Wetlands that are close together without significant hydrological or ecological barriers between them provide refuge and habitat patches for wildlife, support transient or migratory wildlife species, and function as sources of colonists for primary or secondary succession of newly created or restored wetlands (CWMW 2013).

This is a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 2.

GIS score and final score:

AquaAbund =

Step 1. Calculate % cover of wetlands, ponds, lakes, and rivers in a 1 km (0.6 mile) buffer. This part of the metric is size-neutral.

Step 2. Calculate total length stream reaches in a 1 km (0.6 mile) buffer. Note that this calculation gives an advantage to large wetlands, which have more area in the 1 km (0.6 mile) buffer. This advantage is realistic because large wetlands also serve as aquatic resource areas to themselves.

Step 3. Merge and assign points as follows:

2 points: > 5% cover of NWI aquatic resources OR > 8 km (5 miles) of NHD stream reaches within 1-kilometer (0.6 mile) buffer

1 point: 1-5% cover of NWI aquatic resources OR 6-8 km (3.7-5.0 miles) of NHD stream reaches within 1-kilometer (0.6 mile) buffer

0 points: neither of the above criteria are met

Input to: *Habitat & Ecological Integrity / HOpportun / LandHydro*

2.7.2 BRankHUC: Biodiversity Rank of 12-digit HUC Watershed

Watersheds with high documented biodiversity provide opportunities for wetlands to participate in the maintenance and dispersal of native species and natural communities. High species diversity at the watershed level promotes the habitat and ecological integrity functions of wetlands.

This is a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 4, but during the *LandEco* roll-up these points are pro-rated to 1.

GIS score and final score:

BRankHUC =

Select wetlands that intersect B-ranked HUC12 watersheds and assign points as follows:

4 points: wetland intersects a B1-ranked 12-digit watershed (watershed provides habitat for good populations of critically globally imperiled species or natural communities

3 points: wetland intersects a B2-ranked 12-digit watershed (watershed provides habitat for good populations of globally imperiled species or natural communities)

2 points: wetland intersects a B3-ranked 12-digit watershed (watershed provides habitat for good populations of globally vulnerable or disjunct state critically imperiled species or natural habitats)

1 point: wetland intersects a B4- or B5-ranked 12-digit watershed (watershed provides habitat for good populations of state imperiled species or natural habitats)

0 points: none of the above criteria are met

Input to: *Habitat & Ecological Integrity / HOpportun / LandEco*

2.7.3 ConsFocus: Conservation Focus Areas

WVDNR (2015) has identified Conservation Focus Areas (CFAs) as part of the State Wildlife Action Plan. Several of the CFAs have a specific wetland focus. These areas are likely to offer high opportunities for wetlands to provide habitat and ecological integrity functions. They include:

- Cacapon River and Patterson Creek (wetland odonates, Short Mountain wetland),
- Central Reservoirs (wetland birds and odonates),
- High Alleghenies (High Allegheny Wetlands, all taxa groups, largest and most intact wetland complex in WV),
- Little Kanawha and Middle Island Creek (wetland odonates),
- Lower Elk River (wetland odonates),
- Meadow River Wetlands (oak-ash swamps in 2nd largest wetland complex in WV, birds, crayfish, plants),
- Ohio River Corridor (wetland birds, amphibians, plants, Greenbottom Swamp, Ohio River Islands),
- Shenandoah Valley (marl wetlands, Virginia Rail, spotted turtle),
- Sleepy Creek and Back Creek (wetland turtles, amphibians, plants)

This a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 2, but during the *LandEco* roll-up these points are pro-rated to 1.

GIS score and final score:

ConsFocus =

Select wetlands that intersect CFAs. Assign points as follows:
2 points: wetland intersects CFA with specific wetland focus
1 points: wetland intersects any CFA except the "General CFA"
0 points: none of the above criteria are met

Input to: *Habitat & Ecological Integrity / HOpportun / LandEco*

2.7.4 DisturbWshd: Land Use Disturbance in Contributing Watershed

Disturbed land uses in the drainage area of a wetland provide an opportunity for the wetland to improve water quality for areas downstream. A disturbed watershed also degrades the wetland itself. Farming, grazing, golf courses, residential areas, commercial land uses, urban areas, and developed areas in general, are major sources of pollutants (Sheldon et al. 2005). Tilled fields are a source of nutrients, pesticides, and sediment. Pastures are a source of nutrients and pathogenic bacteria, and clearcut areas are a source of sediment (Sheldon et al. 2005).

This a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score for *DisturbWshd* is 1 as input to *WQOpportun*. Note that high scores for *WQOpportun* contribute to lower scores for Habitat & Ecological Integrity.

GIS score and final score:

DisturbWshd =

Calculate the ratio of disturbed area to total area within the drainage area of the wetland. Disturbed land uses include agricultural, pasture, golf course, residential, commercial, urban, or area that have been timbered within the last 5 years. Merge the disturbed land use selections and assign 1 point if more than 10% of the contributing watershed is disturbed.

Input to: *Water Quality / WQOpportun*

2.7.5 HUC12WQ: Water Quality Issues in 12-digit HUC Watershed

The removal of pollutants by wetlands is particularly valuable in watersheds where other aquatic resources are already polluted or have problems with eutrophication. Any further degradation of these resources caused by destroying the wetland could result in irreparable damage to the ecosystem. Karst systems lack natural filtering capacity and are vulnerable to pollution wherever they occur in the state; therefore, wetlands occurring in karst areas are assigned this point whether or not degradation has been documented.

This a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 1.

GIS score and final score:

HUC12WQ =

Select 12-digit HUC watersheds that contain an impaired stream reach, algal lake, algal stream, lake with power boat use, or karst. Assign 1 point to wetlands that intersect these watersheds.

Input to: *Water Quality / WQSociety*

2.7.6 LandEco roll-up: Landscape-level Ecological Connectivity

Landscape-level ecological connectivity provides high opportunities for maintenance and dispersal of native species, rare species, and natural communities. This roll-up metric sums and prorates the values for watershed-level biodiversity rank, conservation focus area, uniqueness of wetland within a watershed, and wetland breeding bird occupancy. This a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 3.

GIS score and final score:

LandEco = [BrankHUC] + [ConsFocus] + [WshdUniq] + [WetldBird]; prorate as:

3 points: sum = 8-11
2 points: sum = 5-7
1 points: sum = 2-4
0 points: sum = 0-1

Input to: *Habitat & Ecological Integrity / HOpportun*

2.7.7 LandHydro roll-up: Landscape-level Hydrologic Connectivity

Landscape-level hydrologic conductivity is a key component of ecological integrity. This roll-up metric sums the values for aquatic area abundance and wetland position in the watershed. This a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 3.

GIS score and final score:

LandHydro = [AquaAbund] + [WshdPos]

Input to: *Habitat & Ecological Integrity / HOpportun*

2.7.8 LandPos: Landscape Position (Tiner)

Landscape position is part of the Tiner (2011) wetland functional classification which describes and classifies wetlands by landscape position, landform, water flow path, and waterbody type (LLWW). Tiner's landscape position characterizes wetlands based on their location within or outside the active floodplain of a waterbody (stream, river, lake). The basic landscape position types in West Virginia wetlands are shown in the table below.

Landscape Position Codes in West Virginia Wetlands (after Tiner 2011)

Code	Landscape Position	Description
LR	Lotic River	Wetland is located in a river (including in-river ponds and shallow lakes), within its banks, or on its active floodplain and is periodically flooded by the river. River is defined as a broad channel mapped as a polygon or 2-lined watercourse on a 1:24,000 U.S. Geological Survey topographic map.
LS	Lotic Stream	Wetland is located in a stream (including in-stream ponds and shallow lakes), within its banks, or on its active floodplain and is periodically flooded by the stream. Stream is defined as a linear or single-line watercourse on a 1:24,000 U.S. Geological Survey topographic map.
LSh	Lotic Stream - headwater	Wetland is located in a stream (including in-stream ponds and shallow lakes), within its banks, or on its active floodplain and is periodically flooded by the stream. Stream is defined as a linear or single-line watercourse on a 1:24,000 U.S. Geological Survey topographic map. *Modifier*: Headwater (wetlands along first- and second-order perennial streams in hilly terrain including all intermittent streams above these perennial streams).
LSc	*Lotic Stream - channelized*	*Not yet used in WV, but may be part of future development.* Wetland is located in a stream (including in-stream ponds and shallow lakes), within its banks, or on its active floodplain and is periodically flooded by the stream. Stream is defined as a linear or single-line watercourse on a 1:24,000 U.S. Geological Survey topographic map. *Modifier*: Channelized (excavated stream course).
LE	Lentic	Wetland is located in or along a lake or reservoir (permanent waterbody where standing water is typically much deeper than 6.6 feet at low water but including large shallow lakes >20 acres), including streamside wetlands in a lake basin (the depression containing the lake). Wetlands contiguous to the lake but at higher elevations and not in the lake basin should NOT be classified as lentic; these wetlands should be treated as terrene outflow types in most cases. This

Code	Landscape Position	Description
		is especially common where lakes are artificially created by diking and/or excavation.
TE	Terrene	Wetland is completely surrounded by upland (non-hydric soils or filled lands that are now upland development). Terrene wetlands may occur: (1) on a slope or flat, or in a depression (including ponds) lacking a stream but may be contiguous to a river or stream, (2) on a historic (inactive) floodplain, (3) in a landscape position crossed by a stream (e.g., an entrenched stream), but where the stream does not periodically inundate the wetland, (4) in a headwater, outflow only, position as the source of a stream.
TEh	Terrene - headwater	Wetland is completely surrounded by upland (non-hydric soils or filled lands that are now upland development). Terrene wetlands (headwater) may occur in a headwater, outflow only, position as the source of a stream.

Preliminary GIS value:

LandPos =

A sequential procedure is used to assign the Tiner landscape position code.

1. *Wetlands within the floodplain are marked Lotic Stream.*
2. *Floodplain wetlands within 200 meters (656 feet) of a wide river are marked Lotic River.*
3. *Assign headwater modifier to Lotic Stream wetlands intersecting first and second order streams, outflow wetlands, and wetlands with intermittent flow. Include isolated wetlands since almost all of these in WV are actually headwater wetlands – the streams are just too small to show up on the National Hydrography Dataset.*
4. *Wetlands within 25 meters (82 feet) of a lake are marked Lentic.*
5. *Unassigned wetlands are marked Terrene.*
6. *Assign headwater modifier to Terrene wetlands that intersect first and second order streams, are outflow wetlands, or have intermittent flow. Include isolated wetlands since almost all of these in WV are actually headwater wetlands – the streams are just too small to show up on the National Hydrography Dataset.*
7. *Assign headwater modifier to Terrene wetlands with small contributing watershed of less than 16 hectares (40 acres).*
8. *Assign headwater modifier to Terrene wetlands that occupy a large proportion (more than 5%) of their contributing watershed.*

Tabular field data:

LandPos is not directly re-calculated in the field; rather, the Headwater metric that incorporates LandPos is modified by field observation of wetland water sources and outlets. If needed for future analyses, the LandPos variable can be modified based on field data. See the procedures listed in the Headwater and WFlowPath metric descriptions.

Input to: *Headwater (multiple functions)*

2.7.9 SlopeWshd: Mean Slope of Contributing Watershed

Steep slopes contribute to rapid runoff and increases in flood flows during storm events. Wetlands below these slopes will have heightened opportunities to intercept and slow flood flows (Miller et al. 2017). This a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 2.

GIS score & final score:

> *SlopeWshd =*
> *Calculate mean percent slope of contributing watershed. Assign points:*
>
> > *2 points: mean slope > 15%*
> > *1 point: mean slope 5-15%*
> > *0 points: mean slope < 5%*

Input to: *Flood Attenuation / FAOpportun / FloodIn*

2.7.10 WetldBird: Wetland Breeding Bird Occupancy

Breeding Bird Atlas blocks with high occupancy by wetland-dependent birds provide a strong indicator of extant biodiversity and the presence of high quality wetland habitat. Breeding Bird Atlas blocks comprise approximately 10 square miles, or one-sixth of a USGS topographic quadrangle. This metric is based on an occupancy geodatabase "WetlandBirds" for wetland breeding birds developed by Elizabeth Byers (WVDEP) in 2017, based on data from the WV Breeding Bird Atlas project (Rich Bailey, WVDNR Coordinator). Note that Breeding Bird Atlas blocks do not cover the entire state; slivers of the state are missing along the Maryland border. This a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 3.

GIS score & final score:

> *WetldBird =*
> *Assign points based on the ranking of atlas blocks for wetland breeding birds:*
>
> > *3 points: wetland intersects block in upper 10% of values (WetBird > 0.493)*
> > *2 points: wetland intersects block in upper 10-50% of values (0.408 < WetBird ≤ 0.493)*
> > *1 point: wetland intersects block in upper 50-75% of values (0.354 < WetBird ≤ 0.408)*
> > *0 points: none of the above criteria are met*
>
> *For wetlands outside the Breeding Bird Atlas coverage area (along the Maryland border), assign the value of the nearest atlas block.*

Input to: *Habitat & Ecological Integrity / HOpportun / LandEco*

2.7.11 WshdPos: Watershed Position

Certain positions in the watershed provide particular opportunities for hydrological and ecological connectivity, promoting habitat quality and ecological integrity. Headwater wetlands are upstream of all aquatic habitats and provide important protection to these ecosystems. Major river floodplains are an important and highly threatened habitat for toads, frogs, wetland birds, and dragonflies. Karst areas have a uniquely sensitive underground ecology and provide calcium-rich water to above-ground ecosystems.

The preliminary GIS score is augmented by field observations of headwater position or karst geology during rapid field assessment. The maximum score is 1.

Preliminary GIS score:

WshdPos = 1 if any of the following conditions are met:

- *Headwater wetland OR*
- *Amphibian habitat: wetland is in the floodplain of a major river, defined as having a drainage area > 5000 square miles, i.e., the Ohio, Kanawha, and lower Potomac (below Little Conococheague Creek, 1 mile downstream of Dam No 5, 7 miles upstream of Rt. 81 bridge). Note: Don't include the Monongahela, New, Big Sandy, Greenbrier, Gauley, Elk, Guyandotte, Little Kanawha, N & S Branch Potomac OR*
- *Odonates: *Ohio, *Kanawha, Meadow, Potomac, Cacapon, Tygart (higher elevation, but slower and sinuous), and lower portions of the North and South Branch. The Mon and Bluestone really don't have much in the way of wetlands because of the dams (except a few localized places Sue Olcott can think of on the Mon)(Note that amphibian habitat is included in Odonata habitat; since there is only one point available for this metric, these two categories can be combined) OR*
- *Wetland occurs on karst (limestone/dolomite bedrock geology or SSURGO karst).*

Tabular field score:

WshdPosT = 1 if ([KarstT] + [HeadwaterT]) > 1

Final score, including tabular field data:

WshdPosA = MAX (WshdPos, WshdPosT)

MS Access SQL expression:

WshdPosA: IIf([WshdPos] > [WshdPosT] , [WshdPos] , [WshdPosT])

Input to: *Habitat & Ecological Integrity / HOpportun / LandHydro*

2.7.12 WshdUniq: Watershed Wetland Size and Uniqueness

Wetlands embedded in a dense or diverse network of nearby wetlands provide greater opportunities to species to thrive and disperse (CWMW 2013). Watershed wetland maps of type diversity, density, and proportional area were developed for West Virginia watersheds.

- Type diversity: number of unique NWI codes in the watershed, not including spoil wetlands (*DiverseNWI*)
- Density: number of vegetated NWI polygons; many of these polygons may be contiguous with each other, forming a single wetland (*DensVegNWI*)
- Proportional Area: proportion of the watershed's total area occupied by vegetated wetlands as mapped by NWI (*RatioVeg*)

Threshold Values for Wetlands 12-digit HUC watersheds

	Top 5%	Top 10%
DiverseNWI	28	22
DensVegNWI	70	45
RatioVeg	0.009	0.005

The largest vegetated wetland within each 12-digit HUC watershed is considered a unique resource for that watershed.

This is a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 2, but during the *LandEco* roll-up these points are pro-rated to 1.

GIS score and final score:

WshdUniq =

2 points: largest vegetated wetland in HUC12, or HUC12 is in top 5% for type diversity, density, or proportional area

1 point: HUC12 is in top 10% for type diversity, density, or proportional area

0 points: none of the above criteria are met

Input to: *Habitat & Ecological Integrity / HOpportun / LandEco*

2.8 Value to Society Metrics

Wetlands are considered more valuable in terms of their functions when those functions are directly used or recognized by society. Indicators of high value to society include public ownership, less restrictive access policies, visibility from roads and trails, physical accessibility to a wide range of users, prior investment of funds for conservation or enhancement, use for compensatory mitigation, inclusion in watershed planning, or a history of scientific monitoring (Adamus et al. 2010, Veselka and Anderson 2011). Value to Society metrics are not included in the Regulatory Score, but are important for the Land Acquisition Score.

2.8.1 EconRisk: Economically Valuable Flood Risk Area

Wetlands upstream of economically valuable flood-prone infrastructure (structures, roads, developed lands, cropland) can reduce the costs and negative impacts of flood damages to society (Miller et al. 2017).

This is a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 4 and is subject to the cap of 4 points total for the *FASociety* roll-up metric.

GIS score and final score:

EconRisk =
Wetland is located in or near a census block with significant predicted total losses during a 100-year flood (Hazus census block data). We approximate "wetland upgradient of risk area" by using three levels of increasing distance: (a) location within a census block with predicted losses, (b) 1 km (0.6 mile) distance from a census block with predicted losses, and (c) location within a HUC12 watershed that contains predicted losses. This will approximately capture wetlands that are upgradient of census blocks with predicted flood losses. Future work could incorporate flow direction. Assign points as follows:

- *4 points: WU intersects TotalLossRP100 > 1204 (top quintile or $1,204,000-$246,103,000)*
- *3 points: WU intersects TotalLossRP100 = 200 – 1204 OR is within 1 km (0.6 mile) of top quintile*
- *2 points: WU intersects TotalLossRP100 = 42 - 200 OR is within 1 km (0.6 mile) of fourth quintile*
- *1 point: WU intersects TotalLossRP100 > 0 – 42 OR WU is in a HUC12 watershed with TotalLossRP100 > 0*
- *0 point: WU is in a HUC12 watershed with TotalLossRP100 = 0 (bottom quintile)*

Input to: *Flood Attenuation / FASociety*

2.8.2 Fisheries: Economically Important Fisheries

Wetlands filter sediments and contaminants and buffer the pH of water entering streams. Wetlands in the contributing basin of an economically important fishery are of high economic and social value.

This is a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 2 and is subject to the cap of 2 points total for the *WQUse* roll-up metric.

GIS score & final score:

Fisheries =
Approximated as wetland located within 1 km (0.6 mile) of an economically important fishery. Future work could include flow direction.

2 points: special fishery: catch-and-release area, children/Class Q fishing area, or fly-fishing-only stream
1 point: high quality fishery, warmwater fishery stream, stocked trout stream, or stream with year-round trout populations. Note that warmwater fisheries are generally included in the "high quality fishery" layer. According to Mike Shingleton (WVDNR), pers. comm. March 2015, they can also be approximated by all polygonal streams below 610 meters (2,000 feet) elevation. For the purposes of WVWRAM, it is assumed that warmwater fisheries are adequately represented by the "high quality fishery" layer.
0 points: none of the above criteria are met

Input to: *Water Quality / WQSociety / WQUse*

2.8.3 Floodway: Location in FEMA Regulatory Floodway

Regulatory floodways have been identified by FEMA (2006) as high priorities for flood control, with strict limits on development. Wetlands occurring in a regulatory floodway have a high value to society. FEMA (2006) defines "Regulatory Floodway" as the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height. Communities must regulate development in these floodways to ensure that there are no increases in upstream flood elevations.

This is a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 4 and is subject to the cap of 4 points total for the *FASociety* roll-up metric.

GIS score and final score:

Floodway = 4 if wetland intersects a mapped Regulatory Floodway

Input to: *Flood Attenuation / FASociety*

2.8.4 HInvest: Societal Investment in Habitat & Ecological Integrity

Society values wetland habitats by investing in them through management and conservation actions. Investments can take a variety of forms including use restrictions, management plans, and restoration activities. Three categories of investment are recognized for this metric.

High investment:

1. Mitigation investment: wetland is all or part of a mitigation site used explicitly to offset impacts elsewhere.
2. Conservation investment: wetland is part of or contiguous to lands which public or private organizational funds were spent to preserve, create, restore, or enhance habitat and not used explicitly to offset impacts elsewhere.
    a. Conservation easement managed for biodiversity, i.e., Gap Status Code = 1 (TNC, some land trust holdings)

b. USDA
    i. FSA Conservation Reserve Program (CRP)
    ii. NRCS Wetland Reserve Program
    iii. NRCS Emergency Watershed Protection easement
    iv. USFS Forest Legacy easement
    v. USFS Special Botanical Area
    vi. USFS Wilderness Area
c. USFWS National Wildlife Refuge
d. USNPS National Park, Monument, or Scenic River
e. WVDNR State Natural Area

Moderate investment in a general area including the wetland, with some focus on habitat and ecological integrity along with other functions.

1. USFS National Forest outside wilderness or special botanical areas

Low investment, i.e., wetlands that are on public land where the primary focus is on functions (e.g., recreation, military operations) other than ecological conservation or restoration, but where wetlands are unlikely to be destroyed or severely adversely impacted.

1. US Department of Defense lands
2. WVDNR State Parks
3. WVDNR Wildlife Management Areas (open access, Gap status 2)
4. WVDOF State Forests (GAP status: managed for multiple uses, subject to extractive, e.g. mining or logging, or OHV use)
5. City and County Parks (all are open access, GAP status code = "no known mandate")
6. Natural Streams Preservation Act (NSPA). Wetland is in the contributing watershed of a stream reach protected by the Natural Streams Preservation Act. These include (a) Greenbrier River from its confluence with Knapps Creek to its confluence with the New River, (b) Anthony Creek from its headwaters to its confluence with the Greenbrier River, (c) Cranberry River from its headwaters to its confluence with the Gauley River, (d) Birch River from the Cora Brown bridge in Nicholas county to the confluence of the river with the Elk River, and (e) New River from its confluence with the Gauley River to its confluence with the Greenbrier River.

The preliminary GIS score is augmented by field observations. The maximum score is 3.

Preliminary GIS score:

HInvest =

3 points: high investment
2 points: moderate investment
1 point: low investment
0 points: no known investment

Tabular field score:

HInvestT =

3 points: wetland contains a mitigation site, conservation easement, or other field-documented conservation investment which could include tree planting, invasive plant removal, fencing out livestock, or culvert replacement.

2 points: habitat plan exists for the wetland

0 points: no known investment

Final Score:

HInvestA = MAX (HInvest, HInvestT)

MS Access expression: HInvestA: IIf([HInvest]>[HInvestT],[HInvest],[HInvestT])

Input to: *Habitat & Ecological Integrity / HSociety*

2.8.5 HUse roll-up: Public Use and Access to Natural Wetland Habitats

Access, infrastructure, and habitat quality all impact public use of wetlands. This roll-up metric sums the values for public ownership, public access and public use of natural wetland habitats. The maximum score is 4.

Preliminary GIS score:

HUse = [OwnerAccess] + [PublicUse]

Final score, including tabular field data:

HUseA = [OwnerAcceA] + [PublicUseA]

Input to: *Habitat & Ecological Integrity / HSociety*

2.8.6 OwnerAccess: Land Ownership and Accessibility

Accessible wetlands and wetlands on public land are more likely to be used and/or appreciated by the public. Two categories of ownership and access are recognized for this metric.

Open access: public land (except for U.S. Navy and Air National Guard), or private land with permanent unrestricted public access to the edge of the wetland (e.g., WV Botanical Garden, TNC Cranesville Swamp Preserve, Brush Creek, Brooklyn Heights, Eidolon, Greenland Gap, Hungry Beech, Murphy Preserve, Pike Knob, Slaty Mountain, Yankauer Preserve, TNC Mt. Porte Crayon, Stauffer's Marsh, Williamstown, Camp Dawson Wetland Boardwalk, Core Arboretum).

Partial access: private land with seasonal, partial, or case-by-case public access (e.g., Harewood Marsh, Ice Mountain, Upper Shavers, Tygart Valley Mitigation Bank, Wetlands of Winfield, New River Birding & Nature Center, Ward Hollow, John Gottschalk Boardwalk in Boy Scout Camp, Page Jackson Elementary School Wetland)

The preliminary GIS score is augmented by field observations regarding accessibility and infrastructure. The maximum score is 2.

Preliminary GIS score:

OwnerAccess =

2 points: open access
1 point: partial access
0 points: no public access

Tabular field score:

OwnerAccessT =

2 points: public land, or private with permanent unrestricted access
1 point: private land, with seasonal, partial, or case-by-case access; note that if public use infrastructure is observed, then access should be non-zero
0 points: private land, without public access

MS Access SQL expression:
[1a_Site]![OwnerAccessT] = IIf([OwnerAccess] = "public or unrestricted", 2, IIf([OwnerAccess]="private partial" Or [Inf_parking]<0 Or [Inf_boardwalk]<0 Or [Inf_kiosk]<0 Or [Inf_trail]<0 Or [Inf_boat]<0,1,0))

Final score, including tabular field data:

OwnerAcceA = MAX (OwnerAccess, OwnerAccessT)

MS Access expression:

OwnerAccA: IIf([OwnerAcces]>[OwnerAccessT],[OwnerAcces],[OwnerAccessT])

Input to: *Habitat & Ecological Integrity / HSociety / HUse*

2.8.7 PublicUse: Public Use or Sustained Monitoring/Research

Wetlands that are used and/or appreciated by the public, or are of importance to long-term scientific research, have a high value to society. Two categories of ownership and access are recognized for this metric: high use and moderate use.

High public use, or built infrastructure offers potential for high public use. Areas included are National Wildlife Refuges (NWR) and selected other public and private lands. Even though parts of NWRs are closed to the public, they still offer outstanding opportunities to experience wetlands. Individual wetlands with infrastructure, public use including birding hotspots, or sustained scientific use are also included.

Infrastructure can include:

Maintained parking area: paved and/or big enough for a schoolbus
Boardwalk
Informational kiosk (e.g., Williamstown wetland, WV Botanical Garden)
Maintained road within 30 meters (98 feet) of wetland with views of wetland (field only)
Maintained trail within 10 meters (33 feet) of wetland
Boat access to wetland

Known wetlands with infrastructure, organized by source data include:

Wildlife Refuges: Canaan Valley & Ohio River Islands
State Parks: Canaan Valley, Blackwater Falls
WMAs: Greenbottom, Little Canaan, McClintic, Short Mountain, Valley Bend Wetlands
County Parks: Meadowood, WV Botanical Garden, McDonough Wildlife Refuge, Johnson T. Janes Nature Preserve and Conservation Park
Exemplary wetlands: Alder Run Bog, Cranberry Glades, Cranesville Swamp, Harewood Marsh, Winfield
Other: New River Birding and Nature Center, Williamstown, Tea Creek Interpretive Trail, Stauffer's Marsh, John Gottschalk Boardwalk and Causeway at the Summit Bechtel Reserve, Camp Dawson wetland boardwalk, Page Jackson Trail Gardens and Wetlands

Birding Hotspot (Brooks Bird Club, WVDNR, Audubon, and citizen birding organization hotspot lists for WV). Initial list combines eBird download of birding hotspots and main wetland sites from Eddy 2009. eBird hotspots were downloaded from:
https://confluence.cornell.edu/display/CLOISAPI/eBird-1.1-HotSpotsByRegion

Wetlands within 100 meters (328 feet) of these hotspots are selected. These hotspots were supplemented by wetlands that intersect main birding wetlands areas from Eddy 2009:

National Wildlife Refuges: Canaan Valley, Ohio River Islands
Wildlife Management Areas: Fairfax Pond / Rehe, Meadow River, Pleasant Creek
State Parks: Canaan Valley, Blackwater Falls, Cathedral
Exemplary Wetlands: Altona, Cranberry Glades, Dolly Sods: Alder Run, Bear Rocks, Spruce Knob Lake, Winfield, McClintic, Greenbottom, Cranesville
Other: Stauffer's Marsh

Sustained scientific use requires that plants, animals, or water in the wetland have been monitored for more than two years, unrelated to any regulatory requirements, and data are available to the public. Known long-term research sites include CVNWR Research Natural Area and Monongahela National Forest special botanical areas.

Moderate public use wetlands are identified as WMAs and State Forests with populations of species identified by WVDNR (Keith Krantz, pers. comm., 10 October 2017) as occurring in wetlands: waterfowl, grouse, woodcock, beaver, mink, muskrat, deer, bear plus wetland edge species: rabbit, bobcat, coyote, red fox, raccoon, opossum.

The preliminary GIS score is augmented by field observations regarding public use or long-term monitoring. The maximum score is 2.

Preliminary GIS score:

> *PublicUse =*
>
> > *2 points: high public use*
> > *1 point: moderate public use*
> > *0 points: no known public use*

Tabular field score:

> *PublicUseT =*
>
> > *2 points: public use infrastructure present including maintained parking, boardwalk, informational kiosk or brochure, maintained road within 30m with view, maintained trail, boat access OR consumptive use (fishing, trapping, hunting, berry-picking, non-timber forest products), or non-consumptive (hiking, walking, bird-watching, photography) OR sustained scientific use observed*
> > *1 point: wetland is viewable from public area < 100m away or walking is possible, i.e., no deep water or dense thickets*
> > *0 points: none of the above criteria are met*
>
> *MS Access SQL expression: [1a_Site]![PublicUseT] =*
>
> *IIf([Inf_parking]<0 Or [Inf_boardwalk]<0 Or [Inf_kiosk]<0 Or [Inf_roadview]<0 Or [Inf_trail]<0 Or [Inf_boat]<0 Or [Monitored]<0 Or [Pub_consum]<0 Or [Pub_nonconsum]<0,2,IIf([Pub_visible]<0 Or [Pub_walking]<0,1,0))*

Final score, including tabular field data:

> *PublicUseA = MAX (PublicUse, PublicUseT)*
>
> *MS Access SQL expression:*
>
> *PublicUseA: IIf([PublicUse]>[PublicUseT], [PublicUse], [PublicUseT])*

Input to: *Habitat & Ecological Integrity / HSociety / HUse*

2.8.8 WaterSupply: Wetland Discharges to Water Supply Intake Area

Wetlands are particularly valuable to society when they contribute to clean water above a drinking water supply, including surface water intakes or groundwater intakes under the direct influence of surface water. Two categories of water supply intake area are identified for this metric: high benefit and moderate benefit.

High benefit is defined as a wetland that intersects a state-mapped public water intake Zone of Critical Concern, Protection Area, or Wellhead Protection Areas where the source is surface water or ground water under the influence of surface water OR the wetland makes up more than 1% of a Surface Intake Drainage Area.

Moderate benefit is defined as a wetland that intersects a state-mapped public water intake Zone of Peripheral Concern or a Secondary Protection Area with surface water connections OR the wetland makes up 0.1-1% of a Surface Intake Drainage Area.

This is a landscape-level metric and is not re-assessed during rapid field assessment. The maximum score is 2 and is subject to the cap of 2 points total for the *WQUse* roll-up metric.

GIS score & final score:

WaterSupply =

2 points: high benefit to water supply protection
1 point: moderate benefit to water supply protection
0 points: none of the above criteria are met

Input to: *Water Quality / WQSociety / WQUse*

2.8.9 WQPlan: Water Quality Plan Exists

Inclusion in a watershed plan, water quality plan, or having legal protected status are all indicators that society values the water quality function of a wetland highly. Types of plans covered by this metric are:

- TMDL. A TMDL exists for the drainage in which the wetland is found. A Total Maximum Daily Load (TMDL) plan is a plan of action used to clean up streams that are not meeting water quality standards. The TMDL program is part of the Watershed Branch of the WVDEP.
- Watershed Plan. Wetland has been identified in a watershed or local plan as important for maintaining water quality. Not all pollution and water quality problems are identified by state water quality monitoring program. Local and watershed planning efforts sometimes identify wetlands that are important in maintaining existing water quality. These wetlands provide a value to society at the local level that needs to be replaced if they are impacted.
- NSPA. Wetland is in the contributing watershed of a stream reach protected by the Natural Streams Preservation Act. These include (a) Greenbrier River from its confluence with Knapps Creek to its confluence with the New River, (b) Anthony Creek from its headwaters to its confluence with the Greenbrier River, (c) Cranberry River from its headwaters to its confluence with the Gauley River, (d) Birch River from the Cora Brown bridge in Nicholas county to the confluence of the river with the Elk River, and (e) New River from its confluence with the Gauley River to its confluence with the Greenbrier River.
- Most federally-owned lands have watershed plans to protect water quality. This includes National Forests, National Wildlife Refuges, and National Parks.

- Conservation easements related to water quality (none known at this time)

The preliminary GIS score is augmented by rapid field assessment, for example on-site discussions with landowners or land managers. The maximum score is 2.

Preliminary GIS score:

WQPlan =

2 points: water quality plan exists for the wetland or its watershed
0 points: no known water quality plan

Tabular field score:

WQPlanT =

2 points: water quality plan exists for the wetland or its watershed
0 points: no known water quality plan

MS Access SQL expression: [1a_Site]![WQPlanT] = IIf([WQPlan]<0,2,0)

Final score, including tabular field data:

WQPlanA = MAX (WQPlan, WQPlanT)

MS Access SQL expression:
WQPlanA: IIf([WQPlan] > [WQPlanT] , [WQPlan] , [WQPlanT])

Input to: *Water Quality / WQSociety*

2.8.10 WQUse roll-up: Public Use of Water Quality

Water quality is particularly important in areas where public use is high. Water supply intakes, swimming areas, economically important fisheries, and consumptive use of wetland flora and fauna are some of the uses that benefit from water quality improvements provided by wetlands.

This roll-up metric sums the values for public water supply, fisheries, swimming areas, and consumptive use. The preliminary GIS score is augmented by field observation of consumptive use. The maximum score is 2.

Preliminary GIS score:

WQUse = [WaterSupply] + [Fisheries] + [Swim]; reduce sum to maximum of 2.

Sum the points for Water Supply and Fisheries. Add an additional point if the wetland is within 1 km (0.6 mile) of a swimming area, and 2 points if the wetland is within 50 meters (164 feet) of a swimming area. If the total points for a wetland exceeds the maximum allowable points for this factor, reduce the total points back to 2.

Tabular field score:

WQUseT =

2 points: evidence of consumptive use (hunting, fishing, trapping, berry-picking, non-timber forest product collection)

0 points: no known consumptive use

MS Access SQL expression: [1a_Site]![WQUseT] = IIf([Pub_consum]<0,2,0)

Final score, including tabular field data:

WQUseA = MAX (WQUse, WQUseT)

MS Access SQL expression:

WQUseA: IIf([WQUse] > [WQUseT] , [WQUse] , [WQUseT])

Input to: *Water Quality / WQSociety*

3.0 MAINTENANCE AND TROUBLE-SHOOTING

3.1 Source Data Maintenance

Annually, WVDEP staff should check the GIS Source Layer Update Schedule (Appendix) for any scheduled updates. Source data layers for the GIS tool must be updated regularly, typically every 5 years or when new versions of the source data are released. The schedule for source layer updates is included in the Appendix.

Every 2-3 years, WVDEP staff should update the statewide NWI_WV work-in-progress layer with field-revised NWI polygon data.

3.1.1 Update, add, or change source data

The GIS tool must access specific, exact filenames and fields in order to work. When updating source data files, it is very important to retain these exact paths to data.

New source layers are best incorporated by

(a) make a copy of the original source layer,

(b) move the original source layer to a backup location,

(c) rename the copy with the exact name of the original,

(d) delete the original data while retaining the schema and fields, and

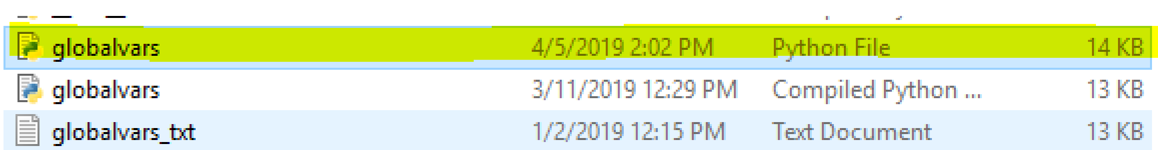
(e) load the new data to the empty original schema.

Each time a layer is updated, the compatibility of the new layer must be checked, including the path in the “globalvars.py” file that provides paths to the GIS tool. The GIS tool should immediately be run on a small dataset to ensure that data integrity has been maintained. Incorrect data paths will cause the tool to crash.

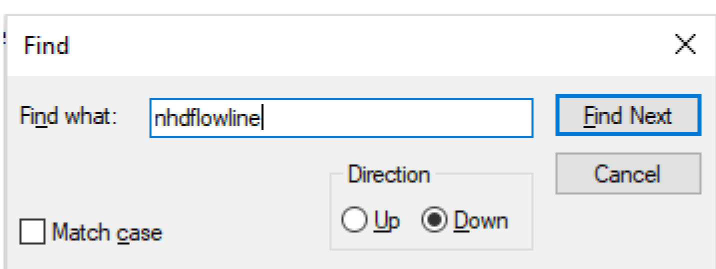
In contrast to regularly updated source data, entirely new source data or new data fields should only be added when they provide a significant improvement in scoring wetlands, and when resources are available to update all of the products associated with the WVWRAM tools, including the python coding. Products requiring updates are the WVWRAM Manuals (including the detailed GIS methods and source layer list in this document), WVWRAM MS-Access database, WVWRAM GIS Tool (ArcGIS 10.6.1 and ArcGIS Pro, including the python coding that drives these tools). Note that the GIS tool runs on both the WVDEP server and the WV GIS Tech Center server, and both must be updated.

If you are not sure whether a data source or attribute is new, check the "GIS Source Layer Update Schedule" appendix to this document and the "globalvars.py" file. Instructions for editing "globalvars.py" on the WVDEP server are below. The same edits must be made to the WV GIS Tech Center server.

1. Go to Q:\WATER RESOURCES\WAB\WETLANDS\Functional Assessment\3_Code\FunctionalAssessmentFramework\globalvars
2. Right-click the file named **globalvars.py** and click "Open With...". Find **Notepad** in the programs list and select it. Note that we want to open the one with the description of "Python File" (highlighted below) instead of the Compiled one.



3. In Notepad, hit **Ctrl+F5** to open up the Find window. Type in either the module name or the dataset name to be updated to locate the particular line for the data source. For example, you can search either "nhdflowline" or "streamedge" or "wflowpath" to locate the NHD Flowline dataset.



4. Replace what's in the quote with the updated data path.

```
srcNHDFlowline = r"M:\basemap\NHD_H_WV.gdb\Hydrography\NHDFlowline" # Also: StreamEdge
```

5. Save and close Notepad.

6. Restart ArcMap/ArcCatalog and re-run the tool.

7. Update the appendix to this document “GIS Source Layer Update Schedule” with the new name\path, and add the new target year for the next update.

8. Send the new data to WV GIS Tech Center to include in their source data for the web tool.

3.1.2 Update the National Wetlands Inventory mapping for WV

Rapid field assessment produces field-updated NWI polygons for input to the WVWRAM GIS tool. These polygons represent an improvement over existing NWI wetland mapping in West Virginia. WVDEP maintains an “NWI_WV” layer with updates to individual polygons. Note that current wetland mapping in West Virginia is based largely on imagery and methods from the 1980’s and thus includes only about two-thirds of the state’s wetlands.

Annually or biennially, the field-mapped NWI polygons should be copied into the NWI_WV statewide layer, including all attributes (NWI attribute, wetland type, date of update, initials of updater, comments). The NWI_WV layer should be exported to a static layer after significant updates are made, for example when more than 1% of the polygons are updated. Prior to export, the NWI data verification tools must be run on NWI_WV to ensure that there are no topology errors or bad attributes. The latest clean, static version of the NWI_WV feature class was exported in March 2019. When a new NWI_WV layer is available, then several GIS steps should be taken by WVDEP staff including

(a) share the layer via WVDEP’s public web service, WVDEP intranet, WV GIS Tech Center Data Clearinghouse, and WVDNR,

(b) offer the layer to the USFWS National Wetland Inventory to serve on their national website,

(c) re-export the layers needed for the WVWRAM GIS tool in NWIExports.gdb,

(d) create Wetland Units (WU) and assign unique WVDEP Wetland Codes to each WU

(e) if there are updated polygons that do not yet have a WVWRAM GIS assessment completed, run these through the WVWRAM GIS tool.

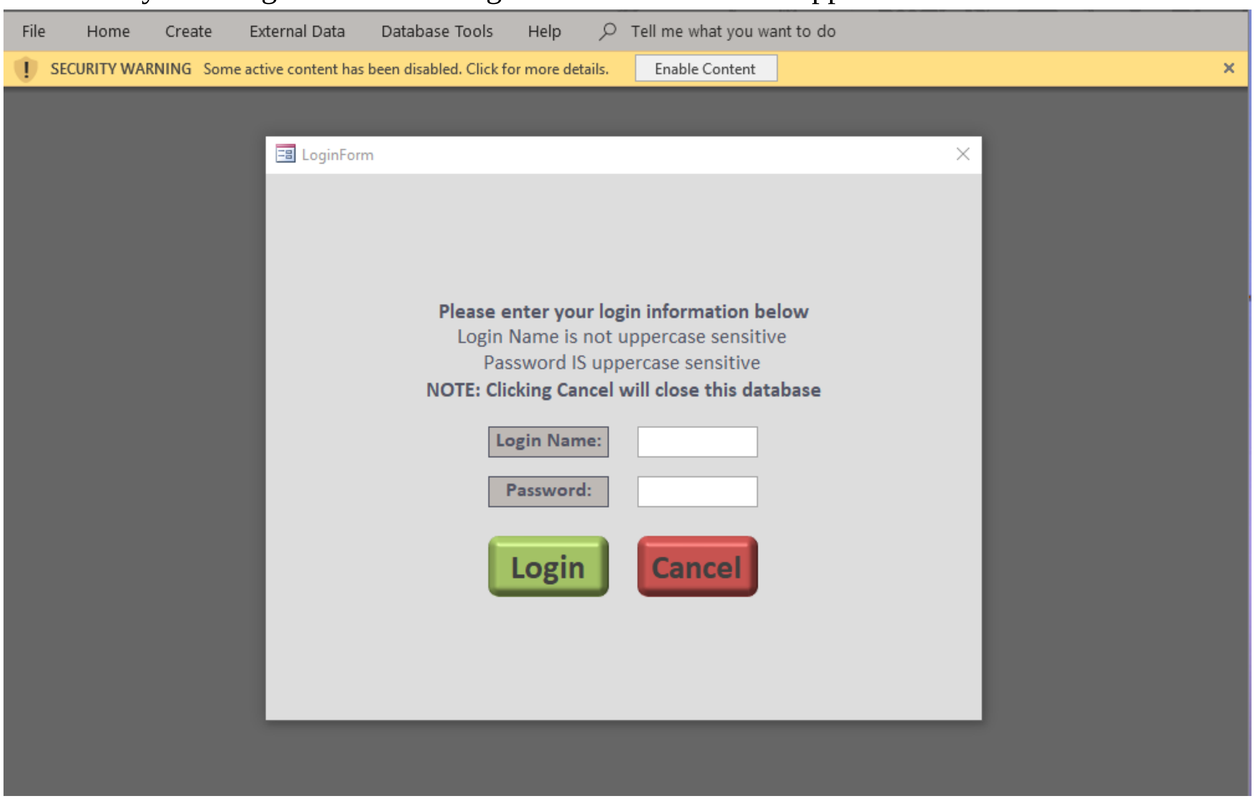
3.2 MS-Access database

3.2.1 MS-Access version

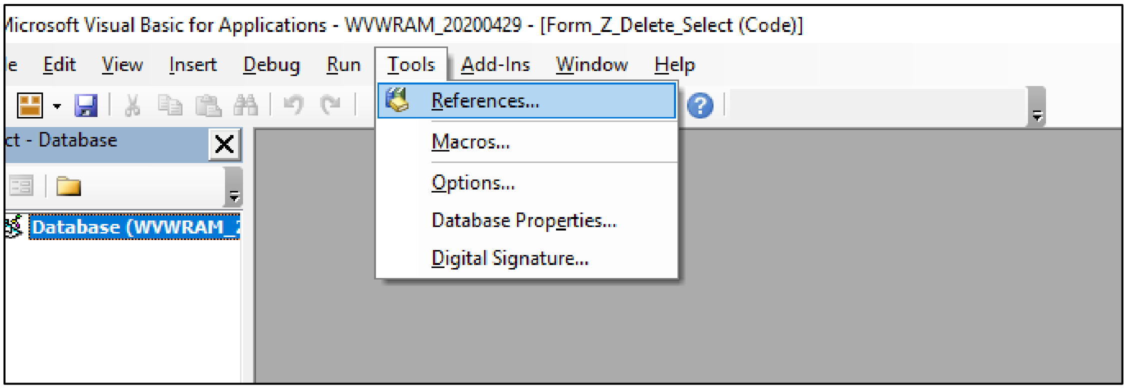
The MS-Access database was created in Access 2016. It may not run on other versions of MS-Access.

3.2.2 Installing the database on a new device

Upon opening the database for the first time a Security Warning ribbon may appear behind the LoginForm window. Click the X on upper right side of the Login Form. Click Enable Content in the Security Warning ribbon. The LoginForm window will reappear.



If this is the first time using the database on a specific computer, a check for required Reference Libraries must be performed. To do this, press the Ctrl and G keys on the keyboard at the same time. The Microsoft Visual Basic for Applications window will appear. Click Tools and then References.

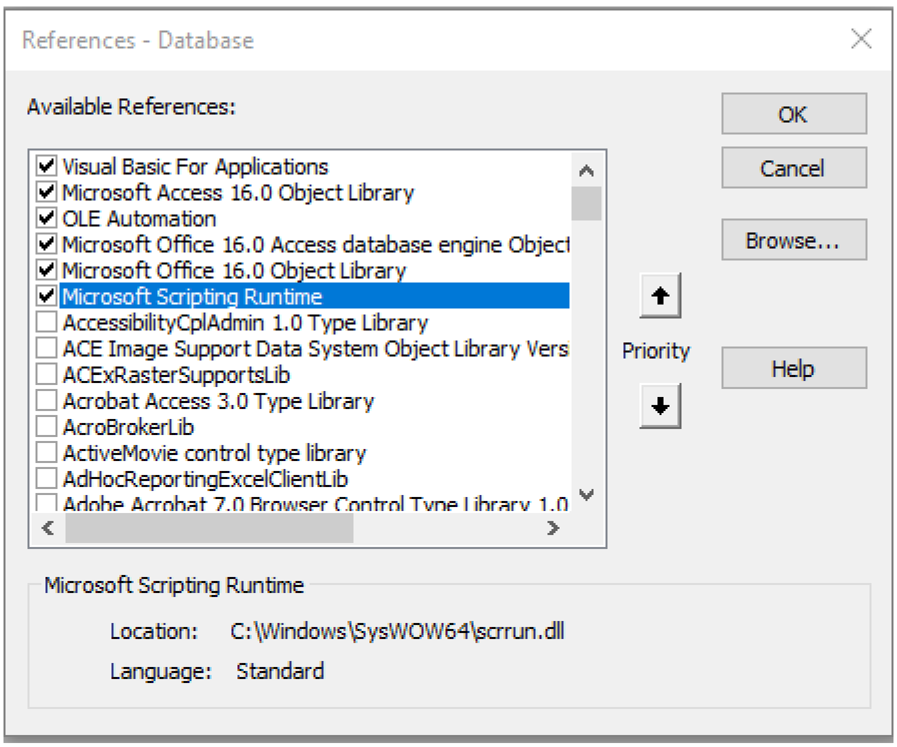


This will open the References – Database window. The following References are needed to run the WVWRAM Database:

-Microsoft Office 16.0 Access database engine Object Library

-Microsoft Office 16.0 Object Library

-Microsoft Scripting Runtime



If the above References are NOT checked, please scroll through the list and check the boxes for the required Libraries. Then click OK. The References – Database window will close. Click File in the upper left corner of the Microsoft Visual Basic for Applications window and select Save. Close the Microsoft Visual Basic for Applications window.

This procedure should only have to be performed once per device.

3.2.3 Business rules and automatic error flags

Certain business rules and automatic error flags have been built into the database. These include range limitations for numeric values. Error flags are automatically generated when a rule is violated. Errors that are flagged must be addressed by the user before proceeding with data entry or database calculations.

3.2.4 Using the interim results to find and fix errors

Each data entry form of the database displays the interim calculations performed on the data entered on that particular form. These values are in gray at the bottom of the form. Data problems can sometimes be identified by checking these interim calculations for unexpected values.

3.2.5 Running queries individually to find and fix errors

Queries can be run individually, in sequential order, to find and fix errors. After running each individual query, check the results of the query to see if there is anything unexpected.

3.3 GIS Tool

3.3.1 ArcGIS and Python versions

The GIS tool is written for ArcGIS 10.5 and Python 2.7 software versions. Earlier or later versions of ArcGIS or Python are likely to generate significant errors and are not supported. Plans are underway to update the GIS tool to ArcGIS Pro and Python 3.

3.3.2 Using the log files to find and fix errors

All Python code used in the GIS tool is heavily commented, typically with comments for every few lines of code. Each time the GIS tool is run, a log file is generated that prints the comments, specifying exactly what was performed. The first step in trouble-shooting is to check the log file and see exactly where the tool failed. This will generally point to the solution of the problem.

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5.0 APPENDICES

5.1 Acronym List

AA	Assessment Area
CoC	Coefficient of Conservatism
COE	U.S. Army Corps of Engineers
CONHP	Colorado Natural Heritage Program
CWMW	California Wetlands Monitoring Workgroup
DQO	Data Quality Objective
FGDC	Federal Geographic Data Committee
FNA	Flora of North America project
FQA	Floristic Quality Assessment
GIS	Geographic Information System
GPS	Geographic Positioning System
HGM	Hydrogeomorphic Wetland Classification System
MI DNRE	Michigan Department of Natural Resources and Environment
MQO	Measurement Quality Objective
mwC	Mean abundance-weighted Coefficient of Conservatism
NAD83	North American Datum 1983
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NWI	National Wetlands Inventory
Ohio EPA	Ohio Environmental Protection Agency
QAPP	Quality Assurance Project Plan
TNC	The Nature Conservancy
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WAB	Watershed Assessment Branch
WVDEP	West Virginia Department of Environmental Protection
WVDNR	West Virginia Division of Natural Resources
WVOHCF	West Virginia Outdoor Heritage Conservation Fund
WVWRAM	West Virginia Wetland Rapid Assessment Method

5.2 Glossary of Terms

Absolute cover: In vegetation sampling, the percentage of the ground surface that is covered by the aerial portions (leaves and stems) of a plant species when viewed from above. Due to overlapping plant canopies, the sum of absolute cover values for all species in a wetland type or stratum may exceed 100 percent. In contrast, "relative cover" is the absolute cover of a species divided by the total coverage of all species in that stratum, expressed as a percent. Absolute cover, NOT relative cover, must be used to calculate rapid floristic quality in WVWRAM.

Acid: Term applied to water or soil with a pH less than 5.5.

Aeration: The exchange of air in soils with air from the atmosphere

Alkaline: Term applied to water or soil with a pH greater than 7.4.

Assessment Area (AA): This is nearly always the contiguous, hydrologically connected areas of a wetland. Different AA's are separated by upland habitat or by hydrologic breaks. Examples of hydrologic breaks include stream riffles, sudden changes in elevation, dams, perched culverts, different water levels on either side of a road, constrictions to flow, or any abrupt change in the water regime. In rare occasions, the AA will be smaller than the wetland, for example in wetlands larger than 25 acres.

Bankfull: Bankfull stage corresponds to the discharge at which stream channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming a changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels (Dunne and Leopold 1978). Bankfull indicators include: 1) Topographic features: berm or other break in slope; 2) Vegetation: A change in vegetation from bare ground or annual hydrophytes to perennial hydrophytes or upland species; 3) Sediment texture: a change in size distribution of surface sediments.

Bar: An elongated landform formed by waves, currents, or deposition of unconsolidated sediments such as sand, gravel, stones, cobbles, or rubble and with water on two sides.

Beach: A sloping landform on the shore of larger water bodies, generated by waves, currents, or deposition of sediments and extending from the water to a distinct break in landform or substrate type.

Brackish: Marine and Estuarine waters with Mixohaline salinity. The term should not be applied to inland waters.

Boulder: Rock fragments larger than 60.4 cm (24 inches) in diameter.

Broad-leaved deciduous: Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season.

Broad-leaved evergreen: Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that generally remain green and are usually persistent for a year or more.

Calcareous: Formed of calcium carbonate or magnesium carbonate by biological deposition or inorganic precipitation. Calcareous sands are usually formed of a mixture of fragments of mollusk shell, echinoderm spines and skeletal material, coral, foraminifera, and algal platelets.

Channel: An open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water.

Circumneutral: Term applied to water with a pH of 5.5 to 7.4.

Cobbles: Rock fragments 7.6 cm (3 inches) to 25.4 cm (10 inches) in diameter.

Deciduous stand: A plant community where deciduous trees or shrubs represent the dominant spatial coverage of woody vegetation.

Dominant: The species making up the majority of spatial cover.

Dormant season: The non-growing portion of the year for vegetation.

Effectively drained: A condition where ground or surface water has been removed by artificial means to the point that an area no longer meets the definition of wetland.

Emergent hydrophytes: Erect, rooted, herbaceous angiosperms that may be temporarily to permanently flooded at the base but do not tolerate prolonged inundation of the entire plant.

Emergent mosses: Mosses occurring in wetlands, but generally not covered by water.

Entrenchment ratio: The entrenchment ratio is the ratio of the width of the flood prone area of a stream to its bankfull width (Rosgen, 1994). The greater the ratio, the more entrenched a stream is within its banks. An entrenched stream lacks access to a broad floodplain, usually due to chronic incision (termed stream degradation). Severely entrenched streams have abandoned their former floodplains. In such streams, the associated riparian flora and fauna are negatively impacted, stream velocity tends to increase, adjacent groundwater levels are reduced, and erosion of the bed and banks is more likely.

Eusaline: Inland water with excessive or supersaturated with inland salts.

Evergreen stand: A plant community where evergreen trees or shrubs represent the dominant spatial coverage of woody vegetation.

Exemplary Wetlands: Exemplary Wetlands are defined as wetlands that support globally rare, threatened, or endangered species or exceptionally high-quality natural communities, as documented in the WVDEP Exemplary Wetlands Database (WVDEP 2019) and the WVDNR Natural Heritage Database (WVDNR 2020). Exemplary Wetlands have a Site Biodiversity Rank of B1, B2, or B3 following criteria developed by WVDNR in cooperation with the national NatureServe network (WVDNR 2014). These criteria have also been in use since 2012 by the West Virginia Outdoor Heritage Conservation Fund established by the West Virginia Legislature (West Virginia Legislature 1985, WVOHCF 2019). Site Biodiversity Ranks for West Virginia wetlands may be summarized as:

Site Biodiversity Rank	Significance	Associated Threat Level	Number of WV Wetlands	Exemplary Wetlands
B1	Outstanding global biodiversity significance	Globally critically imperiled	6	yes

Site Biodiversity Rank	Significance	Associated Threat Level	Number of WV Wetlands	Exemplary Wetlands
B2	High global biodiversity significance	Globally imperiled	100	yes
B3	Global biodiversity significance	Globally vulnerable	129	yes
B4	Outstanding state biodiversity significance	Globally stable but critically imperiled at the state level	270	no
B5	State biodiversity significance	Globally stable but imperiled at the state level	518	no
B6	Local biodiversity significance	Globally stable but vulnerable at the state level	519	no
none	General habitat value	Presumed stable	41,582	no

Flat: Flats are unconsolidated sediments found along lakes, rivers, estuarine or marine near shore areas that may be irregularly shaped or elongate and continuous with the shore.

Floating plant: A non-anchored plant that floats freely in the water or on the surface.

Floating-leaved plant: A rooted, herbaceous hydrophyte with some leaves floating on the water surface; e.g., white water lily, floating-leaved pondweed. Plants such as yellow water lily sometimes have leaves raised above the surface are considered floating-leaved plants or emergents, depending on their growth habit at a particular site.

Floodplain: The area of low-lying ground adjacent to a river, formed mainly of river sediments and subject to flooding.

Flood prone area: The area adjacent to the stream that is innundated or saturated when the elevation of the water is at twice the maximum depth at bankfull stage (Rosgen 2002). The flood prone contour is estimated as twice the maximum bankfull depth, which is estimated as the average height of the bankfull contour above the thalweg. Thalweg and bankfull contours are determined at straight reaches within the assessment area (several determinations can be made and averaged, depending on the size of the assessment area). When the flood prone contour is above the bank top, the width of the flood prone area can be too great to measure in the field. In such cases, the lateral extent of flood prone area can be estimated on an orthophoto or topographic map.

Freshwater: Term applied to water with salinity less than 0.5 ppt dissolved salts.

Gravel: A mixture composed primarily of rock fragments 2 mm (0.08 inch) to 7.6 cm (3 inches) in diameter.

Ground Water: Water filling all the unblocked pores of an underlying material below the water table.

Growing season: The frost-free period or growing portion of the year. Growing season dates are determined through onsite observations of the following indicators of biological activity in a given year: (1) above-ground growth and development of vascular plants and/or (2) soil temperature. If onsite data gathering is not practical, growing season dates may be approximated by using WETS tables available from the NRCS National Water and Climate Center to determine the median dates of 28 ^{o}F (−2.2 ^{o}C) air temperatures in spring and fall based on long-term records gathered at the nearest appropriate National Weather Service meteorological station (Summers et al. 2017).

Haline: Term used to indicate presence of ocean salt.

Herbaceous: Vegetation modifier for plants with no persistent woody tissue (stems and branches) above ground. Most species die back at the end of the growing season.

Histic epipedon: Peat, mucky peat, or muck soil with at least 12-18% organic matter by weight and ≥ 20 cm (8 in) thick, but < 40 cm (16 in) thick, as a surface horizon. Aquic conditions or artificial drainage is required.

Histosol: Peat, mucky peat, or muck soil with at least 12-18% organic matter by weight and ≥ 40 cm (16 in) thick within the upper 80 cm (32 in) of soil profile; note that the 40 cm (16 in) of organic matter is cumulative and can occur anywhere in the top 80 cm (32 in), even in stratified layering; alternatively, organic soil material of any thickness resting on rock or on fragmental material having interstices filled with organic materials.

Histosols formed in thick accumulations of organic matter from decaying plant material. The organic-dominated layers are typically at least 40 cm thick and commonly much thicker. They have a minimum of 12 to 18% organic carbon, by weight (depending on clay content), and most have significantly more than this. Histosols do not exhibit the kinds of horizons common to mineral soils but rather have layers, or tiers, that vary in color, botanical origin of the organic material, amount of mixed-in mineral soil material, degree of decomposition, and other properties. Histosols generally have significantly lower bulk density and higher nutrient- and water-holding capacities than most mineral soils (NRCS 2015). Histosol suborders that pertain to WVWRAM are characterized by decomposition of organic material under wet conditions (but not permanently submerged) and include Fibrists (peat), Saprists (muck), and Hemists (mucky peat).

Hummock: A low mound, ridge, or microtopographic high. In wet areas, plants growing on hummocks may avoid some of the hydrologic stress of inundation or shallow water tables.

Hydric soil: Soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part.

Hydrophyte, **hydrophytic**: Any plant growing in water or on a substrate that is at least periodically deficient in oxygen because of excessive water content.

Invasive species. Non-native species that (1) are not native to, yet can spread into, natural ecosystems, and that also (2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes. WVDNR maintains the list of invasive plant species for West Virginia (WVDNR 2009).

Marl. An earthy, unconsolidated deposit consisting chiefly of calcium carbonate mixed with clay in approximately equal proportions, formed primarily under freshwater lacustrine conditions (USDA 2010).

Mesophyte, **mesophytic**: Any plant growing where moisture and aeration conditions lie between extremes. (Plants typically found in habitats with average moisture conditions, not usually dry or wet.)

Mesosaline: Term to characterize waters with salinity of 5 to 18 ppt land-derived salts.

Mineral soil: Soil composed of predominantly mineral rather than organic materials.

Mixosaline: Term to characterize waters with salinity of 0.5 to 30 ppt land-derived salts.

Mud: Wet soft earth composed predominantly of clay and silt--fine mineral sediments less than 0.074 mm (0.0029 in) in diameter.

Muck: Dark, finely divided, well decomposed organic soil material. Muck, or sapric soil material, is the most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Mucky modified mineral soil: Mucky modified mineral soil is intermediate in its organic carbon content between mineral soil and organic soil. Mucky modified mineral soil with 0 percent clay has between 5 and 12 percent organic carbon. Mucky modified mineral soil with 60 percent clay has between 11 and 18 percent organic carbon. Soils with an intermediate amount of clay have intermediate amounts of organic carbon.

Mucky peat: Also called "hemic soil material", mucky peat is organic soil material intermediate in degree of decomposition between the less decomposed fibric material (peat) and the more decomposed sapric material (muck).

Needle-leaved deciduous: Woody gymnosperms (trees or shrubs) with needle-shaped or scale-like leaves that are shed during the cold or dry season.

Needle-leaved evergreen: Woody gymnosperms with green, needle-shaped, or scale-like leaves that are retained by plants throughout the year.

Nonpersistent emergents: Emergent hydrophytes whose leaves and stems break down at the end of the growing season so that most aboveground portions of the plants are easily transported by currents, waves, or ice. The breakdown may result from normal decay or the physical force of strong waves or ice. At certain seasons of the year there are no visible traces of the plants above the surface of the water.

Oligosaline: Term to characterize water with salinity of 0.5 to 5.0 ppt land-derived salts.

Ordinary high water mark: The term ordinary high water mark means that line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas (33 CFR 328.3e).

Organic soil: Soil composed of predominantly organic rather than mineral material. The organic material is made up of plant and animal residue in the soil in various stages of decomposition.

Peat: Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. Peat, or fibric soil material, is the least decomposed of all organic soil material. Peat contains a large amount of well-preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Persistent emergent: Emergent hydrophytes that normally remain standing at least until the beginning of the next growing season.

pH value: PH is a numerical designation of acidity or alkalinity in water or soil.

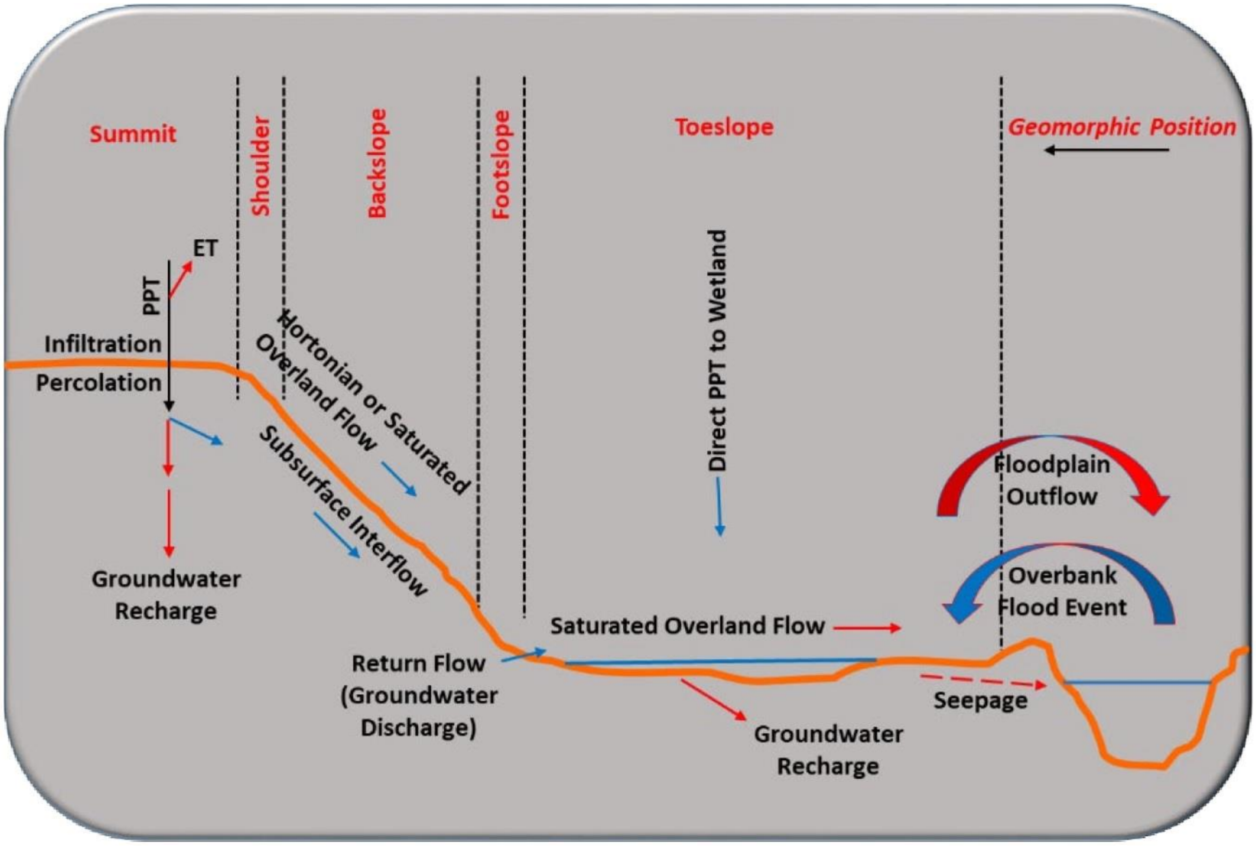
Pioneer plants: Herbaceous annual and seedling perennial plants that colonize areas as a first stage in secondary succession.

Photic zone: The extent (depth) that sunlight penetrates a water column.

Polysaline: Term to characterize water with salinity of 18 to 30 ppt due to land-derived salts.

Relatively permanently-flowing stream: Perennial stream with continuous flow in parts of its stream bed throughout the year during years of normal rainfall. The stream channel typically has a channel bed, banks, and ordinary high-water marks.

Return flow: Groundwater discharge at the base of a slope (see diagram).



Saline: General term for waters containing various dissolved salts. Restricted to description of inland waters where the ratios of the salts often vary; the term haline is applied to estuarine and marine waters where the salts are roughly in the same proportion as found in undiluted seawater.

Salinity: Salinity is the total amount of dissolved salt in grams in one kilogram of seawater, usually reported in parts per thousand.

Sand: Composed predominantly of coarse-grained mineral sediments with diameters larger than 0.074 mm (0.0029 in) and smaller than 2 mm (0.079 in).

Shrub: A woody plant that, at maturity, is usually less than 6 meters (20 feet) tall and generally exhibits several erect, spreading, or prostrate stems.

Rubble Stone: Rock fragments larger than 25 cm (10 inches) but less than 60 cm (24 inches).

Submergent plant: A vascular or nonvascular hydrophyte, either rooted or non-rooted, which lies entirely beneath the water surface, except for flowering parts in some species; e.g., wild celery or the stoneworts.

Terrigenous: Derived from or originating on the land (usually referring to sediments) as opposed to material or sediments produced in the ocean (marine) or because of biologic activity (biogenous).

Thalweg. A line connecting the lowest points along the length of a riverbed. It can be quite sinuous and wander within the channel. It is sometimes referred to as the "low flow channel".

Tree: A woody plant which at maturity is usually 6 meters (20 feet) or more in height and generally has a single trunk, unbranched for 1 meter (3.3 feet) or more above the ground, and a more or less definite crown.

Tussock. A plant growth form, generally in grasses or sedges, in which plants grow in tufts or clumps bound together by roots and elevated above the substrate.

Water table: The upper surface of a zone of saturation.

Wetland Unit. The contiguous, hydrologically connected areas of a wetland. Wetland Units are separated by upland habitat or by hydrologic breaks. Examples of hydrologic breaks include stream riffles, sudden changes in elevation, dams, perched culverts, different water levels on either side of a road, constrictions to flow, or any abrupt change in the water regime.

Woody plant: A seed plant (gymnosperm or angiosperm) that develops persistent, hard, fibrous tissues and includes species of trees and shrubs.

5.3 Lists of Sources, Variables, and Metrics

WVWRAM functional equations draw on a large body of GIS source layers plus field rapid assessment data to calculate 62 primary metrics plus 26 roll-up metrics. These data are the building blocks to calculate assessment scores for regulatory, land acquisition, planning, and monitoring purposes. The GIS source layers are listed in the table below. Detailed information on each layer created specifically for WVWRAM is available in the appendix. Information on layers drawn from secondary sources is available in the Secondary Sources QAPP.

GIS Source Layers

- 303D TMDL Impaired Streams
- Algal Lakes
- Algal Streams
- AML AMD Feb2016
- Composite Disturbed Land (composite)
- eBirdHotspots_20171011
- Estimated total loss from 100-yr flood
- Exemplary Wetlands
- First and Second Order Streams
- Floodplain layer (FEMA 100-yr composited with TNC Active River Area Model)
- Geology
- Hydrologic Protection Units (mining)
- Infrastructure Wetlands
- In-lieu fee sites and mitigation banks
- Karst and Calcareous Areas (composite)
- Monongahela National Forest management areas
- National Priorities List (Superfund) points & boundaries
- National Wetlands Inventory data & exports (open water, rivers, lakes)
- Natural Streams Preservation Act Watersheds
- National Hydrography Dataset (24k rivers, flowlines, stream codes)
- NPDES permits
- Pastures Not Hayfields
- Peatlands_20160228
- Public Land Boundaries
- Public surface water intakes
- Railways
- Recent timber harvests statewide (composite)
- Restored Wetlands
- Runoff-producing land cover (composite)
- Septic Failure Risk Soil Limitation
- Septic System Failure Risk
- Sewered Areas
- Site Biodiversity Rank Input (composite)
- Slope
- SSURGO data & exports (histosol, histic epipedon, organic 8cm, calcareous, karst, marl)
- Structures (SAMB)
- Swimming Areas
- Tiger (Urbanized Areas, All Roads)
- TMDL plan
- TNC Forest patches over 50 acres
- TNC Resilient and Connected Landscapes
- trails_Sep_27_2017
- Trout Streams
- Watershed Plans
- Watershed Wetland Size and Uniqueness
- Watersheds (12 digit HUC)
- WellPads_20160325
- Wetland Breeding Bird Block Occupancy
- Wide Rivers
- WV_Protected_Lands_2015_PUBLIC
- WVDNR Conservation Focus Areas
- WVDNR Landscape Integrity Index 2008
- WVDNR Watershed Biodiversity Rank HUC12_2014
- WVDNR_Fishing (high quality streams, trout streams, public fishing lakes, public access)
- WVDNR_property_boundary_201710 (with attributes)
- wvFloodHazardFeatures (FEMA Floodway)
- WVNHP Palustrine Plots

The 62 basic metrics are listed in the table below, including the metric name, a brief description of the metric, and where the metric is used within the functional formulas. Detailed information on each metric is included in the appendix.

Basic metrics

Basic Metric Name	Short Description	Input To
AquaAbund	Aquatic Area Abundance	LandHydro
BRank	Site Biodiversity Rank	HFunction
BRankHUC	Watershed Biodiversity Rank	LandEco
BufferContig	Contiguous 300m Wildlife Buffer	BufferLand
BufferLand	Buffer and Landscape Integrity	HOpportun
BufferPerim	Wetland Perimeter with Natural 10m Buffer	BufferLand
ConnectFL	Connectivity to Historic Floodplain	FAOpportun, HydroH
ConsFocus	WVDNR Conservation Focus Area	LandEco
Depressions	Surface Water Depressions	WQPotential
Discharges	Discharges to Wetland within 100m	WQOpportun
Dist50mFQ (in VegFQ)	Land Use Disturbance within 50m	VegFQ
Disturb50m	Land Use Disturbance within 50m	WQOpportun
DisturbWshd	Land Use Disturbance within Contributing Watershed	WQOpportun
EconRisk	Economically Value Flood Risk Area	FASociety
Fisheries	Economically Important Fisheries	WQUse
FloodArea	Area of Wetland within Floodplain	ConnectFL
FloodIn	Floodwaters Delivered to Wetland	FAOpportun
Floodplain (in FloodArea)	Location in Floodplain	multiple uses
Floodway	Location in FEMA Floodway	FASociety
Headwater	Headwater Location	WQPotential, FAPotential
Hinvest	Societal Investment in Habitat	HSociety
Histosol	Deep Organic Soil	VegFQ
HUC12WQ	Water Issues in HUC12 Watershed	WQSociety
HydIntact	Intactness of Hydrologic Regime	HydroH
HydSW (in HydroH)	Available Surface Water	HydroH
ImpairedIn	Impaired Waters Impacting Wetland	WQOpportun
ImpairedOut	Wetland Discharges to Impaired Waters	WQSociety
IrrEdge	Irregular Upland-Wetland Edge	ChemTime, Depressions
Karst	Karst or Calcareous Wetland	VegFQ, SoilOrgCalc
LandInteg	Landscape Integrity	VegFQ, BufferLand
LandPos	Landscape Position (Tiner)	Headwater
LowSlope	Low Slope	Depressions, FAPotential
MarlPEM	Emergent Wetland on Marl Deposits	VegFQ
Microtopo	Microtopographic Complexity	Depressions, Runoff
Organic near surface	Organic Soil Near Surface	ClayOrganic
OwnerAccess	Land Ownership and Accessibility	Huse
PublicUse	Public Use and Long-term Research	Huse
RoadRail	Roads and Railroads	WQOpportun
Runoff	Runoff Potential	FAPotential

Basic Metric Name	Short Description	Input To
Runoff50m	Lands Producing Runoff within 50m	FloodIn
RunoffWshd	Runoff within Contributing Watershed	FloodIn
SeasonPond	Seasonal Ponding	ChemTime, ClayOrganic, Runoff
Slope	Median Percent Slope	ChemTime
SlopeWshd	Median Percent Slope of Contributing Watershed	FloodIn
SoilIntact (in Disturb50m)	Lack of Soil Disturbance	SoilH
StreamEdge	Complexity of Wetland-Stream Interface	Runoff, ConnectFL
StrucPatch	Structural Patch Richness	SoilH
SWoutflow	Surface Water Outflow	WQPotential, FAPotential
VegAll	All Vegetation Types	VegFA
VegByLP	Vegetation Fringing Lakes or Ponds	VegWQ
VegFQ	Floristic Quality of Vegetation	VegH
VegHorInt (in Microtopo)	Horizontal Interspersion of Vegetation	VegH
VegPerUng	Persistent Ungrazed Vegetation	VegWQ, VegFA, VegFQ
VegVerStr	Vertical Structure of Vegetation	VegH
VegWoody	Woody Vegetation	VegWQ, VegFA, VegFQ
WaterSupply	Public Water Supply Intake	WQUse
WetldBird	Wetland Breeding Bird Occupancy	LandEco
WFlowPath	Water Flow Path (Tiner)	Swoutflow, SWOutflow2
WQPlan	TMDL or Water Quality Plan Exists	WQSociety
WshdPos	Watershed Position	LandHydro
WshdUniq	Watershed Wetland Size and Uniqueness	LandEco

The 26 roll-up metrics are derived from the basic metrics, and form the building blocks for functional scores. Roll-up metrics are listed in the table below, with detailed information on each metric included in the appendix.

Roll-up Metrics

Roll-up Metric Name	Short Description	Input To
ChemTime	Time and Space for Chemical Reactions to Occur	WQPotential
ClayOrganic	Organic Soil near Surface	WQPotential
FAFunction	Flood Attenuation Function	Function
FAOpportun	Flood Attenuation Landscape Opportunity	FAFunction
FAPotential	Flood Attenuation Instrinsic Potential	FAFunction
FASociety	Flood Attenuation Value to Society	FAFunction
Function	Comprehensive Roll-up of Functions	
HFuncNoBR	Habitat/Ecological Integrity Function without BRank	HFunction
HFunction	Habitat/Ecological Integrity Function	Function
HOpportun	Habitat/Ecological Integrity Landscape Opportunity	HFuncNoBR

Roll-up Metric Name	Short Description	Input To
HPotential	Habitat/Ecological Integrity Intrinsic Potential	HFuncNoBR, HFunction
HSociety	Habitat/Ecological Integrity Value to Society	HFuncNoBR
Huse	Public Use and Access to Habitats	HSociety
HydroH	Hydrology for Habitat/Ecological Integrity	HPotential
LandEco	Landscape Ecological Connectivity	HOpportun
LandHydro	Landscape Hydrologic Connectivity	HOpportun
SoilH	Soil and Structural Patches for Habitat/Ecological Integrity	HPotential
SoilOrgCalc	Deep Organic or Calcareous Soil	SoilH
VegFA	Vegetation for Flood Attenuation	FAPotential
VegH	Vegetation Structure and Quality	HPotential
VegWQ	Vegetation for Water Quality	WQPotential
WQFunction	Water Quality Function	Function
WQOpportun	Water Quality Landscape Opportunity	WQFunction
WQPotential	Water Quality Intrinsic Potential	WQFunction
WQSociety	Water Quality Value to Society	WQFunction
WQUse	Public Use of Water Quality	WQSociety

5.4 GIS Source Layer Update Schedule

GIS Source Layer Update Schedule

Layer Name	Next Update	Update schedule	Function	Location: default is M:\wr\WTRSHD_BRANCH_INTERNAL\WETLAND\
201710_WVDNR_property_boundary	2022	every 5 years	H	WETLAND\SourceAsReceived\201710_WVDNR_property_boundary.gdb\PropertyBoundaries_WVDNR_20171011
AlgalLakes	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb
AlgalStreams	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb
AMLAMDFeb2016	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb
Composite Floodplain layer with 100-yr FEMA and ARA	2022	every 5 years or when major FEMA updates are released	WQ, FA	WETLAND\SourceFunctionalAssessment\FloodplainData.gdb, FloodplainARAFEMA
Disturbed Land	2022	every 5 years or after NLCD data are released	WQ, H	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\DisturbedLand

Layer Name	Next Update	Update schedule	Function	Location: default is M:\wr\WTRSHD_BRANCH_INTERNAL\WETLAND\
DNR_Fishing (high quality streams, trout streams, public fishing lakes, public access)	2022	every 5 years	WQ	WETLAND\SourceAsReceived\DNR_Fishing\HighQualityStreamFisheriesWVDNR20150820.shp, TrStStreams.shp, PublicFishingLakesWVDNR20150820.shp, PublicFishingAccessSites_2017_10.shp
eBirdHotspots_20171011	2022	every 5 years	H	WETLAND\SourceFunctionalAssessment\HabitatData.gdb\eBirdHotspots_20171011
Estimated total loss from 100-yr flood	2022	every 5 years, or when new Hazus data are released	FA	WETLAND\SourceFunctionalAssessment\FloodplainData.gdb\TotalLossRP100
Exemplary Wetlands	2019	every 5 years, but an update should be done with new B-ranks as soon as time permits	H	WETLAND\WetlandsGeodatasets.gdb\ExemplaryOrBrankedWetlands31Mar2015
First and Second Order Streams	2022	every 5 years	all	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\FirstSecondOrderFlowlines
HUC Wetland Size and Uniqueness	2027	every 10 years or when NWI (National Wetlands Inventory) is updated	H	WETLAND\SourceFunctionalAssessment\Watershed.gdb\HUCWetlandSizeUniq
Index of Ecological Integrity U Mass	2019	whenever U Mass releases major updates; next one is due 2019	H	WETLAND\SourceFunctionalAssessment\HabitatData.gdb\IEIUMa2010v32
Infrastructure Wetlands	2022	every 5 years; this layer would benefit from site additions at any time	H	WETLAND\WetlandsGeodatasets.gdb\InfrastructureWetlands
In-lieu fee sites and mitigation banks	2022	every 5 years	H	WETLAND\WetlandsGeodatasets.gdb\ILF_banks
Karst (composite)	2027	every 10 years	H	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\KarstComposite
NPL_point & NPL_Bndry	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb
NWI exports (Open Water, Rivers, Lake, RiversLakes)	2022	every 5 years	all	WETLAND\SourceFunctionalAssessment\NWIExports.gdb
PasturesNotHayfields	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\PasturesNotHayfields
Peatlands_20160228	2022	every 5 years	H	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb
PublicLandBoundaries	2022	every 5 years	H	WETLAND\SourceAsReceived\Boundaries2017\

Layer Name	Next Update	Update schedule	Function	Location: default is M:\wr\WTRSHD_BRANCH_INTERNAL\WETLAND\
Recent timber harvests statewide	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\TimberHarvest
Restored Wetlands	2022	every 5 years; this layer would benefit from site additions at any time	H	WETLAND\WetlandsGeodatasets.gdb\RestoredWetlands
Runoff-producing land cover	2022	every 5 years or after NLCD data are released	FA	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\RunoffLand
Septic Failure Risk Soil Limitation	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\SepticFailureRiskStatsgo
Septic System Failure Risk	2022	every 5 years or after new SAMB or Tiger data are released	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\Septic
SeweredAreas	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\SeweredAreas
Site Biodiversity Rank Input	2022	Every 5 years, depending on availability of Natural Heritage staff expertise and access to sensitive WVDNR Natural Heritage data. If expertise is not available for updates, use the latest version as a static input.	H	WETLAND\SourceFunctionalAssessment\HabitatData.gdb\BRankInput
SSURGO exports (Histosol, Histic epipedon, Organic near surface, Calcareous, Karst, Marl)	2022	every 5 years	all	WETLAND\SourceFunctionalAssessment\SsurgoExports.gdb
Swimming Areas	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\SwimmingAreas2016
TMDL plan	2022	every 5 years or with major releases of new TMDL plans	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\TMDL
trails_Sep_27_2017	2022	every 5 years	H	WETLAND\SourceAsReceived\trails_Sep_27_2017_webmercator.shp
Watershed Plan	2022	every 5 years	WQ	WETLAND\SourceFunctionalAssessment\WaterQualityDatasets.gdb\WatershedPlan
WatershedBiodiversityRankHUC_WVDNR_2014	2022	every 5 years	H	WETLAND\SourceAsReceived\watershedBiodiversityRankHUC_WVDNR_12Nov2014_utm83.shp
WellPads_20160325	2022	every 5 years	WQ	WETLAND\WetlandsGeodatasets.gdb

Layer Name	Next Update	Update schedule	Function	Location: default is M:\wr\WTRSHD_BRANCH_INTERNAL\WETLAND\
Wetland Breeding Bird Block Occupancy	2038	every 20 years, with anticipated schedule of next Breeding Bird Atlas	H	WETLAND\SourceFunctionalAssessment\HabitatData.gdb\WetlandBirds_WetBirdColumnOnly
WV_Protected_Lands_2015_PUBLIC	2022	every 5 years	H	WETLAND\SourceAsReceived\WV_Protected_Lands_2015_PUBLIC\WV_Protected_Lands_2015_PUBLIC.shp
wvFloodHazardFeatures (FEMA Floodway)	2022	every 5 years	FA	WETLAND\SourceAsReceived\Floodplain\wvFloodHazardFeatures_WVGISTC_20130410\wvFloodHazardFeatures20130207.gdb\WV_Floodway_20130205_wgs84wmA
WVNHP Palustrine Plots	2022	every 5 years	WQ	WETLAND\WetlandsGeodatasets.gdb\PalustrinePlotsMarch2015
Source data accessed outside the wetland directory on the WVDEP server and regularly updated by others outside the wetland program.				
303D TMDL Impaired Streams	2024	check with Chris Dougherty (WAB) for updates and path change if needed every 5 years; geometry only (attributes not used); last update 4/8/2019; **SEND TO WV GIS TECH CENTER IN NEXT DATA TRANSFER**	WQ	M:\wr\WTRSHD_BRANCH\303D_TMDL_IMPAIRED\WV2016_ImpairedStreams_24KNHD.shp
All Roads (tiger line files)	2022	check for updates and path change if needed every 5 years	H	M:\basemap\tiger_2013\WV_Transportation_UTM.gdb\All_Roads, Interstates, Primary_Roads, Local_Roads, Other_Roads_and_Trails
Hydrogic Protection Units (mining)	2022	check for updates and path change if needed every 5 years	WQ	M:\mr\hpu.shp
NHD 24k rivers	2022	check for updates and path change if needed every 5 years	all	M:\LayerFiles\arcsde_backup.gdb\basemap_physical_non_replica\SDE_NHD_waterbodies_24k_rivers
NHD flowlines	2024	check for updates and path change if needed every 5 years; last update 4/5/2019; **SEND TO WV GIS TECH CENTER IN NEXT DATA TRANSFER**	all	M:\basemap\NHD_H_WV.gdb\Hydrography\NHDFlowline
NHD stream codes	2022	check for updates and path change if needed every 5 years	all	M:\LayerFiles\arcsde_backup.gdb\wr\NHD_with_stream_codes

Layer Name	Next Update	Update schedule	Function	Location: default is M:\wr\WTRSHD_BRANCH_INTERNAL\WETLAND\
NPDES	2022	check for updates and path change if needed every 5 years	WQ	M:\wr\owrnpdes_outlets.shp, M:\wr\owrnpdes_.shp
Public surface water intakes	2022	check for updates and path change if needed every 5 years	WQ	M:\environmental\CONFIDENTIAL-public_surface_water_intakes\CONFIDENTIAL-source_water_assessment_and_protection.gdb\ZPC_statewide_5hrabove, ZCC_statewide, Source_Water_Protection_Areas
Railway	2022	check for updates and path change if needed every 5 years	H	M:\LayerFiles\arcsde_backup.gdb\basemap_cultural_non_replica\SDE_railway_tiger
Slope	2022	check for updates and path change if needed every 5 years	WQ, FA	M:\dems\ned_slope_aspect.gdb\NED_3meter_meters_augmented_slope_pct_int
SSURGO soils	2022	check for updates and path change if needed every 5 years	all	M:\basemap\ssurgo\SSURGO.gdb\ssurgo_wv
Structures (SAMB)	2022	check for updates and path change if needed every 5 years	WQ	M:\basemap\WVSAMB\structures_SAMB_points_UTM83.shp
Trout Streams	2022	check with Chris Dougherty (WAB) for updates and path change if needed every 5 years (geometry only; attributes not used)	WQ	M:\wr\WTRSHD_BRANCH\TROUT\Trout_Streams.shp
Urbanized Areas (tiger)	2022	check for updates and path change if needed every 5 years	WQ	M:\LayerFiles\arcsde_backup.gdb\tiger2010\urbanized_areas
Watersheds (12 digit HUC)	2022	check for updates and path change if needed every 5 years	WQ, FA	M:\basemap\watersheds_12digit
Wide Rivers	2022	check for updates and path change if needed every 5 years	all	M:\basemap\national_hydrology_dataset\wb-rivers.shp
Some source data layers are essentially static.				
ActiveRiverArea	N/A	static; one-time product from TNC	all	WETLAND\SourceAsReceived directory
ConservationFocusAreas	N/A	static; one-time product from WVDNR	H	WETLAND\SourceAsReceived\HabitatFocusAreas\WV_Conservation_Focus_Areas_SWAP\WV_SWAP_CFA.gdb\conservation_focus_areas
Forest patches over 50 acres	N/A	static; one-time product from TNC	H	WETLAND\SourceAsReceived\forest_patches_over50acres_WVplus10mi.shp

Layer Name	Next Update	Update schedule	Function	Location: default is M:\wr\WTRSHD_BRANCH_INTERNAL\WETLAND\
Geology	N/A	check for path changes on WVDEP server; updates unlikely unless state geologic map is updated and served	WQ, H	M:\basemap\geology_shapefiles\type\geology-TYPE-limestone.shp & geology-TYPE-dolostone.shp
LandscapeIntegrityIndex_WVDNR_2008	N/A	It would be good to update this WVDNR layer but no updates are currently planned.	H	WETLAND\SourceAsReceived\landscapeIntegrityIndex_WVDNR_2008_utm83_img\landscapeIntegrityIndex_WVDNR_2008_utm83.img
MNF botanical areas	N/A	updates unlikely; from USFS	H	WETLAND\SourceAsReceived\USFS\botanical_areas_MNF.shp
NSPA_Natural Streams Preservation Act_Layer	N/A	no updates needed, except in the unlikely event that the legislation is updated	WQ, H	WETLAND\SourceFunctionalAssessment\Watershed.gdb\NatStrPreAct_HUC10
Resilient and Connected Landscapes	N/A	static; one-time product from TNC	H	WETLAND\SourceAsReceived\Resilient_and_Connected_Landscapes\Resilient_and_Connected_Data.gdb\Resilient_and_Connected

5.5 – 5.7 ArcGIS Procedures and Python 2.7 Code [separate document]

[Approximately 500 pages detailing 112 ArcGIS procedures for creating input layers and calculating metrics with their corresponding python code]