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**Glossary of Terms**

Assessment Model – An empirically based model that defines the relationship between ecosystem and landscape scale variables and functional capacity of a wetland. The model is developed and calibrated using reference wetlands from a characteristic regional wetland subclass.

Continuous Saturation – A condition in which all easily drained voids (pores) between soil particles in the root zone (i.e., within 12 inches from the soil surface) are filled with water (at conditions that are greater than atmospheric pressure) for a period of consecutive days.

Credit – A unit of measure (e.g., a functional or areal measure or other suitable metric) representing the accrual or attainment of aquatic functions at a compensatory mitigation site. The measure of aquatic functions is based on the resources restored, established, enhanced, or preserved (33 CFR 332.2; 40 CFR 230.922).

Creation – Creation (Establishment) means the manipulation of the physical, chemical, or biological characteristics present to develop a wetland at a site at which it did not previously exist (33 CFR 332.2; 40 CFR 230.92)

Debit – A unit of measure (e.g., a functional or areal measure or other suitable metric) representing the loss of aquatic functions at an impact or project site. The measure of aquatic functions is based on the resources impacted by the authorized activity (33 CFR 332.2; 40 CFR 230.92).

Diameter at Breast Height (DBH) – Tree diameter measured at 1.4 meters (55 inches) above the ground.

Enhancement – Enhancement means the manipulation of the physical, chemical, or biological characteristics of a wetland to increase or improve a specific aquatic resource function (33 CFR 332.2; 40 CFR 230.92).

Existing Condition – The functional capacity of an associated function-based parameter, or overall wetland area, prior to mitigation actions which is expressed as an index score between 0.00 and 1.00.

Function-Based Parameter – A metric that represents and supports the functional statement of each functional category (e.g. hydrologic processes, maintain plant and animal communities, and biogeochemical processes).

Functional Capacity – The degree to which an area of wetland performs a specific function (33 CFR 332.2; 40 CFR 230.92). Functional capacity is dictated by
characteristics of the wetland and the surrounding landscape, and interaction between
the two.

Functions – The physical, chemical, and biological processes that occur in ecosystems
(33 CFR 332.2; 40 CFR 230.92).

Index Score – A value that expresses whether the associated function-based
parameter, or overall wetland area is functioning compared to a reference condition. An
index score of 0.00 represents that there is no function present for the
parameter/wetland, while an index score of 1.00 represents that the parameter/wetland
is fully functional.

Invasive species – Generally, exotic species without natural controls that out-compete
native species.

Large Woody Debris – Large Woody Debris is defined as down and dead woody stems
that are greater than 7.62 centimeters (approximately 3 inches) in diameter that are no
longer attached to living plants, and minimum of 1 meter in length.

Measurement Method – Specific tools, equations, assessment methods, etc. that are
utilized to quantify a function-based parameter.

Net Functional Lift – The difference between the Proposed Condition and Existing
Condition for an overall wetland area, which represents a change in functional capacity.
The change in functional capacity is expressed as an index score of between 0.00 and
1.00.

Performance Standard – Observable or measurable physical (including hydrological),
chemical and/or biological criteria that are used to determine if a compensatory
mitigation project meets its objectives (33 CFR 332.2; 40 CFR 230.92). The GA HGM
uses performance standards that convert measured field data values (i.e. measurement
methods) to an index value of between 0.00 and 1.00.

Ponding – Standing water above ground surface.

Preservation – Preservation means the removal of a threat to or preventing the decline
of a wetland by an action in or near the wetland. This term includes activities commonly
associated with the protection and maintenance of wetlands through the implementation
of appropriate legal and physical mechanisms (33 CFR 332.2; 40 CFR 230.92).

Proposed Condition – The functional capacity of an associated function-based
parameter, or overall wetland area following the implementation of a mitigation action,
which is expressed as an index score of between 0.00 and 1.00.
Reference Standard – Sites that represent conditions exhibited by the subset of reference wetlands that correspond to the highest level of functioning of the ecosystem across a suite of functions (Brinson and Rheinhardt (1996)).

Restoration – Restoration means the manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former or degraded wetland (33 CFR 332.2; 40 CFR 230.92).

Soil Surface – The soil surface is the top of the mineral soil; or, for soils with an O horizon, the soil surface is the top of the part of the O horizon that is at least slightly decomposed. Fresh leaf or needle fall that has not undergone observable decomposition is excluded from soil and may be described separately.

Tree Stratum – The vegetation layer consisting of self-supporting woody plants greater than or equal to 2.54 centimeters (1 inch) in diameter at breast height.

Upland Buffer – Zone or area of uplands extending outwards from the wetland boundary that is comprised of natural vegetation. In the Southeastern U.S., upland buffer vegetation should typically include a mixed assemblage of native trees, saplings, shrubs, vines, and ground cover vegetation. For the purposes of this model, the assessment of upland buffer will extend perpendicularly to a width of 100 linear feet from the wetland mitigation treatment boundary.

Wetland Type – A hydrogeomorphic wetland class or combination of classes that can be identified based on landscape and ecosystem scale factors.
1. Purpose and Background

The purpose of this User Manual is to introduce the Georgia Freshwater Forested Wetland Hydrogeomorphic Workbook (GA HGM) and provide both background and instruction on its use to calculate functional lift and inform crediting for wetland mitigation projects undertaken in accordance with the Clean Water Act 404 Regulatory Program in Georgia, as administered by the U.S. Army Corp of Engineers, Savannah District. This manual includes descriptions of how to collect data and calculate field values for each measurement method in the wetland condition assessments and describes how those field values are converted to index values in the GA HGM. Few measurements are unique to the GA HGM, and procedures are often detailed in other instruction manuals or literature. Where appropriate, this document will reference other data collection manuals and make clear any differences in data collection or calculation methods needed for the GA HGM. This manual will refer to wetland restoration in accordance with the definition used in the Compensatory Mitigation for Losses of Aquatic Resources; Final Rule (33 CFR 332; 40 CFR 230).

This definition encompasses all activities aimed to improve wetland functions undertaken for compensatory mitigation or other purposes. Smith (1995) described ten (10) important wetland functions aggregated into three categories including: hydrologic processes, maintenance of plant and animal communities, and biogeochemical processes. This research in turn informed the development of, “A Regional Guidebook for Applying the Hydrogeomorphic Approach to Assessing Wetland Functions of Forested Wetlands in Alluvial Valleys of the Coastal Plain of the Southeastern United States” (Wilder et al., 2013), which jointly provide the structural underpinnings of the GA HGM. This User Manual and the GA HGM Worksheets assume the reader has a firm knowledge of wetland processes and HGM (Smith, 1995, and Wilder, 2013); therefore, it does not provide extensive definitions of wetland terms including those related to hydrologic and biogeochemical processes.

Collection and analysis of the watershed-scale and wetland assessment area-scale data necessary to evaluate before selecting a potential wetland restoration site, is not limited to only those variables and methods included in the GA HGM. The GA HGM incorporates only some of the necessary assessment metrics that all wetland mitigation projects will be expected to assess and document for the U.S. Army Corp of Engineers, Savannah District and the Georgia Interagency Review Team. Thus, the GA HGM should not serve as the sole method or protocol for designing a wetland mitigation project.

The GA HGM and supporting documents, including this User Manual, can be downloaded from the RIBITS website at: https://ribits.ops.usace.army.mil/ords/f?p=107:27:9415532409189::NO::P27_BUTTON_KEY:10
The following documents are available at the above website:
• Georgia Freshwater Forested Wetland Hydrogeomorphic Workbook (GA HGM) – Microsoft Excel Workbook.
• User Manual – This manual, describing the GA HGM and how to collect data and calculate inputs to use the GA HGM.

The GA HGM and accompanying documents will be updated periodically as additional data are gathered and reference standards and measurement methods are refined. The latest version of the GA HGM manuals and tool can be downloaded from the RIBITS website.

2. Getting Started with the GA HGM

The GA HGM is used to inform mitigation credit allocations for wetland mitigation projects undertaken pursuant to the Clean Water Act 404 Regulatory Program. The measurement methods and associated performance standards utilized in the GA HGM will not necessarily be the only field variables for which monitoring will be required, nor will they be the only field variables for which performance standards will be assigned.

The GA HGM uses three modified function-based parameters provided by Wilder (2013), along with two additional function-based parameters, which were developed by the Georgia Inter-agency Review Team (GA IRT): Continuous Saturation\(^1\), Wetland Vegetation Composition\(^2\), Wetland Vegetation Structure\(^2\), Large Woody Debris\(^2\), and Upland Buffer\(^1\). All GA HGM function-based parameters and measurement methods used to assess baseline conditions must also be used to assess post-implementation conditions throughout the monitoring period. The maximum possible Net Functional Lift for the GA HGM (i.e. 1.00) is based on all five function-based parameters, but these parameters are not equally weighted in the calculation of the Existing and Proposed Condition Scores.

The Existing Conditions and Proposed Conditions Worksheets in the GA HGM Microsoft Excel workbook provide the only interface for users to input data to support the calculation of credit generation for each wetland treatment area (as outlined in Savannah District’s most current version of the Monitoring Guidelines and Performance Standards that can be downloaded from RIBITS). Users enter data describing the existing and proposed (or monitored) conditions of the project wetland, and the worksheets quantify functional lift or loss. The worksheets contain six areas for data entry: Project Information and Existing (and Proposed) Conditions Summary, Continuous Saturation (\(V_{HYDRO}\)) Calculator, Forested Wetland Vegetative Composition (\(V_{COMP}\)) Calculator,

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\(^1\) These function-based parameters were developed by the Georgia IRT for use in mitigation assessment of freshwater forested wetlands throughout Georgia.

\(^2\) These function-based parameters were originally provided by Wilder (2013) and have been modified for use in mitigation assessment of freshwater forested wetlands throughout Georgia.
Forested Wetland Vegetative Structure ($V_{\text{STRUCT}}$) Calculator, Large Woody Debris ($V_{\text{LWD}}$) Calculator, and Upland Buffer ($V_{\text{UP}}$) Calculator. Cells that allow user input are shaded green and orange, and all other cells are locked.

2.1 Project Information and Existing Conditions Summary

The Project Information and Existing Conditions Summary section of the Existing Condition Worksheet consists of general site information and other project-specific information necessary to determine which performance standards are applied in the GA HGM for calculating index values. Some fields in this section include drop-down menus (orange cells) from which the user will select the appropriate value, while others require information to be manually entered (green cells). The values selected or entered into these fields establish links between the worksheet and the applicable performance standards. It is therefore important for the user to input accurate site information. All of the values entered within the Project Information and Existing Conditions Summary are transferred to the Project Information and Proposed Conditions Summary of the Proposed Conditions Worksheet, with the exception of the Mitigation Potential and the Date of Wetland Credit Assessment fields which require user input.

In addition to providing general site information and other project-specific information, this section also provides the Summary of Existing/Proposed Wetland Function. Further details regarding these summaries are provided in the Scoring Functional Lift section below (Section 2.3).

2.2 Existing and Proposed Condition Worksheet Field Values

Once the Project Information and Existing/Proposed Conditions Summary section has been completed, the user can input data into the field value cells (i.e., green and orange cells, and checkboxes) of the function-based parameter calculators (e.g, Continuous Saturation ($V_{\text{HYDRO}}$) Calculator).

The Existing Condition Worksheet field values are derived from measurements collected in the field during baseline condition assessment of each wetland treatment area on the project site before any mitigation work is undertaken. The Proposed Condition Worksheet field values are representative of estimated, but logical, field values informed by design studies/calculations, reports, and best available science. Proposed condition scores are estimated during the development of the mitigation plan, but then measured in the field during the post-implementation monitoring phase to validate the proposed condition scores.
2.3 Scoring Functional Lift

Scoring occurs automatically as field values are entered into the Existing Conditions or Proposed Conditions Worksheets. The functional parameter index score (yellow cell at the bottom of each calculator) will correspond to an index value ranging from 0.00 to 1.00 for that parameter, based on the performance curves. Parameter scores have been weighted to calculate Existing Condition Functional Score (ECFS) and Proposed Condition Functional Score (PCFS), as follows:

\[
ECFS \text{ and } PCFS = \frac{V_{HYDRO} + \left( \frac{V_{COMP} + V_{STRUCT}}{2} \right) + \left( \frac{V_{LWD} + V_{UP}}{2} \right)}{2}
\]

The Existing Conditions and Proposed Conditions Worksheets summarize the functional parameter index scoring at the top of the sheet, next to Project Information table in each respective worksheet. The summary tables for each of the respective worksheets are entitled “Summary of Existing Wetland Function” and “Summary of Proposed Wetland Function”.

The Summary of Existing Wetland Function table illustrates the index scores for each of the function-based parameters from the existing condition assessment along with a summarized ECFS for the wetland. The Summary of Proposed Wetland Function table provides index scores for each of the function-based parameters from the proposed condition assessment along with a summarized PCFS, the Net Functional Lift Score (\(\Delta\)) occurring within the wetland, and incorporates the area (Acres) of the wetland to calculate the Total Wetland Credits Generated. The change in functional condition of the project wetland is the difference between the PCFS and ECFS.

\[
\Delta = (PCFS - ECFS) \times \text{Acres}
\]

If the Net Functional Lift Score is a positive number, then functional lift is occurring within the wetland. If the Net Function Lift Score is a negative number, then functional loss is occurring within the wetland. If a negative Net Functional Lift Score occurs, replacement compensatory mitigation will be required to compensate for the loss of functional capacity to the wetland.

3. Measurement Method Field Values

Data collection and analysis procedures for existing condition assessments and post-implementation monitoring events should follow the procedures outlined in this section of the User Manual. During the project design and review period, the proposed condition
assessment worksheet is filled out with data from the project design and best professional judgement for the anticipated project outcome. Subsequent to project implementation, actual measured field values collected during each monitoring event are entered into the same worksheet for each wetland treatment area and submitted as part all annual monitoring reports.

The field methods used to collect and calculate measured field values for each function-based parameter are summarized below. No new field sampling protocols have been developed exclusively for the GA HGM, and most parameters should be familiar to practitioners and project sponsors.

3.1 Continuous Saturation ($V_{HYDRO}$)

The GA HGM currently contains one function-based parameter to describe hydrologic processes (e.g., water storage) in wetlands: Continuous Saturation. This parameter is documented through the direct measurement of the shallow groundwater table and aboveground inundation ("ponding") via the installation and maintenance of groundwater monitoring wells as outlined in the Technical Standard for Water-Table Monitoring of Potential Wetland Sites (US Army Corps of Engineers, 2005).

Target continuous soil saturation ranges (i.e. percent of growing season) have been identified for each hydric soil series in Georgia based on soil drainage class, soil taxonomy, soil features described in the USDA NRCS Official Soil Series Descriptions, and the Water Features Tables associated with each mapped series (tables are included within the HGM Workbook). The target continuous soil saturation period for any given site will be based on the field-verified soil series, growing season length and the target soil saturation range for that verified soil series. The GA HGM includes only those soil series with a minimum continuous saturation of 10 percent of the growing season. Figure 1 illustrates how this information is utilized to inform wetland hydrologic performance standards.
Figure 1. Example performance curve for wetland hydrology based on a target soil saturation range for Roanoke series.

Figure 1 has been developed based on a subindex graph, in which the y-axis is a 0.00 to 1.00 index range indicative of the degree to which the variable is performing as it should. In this case, the function-based parameter is continuous saturation within 12 inches of the soil surface during the growing season.

In the example illustrated above, our mitigation wetland is located in Coweta County, Georgia and has been field verified as Roanoke soil. The closest NOAA Weather Station (Station USC00096335, Newnan 7 WNW) indicates that the mitigation site has a 233-day growing season, and the USDA NRCS official soil series description indicates that Roanoke soil is a poorly drained thermic fluvaquentic endoaquept. The target saturation range for a Roanoke soil is greater than or equal to 10% of the growing season, based on the soils worksheets in the HGM workbook, thus the target saturation range on the site is greater than or equal to 23 days during normal climatic conditions.

If water table monitoring data indicate that the number of consecutive days that soil saturation is within 12 inches of the surface is within the target saturation range during normal climatic conditions, the index score is 1.00. As duration moves towards the drier side of the scale (i.e. to the left on the x-axis), the index value declines until saturation is less than the 14-day threshold, which is the technical standard for minimum wetland hydrology. If continuous saturation during normal climatic conditions is less than 14 days, the index value defaults to zero.
The GA HGM has incorporated an additional component to this parameter based on the duration of ponding to evaluate excessive hydrology that is detrimental to the target forested wetland community type. If continuous ponding of a wetland area exceeds the USDA NRCS Ponding Duration Class for the given soil type (as provided in the soils worksheets incorporated in the HGM workbook), then the Continuous Saturation ($V_{HYDRO}$) Calculator will initiate an override function to reduce the continuous saturation performance curve to a $V_{HYDRO}$ index score of no greater than 0.10. This index value does not drop to zero because the site remains a wetland, but it is a wetland with excessive hydrology. Table 1 provides the different ponding duration classes for hydric soils in Georgia.

Table 1. USDA NRCS Ponding Classes for Hydric Soils in Georgia

<table>
<thead>
<tr>
<th>USDA NRCS Ponding Duration Classes</th>
<th>Ponding Duration Range</th>
<th>HGM Ponding Days (Maximum Threshold)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n/a</td>
<td>&lt; 2 days</td>
<td>1 day</td>
</tr>
<tr>
<td>Very Brief</td>
<td>&lt; 2 days</td>
<td>1 day</td>
</tr>
<tr>
<td>n/a to Brief</td>
<td>&lt; 2 days to &lt; 7 days</td>
<td>6 days</td>
</tr>
<tr>
<td>Brief</td>
<td>2 days to &lt; 7 days</td>
<td>6 days</td>
</tr>
<tr>
<td>Brief to Long</td>
<td>7 days to &lt; 30 days</td>
<td>29 days</td>
</tr>
<tr>
<td>Long</td>
<td>7 days to &lt; 30 days</td>
<td>29 days</td>
</tr>
<tr>
<td>n/a (Long)</td>
<td>&lt; 2 days to &lt; 30 days</td>
<td>29 days</td>
</tr>
<tr>
<td>n/a to Long</td>
<td>&lt; 2 days to &lt; 30 days</td>
<td>29 days</td>
</tr>
<tr>
<td>Brief to Very Long</td>
<td>2 days to ≥ 30 days</td>
<td>&gt;=30 days</td>
</tr>
<tr>
<td>Long to Very Long</td>
<td>7 days to ≥ 30 days</td>
<td>&gt;=30 days</td>
</tr>
<tr>
<td>n/a to Very Long</td>
<td>&lt; 2 days to ≥ 30 days</td>
<td>&gt;=30 days</td>
</tr>
<tr>
<td>Very Long</td>
<td>≥ 30 days</td>
<td>&gt;=30 days</td>
</tr>
</tbody>
</table>

In the same example as illustrated above, 23 days is the start of target continuous saturation range (i.e., greater than or equal to 23 days) for a Roanoke soil in the Newnan area. Roanoke soils are characterized as having a Ponding Duration Class of “n/a”, which corresponds to fewer than 2 days of continuous ponding. In a scenario in which our mitigation wetland exhibits a continuous saturation of 23 days, but also has continuous ponding of 1 day, the $V_{HYDRO}$ index score achieved is 1.00. In a second scenario, if our mitigation wetland exhibits a continuous saturation of 23 days, but also has continuous ponding of 2 days, the $V_{HYDRO}$ index score is reduced from 1.00 to 0.10. In a third scenario, if our mitigation wetland exhibits a continuous saturation of 21 days, but also have a continuous ponding of 2 days, the $V_{HYDRO}$ index score achieved is 0.10.
3.2 Wetland Vegetation Composition ($V_{\text{COMP}}$)

Wetland Vegetation Composition is the first of two function-based parameters describing the maintenance of plant and animal communities within the GA HGM.

The wetland vegetation composition parameter reflects the “floristic quality” of the community based on concepts in Andreas and Lichvar (1995), and Smith and Klimas (2002). The focus of this parameter is on the species that dominate the tree stratum. In reference standard freshwater forested wetlands in Georgia, the tallest stratum is composed of native canopy trees. In wetlands that have undergone recent and severe natural or anthropogenic disturbance, the tallest stratum may be dominated by herbaceous species or shrubs and tree saplings. Implicit in this approach is the assumption that the current composition of the tallest canopy layer is a reliable indicator of overall community functional capacity (i.e. dominant native tree species ($\geq$2.54 centimeters) indicate appropriate future canopy composition). Most reference standard wetlands within the reference domain are relatively diverse with several dominant species present. Dominant species are determined using the Dominance Ratio. (Wakeley, 1997). Note that the tree stratum includes trees greater than or equal to 2.54 centimeters (1-inch) diameter at breast height.

Dominant species are classified into three groups reflecting presumed floristic quality. Group 1 consists of species that are typically canopy dominants in undisturbed forested wetlands. Group 2 consists of other native plant species that are not typical canopy dominants of mature, undisturbed forests, but are often characteristic of wetlands that have been disturbed or altered. Group 3 consists of nonnative (exotic) species or native invasive species of all strata (i.e., canopy/tree, sapling/shrub, woody vine, and herbaceous) that are usually found on low functioning sites.

In reference standard forested wetlands in the coastal plain, dominant vegetative composition includes species from Groups 1 and 2, and the number of dominants are 4 or greater in the Slope and Riverine wetland types. Two dominants are present in the reference standard Depressional wetlands in the coastal plain. If either composition or diversity diverges from those conditions, functional capacity is assumed to decline.

The procedure used to calculate an index score for $V_{\text{COMP}}$ is described below and incorporates both quantity and quality of dominant species:

1. If total tree cover is greater than 20 percent, then $V_{\text{COMP}}$ is determined for the tree stratum. If tree cover is less than 20 percent, then $V_{\text{COMP}}$ cannot be calculated and the $V_{\text{COMP}}$ Index Score will default to 0.00.

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3 These sections have been adapted from Wilder (2013).
2. Use the “Dominance Ratio” to identify the dominant species in the tree stratum. For sites containing a tree stratum, only consider trees greater than or equal to 2.54 centimeters (1-inch) diameter at breast height.

3. In the GA HGM Worksheet, place a check beside each dominant species that appears in either Group 1 or 2 for the appropriate wetland type. If a dominant species is not listed but is a species native to the reference domain, it can be added to Group 1 or 2 using the blanks provided. For any dominant species added to Group 1, data from a regionally appropriate wetland reference community must be required as supporting documentation. For exotic and invasive species in the reference domain (Group 3), check all species documented within the vegetation plot without regard to dominance or stratum. Other exotic and invasive species can be added using the blanks provided and should be assigned as Group 3 species.

3.3 Wetland Vegetation Structure ($V_{STRUCT}$)

Wetland Vegetation Structure is the second of two function-based parameters describing the maintenance of plant and animal communities within the GA HGM.

This parameter assesses the tree stratum. The tree stratum is defined as the median diameter at breast height (measured at 1.4 meters (55 inches) above the ground) for the fifteen (15) largest trees in each 0.04-hectare (0.1-acre) plot. Tree diameter is a common measure of dominance in forest ecology that expresses the relative maturity of a forest stand (Bonham, 1989; Spurr and Barnes, 1981; Tritton and Hornbeck, 1982; Whittaker, 1975; Whittaker et al., 1974). Tree basal area, measured as the cross-sectional area of tree stems per unit area (e.g., meters$^2$/hectare) is also a common measure of abundance, dominance, and vegetative functional capacity that has been shown to be proportional to tree biomass (Bonham, 1989; Spurr and Barnes, 1981; Tritton and Hornbeck, 1982; Whittaker, 1975; Whittaker et al., 1974). In Riverine reference wetlands in the coastal plain, the average diameter at breast height of the three largest trees of each plot in a stand ranged from 0.0 centimeters on sites where all trees had been removed to 70 centimeters (27.6 inches) in mature forest stands (Wilder, 2013). The mean diameter at breast height of the three largest trees of each plot at reference standard Slope wetlands in the coastal plain were greater than 35 centimeters (14 inches) (Wilder, 2013). Tree size was generally smaller than at the reference standard wetlands in the Riverine wetland type, where the mean was greater than 40 centimeters (15.7 inches) (Wilder, 2013). However, as vegetative development and performance of wetland mitigation sites are constrained by time (i.e., generally 10 years of annual monitoring), an index value of 1.00 is assigned for all wetland types with a minimum diameter at breast height is ≥7.62 centimeters (3-inches) for 0.04-hectare (0.1-acre) plot. The relationship between tree diameter and functional capacity is
assumed to be linear; consequently, the index increases linearly from 0.10 to 1.0. Figure 2 provides the performance curve equation for the Wetland Vegetation Structure (V\textsubscript{STRUCT}) Calculator.

Figure 2. Performance curve for wetland vegetative structure based on median diameter at breast height of the 15 largest trees per vegetation plot.

![Median DBH for 15 Largest Trees (in cm)](image)

See the corresponding measurement methodology for tree stratum below:

1. Measure the diameter at breast height of the 15 largest trees within each 0.04-hectare (0.1 acre) plot.

2. Only record the trees that are greater than or equal to 2.54 centimeters (1-inch) diameter at breast height in the plot, even if there are fewer than 15 trees present.

3.4 **Large Woody Debris (V\textsubscript{LWD})\textsuperscript{3}**

The GA HGM currently contains two function-based parameters to describe biogeochemical processes, the first of which is the assessment of Large Woody Debris.

Large woody debris is defined as downed and dead woody stems that are greater than 7.62 centimeters (3-inches) in diameter that are no longer attached to living plants. Dead wood is an important component of wildlife habitat and nutrient cycling of forests. Dead wood may be present in snags, small twigs, roots, stumps, and limbs or logs. Some important dead wood habitat features, such as snags, are low in density in a
A healthy forest. An adequate sample design necessary to accurately estimate low density features such as snags in a forest is often outside the scope of a rapid assessment. Large woody debris as defined here matches that of “coarse woody debris” in the Forest Inventory Analysis (FIA), the volume of which may be estimated by a rapid assessment using methods based on those of the FIA (US Department of Agriculture, 2011; Waddell, 2002; Woodall and Monleon, 2008). Volume of large woody debris per hectare is used to quantify this parameter. In reference wetlands across the Coastal Plain, the volume of woody debris ranged from 0 to 700 meters³/hectare (Wilder, 2013). The amount of woody debris in reference standard wetlands in the coastal plain varied by wetland type and were within the range of 20 to 60 meters³/hectare (Wilder, 2013). The decrease in the parameter index is based on the assumption that lower volumes of woody debris indicate an inadequate reservoir of nutrients (and a stand at an early stage of maturity) and the inability to maintain characteristic nutrient cycling over the long term (Wilder, 2013). Above amounts characteristic of reference standard, the parameter index decreases linearly to 0.50 (Wilder, 2013). This correlation is based on the assumption that increasingly higher volumes of woody debris indicate that high levels of nutrients are stockpiled in long-term storage and are thus unavailable for primary production in the short term. This condition can occur in instances of catastrophic wind damage, such as hurricanes or following logging operations. It can also occur if a hydrologic obstruction increases inundation depth or duration to the point that trees experience dieback or death. The procedure used to calculate an index value for $V_{LWD}$ is described below:

1. Establish two 15.24 meter (50-foot) transects perpendicular to one other, one bearing north and one bearing east, originating at the center point of the 0.04-hectare plot. The transect bearings may also be established randomly. For the first transect, note the seconds on a watch and multiply by six. The product is the first transect’s bearing. Add 90 degrees to the first transect bearing to obtain the second transect bearing. For example, if the seconds are 32, the bearing of the first transect is 192 (32 x 6) and the bearing of the second transect is 282 (192+90).

2. Measure and record the diameter of all non-living stems⁴ greater than or equal to 7.62 centimeters (3 inches) in diameter that intersect the plane along the entire length of the 15.24 meter transect. Record the diameter of each stem (in centimeters) from each transect in the spaces provided on the $V_{LWD}$ of the GA HGM Worksheet.

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⁴ Log, or stem, diameter refers to the diameter at the point of intersection with the transect line. Leaning dead stems that intersect the sampling plane are sampled. Dead trees and shrubs still supported by their roots are not sampled. Rooted stumps are not sampled, but uprooted stumps are sampled. Down stems that are decomposed to the point where they no longer maintain their shape but spread out on the ground are not sampled.
3.5 Upland Buffer ($V_{UP}$)\textsuperscript{5}

Upland Buffer is the second of two function-based parameters describing biogeochemical processes in the GA HGM.

The functional importance of upland buffers in improving quality of surface water and groundwater has been well documented in the scientific literature. Upland buffers play an important role in improving water quality, as they trap and transform pollutants such as sediments, nutrients, pathogens, and pesticides in surface water and groundwater (City of Boulder, 2007; Pearsell and Mulamoottil, 1996; Correll, 1996). Upland buffer vegetation also slows surface runoff, causing larger sediment particles and pollutants to settle out (City of Boulder, 2007; Lee et al., 2003; Correll, 1996). The filtering function of upland buffers is improved as both the density of vegetation and width of upland buffer increase. Further removal and/or transformation of pollutants can occur through groundwater filtration, uptake by vegetation, biogeochemical processes, and microbial processes in the upper soil profile (City of Boulder, 2007; Lee et al., 2003; Correll, 1996; USEPA, 2005). Also, unsaturated buffer soils are more effective at reducing bacterial concentrations than saturated wetland soils (City of Boulder, 2007; Pearsell and Mulamoottil et al., 1996). Excessive levels of nitrate can be reduced as groundwater contacts roots of upland buffer vegetation and denitrifying microbes, which can in turn reduce nuisance aquatic vegetation (City of Boulder, 2007; Lee et al., 2003). Mature vegetated upland buffers also minimize the detrimental effects of runoff, which can transport pesticides, fertilizers, and other pollutants to surface waterbodies (City of Boulder, 2007; Miltner et al., 2004; Center for Watershed Protection, 1995; Meyer et al., 2005).

The width of the upland buffer and the percent of the upland buffer protecting the wetland perimeter are assessed in this parameter. Upland buffer will only be considered present if a restrictive covenant and conservation easement are recorded on the entire buffer area. If the upland buffer is not protected by these real property protections, the upland buffer will be considered absent. The maximum upland buffer width is 100 linear feet, measured perpendicular from the treatment boundary. If a given segment of upland buffer is 100 linear feet in width, an index value of 1.00 is assigned. If the entire wetland is protected by 100 linear foot wide upland buffer, then a $V_{UP}$ index score of 1.00 is realized. If there are multiple buffer segments of varying widths, each buffer segment receives a weighted score based on the percentage of its length compared to the total length of the wetland perimeter. Upland buffer can be comprised of both uplands and/or wetlands. Figure 3 provides the performance curve for the width of an upland buffer segment in the Upland Buffer ($V_{UP}$) Calculator.

\textsuperscript{5} The supporting documentation on the functional importance of upland buffers was adapted from “Wetland and Stream Buffers: A Review of the Science and Regulatory Approaches to Protection.” (City of Boulder, 2007).
Figure 3. Performance curve for the width of an upland buffer segment.

4. References


