Supplemental Remedial Investigation Work Plan

Phase I Marsh Reconnaissance

Kerr-McGee Chemical Corp.—Navassa Superfund Site
Navassa, North Carolina
EPA ID #NCD980557805

Prepared for

Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust

Prepared by

integral engineering p.c.

4704 Harlan Street
Suite 690
Denver, CO 80012

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ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CPT	cone penetration test
CTD	conductivity, temperature, and depth
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
GPS	global positioning system
HASP	health and safety plan
HAZWOPER	hazardous waste operations and emergency response
Integral	Integral Engineering, P.C.
LiDAR	light detection and ranging
LSASD	Laboratory Services and Applied Science Division
Multistate Trust	Greenfield Environmental Multistate Trust LLC
NAPL	nonaqueous-phase liquid
NAVD88	North American Vertical Datum of 1988
NCDEQ	North Carolina Department of Environmental Quality
NC WAM	North Carolina Wetland Assessment Method
OU	operable unit
PAH	polyaromatic hydrocarbon
PCP	pentachlorophenol
ROST	Rapid Optical Screen Tool
Site	Kerr-McGee Chemical Corp.—Navassa Superfund site
SRI	Supplemental Remedial Investigation
SVOC	semivolatile organic compound
TarGOST	Tar-specific Green Optical Screening Tool
VOC	volatile organic compound

1 INTRODUCTION

Additional investigation is needed for Operable Units 3, 4, and 5 (OU3, OU4, and OU5) of the Kerr-McGee Chemical Corp.—Navassa Superfund site ("the Site"; U.S. Environmental Protection Agency [EPA] ID# NCD980557805) (Figure 1) to supplement the existing data set collected as part of the remedial investigation and other investigations completed at the Site. This additional investigation work will be completed in phases. This Supplemental Remedial Investigation (SRI) Work Plan – Phase I Marsh Reconnaissance (hereafter referred to as the "Work Plan"), is being submitted by Integral Engineering, P.C. (Integral) on behalf of Greenfield Environmental Multistate Trust LLC, not individually but solely in its representative capacity as Trustee of the Multistate Environmental Response Trust (the Multistate Trust).

This Work Plan is focused on the investigation of OU3 (the "Southern Marsh"), and addresses SRI elements that involve longer-term monitoring (e.g., monitoring over a 6 to 12 month period) or that require execution in the fall while the marsh vegetation is still active. The scope of work for the SRI Phase I investigation includes the following tasks:

- Identify and document areas within OU3 with potential nonaqueous-phase liquid (NAPL) in the shallow subsurface of the marsh.
- Verify the presence, and quantify the extent and composition of the floating marsh in OU3.
- Document the current marsh characteristics, including vegetation and habitat type, and the wetland functions and values.
- Install marker horizons to support long-term monitoring of sediment accumulation rates in OU3.
- Install piezometers and surface water standpipes equipped with water level and conductivity meters to support evaluation of groundwater and surface water interaction in the OU3 marsh.

1.1 SITE OVERVIEW

The Site was formerly owned by the Kerr-McGee Chemical Corporation and was operated as a creosote-based wood treating facility from 1936 to 1974. The Site has been divided into five OUs based on previous land uses and observed impacts (Figure 2).

Since the 1980s, multiple parties have performed investigations at the Site related to Site inspections, Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)-related remedial investigation activities, and human health and ecological risk assessments. Past investigation activities at the Site have included, but are not limited to, soil borings, soil sampling, cone penetration test (CPT) / Rapid Optical Screen Tool (ROST) investigations, Tar-specific Green Optical Screening Tool (TarGOST) investigations, monitoring well/piezometer installations, groundwater sampling, sediment sampling, and porewater sampling. Routine groundwater monitoring is conducted at the Site on a semiannual basis. Summaries of previous remedial investigation activities and findings at the Site through 2016 are provided in the Final Remedial Investigation Report (EarthCon 2019b).

Investigation activities to date indicate the contaminant source areas at the Site are related to the wood treating process in areas formerly associated with the process units, storage tanks, and surface water impoundments, primarily in OU4 (the "Pond and Process Areas"), as represented by concentrations of volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), including polycyclic aromatic hydrocarbons (PAHs) and pentachlorophenol (PCP) (EarthCon 2019b). Groundwater monitoring at the Site indicates current VOC and SVOC impacts in the Surficial Aquifer beneath the southern portion of OU4. VOCs and SVOCs are also present in groundwater in the deeper Peedee Aquifer, although to a more limited extent in the vicinity of the former wastewater and evaporation pond areas. Impacted groundwater at the Site has been designated as OU5.

OU3 is a 33-acre area of intertidal marsh located in the southeastern portion of the Site. Evidence of Site-related impacts have been observed in OU3, including hydrocarbon sheens and odors. Elevated concentrations of VOCs and SVOCs were confirmed in near-surface sediment and porewater collected from the marsh (EarthCon 2019a; Integral et al. 2022) (Figure 3). The source of these chemicals to the marsh is believed to have primarily been due to overland discharges from OU4 (e.g., overtopping of the wastewater ponds) during active Site operations. In addition, EPA has reported evidence of a former pipe east of the wastewater ponds that may have carried process fluids to the marsh surface.

1.2 SOUTHERN MARSH (OU3)

The Southern Marsh is located within the Cape Fear River Estuary and supports a range of salt-tolerant plant species. Marsh areas throughout the lower portion of the Cape Fear River Estuary were used for rice production beginning in the late eighteenth century (Eagles Island Coalition Conservation Planning Committee 2015). Remnants of the linear canals used to take advantage of tidal flow from Sturgeon Creek to support rice farming are present in OU3.

Based on light detection and ranging (LiDAR) data collected in 2015, the mean elevation of the Southern Marsh is 1.47 ft North American Vertical Datum of 1988 (NAVD 88). The marsh is underlain by a peat deposit consisting of decayed organic matter and accumulated fine-grained inorganic sediment. Observations from soil borings completed in the marsh show that the peat layer thickens to the south of the Pond Area in OU4, reaching a maximum thickness of 15–20 ft about 200 ft south of the northern edge of the Southern Marsh.

Previous field observations have noted an approximate 1.4-acre area of the marsh south of the wastewater ponds (Figure 3) where the marsh surface exhibited vertical movement when walked upon—indicating the potential presence of floating and/or quaking marsh conditions in the area. The floating marsh was generally observed at the northern edge of the marsh, as the marsh transitions to upland. Floating marsh consists of a layer of plants, their roots, and peat soils that is not anchored to the underlying soils (Sasser et al. 1996; Thomas 2008). As a result, floating marshes may float on top of the changing water levels and thus not appear to be inundated during high tides. In contrast, typical, non-floating (or "stationary") marshes in tidal and brackish settings do not exhibit vertical movement (even as ample pressure is applied) and experience substantial inundation during high tides. The vertical movement of floating marshes has been shown to exist on a spectrum from free-floating consistently to intermittently (Swarzenski et al. 1991). Restricted floating marsh may exhibit a quaking or trembling sensation when pressure is applied, but does not sink into the water column (Ingram 1983; Nuttle and Hemmond 1988; Holm et al. 2000; Waller 2021). Where floating marsh is present, there is typically water or oozing soil below the marsh mat. The thickness of the marsh mat, the amount of water, and the amount of oozing soil can manifest as a quaking or trembling surface.

Floating marsh is relatively common in the southeastern United States and is frequently observed in areas of low energy, high subsidence, and peat formation (Izdepski et al. 2009). It is not uncommon for conditions such as those observed in OU3 to occur, where patches of floating marsh are present within a broader expanse of stationary marsh and where, on the surface, the floating marsh does not look different from the adjacent stationary marsh (Thomas 2008).

2 DATA QUALITY OBJECTIVES

The Multistate Trust, in collaboration with EPA and the North Carolina Department of Environmental Quality (NCDEQ), has developed data quality objectives (DQOs) for the SRI based on the data collected to date at the Site and data needs identified to support risk management decisions for OU3, OU4, and OU5. This section presents the DQOs associated with the Phase I investigation to be completed under this Work Plan. The DQOs were developed following EPA's Guidance on Systematic Planning Using the Data Quality Objectives Process (USEPA 2006), which describes a seven-step process for developing DQOs. Table 1 provides a summary of the seven-step process for each of the three DQOs identified for this investigation. The DQOs are summarized below.

2.1 DATA QUALITY OBJECTIVE 1: DELINEATE THE AREAS WITHIN OU3 WITH NAPL IN THE SHALLOW SUBSURFACE SEDIMENT

Elevated concentrations of creosote-related SVOCs have been detected in near-surface sediment and porewater collected in OU3 (Integral et al. 2022). These chemicals are believed to be related to overland releases to the Southern Marsh during past facility operations. During past investigations and site visits, personnel have noted petroleum odors and observed sheen when investigating the marsh. These observations suggest that residual NAPL associated with past facility releases may be present in near-surface sediment in localized areas of OU3. These observations have been opportunistic and were not formally documented or mapped. A systematic evaluation is needed to document and map observations of sheen and/or significant odors, and to assess whether these observations are biogenic or petroleum-based (and thus potentially related to past creosote releases from the former facility). Further, at any locations where evidence of potential petroleum-based NAPL is observed, investigation is needed to confirm the presence of residual NAPL that may represent an ongoing source of chemicals release to sediment, sediment porewater, and surface water in OU3.

To meet DQO 1, sediment probing will be completed in a systematic manner to map evidence of potential NAPL in near-surface sediment across an approximate 4.6-acre area of the Southern Marsh. The probing investigation will be completed across a grid within the northern portion of the Southern Marsh, with a greater focus (i.e., greater number of probing locations) in areas where 1) existing data show elevated PAH concentrations in sediment and sediment porewater and/or 2) sheen and odors have been observed during past investigations. A lower density of probing will be conducted in areas where existing data indicate that Site-related impacts are less significant. Additional probing locations will be added, as necessary, to fully delineate the extent of any observed evidence of NAPL.

Where sheen is observed, an evaluation will be completed to determine if the sheen is likely biogenic or petroleum-based. Further, at a subset of the locations where the sheen is determined likely to be petroleum-based (if any), sediment cores will be collected and inspected for visual and olfactory evidence of NAPL. If evidence of NAPL is observed, dye testing will be conducted to confirm the presence of NAPL.

2.2 DATA QUALITY OBJECTIVE 2: DOCUMENT EXISTING CONDITIONS IN THE SOUTHERN MARSH

Site investigations have shown that PAHs are present in sediment and porewater in portions of the Southern Marsh. Data over the course of these investigations show that PAH concentrations in surface sediment (0 to 6 in.) have decreased over time—indicating that natural recovery is occurring as a result of sediment accumulation, PAH biodegradation, and/or other natural processes. However, the available data suggest that higher PAH concentrations may still be present deeper in the marsh (e.g., 0.5 to 5 ft below ground surface).[1] Although there is currently no significant ecological exposure to the PAHs in these deeper sediments, there is a potential for natural and/or anthropogenic processes to destabilize the marsh and for erosion of the marsh surface to expose deeper sediment. There is a need to evaluate the present conditions in the marsh to determine if there is evidence of physical or chemical stresses acting on the marsh that could lead to destabilization and erosion of the marsh in areas where elevated PAH concentrations are present.

Marshes form in low-energy areas, where currents are sufficiently low to allow for sediment and nutrients to accumulate. Marshes maintain elevation through the accumulation of organic and inorganic particulates over time. Flooding and sedimentation are dictated by the combined influence of tides, riverine discharges, and wind. Physical conditions, such as flooding depth, salinity regime, groundwater moisture and salinity, and scour all influence vegetation composition, and all vary in relation to elevation, proximity to the channel, and distance from the river mouth. Climate change, sea level rise, and anthropogenic modification (e.g., dredging, dams) are threatening the stability of North Carolina coastal marshes and wetlands by altering the physical and chemical characteristics of estuaries (Hackney and Yelverton 1986[2]). Most notably, sea level rise is resulting in an increased frequency, depth, and duration of tidal inundation and increased salinity of the tidal water in the marshes and wetlands that fringe estuaries. These changes threaten the viability of the vegetation present and, in some cases, can result in a transition of the marsh to open water and/or mudflats as the vegetation dies off. The survivability of coastal wetlands, will depend of multiple factors, such as the availability and accumulation of sediment, wetland elevation, vegetation, subsidence, and the ability of the wetland to move in a landward direction.

[1] Additional investigation of deeper sediment concentrations will be included in Phase II of the SRI, as needed.

[2] Hackney, C.T., and G.F. Yelverton. 1986. Effects of human activities and sea level rise on wetland ecosystems in the Cape Fear River Estuary, North Carolina. USA Wetland Ecology and Management: Case Studies. pp. 55-61.

At contaminated wetland sites, such as the Southern Marsh, sediment accumulation can result in progressive burial and dilution of contaminated sediments over time, as cleaner sediment is carried in from the estuary and organic matter is deposited as plant matter associated with the marsh vegetation senesces. As a result, evaluation of sediment accumulation in the Southern Marsh is not only important to understanding the long-term stability of the marsh, but also to projecting long-term natural recovery of the marsh due to burial processes.

A systematic survey of the marsh physical conditions and ecology is needed to determine if there is evidence of potential stressors acting on the marsh that could lead to destabilization of the marsh and erosion of marsh sediment in areas of OU3 where elevated PAH concentrations are present. A formal marsh functions and values assessment utilizing the State of North Carolina's Wetland Assessment Method (NC WAM) (N.C. Wetland Functional Assessment Team 2016) will be conducted to evaluate the hydrology, vegetation diversity and health, and other conditions (such as presence of floating marsh conditions) in the Southern Marsh. In addition, marker horizon beds will be installed in the marsh to quantify sediment accumulation over time.

2.3 DATA QUALITY OBJECTIVE 3: EVALUATE WATER LEVELS AND CONDUCTIVITY IN GROUNDWATER, MARSH POREWATER, AND SURFACE WATER

Groundwater in the Surficial and the Peedee aquifers flows toward the Southern Marsh and Sturgeon Creek, and it is likely that some of the groundwater from the Surficial Aquifer discharges to the marsh. Groundwater underlying OU4 has been impacted by releases associated with past operations associated with the former wood treatment operations at the Site, and these impacts extend to immediately adjacent to the Southern Marsh. As a result, discharge of groundwater has the potential to transport contaminants, including PAHs and VOCs, to the marsh surface sediment and sediment porewater where ecological exposure to the contaminants may occur.

Water level and conductivity data are needed to evaluate groundwater flow patterns, vertical and lateral hydraulic gradients, tidal influences, and groundwater/surface water mixing in near-surface sediment porewater. Existing groundwater monitoring wells, existing and new marsh piezometers, and new surface water standpipes will be equipped with transducers and/or conductance, depth, and temperature (CTD) probes to support collection of water level and conductivity data at high temporal resolution (e.g., minimum of once per hour) to support the assessment and consideration of tidal fluctuations in the evaluation of the data.

3 FIELD ACTIVITIES

Field activities will be conducted in general accordance with the EPA Region 4 Laboratory Services and Applied Science Division (LSASD) operating procedures, and other procedures described in previous SRI Work Plans, dated May 2012 (AECOM 2012) and September 2015 (CH2M Hill 2015a); the OU2/OU4 Soil Sampling Work Plan, dated May 2021 (Integral 2021a), and the OU2 Pre-design Investigation, OU4, and Eastern Upland 2021 Soil Sampling Work Plan, dated September 2021 (Integral 2021b).

3.1 PRE-INVESTIGATION ACTIVITIES

It is anticipated that the majority of the OU3 area that will be evaluated as part of this Work Plan will be accessed from the uplands area of the Site, which is owned by the Multistate Trust. The Southern Marsh is owned by the State of North Carolina. Prior to the commencement of SRI field activities, access to the Vertical Bridge property located west of the Site across Navassa Road will be obtained to access the two proposed piezometer locations (PZ-A-01 and PZ-A-02) in the marsh west of Navassa Road.

The accessibility of all proposed sampling locations will be confirmed (e.g., potential obstacles to piezometer installation will be identified). Should the relocation of any proposed piezometers be deemed necessary, minor adjustments in locations of 20 feet or less will be considered to be in conformance with the Work Plan and will not require agency approval. Significant changes in locations of greater than 20 ft will be proposed for agency approval during the sampling activities and prior to installation of the piezometer. Relocated piezometers, regardless of their magnitude, will be documented in the field log, including the reason for the change, and summarized in the SRI report.

The Multistate Trust will obtain NCDEQ monitoring well permits for the new piezometer locations prior to installation. No other permits are anticipated to be required.

3.2 HEALTH AND SAFETY

A site-specific Health and Safety Plan (HASP) will be developed prior to field mobilization. All onsite personnel shall have 40 hours of hazardous waste operations and emergency response (HAZWOPER) training meeting the provisions established in Title 29, Code of Federal Regulations (CFR), Part 1910.120, and will have completed annual refresher training in accordance with 29 CFR 1910.120(e)(8) within the previous 365 days.

In general, fieldwork within the marsh will be conducted by foot at low tide. A safety officer will remain on land (i.e., in OU4) and maintain verbal communication or line of sight to field crews at all times. The HASP will spell out procedures for the following:

- Project roles and responsibilities
- Safety planning and change management
- Project hazard analysis
- Hazards and controls (general, project-specific, physical, and biological)
- Personal protective equipment
- Training requirements and qualifications
- Emergency preparedness
- Incident reporting

3.3 MARSH NAPL SURVEY

Mapping of potential shallow NAPL in the marsh will be performed using systematic probing of the marsh sediment surface for visual evidence of sheen or significant odors that may be an indication of the potential presence of NAPL. The probing will involve manually inserting a rod (e.g., rebar) into the marsh surface to a target depth of 5 ft below the marsh surface. The field team will then record any observations of NAPL, sheen, and/or petroleum-based odors on the rod and water expressed to the marsh surface as the rod is extracted from the marsh.[3] The color and appearance of the sheen, presence of NAPL, and presence of any odors will be recorded in a field form or field book. Where appropriate, a photograph will be taken of sheen or NAPL observed.

The probing will be completed across a grid pattern, as shown in Figure 3. Grid cells within the area of elevated sediment concentrations and along the shoreline south of the wastewater ponds, where sheen and odors have been previously observed, will be probed along transects. The transects will include probing at approximately every 20–30 ft in areas along the shoreline and in areas with elevated PAHs (i.e., greater than 1,000 mg/kg), resulting in 9–16 probe locations per grid. Probing density will be reduced to every 40-60 ft (5–10 locations per grid) for the remaining grids where existing data indicate that Site-related impacts are less significant/likely. If evidence of NAPL is identified at the southern edge of the grid or within a grid with less probing density, probing will be extended approximately every 20–30 feet along the transect until an approximate boundary of the impacts is identified.

The location of each probing location where sheen, odor, or other evidence of NAPL is observed will be recorded using a handheld global positioning system (GPS) unit with submeter

[3] The probing work will be completed during periods when the tide elevation is below the marsh surface. However, past investigations involving probing and similar activities have shown that water levels in the marsh under these lower tide conditions are close to marsh surface, and that water is expressed to the marsh surface when a probe inserted into the marsh sediment is extracted.

accuracy. The probing investigation will be conducted at low tide when water at the marsh surface is minimized. Any incidental observations of NAPL during the SRI Phase I work will also be recorded on the field forms. The probe rod will be cleaned between probing locations to avoid spreading/mobilizing any potential NAPL in accordance with the procedures outlined in Section 3.9.

Based on past field observations, it is anticipated that observations of sheen will be a primary line of evidence of the potential presence of NAPL. Observation of a "silvery" or "metallic" gloss, increased reflectivity, visual color, iridescence, or an oil slick are indicative of a sheen (EPA Method 1617). However, naturally occurring, biogenic sheens, such as humic and fluvic acids or bacteria-generated sheens, are commonly observed in marsh environments. Agitation testing will be conducted to differentiate between biogenic and petroleum-related sheens (such as a sheen related to creosote NAPL). The sheen will be gently agitated by moving the probe rod horizontally through the sheen to determine the structure and distribution of the sheen. Observations will include whether the sheen rapidly coalesces as a liquid ("non-brittle sheen") or if the sheen cracks, breaks, and disaggregates ("brittle sheen"). Brittle sheens are often of natural biogenic origin (MPCA 2008).

In addition, at up to 10 percent of locations with heavy sheen or NAPL observed, sediment cores will be collected to 5 ft below marsh surface using a Russian peat borer, push-sampler, or similar device. The cores will be evaluated for visual NAPL impacts (i.e., free products or sheen) or odors. Dye testing for NAPL using Oil-In-Soil™ red dye test will be conducted for any segments of the sediment cores with observed evidence of NAPL. The oil-in-soil tests are performed by adding the required amount of soil and deionized clean water to the testing jar and shaking until the dye dissolves. If hydrocarbons are present in the sample, a red meniscus will appear within 30–60 seconds. The Oil-In-Soil™ kits can detect NAPL to a concentration of at least 500 parts per million (Appendix A). Coring devices will be cleaned between locations in accordance with the procedures in Section 3.9. If no evidence of gross contamination is observed in the core, the core material will be placed back at the location from which it was removed. Grossly contaminated material will be place in a drum for disposal in accordance with the procedures outlined in Section 3.11.

3.4 FLOATING MARSH SURVEY

Potential areas of floating and/or quaking marsh were identified along the northwestern area of the Southern Marsh during previous field visits (Figure 3). The extent and composition of the floating and/or quaking marsh will be assessed via a field survey and collection of cores through the marsh mat and underlying sediment. The survey of the marsh will be conducted within the same grid area and along the same transects as the NAPL survey. Marsh conditions will be surveyed along each transect at approximately every 20 to 30 ft.

At each survey location, any potential floating marsh areas will be qualitatively assessed for marsh type and identified as stationary, floating, or quaking marsh. Floating marshes will be identified by their tendency to sink when pressure, such as standing on the surface, is applied (Waller 2021). Stationary marshes do not have buoyancy or exhibit vertical movement (even as ample pressure is applied) and experience substantial inundation during high tides. Quaking marshes tremble underfoot, but do not sink into the water column (Ingram 1983; Nuttle and Hemmond 1988; Holm et al. 2000; Waller 2021). The location and description of the marsh type will be recorded in the field notes. The boundary of the floating and quaking marsh areas will be logged using a handheld GPS unit with submeter accuracy. GPS coordinates will also be logged for several nearby landmarks (e.g., bridge, telephone pole, etc.) to assist with future mapping efforts.

Cores will be collected and logged from at least survey 10 locations to evaluate the differences between the floating and/or quaking marsh types. The locations will be selected based on the observations made during the survey. Cores will be collected using a Russian peat borer, push-sampler, or similar device. For each core, the thickness of the root/marsh mat, the thickness of the underlying ooze/muck layer, and the depth to sediment will be recorded. Coring devices will be cleaned between locations in accordance with the procedures outlined in Section 3.9. If no evidence of gross contamination is observed in the cores, the core material will be placed back at the location from which it was removed. Grossly contaminated material will be placed in a drum for disposal in accordance with the procedures outlined in Section 3.11. Core locations will be logged using a handheld GPS unit.

3.5 MARSH FUNCTIONS AND VALUES ASSESSMENT

A wetland functions and values assessment will be performed to determine the ecosystem services and functions that are being provided by the Southern Marsh and whether there is any evidence that natural or anthropogenic stressors may be adversely influencing the health of the marsh. A rapid assessment of the marsh's functions and values will be performed using modified wetland delineation methods and the NC WAM (Appendix B). The NC WAM is a method to determine the level of function of wetlands relative to a reference condition for each general wetland type identified in North Carolina. The marsh functions and values assessment will include the entirety of the Southern Marsh and will be divided based on wetland type. For each wetland type, the following marsh functions will be assessed:

- Hydrology: surface storage and retention, subsurface storage and retention, soil structure, watershed land uses, hydraulic connectivity
- Water Quality: potential pollution sources (i.e., runoff, etc.), sediment deposition
- Habitat: physical structure, landscape patch structure, and vegetation composition and diversity.

The marsh assessment will include desktop and field components. Prior to the field assessment, a desktop analysis will be completed to review the Site's regional physiography, soils, hydrology, vegetation, wetlands, and watershed activities affecting the site. Field assessments will be conducted concurrent to the marsh NAPL and floating marsh surveys. Assessments will be conducted for each wetland type or subarea that is identified in the field. Results will be recorded on a NC WAM field assessment form (Appendix B).

3.6 MARKER HORIZONS

A marker horizon is an artificial soil horizon placed on a wetland surface to measure vertical sediment accretion rates. The objective of this task is to establish a minimum of three marker horizons in the marsh for monitoring sediment accumulation. Once the marker horizons are installed, they will be evaluated on an annual basis.[4] The following summarizes the procedures that will be used for installing the marker horizons. These procedures were adapted from the Natural Resource Report, The Surface Elevation Table and Marker Horizon Technique (Lynch et al. 2015; Appendix C).

Feldspar clay, or similar, will be used as the marker. At each location, a small frame (approximately 20 by 20 in.) will be laid down on the marsh surface as a temporary guide and approximately 8 lb of the feldspar clay will be spread on the marsh surface to create the marker. Each marker horizon location will be recorded using a handheld GPS unit with submeter accuracy and marked in the field by installing PVC pipes or similar markers at the northwest and southeast corners. Monitoring of the marker horizons will be initiated during Phase II of the SRI.

3.7 PIEZOMETER INSTALLATION

Twelve piezometers will be installed in the marsh at the locations shown in Figure 4. The coordinates for the piezometer locations are included in Table 2. The piezometers will be installed by hand using the same methods used to install the marsh piezometers in April 2022 (Integral 2022). Equipment and supplies will be transported to the locations via foot at low tide. The piezometers will be installed to a depth of 5 ft below the marsh surface with 1 ft of well screen. The piezometers will consist of a 2-in.-diameter, pre-packed screen connected to PVC casing. A 4-in.-diameter PVC casing will be manually driven into the ground and the well screen/PVC casing will be inserted into the center of the 4-in. casing. Approximately 1.5 ft of sand will be placed in the annulus around the well screen. The 4-in. PVC will be removed and the borehole will be filled with bentonite to the surface. The PVC casing will extend to approximately 5 ft above the marsh surface to prevent inundation during high tides. A locking

[4] Monitoring of the marker horizon beds is not included in the Phase I SRI scope. Procedures for this monitoring will be included in future work plans.

well cap will be placed on each piezometer. Figure 5 shows the proposed piezometer construction details.

Once installed, each piezometer will be developed using a peristaltic pump for approximately 5 well volumes or until the water is no longer turbid, whichever is longer. Purge water will be containerized onsite and managed in accordance with the investigation-derived waste procedures in Section 3.11. The piezometer locations will be recorded using a handheld GPS unit with submeter accuracy.

3.8 SURFACE WATER STANDPIPE INSTALLATION

Surface water standpipes will be installed at one location within the marsh in one of the existing canals and at one location at the edge of the marsh along Sturgeon Creek (Figure 4). The coordinates for the standpipe locations are included in Table 2. The standpipes will be installed at a location along the canal and/or creek to ensure that water is in the standpipe at low-low tide.

The standpipes will be constructed of 4-in.-diameter PVC pipe or equivalent, capped on the bottom, with holes installed along the length of the pipe to allow the water level within the standpipe to fluctuate with the surface water level. The standpipes will be tall enough such that the top is not submerged at high tide. A section of rebar will be driven manually into the stream bed until the rebar is firmly embedded and stable, and the standpipe will be attached to the rebar so that the bottom of the standpipe sits flush with the bottom of the canal/creek bed. Figure 6 shows the proposed standpipe construction details.

3.9 TRANSDUCER AND CTD PROBE INSTALLATION

Transducers and CTD probes will be installed to monitor water levels and tidal effects along groundwater transects that run from existing upland monitoring wells to existing and new piezometers in the marsh. In addition, transducers and CTD probes will be installed in the surface water standpipes to monitor water levels and water quality parameters concurrently with the groundwater monitoring. The locations and coordinates to the transducer and CTD probe monitoring locations are included in Table 3.

CTD probes will be deployed at 9 piezometers, and 2 surface water locations as shown on Figure 4. Transducers will be installed at 13 piezometers, and 10 monitoring wells. Transducers will be the Solonist Levellogger® or similar device. CTD probes will be the VanEssen CTD-Diver® or similar device. The CTD probes and transducers will be installed in accordance with manufacturer recommendations using a stainless-steel cable and positioned slightly off the bottom of the monitoring well/piezometer/standpipe (Appendices D and E). An O-ring or equivalent method may be used to seal well cap around the sensor cables and prevent rain water from entering the top of the well/piezometer.

Manufacturer-specific instructions will be followed to calibrate the probes prior to installation, and the probes will be programed to collect data every 15 minutes. Data will be retrieved 2 weeks following deployment to verify that the probes are working correctly. Following this verification, the data will be retrieved from the probes approximately every 3 months. At each location, the probe serial number, location, date, time, water depth, and hydrologic condition of the deployment area (visible surface flow continuous, visible flow interstitial, surface water present but no visible flow, surface water in pools only, or no surface water) at the time of deployment will be recorded in the field notes. Photographs will be taken of each deployment location.

3.10 EQUIPMENT DECONTAMINATION

All reusable sampling equipment, except for the probe rod, will be decontaminated prior to and immediately after each use as described in 2015 SRI Waste Management Plan (CH2M Hill 2015b) and LSASDPROC-205-R4. Field equipment will be decontaminated by washing with a phosphate-free detergent solution, followed by a rinse of potable water, then deionized water, between each use. Because of the number of probe holes proposed for the sheen survey, the difficulty in walking through the marsh, and the qualitative nature of the method, the probing rod used during marsh field investigations will be wiped clean using disposable wipes soaked in a phosphate-free detergent solution following any locations where evidence of NAPL is observed.

Decontamination water will be containerized and disposed of in accordance with the investigation-derived waste procedures described in Section 3.11.

3.11 INVESTIGATION-DERIVED WASTE

The following waste streams may be generated during this investigation:

- Sediment
- Purged groundwater
- Used personal protective equipment, trash, and sampling materials
- Decontamination fluids.

Investigation-derived waste will be managed in accordance with the 2015 SRI Waste Management Plan (CH2M Hill 2015b) and LSASDPROC-202-R4.

Decontamination water, purge water, and impacted sediment will be collected in separate U.S. Department of Transportation-approved 55-gal steel drums and separated for waste characterization, management, and offsite disposal, as described in the 2015 SRI Waste Management Plan (CH2M Hill 2015b). If any areas appear to contain NAPL waste or sampling generates free product waste, it will be separated and managed accordingly. All waste drums will be labeled with the date, location where the waste was generated (e.g., borehole numbers, monitoring well or piezometer identification numbers) and its contents.

3.12 SURVEYING

After the piezometers, surface water standpipes, and marker horizons are installed, each location will be surveyed by a North Carolina-licensed surveyor. Horizontal data will be reported on the North American Datum of 1983 and in the North Carolina State Plane Coordinate System. Vertical data will be reported on NAVD88. Data will be delivered in United States Survey Feet.

4 REPORTING

The results of this investigation will be reported in a technical memorandum. This memorandum will include the following:

- Summary of the piezometer and stand pipe installations, and marker horizon installations including any changes in proposed locations
- Summary of the transducer and CTD probe installation including any changes in proposed locations, and a review of preliminary data collected from the first 2 weeks of deployment
- Summary and maps of the floating marsh and NAPL survey
- Summary and maps from the marsh functions and values assessment.

Full reporting of the SRI Phase I field work, including longer-term data collection (e.g., sediment accumulation measurements from marker horizon beds, water level and conductivity data) will be included in an SRI report that incorporates all phases of the SRI.

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Tables

Table 1. Development of Data Quality Objectives

Data Quality Objective	Step 1: Problem Statement	Step 2: Study Goals	Step 3: Decision Inputs	Step 4: Study Boundaries	Step 5: Decision Rules	Step 6: Performance / Acceptance Criteria	Step 7: Plan for Obtaining Data
DQO 1: Delineate the areas within OU3 with NAPL in the shallow subsurface sediment	Elevated PAH concentrations and past observations of sheen and odors suggest the potential presence of NAPL in shallow marsh sediment. A systematic investigation is needed to determine if NAPL is present and, if so, to delineate its extent.	Delineate the areas within OU3 where NAPL is visibly present in shallow marsh sediment or where visual evidence of chemical sheens or significant odors are present, which may be an indication of the presence of NAPL.	- Presence or absence of NAPL will be based on visual observations by field staff. - Evidence of NAPL will be based on detections of chemical, petroleum-like odor by field staff and visual observations of sheen; and, where sheen is detected, testing to determine if the sheen is biogenic or petroleum-based. - Confirmatory sediment cores will be collected to 5 ft below marsh surface at up to 10% of locations with NAPL observations. The cores will be evaluated for visual NAPL impactsor odors. Dye testing for NAPL will be conducted for any segments of the sediment cores with observed evidence of NAPL.	**Geographical Boundary:** The investigation will focus on the area shown in Figure 3. Area will be expanded as necessary within OU3 to bound the observations of NAPL, sheen, or odor. **Temporal Boundary:** The study will occur during the fall. **Physical Hindrances:** The work will evaluate up to 5 ft bgs. Daily tidal fluctuation will provide a hindrance to the collection of data within OU3. Unforeseen weather conditions can affect the work.	If NAPL and/or a petroleum-based odor or sheen is observed at a boundary location of the sediment probing grid (see Step 7), step out probing will be conducted along the monitoring transect to delineate the extent. Confirmatory sediment cores will be collected to 5 ft below marsh surface at up to 10% of locations with NAPL observations.	The sediment probing will be considered acceptable if the extents of any observations of NAPL, sheen, or odor are bounded (i.e., no sheen is visible or odor is detected on the probe).	Sediment will be probed to a maximum depth of 5 ft bgs across a systematic grid of locations in OU3. The locations will be oriented along a transect extending from the shoreline. At each location, a rod (or equivalent) will be hand-pushed into the sediment and extracted. Observations will be made of any NAPL on the rod, odors, and any sheen present on surface water around the extraction point. If sheen is observed, field testing will be conducted to determine if the sheen is biogenic in origin or is petroleum-based. Confirmatory sediment cores will be collected to 5 ft below marsh surface at up to 10% of locations with NAPL observations. The cores will be evaluated for visual NAPL impactsor odors. Dye testing for NAPL will be conducted for any segments of the sediment cores with observed evidence of NAPL.
DQO 2: Document existing conditions in the Southern Marsh	A systematic survey of the marsh physical conditions and ecology is needed to determine if there is evidence of potential stressors acting on the marsh that could lead to destabilization of the marsh and erosion of marsh sediment in areas of OU3 where elevated PAH concentrations are present.	Perform a marsh functions and values assessment to characterize the ecology and stability of the existing marsh by documenting the habitat types, functions and values, and sedimentation rate.	- The NC WAM method will be used to assess the marsh's functions and values and to document indicators of marsh health. - The extent and composition of the floating or quaking marsh will be assessed via a field survey and collection of cores - Marker horizons will be placed on the marsh surface to measure sediment accumulation over time.	**Geographical Boundary:** The study area will consist of the OU3 Southern Marsh, with a primary focus on areas where elevated PAH concentrations are present and where floating marsh has been observed during previous investigations. **Temporal Boundary:** The study will occur during the fall, when a majority of species should have mature seed heads visible. It is noted that early spring or summer herbaceous species may not be present or identifiable. **Physical Hindrances:** The water body and daily tidal fluctuation will provide a hindrance to the collection of data. Unforeseen weather conditions can affect the work.	If the evaluation suggests the potential instability of the marsh, additional investigation or monitoring may be warranted.	The investigation will be acceptable if conditions allow for survey of conditions throughout the majority of the area of marsh with elevated PAH concentrations.	- Perform a marsh functions and values assessment in accordance with the methods in the NC WAM. - Collect cores in areas where floating or quaking marsh is evident based on observed surface conditions. Cores will be collected and logged from at least 5 locations. - Place marker horizons at 3 locations in the marsh and initiate long-term monitoring of sediment accumulation.
DQO 3: Evaluate water levels and conductivity in groundwater, marsh porewater, and surface water	Groundwater in the Surficial and Peedee aquifers is impacted by contaminant releases from OU4, and is anticipated to discharge to the Southern Marsh and Sturgeon Creek. Water level and conductivity data are needed to understand the interaction of groundwater with the marsh and surface water, and to evaluate the influence of tidal fluctuation on groundwater flow patterns.	Collect high-resolution water level and conductivity data in groundwater monitoring wells, marsh piezometers, and surface water standpipes at representative locations along the groundwater flow path to support evaluation of tidal influence, quantification of vertical and lateral gradients, and to quantify groundwater and surface water mixing.	- Water level and conductivity data collected at a 15 minute frequency	**Geographical Boundary** This study will occur in OU3, OU4, and OU5. **Temporal Boundary:** Water levels and conductivity will be measured at a 15 minute frequency for a period of 3 to 12 months. **Physical Hindrances:** The water body, daily tidal fluctuation, and challenging muddy terrain will provide a hindrance to installation activities within marsh habitat. Unforeseen weather conditions that can affect the work are a potential hindrance.	The data will be evaluated after 2 weeks to verify the meters are recording data and after a 3 month period to determine if the data set is sufficient to understand groundwater discharge and mixing, and encompasses a representative range of site conditions (tidal conditions, surge event, storm events, etc.). Based on this evaluation, the monitoring may be continued to up to a total of 12 months.	The meters will be considered to have operated correctly if data is recorded every 15 minutes throughout the recording period. The data will acceptable if the instruments are demonstrated to have remained within calibration limits and that there has not been significant "drift."	- Install 12 marsh piezometers and 2 surface water stand pipes. - Deploy CTD probes in 9 marsh piezometers and 2 surface water stand pipes. - Deploy transducers in 10 monitoring wells and 13 marsh piezometers.

Notes:
CTD = conductivity, temperature, depth
DQO = data quality objective
ft bgs = feet below ground surface
NAPL = nonaqueous-phase liquid
NC WAM = North Carolina Wetland Assessment Method
OU = operable unit
PAH = polycyclic aromatic hydrocarbon

Table 2. Piezometer and Surface Water Standpipe Locations

	Installation Type		Coordinates	
Sample Location	Piezometer	Standpipe	Northing (ft)	Easting (ft)
PZ-A-01	X		182606.894	2301948.887
PZ-A-02	X		182487.536	2301794.807
PZ-B-03	X		182253.639	2302316.734
PZ-B-04	X		182069.264	2302252.150
PZ-G-01	X		182313.014	2302731.317
PZ-G-02	X		182040.098	2302729.234
PZ-I-03	X		182323.330	2302954.410
PZ-I-04	X		182214.977	2302975.738
PZ-I-05	X		182061.050	2303003.926
PZ-K-03	X		182383.850	2303090.330
PZ-K-04	X		182277.712	2303127.378
PZ-K-05	X		182059.398	2303203.582
SW-1		X	182331.286	2303305.224
SW-2		X	182281.373	2304125.536

Notes:

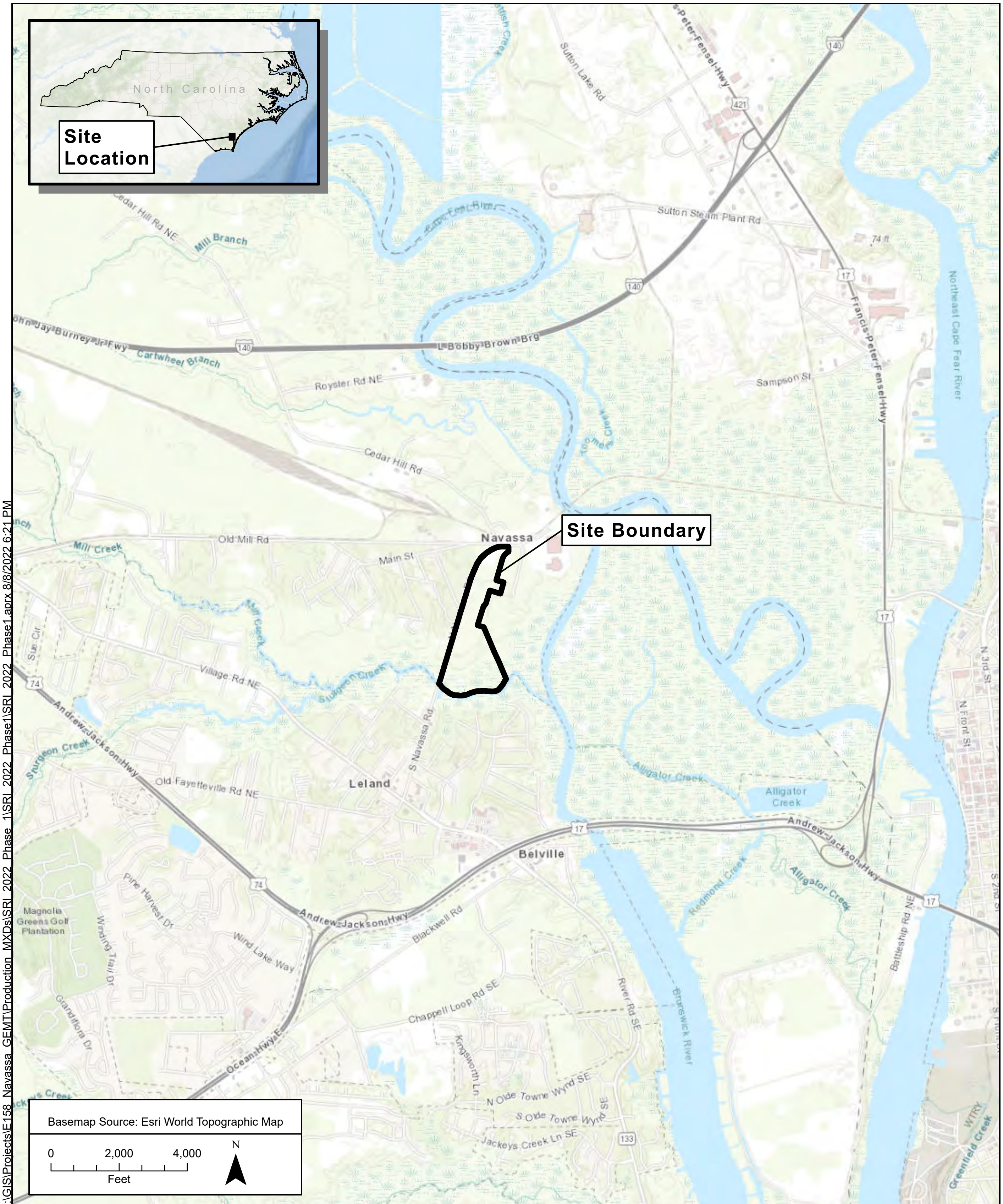
Coordinates are presented in North Carolina State Plane, North American Datum 1983.

Table 3. Transducer and CTD Probe Monitoring Locations

	Probe Type		Coordinates	
Sample Location	Transducer	CTD	Northing (ft)	Easting (ft)
PZ-A-01	X		182606.894	2301948.887
PZ-A-02	X		182487.536	2301794.807
PZ-B-01	X		182393.587	2302349.622
PZ-B-02	X		182381.608	2302346.642
PZ-B-03	X		182253.639	2302316.734
PZ-B-04	X		182069.264	2302252.150
PZ-D-01		X	182326.790	2302498.264
PZ-D-02		X	182299.408	2302493.624
PZ-D-03		X	182214.098	2302456.699
PZ-D-04		X	182014.446	2302415.466
PZ-G-01	X		182313.014	2302731.317
PZ-G-02	X		182040.098	2302729.234
PZ-I-01		X	182386.026	2302938.424
PZ-I-02		X	182399.505	2302935.499
PZ-I-03		X	182323.330	2302954.410
PZ-I-04		X	182214.977	2302975.738
PZ-I-05		X	182061.050	2303003.926
PZ-K-01	X		182450.395	2303054.743
PZ-K-02	X		182439.191	2303044.530
PZ-K-03	X		182383.850	2303090.330
PZ-K-04	X		182277.712	2303127.378
PZ-K-05	X		182059.398	2303203.582
SW-1		X	182331.286	2303305.224
SW-2		X	182281.373	2304125.536
MW-03	X		183044.100	2302586.500
MW-06	X		182424.900	2302539.500
MW-12	X		183218.120	2303117.610
MW-13	X		182875.360	2303521.000
MW-14	X		182564.190	2303013.770
MW-16	X		182620.290	2302481.080
MW-18	X		182736.700	2302080.310
MW-20	X		183052.776	2302198.596
MW-28	X		182874.975	2302864.440
MW-29	X		182740.531	2301792.203

Notes:
CTD = conductivity, temperature, and depth
Coordinates are presented in North Carolina State Plane, North American Datum 1983.

Figures



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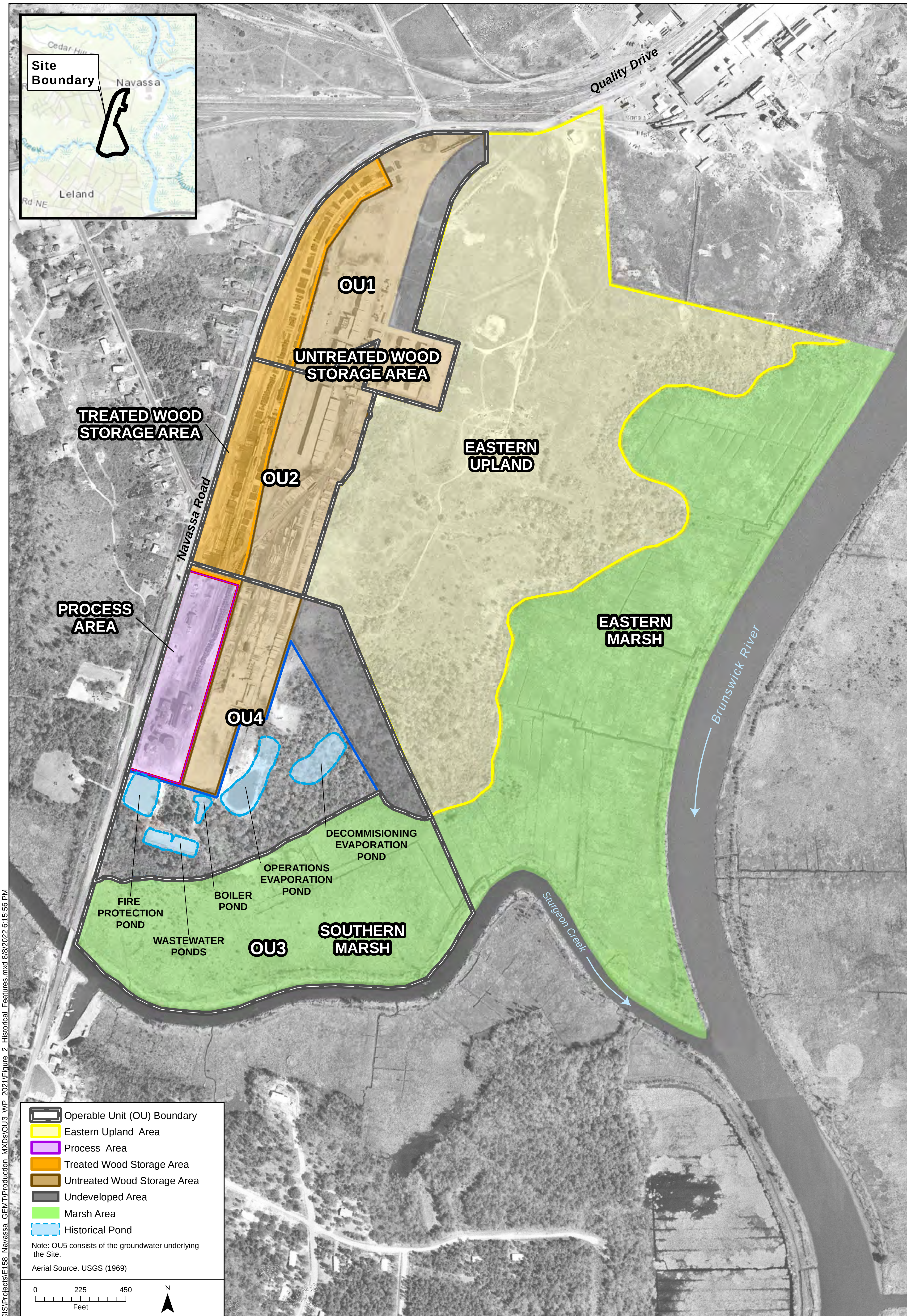
Prepared for:

Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust

Prepared by: integral engineering p.c.

Figure 1.
Site Location
Kerr-McGee Chemical Corp. - Navassa
Navassa, North Carolina
Supplemental Remedial Investigation Work Plan - Phase I Marsh Reconnaissance
September 2022



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Prepared for: Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental
Response Trust

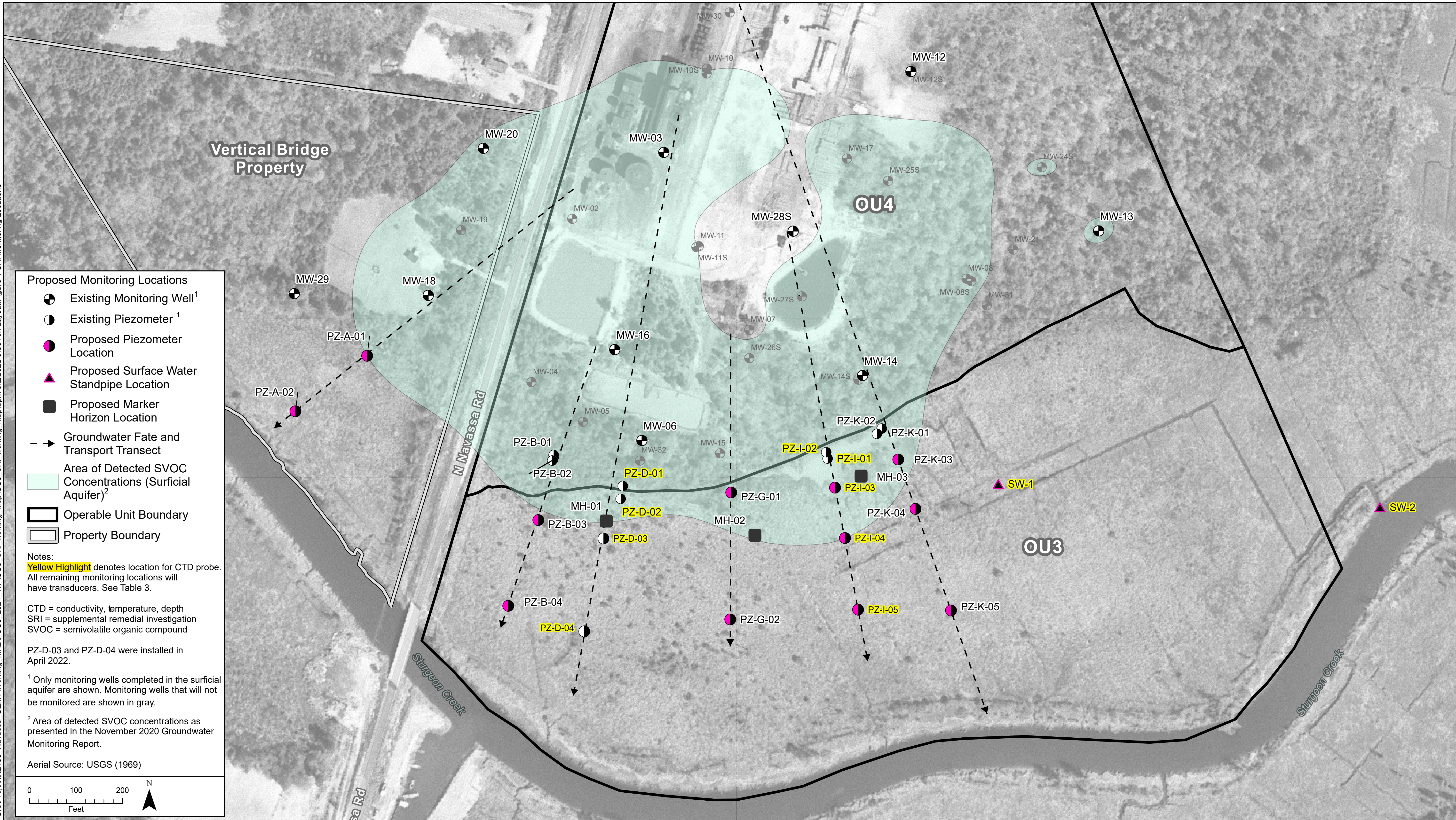
Prepared by: integral engineering p.c.

Figure 2.
Site Plan
Kerr-McGee Chemical Corp. - Navassa
Navassa, North Carolina
Supplementatl Remedial Investigation Work Plan -
Phase I Marsh Reconnaissance
September 2022

Prepared for: Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust

Prepared by: integral engineering p.c.

Figure 3.
Marsh NAPL and Floating Marsh Survey Grid
Kerr-McGee Chemical Corp. - Navassa
Navassa, North Carolina
Supplemental Remedial Investigation Work Plan -
Phase I Marsh Reconnaissance
August 2022



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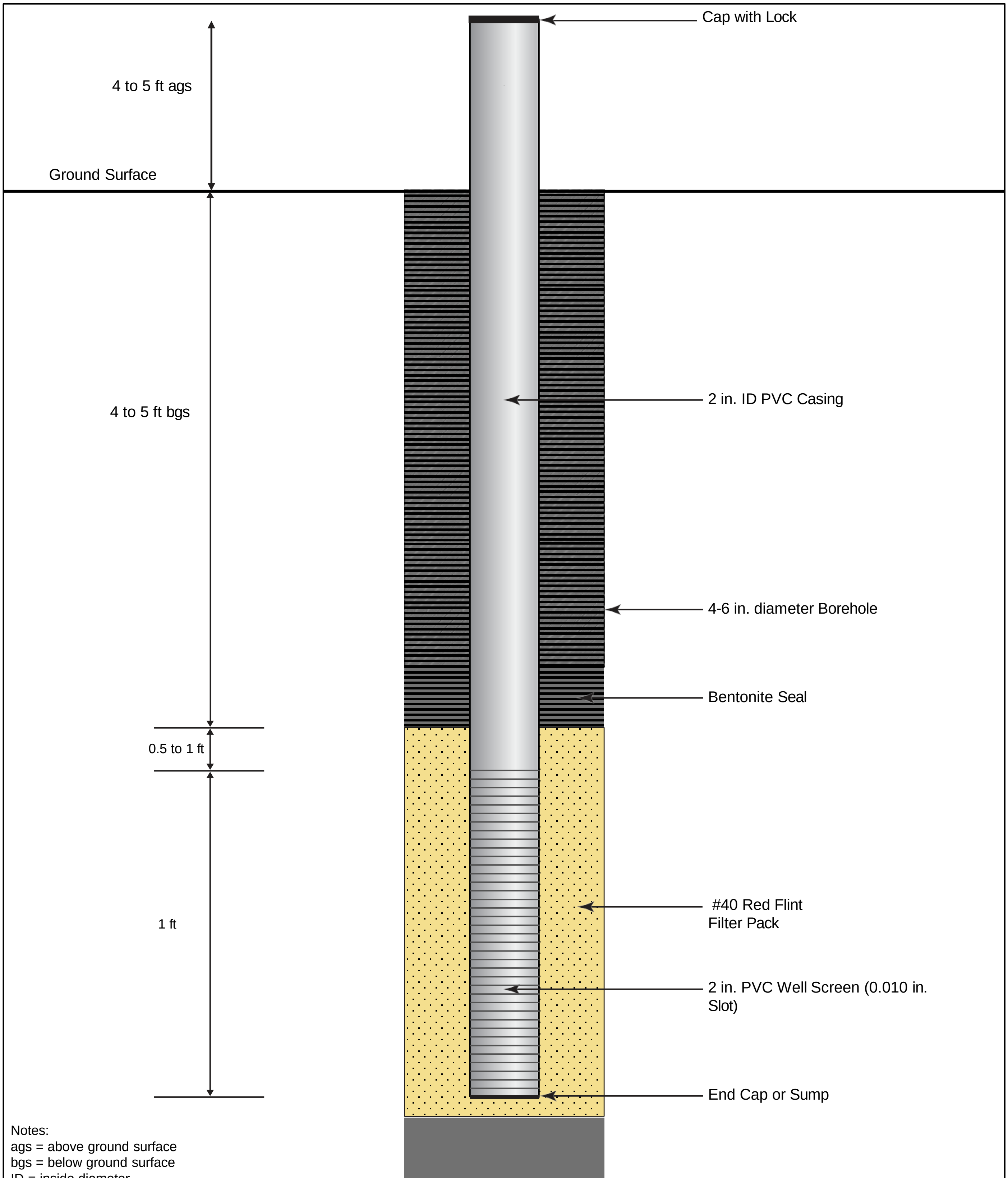
Prepared for: Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust

Prepared by: integral engineering p.c.

Figure 4.
SRI Monitoring Locations
Kerr-McGee Chemical Corp. - Navassa
Navassa, North Carolina
Supplemental Remedial Investigation Work Plan -
Phase I Marsh Reconnaissance
September 2022

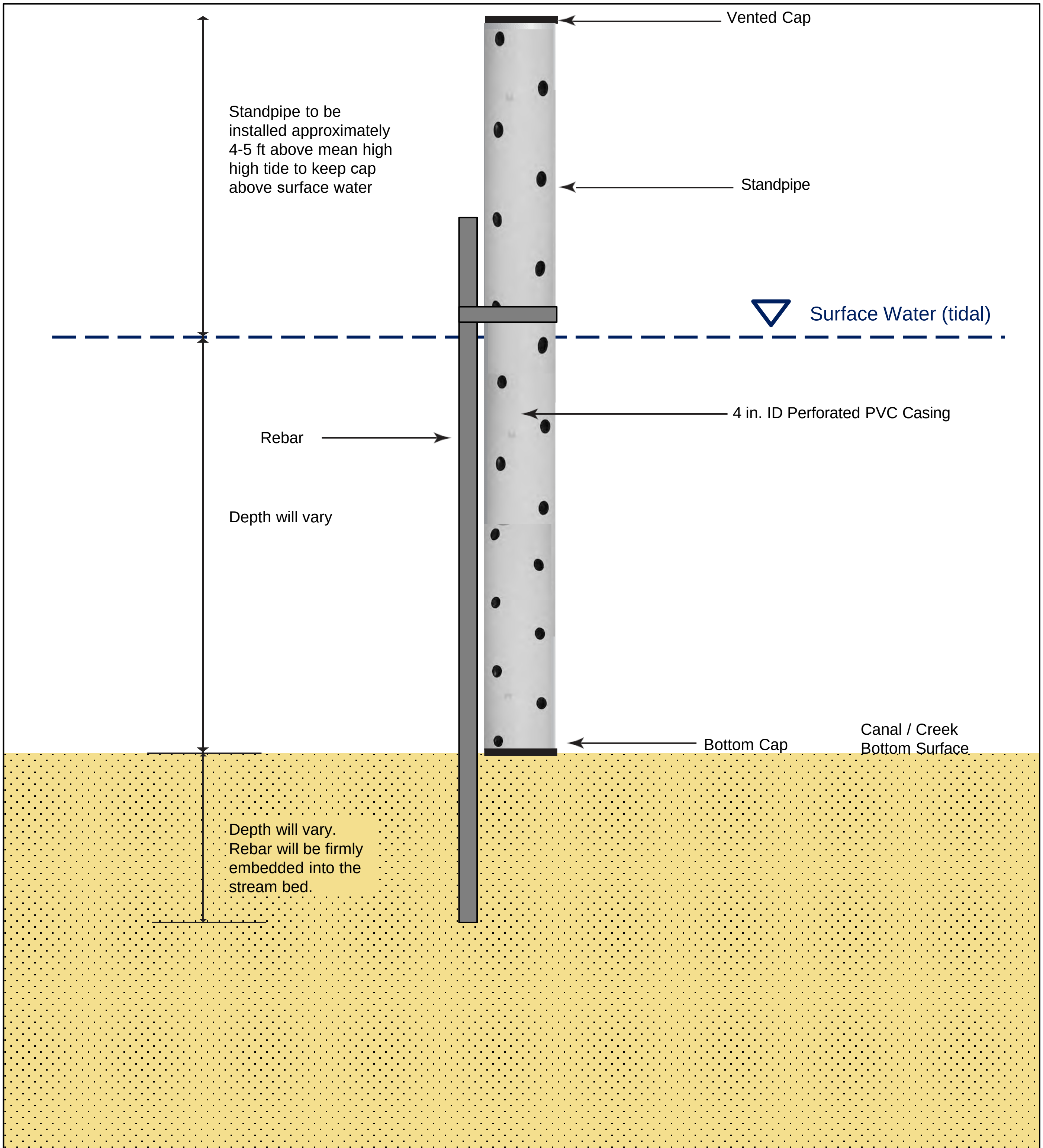


Notes:
ags = above ground surface
bgs = below ground surface
ID = inside diameter
Not to Scale

Prepared for: Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental
Response Trust

Prepared by: integral

Figure 5.
Proposed Piezometer Construction Details
Kerr-McGee Chemical Corp. - Navassa
Navassa, North Carolina
Supplemental Remedial Investigation Work Plan -
Phase I Marsh Reconnaissance
September 2022



Notes:
ID = inside diameter
Not to Scale

Prepared for: Greenfield Environmental Multistate Trust LLC
Trustee of the Multistate Environmental Response Trust

Prepared by: integral engineering

Figure 6.
Proposed Surface Water Standpipe Construction Details
Kerr-McGee Chemical Corp. - Navassa
Navassa, North Carolina
Supplemental Remedial Investigation Work Plan – Phase I Marsh Reconnaissance
September 2022

Appendix A

Oil-In-Soil Test Procedures

MANUFACTURER'S GUARANTEE:

We will replace any broken or defective kits purchased through PINE Environmental Services or OIL-IN-SOIL, LLC.

If you are not satisfied with our product, return any defective kits for a refund. We reserve the right not to provide refunds if the kits have been tampered with in any way, or if not used in accordance with the OIL-IN-SOIL Instructions.

A SDS IS NOT NECESSARY FOR THIS PRODUCT BECAUSE OF EXTREAMLY SMALL QUANTITIES OF DYES USED IN SUGAR CUBE. However product in soil may be hazardous. SDS for Dyes used is available.

RECOMMENDED PROTECTIVE EQUIPMENT:
Because you are testing for petroleum products, always use gloves and safety glasses when using the OIL-IN-SOIL™ kits.

Shelf Life is at least 10 years when kept away from DIRECT SUNLIGHT or temperatures more than 90° F.

OIL IN SOIL, LLC
Southampton ,PA
USA

OIL IN SOIL™

OIL IN SOIL, LLC
352 2nd Street Pike , Box 327
Southampton, PA 18966 - USA
Tel: (215) 687-0355

Manufacturers of Soil Screening Kits for:
Diesel Fuel - Heating Oil – Hydraulic Fluid Gasoline – Lubricating Oil – Mineral Oil – Kerosene and many other petroleum based products

OIL-IN-SOIL™
Oil Screening Test Kit

Instruction Manual

“Congratulations on purchasing the easiest and fastest test kit available today for screening hydrocarbons and DNAPL!”

INTRODUCTION:
The OIL-IN-SOIL™ screening kit is composed of a plastic bottle; a label indicating recommended soil and water levels; a small Styrofoam ball, and a cube containing finely dispersed dyes which is glued to the inside of the jar lid.

In the RED version of the screening test kit the cube is impregnated with two dyes:

- OIL RED, a Red Azo Dye (Chemically Equivalent to SUDAN IV™ and NON Mutagenic) soluble in most petroleum products, red color and a

- Fluorescent Green/Yellow water soluble dye to color the water and provide a visual backdrop for the red dye.

The dual dye method is employed to improve detection by the user. The Blue soil test kits all contain only a blue anthraquinone dye and is primarily for users who are red-green colorblind.

USING THE KIT:
OIL-IN-SOIL kits are designed with ease of use in mind. Simply follow the instructions on the label:

Step 1 Fill the bottle with soil to the line “*Fill soil to HERE*”→
Note: Do not compact the soil.
Step 2 Fill the bottle to the line “*Fill water to HERE*” →
Note: ensure water is warm enough to dissolve the cube.

Step 3 Replace cap on bottle and shake jar until cube is **completely** dissolved.

If petroleum is present in the sample a red meniscus (or red spots on the side of the jar) will appear within 30-60 seconds. If color is not immediately apparent in the jar – check the polystyrene ball. The presence of ANY color on the ball (even a faint pink halo or hue) indicates the presence ore more than a small quantity in that sample material. Conversely, a “clean white” ball indicates, in general, that there is less than 500ppm petroleum..

Note: Whenever possible, use tap or bottled water for the screening tests. However, salt water can be used if necessary.

Cold water can inhibit the rapid release of viscous hydrocarbons from soil and cause False Negative results. Therefore, at temperatures below 68º F (20º C), we recommend an insulated jug with hot tap water.

Appendix B

North Carolina Wetland Assessment Method Manual

N.C. Wetland Assessment Method (NC WAM)

User Manual

Prepared by the N.C. Wetland Functional Assessment Team

Version 4.1
October 2010

EXECUTIVE SUMMARY

The North Carolina Wetland Assessment Method (NC WAM) is the culmination of a process begun in 2003 by an interagency team of federal and state agency staff – the N.C. Wetland Functional Assessment Team (WFAT). The goal of the WFAT was to develop an accurate, consistent, rapid, observational, and scientifically based field method to determine the level of function of a wetland relative to reference condition (where appropriate) for each of 16 North Carolina general wetland types. The WFAT defined "rapid" as taking no more than 15 additional minutes for a trained observer to evaluate a wetland within an assessment area.

The WFAT identified 16 general wetland types: 1) Salt/Brackish Marsh, 2) Estuarine Woody Wetland, 3) Tidal Freshwater Marsh, 4) Riverine Swamp Forest, 5) Seep, 6) Hardwood Flat, 7) Non-Riverine Swamp Forest, 8) Pocosin, 9) Pine Savanna, 10) Pine Flat, 11) Basin Wetland, 12) Bog, 13) Non-Tidal Freshwater Marsh, 14) Floodplain Pool, 15) Headwater Forest, and 16) Bottomland Hardwood Forest. A dichotomous key is used for identifying wetland types.

Functional ratings are developed for each assessment area wetland type in comparison to a reference wetland. Three major functions are recognized with ten sub-functions as follows: hydrology (surface storage and retention and sub-surface storage and retention), water quality (pathogen change, particulate change, soluble change, physical change, and pollution change), and habitat (physical structure, landscape patch structure, and vegetation composition).

Sub-functions and functions are evaluated using 22 field metrics listed on a field assessment form. These metrics have been designed and tested to be appropriate to North Carolina wetland types. Data from completed field assessment forms are entered into a computer program to generate High, Medium, and Low ratings for each sub-function, function, and the assessment area. The sub-function ratings are reported both with and without consideration of overall wetland function of the opportunity that the wetland has to perform specific functions. The computer program was developed based on an iterative Boolean logic process and then field tested across the state at more than 200 sites of various levels of wetland quality.

This user manual provides conceptual background and instruction essential to implementing NC WAM. Each of the 22 metrics is described with examples to calibrate the user. A comprehensive Glossary of Terms as well as other detailed appendices is also included. The WFAT expects that a multi-day training class, coupled with subsequent field experience with the methodology, will be needed to use NC WAM properly. An additional resource developed to familiarize users with the NC WAM methodology is the GIS-based NC WAM "Tool Box." The Tool Box is a collection of previously evaluated reference and non-reference sites and will be available via an internet website.

NC WAM was created to be used for project planning, alternatives analysis, compliance and enforcement, mitigation planning, and tracking functional replacement. The details of how NC WAM will be used will be developed by the regulatory agencies after appropriate public notice and comment.

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Appendices Available On-Line

Dichotomous Key to General North Carolina Wetland Types

Accompanies NC WAM User Manual, Version 4.1

Before using this key, the assessor should read and become familiar with descriptions of the general wetland types. The assessor should use best professional judgment to verify that the wetland type determined with the use of this key matches the written description (see User Manual page number following wetland type name).

The following rule should be used to assist in the selection of the most appropriate general wetland type. Narrative descriptions are also available to assist in this choice (see User Manual Section 3.1).

> Wetlands with alterations (man-made or natural) should generally be classified as the original, naturally occurring type if this determination can be made. However, if the full range of stable, existing, wetland parameters (vegetation, hydrology, and soils) better resembles another wetland type because of long-established, permanent alterations, the wetland should be classified as this current, more appropriate type.

If there is evidence suggesting the wetland is a type other than the keyed type, the wetland may be classified as the evidenced type. Also, if the wetland does not appear to conform to any of the following general types, the site should be evaluated based on what the assessor believes is the closest wetland type. If the wetland is "intensively managed" or "intensively disturbed," the assessor should note this fact on the field assessment form and then select the most appropriate general wetland type based on the guidance provided above.

I. Wetland affected by lunar or wind tide, may include woody areas contiguous with tidal marsh
  - A. Wetland affected, at least occasionally, by brackish or salt water
    - i. Dominated by herbaceous vegetation – **Salt/Brackish Marsh** (p. 12)
    - ii. Dominated by woody vegetation – **Estuarine Woody Wetland** (p. 15)
  - B. Wetland primarily affected by freshwater
    - i. Dominated by herbaceous vegetation – **Tidal Freshwater Marsh** (p. 17)
    - ii. Dominated by woody vegetation – **Riverine Swamp Forest** (p. 19)

II. Wetland not affected by tides
  - A. Not in a geomorphic floodplain or a natural topographic crenulation <u>and</u> not contiguous with an open water 20 acres or larger
    - i. On a side slope – **Seep** (p. 24)
    - ii. On interstream divides <u>or</u> on a coastal island
      - 1. Flats on interstream divides in Coastal Plain ecoregions
        - a. Dominated by deciduous trees
          - i. Seasonally saturated to seasonally inundated (typically dominated by sweetgum and oaks) – **Hardwood Flat** (p. 26)
          - ii. Seasonally to semi-permanently inundated (typically dominated by cypress and black gum) – **Non-Riverine Swamp Forest** (p. 28)
        - b. Dominated by evergreens
          - i. Dominated by dense, waxy shrub species (typically include gallberries, fetterbushes, honeycup, greenbriar); canopy may include pond pine, Atlantic white cedar, and bays – **Pocosin** (p. 30)
          - ii. Not dominated by dense, waxy shrub species
            - 1. Dominated by long-leaf or pond pine and wire grass – **Pine Savanna** (p. 32)
            - 2. Dominated by loblolly or slash pines – **Pine Flat** (p. 33)
      - 2. In depressions surrounded by uplands anywhere in the state (mafic depressions, lime sinks, Carolina bays) or contiguous with an open water

Dichotomous Key to General NC Wetland Types, Continued

2. In depressions surrounded by uplands anywhere in the state (mafic depressions, lime sinks, Carolina bays) or contiguous with an open water (repeated from the previous page)
   a. Dominated by dense, waxy shrub species (typically include gallberries, fetterbushes, honeycup, greenbriar); canopy may include pond pine, Atlantic white cedar, and bays and not characterized by clay-based soils– **Pocosin** (p. 30)
   b. Not dominated by dense, waxy shrub species and not characterized by a peat-filled bay – **Basin Wetland** (p. 35)

B. In a geomorphic floodplain or a natural topographic crenulation or contiguous with an open water 20 acres or larger
   i. Northern Inner Piedmont or Blue Ridge Mountains ecoregions and dense herbaceous or mixed shrub/herbaceous vegetation with characteristic bog species (see wetland type description), with or without tree canopy; at least semi-permanent saturation; typically on organic or mucky soils; sphagnum moss commonly present – **Bog** (p. 37)
   ii. Anywhere in the state and not Bog
      1. Dominated by herbaceous vegetation. At least semi-permanently inundated or saturated. Includes lacustrine and riparian fringe and beaver ponds with dense herbaceous vegetation; sphagnum moss scarce or absent – **Non-Tidal Freshwater Marsh** (p. 40)
      2. Dominated by woody vegetation. Trees may be present on edges or hummocks.
         a. Localized depression and semi-permanently inundated – **Floodplain Pool** (p. 43)
         b. Not “a”
            i. Less than second-order stream or in a topographic crenulation without a stream. Diffuse surface flow and groundwater more important than overbank flooding.
               1. Seasonally to semi-permanently saturated and/or only intermittently inundated – **Headwater Forest** (p. 45)
               2. Seasonally to semi-permanently inundated – **Riverine Swamp Forest** (p. 19)
            ii. Second-order or greater stream or contiguous with an open water 20 acres or larger
               1. Intermittently to seasonally inundated (may be dominated by sweetgum, ash, sycamore, and oaks) – **Bottomland Hardwood Forest** (p. 49)
               2. Seasonally to semi-permanently inundated (may be dominated by cypress and blackgums in Coastal Plain and ash, overcup oak, and elms in Piedmont and Mountains) – **Riverine Swamp Forest** (p. 19)

[1]See stream order schematic diagrams in User Manual Appendix C.

NC WAM FIELD ASSESSMENT FORM
Accompanies User Manual Version 4.1

Wetland Site Name		**Date**	
Wetland Type		**Assessor Name/Organization**	
Level III Ecoregion		**Nearest Named Water Body**	
River Basin		**USGS 8-Digit Catalogue Unit**	
☐ **Yes** ☐ **No**	**Precipitation within 48 hrs?**	**Latitude/Longitude (deci-degrees)**	

Evidence of stressors affecting the assessment area (may not be within the assessment area)
Please circle and/or make note on the last page if evidence of stressors is apparent. Consider departure from reference, if appropriate, in recent past (for instance, within 10 years). Noteworthy stressors include, but are not limited to the following.

- Hydrological modifications (examples: ditches, dams, beaver dams, dikes, berms, ponds, etc.)
- Surface and sub-surface discharges into the wetland (examples: discharges containing obvious pollutants, presence of nearby septic tanks, underground storage tanks (USTs), hog lagoons, etc.)
- Signs of vegetation stress (examples: vegetation mortality, insect damage, disease, storm damage, salt intrusion, etc.)
- Habitat/plant community alteration (examples: mowing, clear-cutting, exotics, etc.)

Is the assessment area intensively managed? ☐ **Yes** ☐ **No**

Regulatory Considerations (select all that apply to the assessment area)
☐ Anadromous fish
☐ Federally protected species or State endangered or threatened species
☐ NCDWQ riparian buffer rule in effect
☐ Abuts a Primary Nursery Area (PNA)
☐ Publicly owned property
☐ N.C. Division of Coastal Management Area of Environmental Concern (AEC) (including buffer)
☐ Abuts a stream with a NCDWQ classification of SA or supplemental classifications of HQW, ORW, or Trout
☐ Designated NCNHP reference community
☐ Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream

What type of natural stream is associated with the wetland, if any? (check all that apply)
☐ Blackwater
☐ Brownwater
☐ Tidal (if tidal, check one of the following boxes) ☐ Lunar ☐ Wind ☐ Both

Is the assessment area on a coastal island? ☐ Yes ☐ No
Is the assessment area's surface water storage capacity or duration substantially altered by beaver? ☐ Yes ☐ No
Does the assessment area experience overbank flooding during normal rainfall conditions? ☐ Yes ☐ No

1. Ground Surface Condition/Vegetation Condition – assessment area condition metric

Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
☐A	☐A	Not severely altered
☐B	☐B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, reduced diversity [if appropriate], hydrologic alteration)

2. Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric

Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
☐A	☐A	Water storage capacity and duration are not altered.
☐B	☐B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
☐C	☐C	Water storage capacity or duration is substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

3. Water Storage/Surface Relief – assessment area/wetland type condition metric (evaluate for non-marsh wetlands only)

Check a box in each column for each group below. Select for the assessment area (AA) and the wetland type (WT).

	AA	WT	
3a.	☐A	☐A	Majority of wetland with depressions able to pond water > 1 foot deep
	☐B	☐B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
	☐C	☐C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
	☐D	☐D	Depressions able to pond water < 3 inches deep
3b.	☐A		Evidence that maximum depth of inundation is greater than 2 feet
	☐B		Evidence that maximum depth of inundation is between 1 and 2 feet
	☐C		Evidence that maximum depth of inundation is less than 1 foot

4. Soil Texture/Structure – assessment area condition metric

Check a box from each of the three soil property groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the top 12 inches. Use most recent guidance for National Technical Committee for Hydric Soils regional indicators.

4a.
- ☐A Sandy soil
- ☐B Loamy or clayey soils exhibiting redoximorphic features (concentrations, depletions, or rhizospheres)
- ☐C Loamy or clayey soils not exhibiting redoximorphic features
- ☐D Loamy or clayey gleyed soil
- ☐E Histosol or histic epipedon

4b.
- ☐A Soil ribbon < 1 inch
- ☐B Soil ribbon ≥ 1 inch

4c.
- ☐A No peat or muck presence
- ☐B A peat or muck presence

5. Discharge into Wetland – assessment area opportunity metric

Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
☐A	☐A	Little or no evidence of pollutants or discharges entering the assessment area
☐B	☐B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
☐C	☐C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

6. Land Use – opportunity metric

Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles and within the watershed draining to the assessment area (5M), and within 2 miles and within the watershed draining to the assessment area (2M).

WS	5M	2M	
☐A	☐A	☐A	≥ 10% impervious surfaces
☐B	☐B	☐B	< 10% impervious surfaces
☐C	☐C	☐C	Confined animal operations (or other local, concentrated source of pollutants)
☐D	☐D	☐D	≥ 20% coverage of pasture
☐E	☐E	☐E	≥ 20% coverage of agricultural land (regularly plowed land)
☐F	☐F	☐F	≥ 20% coverage of maintained grass/herb
☐G	☐G	☐G	≥ 20% coverage of clear-cut land
☐H	☐H	☐H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic alterations that prevent drainage or overbank flow from affecting the assessment area.

7. Wetland Acting as Vegetated Buffer – assessment area/wetland complex condition metric

7a. Is assessment area within 50 feet of a tributary or other open water?
☐Yes ☐No If Yes, continue to 7b. If No, skip to Metric 8.
Wetland buffer need only be present on one side of the open water. Make buffer judgment based on the average width of wetland. Record a note if a portion of the buffer has been removed or disturbed.

7b. How much of the first 50 feet from the bank is wetland?
- ☐A ≥ 50 feet
- ☐B From 30 to < 50 feet
- ☐C From 15 to < 30 feet
- ☐D From 5 to < 15 feet
- ☐E < 5 feet or buffer bypassed by ditches

7c. Tributary width. If the tributary is anastomosed, combine widths of channels/braids for a total width.
☐≤ 15-feet wide ☐> 15-feet wide ☐ Other open water (no tributary present)

7d. Do roots of assessment area vegetation extend into the bank of the tributary/open water?
☐Yes ☐No

7e. Is the tributary or other open water sheltered or exposed?
☐Sheltered – open water width < 2500 feet and no regular boat traffic.
☐Exposed – open water width ≥ 2500 feet or regular boat traffic.

8. Wetland Width at the Assessment Area – wetland type/wetland complex condition metric (evaluate for riparian wetlands only)

Check a box in each column. Select the average width for the wetland type at the assessment area (WT) and the wetland complex at the assessment area (WC). See User Manual for WT and WC boundaries.

WT	WC	
☐A	☐A	≥ 100 feet
☐B	☐B	From 80 to < 100 feet
☐C	☐C	From 50 to < 80 feet
☐D	☐D	From 40 to < 50 feet
☐E	☐E	From 30 to < 40 feet
☐F	☐F	From 15 to < 30 feet
☐G	☐G	From 5 to < 15 feet
☐H	☐H	< 5 feet

9. **Inundation Duration – assessment area condition metric**

Answer for assessment area dominant landform.

☐A Evidence of short-duration inundation (< 7 consecutive days)
☐B Evidence of saturation, without evidence of inundation
☐C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

10. **Indicators of Deposition – assessment area condition metric**

Consider recent deposition only (no plant growth since deposition).

☐A Sediment deposition is not excessive, but at approximately natural levels.
☐B Sediment deposition is excessive, but not overwhelming the wetland.
☐C Sediment deposition is excessive and is overwhelming the wetland.

11. **Wetland Size – wetland type/wetland complex condition metric**

Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the wetland complex (WC), and the size of the forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
☐A	☐A	☐A	≥ 500 acres
☐B	☐B	☐B	From 100 to < 500 acres
☐C	☐C	☐C	From 50 to < 100 acres
☐D	☐D	☐D	From 25 to < 50 acres
☐E	☐E	☐E	From 10 to < 25 acres
☐F	☐F	☐F	From 5 to < 10 acres
☐G	☐G	☐G	From 1 to < 5 acres
☐H	☐H	☐H	From 0.5 to < 1 acre
☐I	☐I	☐I	From 0.1 to < 0.5 acre
☐J	☐J	☐J	From 0.01 to < 0.1 acre
☐K	☐K	☐K	< 0.01 acre <u>or</u> assessment area is clear-cut

12. **Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)**

☐A Pocosin is the full extent (≥ 90%) of its natural landscape size.
☐B Pocosin is < 90% of the full extent of its natural landscape size.

13. **Connectivity to Other Natural Areas – landscape condition metric**

13a. **Check appropriate box(es) (a box may be checked in each column).** Involves a GIS effort with field adjustment. This metric evaluates whether the wetland is well connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, regularly maintained utility line corridors the width of a four-lane road or wider, urban landscapes, maintained fields (pasture and agriculture), or open water > 300 feet wide.

Well	Loosely	
☐A	☐A	≥ 500 acres
☐B	☐B	From 100 to < 500 acres
☐C	☐C	From 50 to < 100 acres
☐D	☐D	From 10 to < 50 acres
☐E	☐E	< 10 acres
☐F	☐F	Wetland type has a poor or no connection to other natural habitats

13b. **Evaluate for marshes only.**

☐Yes ☐No Wetland type has a surface hydrology connection to open waters/tributary or tidal wetlands.

14. **Edge Effect – wetland type condition metric (skip for all marshes)**

May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include non-forested areas ≥ 40 feet wide such as fields, development, roads, regularly maintained utility line corridors, and clear-cuts. Consider the eight main points of the compass.

☐A No artificial edge within 150 feet in all directions
☐B No artificial edge within 150 feet in four (4) to seven (7) directions
☐C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

15. **Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)**

☐A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
☐B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clearcutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
☐C Vegetation severely altered from reference in composition. Expected species are unnaturally absent (planted stands of non-characteristic species or at least one stratum inappropriately composed of a single species). Exotic species are dominant in at least one stratum.

16. **Vegetative Diversity – assessment area condition metric (evaluate for Non-tidal Freshwater Marsh only)**

☐A Vegetation diversity is high and is composed primarily of native species (< 10% cover of exotics).
☐B Vegetation diversity is low or has > 10% to 50% cover of exotics.
☐C Vegetation is dominated by exotic species (> 50% cover of exotics).

17. Vegetative Structure – assessment area/wetland type condition metric

17a. Is vegetation present?

☐Yes ☐No If Yes, continue to 17b. If No, skip to Metric 18.

17b. Evaluate percent coverage of assessment area vegetation **for all marshes only**. Skip to17c for non-marsh wetlands.

☐A ≥ 25% coverage of vegetation
☐B < 25% coverage of vegetation

17c. **Check a box in each column for each stratum.** Evaluate this portion of the metric **for non-marsh wetlands**. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

	AA	WT	
Canopy	☐A	☐A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
	☐B	☐B	Canopy present, but opened more than natural gaps
	☐C	☐C	Canopy sparse or absent
Mid-Story	☐A	☐A	Dense mid-story/sapling layer
	☐B	☐B	Moderate density mid-story/sapling layer
	☐C	☐C	Mid-story/sapling layer sparse or absent
Shrub	☐A	☐A	Dense shrub layer
	☐B	☐B	Moderate density shrub layer
	☐C	☐C	Shrub layer sparse or absent
Herb	☐A	☐A	Dense herb layer
	☐B	☐B	Moderate density herb layer
	☐C	☐C	Herb layer sparse or absent

18. Snags – wetland type condition metric

☐A Large snags (more than one) are visible (> 12 inches DBH, or large relative to species present and landscape stability).
☐B Not A

19. Diameter Class Distribution – wetland type condition metric

☐A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
☐B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12 inch DBH.
☐C Majority of canopy trees are < 6 inches DBH or no trees.

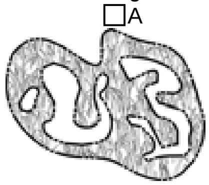
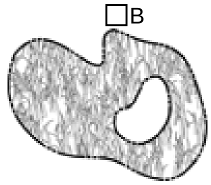
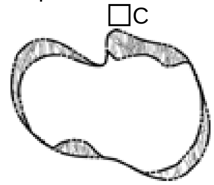
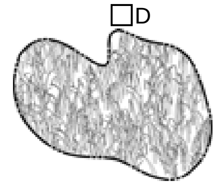
20. Large Woody Debris – wetland type condition metric

Include both natural debris and man-placed natural debris.

☐A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
☐B Not A

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

☐A

☐B

☐C

☐D


22. Hydrologic Connectivity – assessment area condition metric (evaluate for riparian wetlands only)

Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.

☐A Overbank <u>and</u> overland flow are not severely altered in the assessment area.
☐B Overbank flow is severely altered in the assessment area.
☐C Overland flow is severely altered in the assessment area.
☐D Both overbank <u>and</u> overland flow are severely altered in the assessment area.

Notes

NC WAM Wetland Rating Sheet
Accompanies User Manual Version 4.1

Wetland Site Name ____________ Date of Assessment ____________

Wetland Type ____________ Assessor Name/Organization ____________

Notes on Field Assessment Form (Y/N) ______

Presence of regulatory considerations (Y/N) ______

Wetland is intensively managed (Y/N) ______

Assessment area is located within 50 feet of a natural tributary or other open water (Y/N) ______

Assessment area is on a coastal island (Y/N) ______

Assessment area is substantially altered by beaver (Y/N) ______

Assessment area experiences overbank flooding during normal rainfall conditions (Y/N) ______

Sub-function Rating Summary

Function	Sub-function	Metrics	Rating
Hydrology	Surface Storage and Retention	Condition	
	Sub-surface Storage and Retention	Condition	
Water Quality	Pathogen Change	Condition	
		Condition/Opportunity	
		Opportunity Presence (Y/N)	
	Particulate Change	Condition	
		Condition/Opportunity	
		Opportunity Presence (Y/N)	
	Soluble Change	Condition	
		Condition/Opportunity	
		Opportunity Presence (Y/N)	
	Physical Change	Condition	
		Condition/Opportunity	
		Opportunity Presence (Y/N)	
	Pollution Change	Condition	
		Condition/Opportunity	
		Opportunity Presence (Y/N)	
Habitat	Physical Structure	Condition	
	Landscape Patch Structure	Condition	
	Vegetation Composition	Condition	

Function Rating Summary

Function	Metrics	Rating
Hydrology	Condition	
Water Quality	Condition	
	Condition/Opportunity	
	Opportunity Presence (Y/N)	
Habitat	Condition	

Overall Wetland Rating ____________

NORTH CAROLINA WETLAND ASSESSMENT METHOD (NC WAM)

USER MANUAL

1.0 INTRODUCTION

1.1 Background

This manual provides guidance for the use of the field-based, rapid wetland assessment method, the N.C. Wetland Assessment Method (NC WAM). A companion document to this manual is an initial position paper (white paper – entitled "Status Report: North Carolina Wetland Functional Assessment," dated January 13, 2004), which describes the purpose, reasoning, and process behind the development of this method; an intermediate development position paper (gray paper – entitled "Report of the North Carolina Wetland Functional Assessment Team GIS- and Field-Based Methods [Final, but Not Complete]," dated October 15, 2004), which describes the decision-making process during development of this method. NC WAM was developed as part of a collaborative effort by representatives of the U.S. Army Corps of Engineers (USACE), U.S. Department of Transportation Federal Highway Administration (USFHWA), U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), N.C. Division of Coastal Management (NCDCM), N.C. Department of Transportation (NCDOT), N.C. Division of Water Quality (NCDWQ), N.C. Wildlife Resources Commission (NCWRC), N.C. Natural Heritage Program (NCNHP), and the Ecosystem Enhancement Program (EEP).

In May 2003, the USACE, NCDWQ, and NCDOT, with the active participation of several other state and federal agencies, established the N.C. Wetland Functional Assessment Team (WFAT) to address and develop an accurate, consistent, rapid, observational, and scientifically based field method for wetland functional assessment. The WFAT had its last regular meeting in June 2005 and a follow-up meeting to discuss public comments on the draft method in October 2007. WFAT members included the following.

N.C. Division of Water Quality – John Dorney (Co-Chair)
N.C. Department of Transportation – LeiLani Paugh (Co-Chair)
U.S. Army Corps of Engineers – Dave Lekson and Amanda Jones
U.S. Fish and Wildlife Service – Gary Jordan (replaced by Howard Hall)
N.C. Division of Coastal Management – Kelly Williams (replaced by Melissa Carle)
U.S. Environmental Protection Agency – Kathy Matthews and Becky Fox
N.C. Wildlife Resources Commission – David Cox
Ecosystem Enhancement Program – Jim Stanfill
N.C. Natural Heritage Program – Mike Schafale
Federal Highway Administration – Clarence Coleman and Donnie Brew
U.S. Army Corps of Engineers (Coordination Group representative) – Scott McLendon

In addition, the team was ably assisted by staff of EcoScience Corporation (Sandy Smith, Matt Cusack, and Brad Allen) in development and testing of this method.

WFAT met from May 2003 to June 2005. During the development and testing of NC WAM, the WFAT visited approximately 200 wetland sites across the state and spent more than 140 person-days in the field.

NC WAM training classes were organized by the WFAT in the Mountains (Brevard), Piedmont (Greensboro), and Coastal Plain (Washington) and held in 2008, 2009, and 2010. Each class consisted of approximately 25 students representing either various public agencies or private consultants. The experience with NC WAM gained through these training exercises, ongoing discussions among the NC WAM instructors, valuable and much appreciated input from students, and use of NC WAM for real-world project documentation has resulted in the accumulation of sufficient additions and revisions to the User Manual to warrant generation of this edition of the fourth version (v4.1).

1.2 Purpose and Overview of NC WAM

The purpose of NC WAM is to provide the public and private sectors with an accurate, consistent, rapid, observational, and scientifically based field method to determine the level of function of a wetland relative to reference condition (when appropriate) for each general wetland type identified within North Carolina. For this method, the term "rapid" is defined as taking no more than 15 minutes for a trained individual (assessor) to evaluate a defined wetland within an "assessment area" after the wetland boundary has been determined or delineated. <u>It is important to emphasize that NC WAM is not a wetland/upland determination or delineation method; NC WAM is a method to determine the level of function of wetlands.</u>

This method will not replace more comprehensive wetland evaluation methods that may be more appropriate for other purposes. However, NC WAM is expected to replace other rapid assessment methods in North Carolina (such as the NCDWQ Guidance for Rating the Values of Wetlands in North Carolina [NCDEM 1995]).

NC WAM defines 16 general wetland types in North Carolina, which are described in Section 3.1. NC WAM generates an overall functional rating relative to reference for each wetland type, if available. Functional ratings depend on indicators of function rather than actual measurements of function. Functional ratings are generated based on an assessor's evaluation of 22 questions (metrics) concerning wetland field indicators. The 22 metrics are presented on the NC WAM Field Assessment Form. The Field Assessment Form is included at the beginning of the User Manual (see pp. ix to xii). A discussion of individual metrics and guidance for use of metrics are provided in Section 4.3.2. To complete the Field Assessment Form, the assessor selects the appropriate answer(s), or descriptor(s), for each metric. The selected descriptors are then converted by a computer program (the NC WAM Rating Calculator) into a functional rating for each metric. Ratings are provided as "High," "Medium," or "Low" relative only to other wetlands of the same type. Metric descriptors are combined to provide sub-function ratings using a weighting strategy that reflects the relative importance of the metric to the wetland sub-functions. Likewise, sub-function ratings are combined to generate function ratings (Hydrology, Water Quality, and Habitat; see Section 5.4.1), and wetland function ratings are combined to yield an overall wetland rating. All functional ratings are provided on a Wetland Rating Sheet. The Wetland Rating Sheet is included at the beginning of the User Manual (see p. xiii).

General wetland types have been defined with wetland function in mind. Functions are considered to vary among these wetland types, but are relatively consistent within each wetland type (when wetlands of a particular type are located in the same ecoregion). NC WAM generates functional ratings for each assessed wetland through comparison with reference examples of the same wetland type only (in-kind functional assessment). This approach allows each wetland to be located on a conceptual functional continuum, ranging from relatively undisturbed, reference examples of the specific wetland type (functional rating of "High") to heavily disturbed examples of the same wetland type (functional rating of "Low"). The developers of NC WAM have reasoned that the generation of an in-kind functional assessment rating for each wetland will give an accurate indication of the function or importance of that wetland based on its landscape position and level of disturbance. The functional rating produced by NC WAM will thereby provide regulators, planners, and the general public with a more meaningful estimate of wetland function than previously available for use in the consideration of wetland function when evaluating potential wetland impacts and mitigation activities.

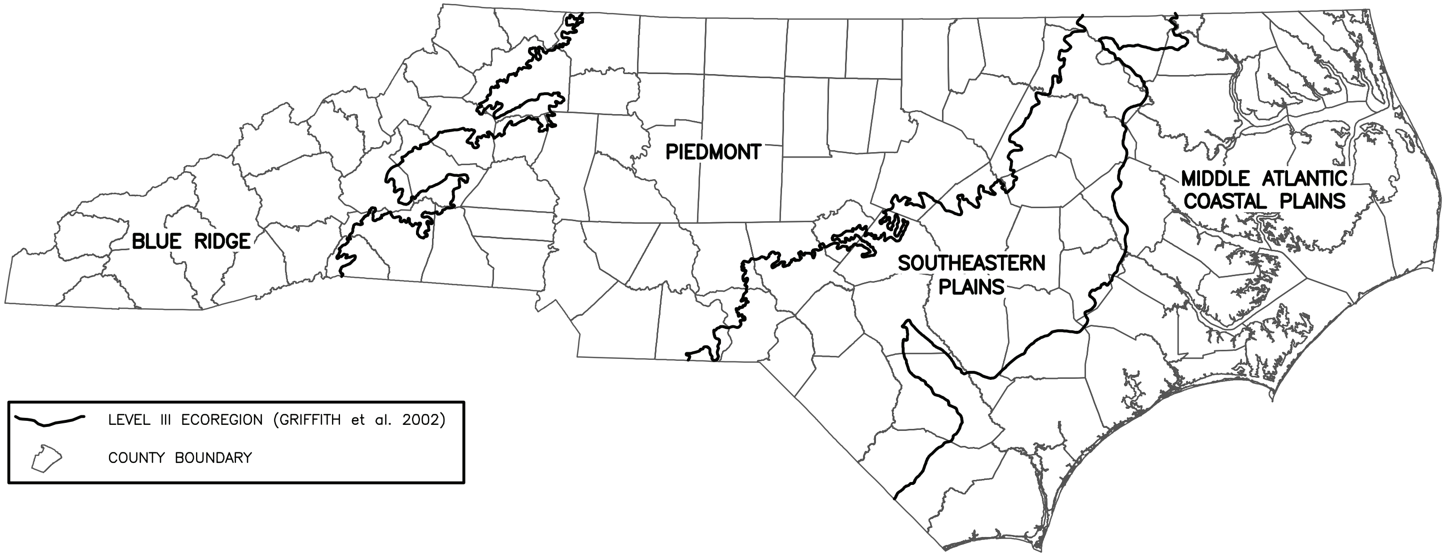
Unique to the Water Quality function and associated sub-functions, NC WAM generates two wetland functional ratings: the first is a reflection of wetland condition as represented by on-site indicators of function, and the second is wetland condition as modified by wetland opportunity. Wetland opportunity is determined by the condition of the watershed draining to a specific wetland (see Section 2.2). The distinction acknowledges that in some cases, the condition (degree of disturbance) of the immediate watershed may increase the wetland's opportunity to provide Water Quality function. The proximity of wetlands to disturbance within a watershed may only increase the functional rating. Both Water Quality sub-function and function ratings are provided on the Wetland Rating Sheet (see p. xiii).

NC WAM has been designed by an interagency team to provide project reviewers with a consistent tool to aid in consideration of project design and information concerning assessed wetland characteristics and functions that may be used at the discretion of the regulatory community. Experience has shown that regulatory concerns will change over time, but this assessment method is intended to provide a consistent source of functional assessment information to support the regulatory review process. It is fully expected by the developers of NC WAM that the current method may be modified for more specific applications concerning project planning, alternatives analysis, compliance/enforcement, mitigation planning, and mitigation success monitoring. Updates to the method itself may be applied as more scientific information and field experience become available.

1.3 Organization of the User Manual

The main body of the User Manual provides an introduction to NC WAM, a conceptual discussion of the NC WAM approach to wetland functions and sub-functions, a general discussion of the wetland classification system (including detailed descriptions of general wetland types utilized by NC WAM, a discussion of the concept of reference wetlands, and guidance for use of the key to general wetland types), a discussion of functional assessment metrics including guidance for evaluating metrics in the field, and guidance for implementation of NC WAM. To promote ease of reference, additional information necessary for the implementation of NC WAM has been organized into the attached appendices. The Table of Contents contains a complete list of information provided in the appendices. Many terms used in the manual and appendices are defined in the NC WAM Glossary of Terms (Appendix I). Abbreviations used in NC WAM are defined in Appendix A.

Throughout the User Manual, NC WAM general wetland types are discussed in terms of occurrence within the four level III ecoregions of North Carolina (Griffith et al. 2002). The level III ecoregions of North Carolina, from east to west, include 1) Middle Atlantic Coastal Plain, 2) Southeastern Plains, 3) Piedmont, and 4) Blue Ridge (see Figure 1 and Appendix E). For the sake of simplicity, the Middle Atlantic Coastal Plain (commonly known as the Outer Coastal Plain) and Southeastern Plains (commonly known as the Inner Coastal Plain) are collectively referred to as the Coastal Plains ecoregions in this manual. More detailed descriptions of the ecoregions, including correlations between North Carolina physiographic provinces, are provided in the NC WAM Glossary of Terms (Appendix I). The most recent version of the 7.5-minute topographic quadrangle prepared by the U.S. Geologic Survey (USGS) is referred to as the USGS 7.5-minute quadrangle in this manual. The scale of mapping presented in figures throughout this manual is variable, and is provided when deemed important to the purpose of the figure.



WETLAND TYPE	LEVEL III ECOREGION			
	BLUE RIDGE	PIEDMONT	SOUTHEASTERN PLAINS	MIDDLE ATLANTIC COASTAL PLAINS
SALT/BRACKISH MARSH	–	–	–	X
ESTUARINE WOODY WETLAND	–	–	–	X
TIDAL FRESHWATER MARSH	–	–	–	X
RIVERINE SWAMP FOREST	X	X	X	X
SEEP	X	X	X	X
HARDWOOD FLAT	–	–	X	X
NON–RIVERINE SWAMP FOREST	–	–	X	X
POCOSIN	–	–	X	X
PINE SAVANNA	–	–	X	X
PINE FLAT	–	–	X	X
BASIN WETLAND	X	X	X	X
BOG	X	X	–	–
NON–TIDAL FRESHWATER MARSH	X	X	X	X
FLOODPLAIN POOL	X	X	X	X
HEADWATER FOREST	X	X	X	X
BOTTOMLAND HARDWOOD FOREST	X	X	X	X

NC WAM USER MANUAL

WETLAND TYPE OCCURRENCE BY LEVEL III ECOREGION

FIGURE 1

2.0 GENERAL APPROACH TO WETLAND FUNCTIONS AND SUB-FUNCTIONS

2.1 Wetland Functions and Sub-functions

NC WAM considers chemical, physical, and biological functions for each general wetland type and assesses the general performance of each function relative to that wetland type. Scientific literature, existing wetland functional assessment methods, and best professional judgment were the basis for generation of a list of wetland functions, sub-functions, and field indicators for this field-based method. The primary reference source for wetland functional assessments was Bartoldus (1999). The Bartoldus document provides a review of 40 wetland assessment procedures. This list of assessment procedures was augmented with a literature search.

Three wetland functions were identified for use by NC WAM: Hydrology, Water Quality, and Habitat. Each of these primary functions has been sub-divided into sub-functions that vary by general wetland type. The Hydrology function is divided into 1) surface storage and retention, and 2) sub-surface storage and retention. The Water Quality function is divided into 1) particulate change, 2) soluble change, 3) pathogen change, 4) physical change, and 5) pollution change. The first four Water Quality sub-functions are considered for riparian wetlands, and the fifth Water Quality sub-function (a combination of components of the first four) is considered for non-riparian wetlands. The Habitat function is divided into 1) physical structure, 2) landscape patch structure, and 3) vegetation composition. Various combinations of Habitat sub-functions are used for the general wetland types.

Subsequently, the WFAT generated and refined through field testing a series of field indicators to be evaluated during a wetland assessment. The field indicators are evaluated by an assessor through questions (or metrics) presented on a Field Assessment Form (see pp. ix to xii). Due to the broad-based approach of the wetland assessment method, WFAT decided that ratings would be qualitative (High, Medium, and Low) as opposed to quantitative (a specific numerical system). The WFAT agreed that assigning a specific value along a numeric continuum of functional significance would greatly exaggerate the accuracy with which current knowledge (and this method) can realistically be applied.

2.2 Wetland Condition and Opportunity

It is recognized that direct measurement of wetland function is impractical with the time limitations imposed on this rapid field assessment method. Therefore, NC WAM uses indicators of wetland condition (**condition metrics**) relative to a reference wetland (if available) as a surrogate for wetland function. In effect, observed wetland condition is used to infer wetland function. These indicators are general measures (metrics) of the condition of the subject wetland. A condition metric rates inherent characteristics of a wetland that affect its ability to perform a given function. Most condition metrics are rated relative to a reference wetland of the same type, but a few condition metrics are used to rate characteristics that naturally vary among wetlands. The condition of a wetland can range from reference (little apparent disturbance, indicating a fully functional wetland) to severely degraded (disturbance has altered a wetland's ability to perform one or more functions).

An **opportunity metric** considers landscape position of a wetland relative to activities on-going in the watershed. In NC WAM, opportunity metrics apply only to the Water Quality function. When runoff from watershed alterations and/or discharges is directed to a wetland, the wetland has an opportunity to improve water quality, and when the watershed draining to the wetland is not characterized by disturbance or runoff from watershed alterations and/or discharges is directed away from the wetland, no opportunity is present.

NC WAM recognizes that measures of opportunity for a change in Water Quality function, due to circumstances directly or indirectly affecting a wetland, may be useful to some regulatory agencies in estimating the level of wetland function. NC WAM utilizes indicators of both condition and opportunity in the generation of Water Quality functional ratings, and condition and opportunity indicators are analyzed independently of each other. NC WAM presents results derived from both indicators for consideration by permitting agencies. The Wetland Rating Sheet (see p. xiii) provides 1) Water Quality sub-function ratings based on condition metrics only, 2) Water Quality sub-function ratings based on condition metrics as modified by the presence of an opportunity to enhance wetland function in the watershed, and 3) an indication as to whether an opportunity to enhance wetland function is present in the watershed.

Human values were also considered during development of NC WAM. In particular, the WFAT considered whether urban wetlands were undervalued by the proposed approach and whether an "urban uniqueness" sub-function was needed. Deliberations on this issue resulted in the development of the concept of the aforementioned "opportunity" metrics. Opportunity metrics used in the Water Quality function are expected to help address the issue of possibly undervaluing urban wetlands.

2.3 Disturbance and Stressors

The term "disturbance" refers to both natural and anthropogenic activities that may result in alteration to one or more wetland functions. Natural disturbances include, but are not limited to, storm and fire damage, salt-water intrusion (when inappropriate for that wetland type), beaver impoundment, stream migration, and sedimentation. The term "stressor" refers to a typically anthropogenic activity that affects one or more wetland functions by altering the wetland from reference condition. The response of a wetland to a stressor depends on the wetland type, size, and severity of the stressor.

Examples of stressors may include the following (modified from Adamus and Brandt 1990). Wetland functions likely to be affected by each stressor are indicated in parentheses.

- Nutrient enrichment/eutrophication (Water Quality, Habitat)
- Organic loading and reduced dissolved oxygen (Water Quality, Habitat)
- Contaminant toxicity (Water Quality, Habitat)
- Acidification (Water Quality, Habitat)
- Salinization (Water Quality, Habitat)
- Sedimentation/burial (Water Quality, Habitat)
- Turbidity/shade (Water Quality, Habitat)
- Vegetation removal (Hydrology, Water Quality, Habitat)

- Thermal alteration (Water Quality, Habitat)
- Dehydration, inundation (Hydrology, Water Quality, Habitat)
- Fragmentation of habitat (Hydrology, Water Quality, Habitat)
- Soil disturbance (Hydrology, Water Quality, Habitat)
- Sea level rise (Hydrology, Habitat, Water Quality)
- Salt run-off from roads (Water Quality, Habitat)

2.3.1 Within-Wetland Stressors

The presence of stressors within a wetland is anticipated to always degrade the condition of the wetland. Common stressors located within wetlands and their impact on wetland functions are discussed below.

Ditching

Ditching can typically be considered to remove water from a site; however, ditching is more effective if the ditches are connected and transport water off site. In the Coastal Plain ecoregions, ditches are sometimes not connected. In this case, ditches provide storage with negligible drainage. Also, depth of ditching may determine the effectiveness of drainage. An assessor should determine whether ditches are connected and draining an area prior to conducting a wetland assessment.

Effective ditching can degrade all three wetland functions through a reduction in both surface and sub-surface storage and retention. Ditching potentially increases flashiness of water volumes draining to downstream surface waters, reduces treatment time for overbank flows and upland runoff, increases the potential for erosion and sedimentation, and degrades wildlife habitat. Also, in the Coastal Plain ecoregions, ditching may provide a conduit for wind-driven saltwater intrusion into freshwater areas.

Beaver

Beaver activity may have a substantial effect on all three wetland functions. Whether the effects are considered positive or negative depends on the circumstances. Beaver activity tends to alter the local plant community composition and structure through flooding and tree cutting. Removal of vegetation may reduce energy dissipation; however, formation of open-water impoundments may provide more storage than was previously available. Impoundments may also act as sinks for water-borne particulates and toxicants, while at the same time reducing a wetland’s efficiency at removing water-borne pathogens. The alterations to Hydrology, Water Quality, and vegetation structure and composition combine to change local habitats available to wildlife and aquatic species.

Beaver impoundments are generally not thought to result in wetland type change in the short term (generally less than 10 years), but are expected to result in wetland type change over the long term (if long established [generally in existence for 10 years or more] and permanent). A beaver impoundment should not be considered a stressor if it is a long-established, permanent alteration. An assessor will need to decide if a beaver-impacted wetland appears to be stable, in terms of hydroperiod and vegetation. When beaver activity has been recently introduced, or is in a state of flux, a change in vegetation should be apparent, such as die-off of less hydrophytic species in areas subject to longer-duration saturation or inundation.

Vegetation Removal

Removal of vegetation affects all three wetland functions. Hydrology is affected through the loss of evapotranspiration. Mechanical clear-cutting may compact soils, especially if conducted during the winter wet season. Compaction of surface soils increases potential for surface scour and reduces infiltration. Vegetation acts to slow and hold flood flows and sequesters nutrients and toxicants. Removal of vegetation reduces shade, which moderates surface water temperatures. Removal of vegetation, along with the associated ground disturbance, removes food and habitats for all fauna (arboreal, ground dwelling, and fossorial).

Livestock

Livestock operations may negatively affect all three wetland functions. Removal of wetland/riparian vegetation through grazing may increase erosion, reduce energy dissipation, reduce surface water shading, reduce habitat diversity, and degrade water quality. The presence of livestock will result in soil compaction, thereby increasing runoff rates and flow velocity and decreasing sub-surface storage. Livestock excrements are a discharge and should be considered pollutants.

2.3.2 Watershed Stressors

The presence of stressors within the watershed draining to the wetland may provide opportunities to enhance components of the wetland's Water Quality function – but only if the stressors are not overwhelming the assimilative capacity of the wetland. Water Quality sub-functions potentially enhanced due to the presence of one or more stressors in the watershed include Pathogen Change (retention of and reduction of increased loads of bacteria and viruses), Particulate Change (retention of increased loads of sediment and particle-sized toxicants), Soluble Change (retention of increased loads of dissolved materials and suspended toxicants and nutrients), Physical Change (dissipation of energy), and Pollution Change (retention of increased loads of sediment, toxicants, and nutrients). See Section 2.2 for a brief discussion of wetland condition and opportunity.

3.0 WETLAND CLASSIFICATION SYSTEM

3.1 General Wetland Types

NC WAM recognizes 16 general wetland types for North Carolina. The purpose of specifying general wetland types is to 1) provide a unified list of wetland types for North Carolina, 2) account for impacts by wetland type, and 3) account for the inherent differences in function for each wetland type.

- Salt/Brackish Marsh
- Estuarine Woody Wetland
- Tidal Freshwater Marsh
- Riverine Swamp Forest
- Seep
- Hardwood Flat
- Non-Riverine Swamp Forest
- Pocosin
- Pine Savanna
- Pine Flat
- Basin Wetland
- Bog
- Non-Tidal Freshwater Marsh
- Floodplain Pool
- Headwater Forest
- Bottomland Hardwood Forest

The general wetland types are a consolidation of wetland types previously defined by the NCNHP in *Classification of the Natural Communities of North Carolina: Third Approximation* (Schafale and Weakley 1990), NCDWQ in *A Field Guide to North Carolina Wetlands* (NCDEM 1996), NCDCM in *DCM Wetland Mapping in Coastal North Carolina* (Sutter 1999), and USACE in the Hydrogeomorphic Method (HGM) (Brinson unpublished). NCNHP classified North Carolina wetlands into 59 types, NCDWQ classified North Carolina wetlands into 14 types, NCDCM classified Coastal Plain (physiographic province) wetlands into 13 types, and HGM currently recognizes five wetland classes. It should be noted that since the resulting grouping of general wetland types in NC WAM is a consolidation of types defined by these sources, definitions may overlap to some extent. A table cross-referencing NC WAM, NCNHP, NCDCM, and HGM wetland types is provided in Appendix B.

NC WAM separates the 16 general wetland types into three categories: Salt/Brackish Marsh, riparian, and non-riparian. NC WAM considers the term riparian wetlands to refer to wetland types typically found in one or more of the following landscape positions: in a geomorphic floodplain or a natural topographic crenulation; contiguous with an open water 20 acres or larger; or subject to tidal flow regimes, excluding Salt/Brackish Marsh (see NC WAM wetland type key). Riparian wetlands include the following eight NC WAM general wetland types: Estuarine Woody Wetland, Tidal Freshwater Marsh, Riverine Swamp Forest, Bog, Non-Tidal Freshwater Marsh, Floodplain Pool, Headwater Forest, and Bottomland Hardwood Forest. The remaining seven NC WAM general wetland types are considered to be non-riparian wetlands: Seep, Hardwood Flat, Non-Riverine Swamp Forest, Pocosin, Pine Savanna, Pine Flat, and Basin Wetland. These terms (riparian and non-riparian) are used on the Field Assessment Form to indicate the applicability of metrics to specific wetland types (example: "evaluate for riparian wetlands only").

Following are the groupings of the wetland types among the three categories.

- Salt/Brackish Marsh
  - Salt/Brackish Marsh

- Riparian
  - Estuarine Woody Wetland
  - Tidal Freshwater Marsh
  - Riverine Swamp Forest
  - Bog
  - Non-Tidal Freshwater Marsh
  - Floodplain Pool
  - Headwater Forest
  - Bottomland Hardwood Forest

- Non-riparian
  - Seep
  - Hardwood Flat
  - Non-Riverine Swamp Forest
  - Pocosin
  - Pine Savanna
  - Pine Flat
  - Basin Wetland

The WFAT also generated a list of four non-wetland open water types: natural waterbodies, artificial waterbodies, estuarine waters, and ocean. A method of functional assessment has not been generated for these open water types, and these open water types will not be discussed in this manual.

Some general guidance regarding the narrative descriptions of the general wetland types follows. References to inundation pertain to inundation during the growing season. Figure 1 depicts boundaries of North Carolina level III ecoregions and provides tables of the occurrence of general wetland types by ecoregion (while Appendix E depicts boundaries of level IV and level III ecoregions). Vascular plant names follow nomenclature found in Weakley (2006) or Radford et al. (1968).

3.1.1 Salt/Brackish Marsh

Salt/Brackish Marshes are found in the tidewater region of the Middle Atlantic Coastal Plain ecoregion (see Figure 1 and Appendix E) in areas subject to regular or occasional flooding by tides, including wind tides (whether or not the tidal waters reach wetlands through natural or artificial watercourses), provided that 1) water salinities equal or exceed 0.5 parts per thousand during the period of average, annual low flow; 2) flooding by saline waters is not limited to storm events; and 3) woody vegetation constitutes less than 50 percent coverage of the community. The salt marsh component is associated more closely with ocean and inlet waters, while the brackish marsh component is somewhat removed from a direct connection with ocean and inlet saline waters. Salt/Brackish Marshes typically occur on both organic and mineral soils. This wetland type is characterized by predominantly herbaceous vegetation (less than 50 percent coverage by woody species). Salt marsh vegetation is dominated by saltmarsh cordgrass (*Spartina alterniflora*) and contains black needle rush (*Juncus roemerianus*) and large saltmeadow cordgrass (*Spartina patens*). Brackish marsh vegetation may include salt marsh species, but are typically more diverse in the vegetation assemblage, which commonly includes giant cordgrass (*Spartina cynosuroides*) and sawgrass (*Cladium jamaicense*).

Most examples of Salt/Brackish Marsh are considered by regulatory agencies as high-quality wetlands. Indicators of degradation within this wetland type may include dead vegetation, altered hydrology, ditching, spoil piles, reduced size, and extensive presence of invasive species.

Reference wetlands (Section 3.2) are available for this type. This wetland type may vary in size from small, narrow, fringing bands to hundreds of acres. Salt/Brackish Marsh can transition upstream to Tidal Freshwater Marsh and upslope to Estuarine Woody Wetland, Non-Riverine Swamp Forest, and Pocosin.

Salt/Brackish Marsh includes NCNHP types Salt Marsh, Brackish Marsh, and Salt Flat when these sites are wetlands. This type is included in the NCDCM wetland type of Salt/Brackish Marsh. Salt/Brackish Marsh corresponds with HGM class Estuarine Tidal Fringe (sub-classes Estuarine Lunar and Estuarine Wind). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-1

Photo 3-2

Salt/Brackish Marsh. These examples of Salt Marsh are located along the lower Cape Fear River, New Hanover County (Photo 3-1); along an armored shoreline of Calico Creek, Carteret County (Photo 3-2); near Mad Inlet, Brunswick County (Photo 3-3); and just east of the Bodie Island lighthouse, Dare County (Photo 3-4).

Photo 3-3

Photo 3-4

Photo 3-5

Photo 3-6

Salt/Brackish Marsh. These examples of Brackish Marsh are in association with Estuarine Woody Wetland in Huddy Gut, Beaufort County (Photo 3-5); along Rose Bay at Bell Island, Swanquarter National Wildlife Refuge, Hyde County (Photo 3-6); near the battleship U.S.S. North Carolina, New Hanover County (supporting a stand of the exotic species *Phragmites australis*) (Photo 3-7); and fringing a roadside canal near the US 64/US 264 junction, Dare County (Photo 3-8).

Photo 3-7

Photo 3-8

3.1.2 Estuarine Woody Wetland

Estuarine Woody Wetlands occur in the tidewater region of the Middle Atlantic Coastal Plain ecoregion (see Figure 1 and Appendix E). These wetlands are transitional in nature. They occur on the margins of estuaries, are typically fringing tidal marshes, and have the following attributes: 1) they are subject to occasional flooding from salt or brackish water; 2) they are subject to occasional flooding by tides, including wind tides (regardless of whether or not the tidal waters reach wetlands through natural or artificial watercourses); and 3) they are dominated (greater than 50 percent coverage) by woody vegetation including shrubs and trees. Estuarine Woody Wetlands occur on mineral or organic soils. Due to typically unstable hydrological and chemical influences, the plant community is one adapted to disturbance, resulting in variable vegetation composition and physical structure. The vegetation assemblage is typically dominated by loblolly pine (*Pinus taeda*), cedars (*Juniperus* spp.) and hardwoods adapted to disturbance such as red maple (*Acer rubrum*) and sweetgum (*Liquidambar styraciflua*), or by shrubs. Shrubs include bays, silverling (*Baccharis halimifolia*), marsh elder (*Iva frutescens*), and common wax myrtle (*Morella cerifera*). Herbs may include grasses and sedges from contiguous marshes.

Reference wetlands (Section 3.2) exist for this type; however, an assessor must recognize that this community occurs with variable vegetation composition and structure components. The size and shape of this wetland type ranges from narrow, sometimes intermittent bands along the outer fringe of Salt/Brackish Marshes to broad expanses of hundreds of acres. Estuarine Woody Wetland may transition up slope to Pocosin, Pine Flat, Hardwood Flat, and Non-Riverine Swamp Forest and down slope to Tidal Freshwater Marsh or Salt/Brackish Marsh.

Estuarine Woody Wetland includes NCNHP types Salt Shrub and Estuarine Fringe Loblolly Pine Forest. This type is included in the NCDCM wetland type of Estuarine Shrub-Scrub and Estuarine Forested Wetlands. Estuarine Woody Wetland corresponds to HGM class Estuarine Tidal Fringe (sub-classes Estuarine Lunar and Estuarine Wind). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-9

Photo 3-10

Estuarine Woody Wetland. These examples of Estuarine Woody Wetland are on Bell Island east of Rose Bay, Swanquarter National Wildlife Refuge, Hyde County (Photo 3-9); at the east end of East Lake near Mashoes, Alligator River National Wildlife Refuge, Dare County (Photo 3-10); islands in a sea of brackish marsh along Croatan Sound, Dare County (Photo 3-11); and a wooded border along the upslope edge of salt marsh fringing Bogue Sound on Emerald Isle, Carteret County (Photo 3-12).

Photo 3-11

Photo 3-12

3.1.3 Tidal Freshwater Marsh

Tidal Freshwater Marshes are found in the tidewater region of the Middle Atlantic Coastal Plain ecoregion (see Figure 1 and Appendix E) on the margins of estuaries and in lower reaches of streams and rivers where they are saturated most of the time and are also subject to regular or occasional flooding by tides, including wind tides (regardless of whether or not the tidal waters reach wetlands through natural or artificial watercourses). Tidal Freshwater Marshes typically have salinities below the threshold of 0.5 parts per thousand, but may be subject to salinities above this threshold as a result of storm events. Tidal Freshwater Marshes occur on mineral or organic soils. This wetland type is characterized by predominantly herbaceous vegetation (less than 50 percent coverage by living woody species). Tidal Freshwater Marshes typically support a larger diversity of plant species than either Non-Tidal Freshwater Marshes or Salt/Brackish Marshes. Indicators of degradation within this wetland type may include dead vegetation, ditching, spoil piles, reduced size, lack of vegetation diversity, presence of invasive species and saltwater intrusion. Presence of snags is only considered to be an indicator of degradation if there is evidence of a recent die-off.

Reference wetlands (see Section 3.2) are available for this type. This wetland type may vary in size from small, narrow, fringing bands to broad patches extending hundreds of acres. Tidal Freshwater Marsh can transition upstream to Riverine Swamp Forest; upslope to Estuarine Woody Wetland, Non-Riverine Swamp Forest, and Pocosin; and downstream to Salt/Brackish Marsh.

Tidal Freshwater Marsh includes the NCNHP type Tidal Freshwater Marsh. This type is included in the NCDCM wetland type of Freshwater Marsh. Tidal Freshwater Marsh corresponds to the HGM class Estuarine Tidal Fringe (sub-classes Estuarine Lunar and Estuarine Wind). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-13

Photo 3-14

Tidal Freshwater Marsh. These examples of Tidal Freshwater Marsh are fringing Lockwood Folly River, Brunswick County (Photo 3-13); Sturgeon Creek, Brunswick County (Photo 3-14); an unnamed tributary to Hidden Lake in Palmetto-Peartree Preserve, Tyrrell County (Photo 3-15); and the Broad Creek Arm of South Lake in Alligator River National Wildlife Refuge, Dare County (Photo 3-16). The unnamed tributary to Hidden Lake is a naturalized excavated canal, which has provided a conduit for periodic brackish water intrusion into the fringing wetland, resulting in a change in wetland type from a likely Riverine Swamp Forest to the present Tidal Freshwater Marsh. Lockwood Folly River and Sturgeon Creek are subject to lunar tides, while the unnamed tributary to Hidden Lake and South Lake are subject to wind tides.

Photo 3-15

Photo 3-16

3.1.4 Riverine Swamp Forest

Riverine Swamp Forests are found throughout the state, but are most extensive and abundant in Coastal Plain ecoregions (see Figure 1 and Appendix E). This wetland type may occur in a variety of landscape positions and on mineral or organic soils, but all undisturbed Riverine Swamp Forests are characterized by seasonal to semi-permanent inundation. This wetland type occurs in (but is not limited to) the following settings (listed from highest to lowest in the landscape).

- Headwaters of streams in depressions subject to surface flow and/or groundwater expression
- Wettest portions of large river floodplains and other permanent water bodies, including linear depressions that lead to stream systems
- Tidally-influenced lower river reaches (primarily freshwater, but also brackish water in the upper reaches of estuaries)
- Linear depressions (both with and without surface water channels [natural or man-made]) draining to rivers and sounds in the Middle Atlantic Coastal Plain
- Shorelines of open waters 20 acres or larger

Overbank or tidal flooding is usually an important source of water, but groundwater and overland runoff are also important. Long-established beaver impoundments may be the cause of semi-permanent to permanent inundation. Many Riverine Swamp Forests in North Carolina were formed under the influence of long-established beaver impoundments. Seasonal fluctuations in water levels of large open waters (20 acres or larger) may mimic the seasonal flooding of rivers. These large open waters may provide enough fetch for effective wind tides, approximating overbank flooding as experienced in floodplains. The size threshold used to determine small versus large open waters was taken from Cowardin et al. (1979).

Vegetation is most often dominated by mesic and hydrophytic tree species such as overcup oak (*Quercus lyrata*), ashes (*Fraxinus* spp.), and American elm (*Ulmus americana*) in the Piedmont and Blue Ridge ecoregions and bald cypress (*Taxodium distichum*), black gum (*Nyssa biflora*), and water tupelo (*N. aquatica*) in the Coastal Plain ecoregions. Herbaceous cover is typically more open than in Bottomland Hardwood Forest. In estuaries, lower reaches of rivers, and along the shorelines of large open waters, Riverine Swamp Forest can be distinguished from marshes by having a predominance of woody vegetation.

Reference wetlands (see Section 3.2) are available for this type. The size of this wetland type varies widely from narrow strips of backwater at the toe of valley walls along the outer extent of floodplains to broad expanses extending for hundreds of acres. Areas of Riverine Swamp Forest are typically larger in the Coastal Plain ecoregions and smaller in the Piedmont and Blue Ridge ecoregions. Riverine Swamp Forest is often a result of the impoundment of water by beaver dams or man-made dams. When determining the type of a riparian wetland dominated by woody vegetation and characterized by seasonal to semi-permanent inundation, the assessor should consider whether the stated hydrology is long established and permanent or not. The wetland type may be a Riverine Swamp Forest in the former instance, and a disturbed

Headwater Forest or Bottomland Hardwood Forest if the alteration is not long-established and permanent.

In the Southeastern Plains, Piedmont, and Blue Ridge ecoregions, Riverine Swamp Forest may transition upslope to Bottomland Hardwood Forest, Headwater Forest, Bog, and Seep and down slope to Non-Tidal Freshwater Marsh. In the Middle Atlantic Coastal Plain, Riverine Swamp Forests may transition upslope to Headwater Forest and Seep; laterally (perpendicular to a linear depression) to Non-Riverine Swamp Forest, Pocosin, and Hardwood Flat; and down slope to Tidal Freshwater Marsh, Salt/Brackish Marsh, and Estuarine Woody Wetland. In the Coastal Plain ecoregions, Bottomland Hardwood Forest often occurs in extensive mosaics with Riverine Swamp Forest.

Riverine Swamp Forest corresponds to NCNHP types Cypress–Gum Swamp (Blackwater and Brownwater Subtypes), Coastal Plain Small Stream Swamp (part), Piedmont/Mountain Swamp Forest, Tidal Cypress–Gum Swamp, and Natural Lake Shoreline (part). Riverine Swamp Forest is included in the NCDCM wetland type of Swamp Forest. Riverine Swamp Forest corresponds to the HGM classes Riverine (sub-classes Headwater Complex, Lower Perennial, Beaver Impounded, and Human Impounded), Lacustrine Fringe (sub-classes Semi-permanently Flooded, Intermittently Flooded, and Reservoir), and Estuarine Tidal Fringe (subclass Estuarine Wind Intertidal). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-17

Photo 3-18

Riverine Swamp Forest. These photos depict Riverine Swamp Forest in settings affected by lunar or wind tides and primarily affected by freshwater (key location I.B.ii): along the eastern shore of the Alligator River (subject to wind tides and wave action), Dare County (Photo 3-17); in the floodplain of Doe Creek (subject to lunar tides), Brunswick County (Photo 3-18); in the floodplain of Town Creek (subject to lunar tides), Brunswick County (Photo 3-19); and in Deep Creek, a broad natural topographic crenulation with no readily identifiable channel, Washington County (Photo 3-20).

Photo 3-19

Photo 3-20

Photo 3-21 **Photo 3-22**

Riverine Swamp Forest. These photos depict Riverine Swamp Forests on less than a second-order stream or within a natural topographic crenulation without a channel (key location II.B.2.b.i.2): a natural topographic crenulation without a channel in the headwaters of Huddle's Cut, Beaufort County (Photo 3-21); an unnamed, anastomosed, first-order stream in the Green Swamp, Brunswick County (Photo 3-22); a first-order unnamed tributary to Robertson's Millpond on Buffalo Creek, Wake County (Photo 3-23); and within a beaver-impacted first-order unnamed tributary to Milburnie Lake, Wake County (Photo 3-24).

Photo 3-23

Photo 3-24

Photo 3-25

Photo 3-26

Riverine Swamp Forest. The first three photos depict Riverine Swamp Forests on second-order or larger streams (key location II.B.2.b.ii.2): the Broomfield Swamp floodplain, Beaufort County (Photo 3-25); a beaver-impacted portion of the Mingo Creek floodplain, Wake County (Photo 3-26); and the Little River floodplain in DuPont State Forest, Transylvania County (Photo 3-27). The final photo depicts Riverine Swamp Forest along the shoreline of an open water greater than 20 acres in size. This wetland is subject to wave action, seasonal water-table variation, and wind tides and is located along the western shore of Phelps Lake, Washington County (Photo 3-28).

Photo 3-27

Photo 3-28

3.1.5 Seep

Seeps are located throughout the state where groundwater is discharged to the surface on a slope not in a geomorphic floodplain or a natural topographic crenulation. Wetlands of this type usually occupy small areas on sloping hillsides in interstream divides or on the valley wall outside of floodplains and are semi-permanently to permanently saturated by ground water on mineral or organic soils. This wetland type typically does not have sufficient surface flow to form channels, but is usually saturated to the surface. Topographic mapping is useful in determining the extent of Seeps, especially when a Seep abuts another wetland type. For instance, a Seep may occur on the valley wall outside of a geomorphic floodplain and extend down slope into another wetland type on the floodplain (such as Headwater Forest, Bottomland Hardwood Forest, Riverine Swamp Forest, Floodplain Pool, Non-Tidal Freshwater Marsh, or Bog). In this case, the lower boundary of this wetland type may be defined using topographic mapping at the point where the toe of the valley wall meets the floodplain. Likewise, a wetland on a ridge or valley wall slope is a Seep, but it becomes another wetland type when it enters a natural topographic crenulation. When making this determination, an assessor may use the most detailed topographic mapping available. Assessors will need to use best professional judgment to determine the boundary between a Seep and the upper limit of a Headwater Forest.

Vegetation in Seeps is quite variable. Depending on size, vegetation of Seeps in the Piedmont and Blue Ridge ecoregions may be zoned, with open interiors characterized by sparse to dense wetland herbs and a forested outer edge. This wetland type may be small enough to be shaded by trees. Vegetation structure in the Coastal Plain ecoregions is dependent on fire regime and may vary from dense to sparse growth of shrubs.

Reference wetlands (see Section 3.2) are available for this type. Because this type is very heterogeneous, care will be needed to select the appropriate reference, which will vary by ecoregion and site conditions. Seeps are typically small relative to other general wetland types, but may be larger in the Sandhills ecoregion and in the higher mountains. A Seep can transition to Headwater Forest, Bottomland Hardwood Forest, Riverine Swamp Forest, Non-Tidal Freshwater Marsh, Pine Flat, and Bog. Seeps can be distinguished from all these wetland types by location on a slope.

Seep includes the NCNHP types Low Elevation Seep, High Elevation Seep, Sandhill Seep, and Hillside Seepage Bog. This wetland type is not separately identified with the NCDCM wetland classification system. Seep corresponds to the HGM class Slope (sub-classes Organic Soil and Mineral Soil). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-29

Photo 3-30

Photo 3-31

Seep. These examples of Seep are located on a slope outside of the geomorphic floodplain of an unnamed tributary to Little River, Wake County (Photo 3-29); on a mountain slope near Deep Gap, Watauga County (Photo 3-30); and on the valley wall just outside of the floodplain of an unnamed tributary to McPherson Creek in Cumberland County (Photo 3-31). The source of wetland hydrology in all examples is groundwater expressing to the surface over impermeable surfaces, bedrock in the first two examples and a clay lens in the third example.

3.1.6 Hardwood Flat

Hardwood Flats are found primarily in the Coastal Plain ecoregions (see Figure 1 and Appendix E) on poorly drained, interstream flats. These areas are usually seasonally saturated or intermittently to seasonally inundated by a high water table or poor drainage, but have a shorter hydroperiod than Non-Riverine Swamp Forests. The primary source of water is a high water table resulting from precipitation and overland runoff. In their reference state, Hardwood Flats generally occur on mineral soils. These systems are commonly dominated by hardwood tree species including various oaks (examples: swamp chestnut oak [*Quercus michauxii*], laurel oak [*Q. laurifolia*], cherrybark oak [*Q. pagoda*]), tulip poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), American elm (*Ulmus americana*), red maple (*Acer rubrum*), and black gum (*Nyssa biflora*).

Reference wetlands (see Section 3.2) are available for this type. This wetland type may vary widely in size, but can be quite large, dependent on landscape position and disturbance. Hardwood Flat can transition to Pocosin, Pine Savanna, Pine Flat, and Non-Riverine Swamp Forest on interstream flats and can transition to Headwater Forest at the upper extent of drainage slopes. Hardwood Flat is distinguished from Pocosin, Pine Savanna, and Pine Flat through canopy species composition and from Non-Riverine Swamp Forest by hydrology indicators. Headwater Forest is distinguished from a Hardwood Flat by location in a natural topographic crenulation, likely in combination with indicators of some surface flow.

Hardwood Flat comprises the NCNHP types Non-Riverine Wet Hardwood Forest, Wet Marl Forest, and successional forests in similar landscape positions. Hardwood Flats are included in the NCDCM wetland type of Hardwood Flats. Hardwood Flat corresponds to the HGM class Flat (sub-class Mineral Soil). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-32

Photo 3-33

Hardwood Flat. These examples of Hardwood Flat are located south of the Pamlico River, Beaufort County (Photo 3-32), near the community of East Lake, Dare County (Photo 3-33), north of Phelps Lake, Washington County (this wetland had recently suffered storm damage from Hurricane Isabel) (Photo 3-34), and on an interstream flat east of I-95 in northern Robeson County (Photo 3-35).

Photo 3-34

Photo 3-35

3.1.7 Non-Riverine Swamp Forest

Non-Riverine Swamp Forests occur primarily in the embayed region (the northeastern Middle Atlantic Coastal Plain ecoregion; see Figure 1 and Appendix E) on poorly drained, interstream flats not contiguous with streams, rivers, or estuaries. This wetland type is seasonally to semi-permanently inundated with hydrology driven by groundwater discharge, overland runoff, and/or precipitation rather than overbank or tidal flooding. Non-Riverine Swamp Forest is typically characterized by hummocky ground surface relief that provides good water storage. This wetland type occurs on mucky mineral or organic soils. Non-Riverine Swamp Forest is typically characterized by forest vegetation, often dominated by bald cypress (*Taxodium distichum*), black gum (*Nyssa biflora*), Atlantic white cedar (*Chamaecyperis thyoides*), loblolly pine (*Pinus taeda*), pond pine (*P. serotina*), tulip poplar (*Liriodendron tulipifera*), and red maple (*Acer rubrum*).

Reference wetlands (see Section 3.2) are available for this type. This wetland type varies in size, but may be quite extensive in the northeastern Middle Atlantic Coastal Plain ecoregion. Non-Riverine Swamp Forest transitions to Pocosin, Hardwood Flat, or Pine Flat with decreasing wetness and to Riverine Swamp Forest in proximity to riparian or tidal systems and large open waters (20 acres or larger, Cowardin et al. 1979).

Non-Riverine Swamp Forest includes NCNHP types Nonriverine Swamp Forest, Peatland Atlantic White Cedar Forest, Maritime Swamp Forest, and Maritime Shrub Swamp. This wetland type is included in the NCDCM wetland type of Swamp Forest and Maritime Forest on coastal islands. Non-Riverine Swamp Forest corresponds to HGM classes Depression (sub-classes Isolated Groundwater and Isolated Precipitation) and Flat (sub-classes Organic Soil and Mineral Soil). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-36

Photo 3-37

Photo 3-38

Non-Riverine Swamp Forest. These examples of Non-Riverine Swamp Forest are in Buckridge Estuarine Reserve in southeastern Tyrrell County (Photo 3-36); between US 64 and the Albemarle Sound in northeastern Tyrrell County (Photo 3-37); and in a hurricane-damaged area west of Phelps Lake, Washington County (Photo 3-38).

3.1.8 Pocosin

Pocosins are found in the Coastal Plain ecoregions (see Figure 1 and Appendix E) on poorly drained, interstream flats and in basins of various sizes such as peat-filled Carolina bays. Pocosins can be seasonally saturated or inundated by a high or perched water table. The primary source of water is a high water table resulting from precipitation and slow drainage, but, rarely, Pocosins are found in proximity to surface waters. Pocosins occur on mineral or organic soils. Vegetation is dominated by dense, waxy evergreen shrubs that typically include gallberries (*Ilex* spp.), fetterbushes (*Leucothoe* spp.), honey-cup (*Zenobia pulverulenta*), and bamboo-vine (greenbrier – *Smilax laurifolia*) often mixed with pond pine (*Pinus serotina*) and evergreen hardwoods such as loblolly bay (*Gordonia lasianthus*), swamp bay (*Persea palustris*), and sweet bay (*Magnolia virginiana*).

Pocosin vegetation structure may take a variety of forms, resulting in the need for the assessor to be familiar with multiple sub-type reference wetlands (see Section 3.2) (see corresponding NCNHP wetland types below). Pocosin may transition to a variety of wetland types depending on topography, hydrologic regime, and disturbance including Non-Riverine Swamp Forest, Pine Savanna, Pine Flat, Hardwood Flat, Riverine Swamp Forest, Salt/Brackish Marsh, Non-Tidal Freshwater Marsh, and Estuarine Woody Wetland. Areas of this wetland type vary greatly in size dependent on landscape position. The extent of the wetland type may not be apparent in the field or with the use of aerial photography due to past disturbance; however, soils mapping may prove useful in determining the potential extent of Pocosin prior to disturbance. Appendix D contains a list of soils that are known to typically support Pocosin; more specifically, these soils typically support a vegetation community dominated by dense waxy shrub species and that includes pond pine and/or bays. This list is not considered to be all-inclusive, but rather a guide for use when estimating the original aerial extent of a Pocosin.

Pocosin comprises NCNHP types Low Pocosin, High Pocosin, Pond Pine Woodland, Small Depression Pocosin, and Bay Forest. Pocosins are included in the NCDCM wetland type of Pocosin along with some of the Pine Flat wetland type if it is dominated by pond pine. Pocosin corresponds to the HGM classes Flat (sub-classes Mineral Soil and Organic Soil) and Depression (sub-classes Isolated Groundwater and Isolated Depression). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-39

Photo 3-40

Photo 3-41

Photo 3-42

Photo 3-43

Pocosin. These examples of Pocosin are the low pocosin sub-type, Brunswick County (Photo 3-39); the high pocosin subtype, Brunswick County (Photo 3-40); intensively managed Pocosin within a power line corridor, Brunswick County (Photo 3-41); a pond pine woodland dominated by pond pine and loblolly bay in Alligator River National Wildlife Refuge, Dare County (Photo 3-42); and a double Carolina bay, Bladen County (Photo 3-43).

3.1.9 Pine Savanna

Pine Savannas are found in the Coastal Plain ecoregions (see Figure 1 and Appendix E) on poorly drained, interstream flats. These areas are usually seasonally saturated by a high water table or poor drainage, but have a shorter hydroperiod than Non-Riverine Swamp Forest. The primary sources of water are a high water table resulting from precipitation and overland runoff. This wetland type is characterized by relatively flat ground surface that provides little surface water storage. Pine Savannas are maintained by frequent, low-intensity fires and occur on mineral soils. This wetland type is dominated by long-leaf (*Pinus palustris*) and pond pine (*P. serotina*), with scattered, low shrubs such as little gallberry (*Ilex glabra*), creeping blueberry (*Vaccinium crassifolium*), common wax-myrtle (*Morella cerifera*), and dangleberry (*Gaylussacia frondosa*) (Schafale and Weakley 1990) and grassy ground cover (dominated by grasses, sedges, composites, orchids, and lilies (Schafale and Weakley 1990) in reference condition. Regular burns provide conditions for very high herb species diversity.

Reference wetlands (see Section 3.2) are available for this type; the few examples remaining in North Carolina are located primarily in the southeastern portion of the state. Size of this wetland type is dependent on long-term fire frequency. Pine Savanna can transition to Pocosin and Pine Flat.

Pine Savanna corresponds to NCNHP types Wet Pine Flatwoods and Pine Savannas. Pine Savannas are included in the NCDCM wetland type of Pine Flats. Pine Savanna corresponds to the HGM class Flat (sub-class Mineral Soil). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-44

Photo 3-45

Pine Savanna. These examples of Pine Savanna are both from Brunswick County and are located within the Military Ocean Terminal, Sunny Point (Photo 3-44) and along NC 211 in the Green Swamp (Photo 3-45).

3.1.10 Pine Flat

Pine Flats are found primarily in the Coastal Plain ecoregions (see Figure 1 and Appendix E) on poorly drained interstream flats. These areas are usually seasonally saturated or intermittently to seasonally inundated by a high water table or poor drainage. The primary source of hydrology is a high water table resulting from precipitation and overland runoff. Pine Flats generally occur on mineral soils. This wetland type may be dominated by forest, early successional forest/shrub, or managed pine plantation. Common canopy trees are pines including loblolly (*Pinus taeda*) and slash pine (*P. elliottii*), and may include a large component of red maple (*Acer rubrum*) and sweetgum (*Liquidambar styraciflua*). The shrub component is typically not dense and may include horsesugar (*Symplocos tinctoria*), American holly (*Ilex opaca*), swamp bay (*Persea palustris*), coastal white alder (sweet pepperbush – *Clethra alnifolia*), and common wax-myrtle (*Morella cerifera*).

Almost all Pine Flats are successional in nature and represent altered variants of Pine Savanna, Hardwood Flat, or Non-Riverine Swamp Forest; therefore, there are no reference wetlands for this type (see Section 3.2). This wetland type is typically managed and is often characterized by low species diversity and structural complexity, which decreases the Habitat function of this wetland. Pine Flats may vary widely in size, but can be quite large, dependent on landscape position and disturbance. Pine Flat can transition to Pocosin, Pine Savanna, Hardwood Flat, and Non-Riverine Swamp Forest on interstream flats; to Headwater Forest at the upper extent of drainage slopes; and to Estuarine Woody Wetland and Salt/Brackish Marsh in the embayed portion of the Middle Atlantic Coastal Plain ecoregion.

This wetland type has no NCNHP counterpart, but includes disturbed variants of several types of non-alluvial forests such as Nonriverine Wet Hardwood Forest, Nonriverine Swamp Forest, Wet Pine Flatwoods, and Pine Savanna. Pine Flat is included in the NCDCM wetland type of Pine Flat and Managed Pineland. Pine Flat corresponds to the HGM class Flat (sub-class Mineral Soil). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-46

Photo 3-47

Photo 3-48

Photo 3-49

Pine Flat. These examples of Pine Flat are south of the Pamlico River, Beaufort County (Photo 3-46); east of I-95 in northern Robeson County (Photo 3-47); south of US 64, Tyrrell County (Photo 3-48); and east of Havelock, Craven County (Photo 3-49).

3.1.11 Basin Wetland

Basin Wetlands occur throughout the state in depressions surrounded by uplands (usually on interstream flats or in localized depressions). This wetland type may also occur on the fringe of small open waters (less than 20 acres in size). Wetlands fringing larger water bodies are subject to hydrology more closely matching riparian conditions and are therefore considered Riverine Swamp Forest or Non-Tidal Freshwater Marsh. The size threshold used to determine small versus large open waters was taken from Cowardin et al. (1979). Basin Wetlands are seasonally to semi-permanently inundated but may lose surface hydrology during later portions of the growing season. Sources of water are perched groundwater, groundwater discharge, overland runoff, and precipitation. Seasonal waterlines are often apparent on the vegetation. Basin Wetlands generally occur on mineral soils. Basin Wetlands may be characterized by a variety of mineral soil types ranging in particle size and type from sandy soils associated with Coastal Plain lime sinks and inter-dune swales to clay-based soils underlying mafic depressions. Vegetation structure within this wetland type may vary widely from forest in mafic depressions and ephemeral pools, to primarily herbaceous or emergent in lime sinks, man-excavated depressions, and along the shorelines of small open waters.

Reference wetlands (see Section 3.2) are available for some forms of this wetland type, but since this wetland type is so heterogeneous, an assessor must recognize that an appropriate reference must be considered on a case-by-case basis. Sub-types of Basin Wetland that are considered to have reference wetlands include mafic depressions and Carolina bays. Non-reference Basin Wetlands most frequently include the wetland edges of excavated farm ponds. Basin Wetlands vary in size based on the variable landscape positions that they may occupy. This wetland type is generally surrounded by uplands, but may occasionally transition to Pine Savanna, Pocosin, or Pine Flat.

Basin Wetland comprises NCNHP types Vernal Pool, Cypress Savanna, Upland Depression Swamp Forest, Small Depression Pond, Inner Dune Pond, and Upland Pool. This wetland type is not separately identified in the NCDCM methodology, but would likely be included in the Swamp Forest (non-riverine) and Freshwater Marsh in some cases. Basin Wetland corresponds to the HGM classes Depression (sub-classes Isolated Groundwater, Isolated Precipitation, and Human Impounded or Excavated) and Estuarine (sub-class Impounded). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-51

Photo 3-50

Photo 3-52

Photo 3-53

Basin Wetlands. These examples of Basin Wetland are a mafic depression on an interstream divide, Mecklenburg County (Photo 3-50), an herb-dominated wetland within an interdune swale at Cape Lookout, Carteret County (Photo 3-51); a woody vegetation-dominated wetland within an inter-dune swale on Bogue Banks, Carteret County (Photo 3-52); and a grass and sedge-dominated limesink depression within Carolina Beach State Park, New Hanover County (Photo 3-53).

3.1.12 Bog

Bogs are typically found in the Blue Ridge and Northern Inner Piedmont ecoregions (see Figure 1 and Appendix E). This wetland type occurs in geomorphic floodplains or natural topographic crenulations and is typically located on flat or gently sloping ground. Bogs are formed by a poorly understood combination of groundwater seepage and/or blocked overland runoff. This wetland type is at least semi-permanently saturated, but typically not inundated. Bogs occur on organic or mucky mineral soils, and this is a key feature in distinguishing Bogs from other wetland types. This wetland type is generally transitional in nature and may therefore be found in many forms, from forested to lacking canopy trees, and with sparse ground cover to dense mats of moss and herbs. Bogs are frequently impacted by beaver, and if beaver activity causes long-term inundation, areas formerly supporting Bog may transition to Non-Tidal Freshwater Marsh.

Although sphagnum mosses (*Sphagnum* spp.) are commonly present in Bogs, they do not occur in all Bogs. In general, vegetation structure may vary, but typically occurs in one of two forms: 1) dominated by dense herbaceous or mixed shrub/herbaceous vegetation with herbs consisting of small, grass-like plants and forbs with or without tree canopy and 2) tree cover over much of the wetland area and dense herb cover limited to small openings. Indicative herbaceous species include sphagnum moss, various sedges – upright sedge (*Carex stricta*), nodding sedge (*C. gynandra*), prickly bog sedge (*C. atlantica*), bristlystalked sedge (*C. leptalea*), three seeded sedge (*C. trisperma*), long sedge (*C. folliculata*), and Collins sedge (*C. collinsii*) – cinnamon fern (*Osmunda cinnamomea*), royal fern (*O. regalis*), melic mannagrass (*Glyceria melicaria*), roundleaf goldenrod (*Solidago patula*), white beaksedge (*Rhynchospora alba*), Pennsylvania rush (*Juncus gymnocarpus*), woodland rush (*J. subcaudatus*), various pitcher-plants – purple pitcher-plant (*Sarracenia purpurea*), Jones' pitcher-plant (*S. jonesii*), and green pitcher-plant (*S. oreophila*) – smooth sawgrass (*Cladium mariscoides*), and cotton grass (*Eriophorum virginicum*). Indicative shrub species include possumhaw (*Viburnum nudum*), northern wild raisin (*V. cassinoides*), tag alder (*Alnus serrulata*), swamp rose (*Rosa palustris*), winterberry (*Ilex verticillata*), long-stalked holly (*I. collina*), and Canada yew (*Taxus canadensis*).

Reference wetlands (see Section 3.2) are available for this type, but due to the variability of vegetation structure found in Bogs, an assessor must recognize the proper reference type. This wetland type is typically limited in size by the availability of flat, wet sites in the Blue Ridge and western Piedmont ecoregions. A Bog can transition to Seep, Headwater Forests, Bottomland Hardwood Forest, or Non-Tidal Freshwater Marsh or may be surrounded by non-jurisdictional bottomlands or uplands. A Bog can be distinguished from Seep by a lack of slope, from Headwater Forest by presence of organic or mucky mineral soils, and from Bottomland Hardwood Forest and Non-Tidal Freshwater Marsh by lack of surface inundation.

Bog includes NCNHP types Southern Appalachian Bog (Northern and Southern Subtypes), Southern Appalachian Fen, and Swamp Forest–Bog Complex (Typic and Spruce Subtypes). This type is not separately identified with the NCDCM wetland mapping since this wetland type is not found in the Coastal Plain ecoregions. Bog corresponds to HGM classes Riverine (sub-classes Headwater Complex and Lower Perennial) and Depression (sub-class Surface-connected). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-54

Photo 3-55

Bog. These examples of Bog are located on an unnamed tributary to Cranberry Creek, Avery County (Photo 3-54); in the Pink Beds on an unnamed tributary to the South Fork Mills River, Transylvania County (Photo 3-55); on an unnamed tributary to Price Creek, Watauga County (Photo 3-56); and at Franklin Bog on Blyths Mill Creek, Henderson County (Photo 3-57).

Photo 3-56

Photo 3-57

Photo 3-58

Photo 3-59

Bog. These examples of Bog are located on Dry Branch, near the Transylvania/Henderson County border (Photo 3-58); at the foot of The Nooks in the Little River floodplain, Transylvania County (Photo 3-59); in the floodplain of Tom Creek, Transylvania County (Photo 3-60); and in the vicinity of the Pisgah Forest National Fish Hatchery in the Davidson River floodplain, Transylvania County (Photo 3-61). Dry Branch bog currently supports an early successional forest. Woody vegetation in the Fish Hatchery Bog has been removed to enhance bog turtle habitat.

Photo 3-60

Photo 3-61

3.1.13 Non-Tidal Freshwater Marsh

Non-Tidal Freshwater Marshes are found throughout the state in geomorphic floodplains, in natural topographic crenulations, or contiguous with open waters 20 acres or larger (Cowardin et al. 1979). These wetlands are subject to semi-permanent inundation or saturation, but are typically not subject to regular or occasional flooding by tides, including wind tides (regardless of whether or not the tidal waters reach wetlands through natural or artificial watercourses). Non-Tidal Freshwater Marshes occur on mineral or organic soils. Vegetation within this wetland type is predominantly herbaceous (less than 50 percent coverage by living woody species).

Due to the transitional nature of this wetland type, reference wetlands are not available for this type (see Section 3.2). Since this general wetland type has no reference, the condition of Non-Tidal Freshwater Marshes may be difficult for an assessor to discern. Indicators of condition degradation within this wetland type may include dead vegetation, ditching, spoil piles, reduced size, lack of vegetation diversity, and presence of invasive species. The size of these marshes varies depending on landscape position from very small to rarely 50 acres or more. Non-Tidal Freshwater Marsh can transition to other riparian wetlands such as Bottomland Hardwood Forest, Riverine Swamp Forest, and Headwater Forest.

Non-Tidal Freshwater Marshes may occur naturally along the fringes of streams, rivers, and large open waters, whether man-made or natural (example: beaver impoundments). These wetlands also commonly occur in association with regularly disturbed areas (maintained utility-line corridors) in the aforementioned landscape positions. Other wetland types with similar hydroperiods (Riverine Swamp Forest, Non-Riverine Swamp Forest, Bog, Seep) may acquire marsh-like vegetation due to disturbance (examples: fire or clear-cuts). However, when identifying the wetland type, an assessor will need to determine whether the full range of stable, existing wetland parameters better resemble Non-Tidal Freshwater Marsh or another wetland type that existed prior to disturbance. Freshwater marshes found outside of geomorphic floodplains or natural topographic crenulations and contiguous with small (less than 20 acres) open waters are considered Basin Wetlands. Localized depressions that are dominated by woody vegetation and located within geomorphic floodplains or adjacent to tributaries are considered Floodplain Pools.

Non-Tidal Freshwater Marsh includes NCNHP types Piedmont/Mountain Semipermanent Impoundment (part), Coastal Plain Semipermanent Impoundment (part), and Natural Lake Shoreline (part). This type is included in the NCDCM wetland type of Freshwater Marsh. Non-Tidal Freshwater Marsh corresponds to HGM classes Riverine (sub-classes Headwater Complex, Beaver Impounded, and Human Impounded), Lacustrine Fringe (sub-classes Semipermanently Flooded and Reservoir), and Depression (sub-class Surface-connected). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-62

Photo 3-63

Non-Tidal Freshwater Marsh. These examples of Non-Tidal Freshwater Marsh are located on a beaver impounded oxbow of the North Fork Mills River, Henderson County (Photo 3-62); on a beaver-impounded reach of an unnamed tributary to the Rocky River, Cabarrus County (Photo 3-63); within the Haw River floodplain, Guilford County (Photo 3-64); and along an intensively managed utility line corridor through the Haw River floodplain, Rockingham County (Photo 3-65).

Photo 3-64

Photo 3-65

Photo 3-66

Photo 3-67

Non-Tidal Freshwater Marsh. These examples of Non-Tidal Freshwater Marsh are located on a man-impounded reach of an unnamed tributary to McPherson Creek, Cumberland County (Photo 3-66); in association with a beaver dam spillway on an unnamed tributary to Little River, Transylvania County (Photo 3-67); at the upper end of a man-made impoundment on Stewarts Creek, Hoke County (Photo 3-68); and in a beaver impoundment in the floodplain of Jimmy's Creek, Davidson County (Photo 3-69).

Photo 3-68

Photo 3-69

3.1.14 Floodplain Pool

Floodplain Pools are found throughout the state in geomorphic floodplains. These wetlands often occur in abandoned stream or river channels (oxbows) or in localized depressions near the toe of slopes. They are generally small in size, typically occur on mineral soils, and are semi-permanently inundated. Sources of water are primarily ground water, precipitation, and sometimes overbank flooding. A distinctive feature of Floodplain Pools is that they usually dry out at some point of the year and thereby provide important habitat for amphibians due to the lack of fish communities. Trees characteristic of wetland and upland floodplains and levees are commonly found around the edge of the pool rather than growing within the pool. Vegetation within the pool can be sparse or variable with a variety of ferns, sedges, and other herbaceous plants present.

Reference wetlands (see Section 3.2) are available for this type. Floodplain Pool can transition to Bottomland Hardwood Forest, Riverine Swamp Forest, and Bog or may be surrounded by uplands. Relative to Riverine Swamp Forest, Floodplain Pools typically support vegetation only on the periphery and exist as local depressions. Floodplain Pools can be distinguished from Bogs by hydrology and soils. Floodplain Pools are characterized by semi-permanent inundation, while Bogs are characterized by long-duration saturation and little or no inundation. Floodplain Pools typically occur on mineral soils, while Bogs typically occur on organic or mucky mineral soils. Floodplain Pools near the outer boundary of geomorphic floodplains may transition to Seeps along the toe of the valley wall. As stated above, Floodplain Pools are generally small in size.

Floodplain Pool corresponds to the NCNHP type of Floodplain Pool. This wetland type is not separately identified within the NCDCM wetland classification system. Floodplain Pool corresponds to the HGM classes Riverine (sub-classes Headwater Complex, Intermittent-Upper Perennial, and Lower Perennial) and Depression (sub-class Surface-connected). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-70

Photo 3-71

Floodplain Pool. These examples of Floodplain Pool are located in the floodplain of Ready Branch, Martin County (Photo 3-70), the floodplain of Swift Creek at Hemlock Bluffs Nature Preserve, Wake County (Photo 3-71), the floodplain of Speight Branch, Wake County (Photo 3-72), and at the foot of The Nooks in the floodplain of Little River, Transylvania County (Photo 3-73).

Photo 3-72

Photo 3-73

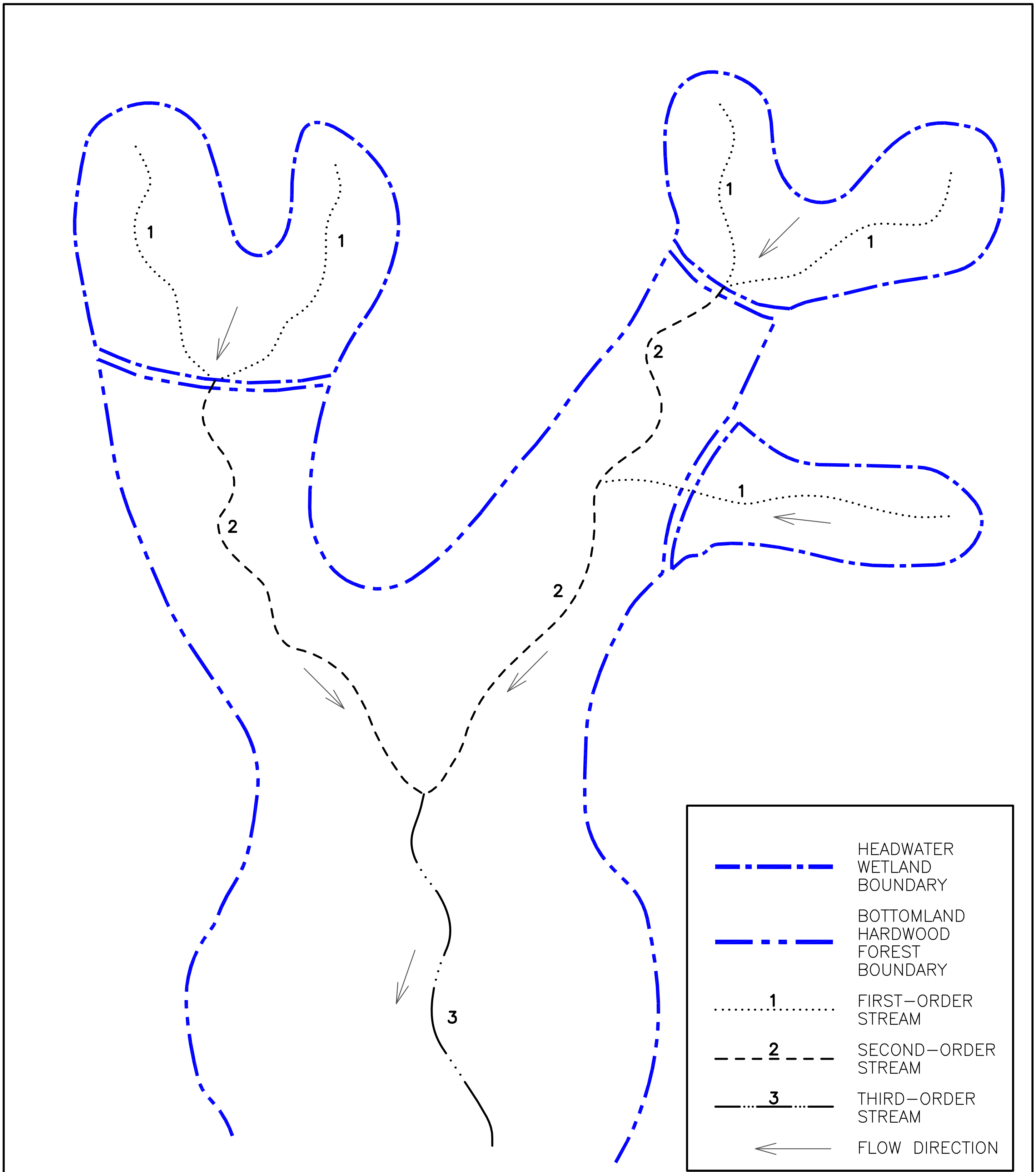
3.1.15 Headwater Forest

Headwater Forests are found throughout the state in geomorphic floodplains of first-order or smaller streams and in topographic crenulations without a stream. For the purposes of NC WAM, zero-order streams are tributaries not shown on the USGS 7.5-minute quadrangle and first-order streams are the lowest-order streams shown on the USGS 7.5-minute quadrangle (see Appendix C for guidance on stream-order determinations). Guidance for the identification of a natural topographic crenulation is provided in Section 3.4 and in the Glossary of Terms (Appendix I).

Groundwater seepage and diffuse surface flow are often important sources of water, and this wetland type frequently has surface flow, especially through ephemeral channels. Overbank flooding is not a substantial source of water, and Headwater Forests are relatively dry when compared to other riparian wetland types. This wetland type is characterized by relatively flat ground surface that provides little water storage. Headwater Forests generally occur on mineral soils that may be intermittently inundated by surface water or seasonally saturated to semi-permanently saturated.

Hardwood tree and shrub species (examples: swamp chestnut oak [*Quercus michauxii*], hackberry [*Celtis laevigata*], sycamore [*Platanus occidentalis*], green ash [*Fraxinus pennsylvanica*], red maple [*Acer rubrum*], American hornbeam [ironwood – *Carpinus caroliniana*], tulip-tree [*Liriodendron tulipifera*], American elm [*Ulmus americana*], American holly [*Ilex opaca*], silky dogwood [*Cornus amomum*], and spicebush [*Lindera benzoin*]) are the predominant vegetation from most of the Southeastern Plains ecoregion (Figure 1) westward. Within the Sandhills level IV ecoregion (see Appendix E), typical species include pond pine (*Pinus serotina*) and/or Atlantic white cedar (*Chamaecyparis thyoides*). Species typically present and sometimes predominant in the Middle Atlantic Coastal Plain ecoregion include bald cypress (*Taxodium distichum*), black gum (*Nyssa biflora*), and water tupelo (*N. aquatica*).

Reference wetlands (see Section 3.2) are available for this type, but vary in characteristics among ecoregions. The size of Headwater Forests may vary depending on hydrology, topography, and ecoregion; and Headwater Forests can gradually grade into other wetland types making their identification problematic. In areas with steeper topography (Southeastern Plains ecoregion [see Figure 1 and Appendix E] and westward), these wetlands will typically be restricted in size and may grade up slope to Seep and down slope to Bottomland Hardwood Forest and Riverine Swamp Forest; while, in areas with more gentle topography (Middle Atlantic Coastal Plain ecoregion), these wetlands may be broader and may grade up slope into non-riparian wetland types (Seep, Pocosin, Hardwood Flat, Pine Flat, Pine Savanna, and Non-Riverine Swamp Forest) and down slope to Bottomland Hardwood Forest and Riverine Swamp Forest. Headwater Forest is distinguished from Bottomland Hardwood Forest by stream order. See Figure 2 for an example of how to delineate the difference between a Headwater Forest and a Bottomland Hardwood Forest at the confluence of a first-order stream and a second-order stream. Headwater Forest is distinguished from Riverine Swamp Forest by duration of surface



NC WAM USER MANUAL

HEADWATER WETLAND/BOTTOMLAND HARDWOOD FOREST STREAM-ORDER BOUNDARY DETERMINATION

FIGURE

2

inundation (see Section 3.4 for a discussion concerning this determination); however, Headwater Forest may be characterized by long-duration saturation (but not inundation) and therefore support plant species typical of a Riverine Swamp Forest. Headwater Forest is distinguished from Bog by soils; Headwater Forest typically occurs on mineral soils, while Bogs typically occur on organic or mucky soils. Headwater Forest is distinguished from contiguous non-riparian wetlands by its occurrence in a geomorphic floodplain or natural topographic crenulation. Field indicators of some surface flow may aid in making this determination. However, a Seep may be characterized by flowing surface water, but this wetland type occurs on a slope outside of a geomorphic floodplain and not in a natural topographic crenulation. Pocosin, Hardwood Flat, Pine Flat, Pine Savanna, and Non-Riverine Swamp Forest may be characterized by surface saturation or inundation for various lengths of time, but these non-riparian wetlands will typically not show signs of directional flow, while Headwater Forest will. Finally, Headwater Forests in the Sandhills level IV ecoregion (see Appendix E) are sometimes abutting tributaries with no well-developed floodplain, in which overbank flooding is not common due to the high porosity of the soil. In this landscape position, Headwater Forests may have some of the vegetation components of Pocosins.

Headwater Forests correspond to NCNHP types Piedmont/Low Mountain Alluvial Forest, Coastal Plain Small Stream Swamp (part), Streamhead Atlantic White Cedar Forest, and Streamhead Pocosin. This type is included in the NCDCM wetland type of Headwater Forest. Headwater Forest corresponds to the HGM class Riverine (sub-classes Headwater Complex and Intermittent–Upper Perennial). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-74

Photo 3-75

Headwater Forest. Headwater forests depicted by both Photo 3-74 and Photo 3-75 are located in Cumberland County, the former on an unnamed tributary to Bones Creek, and the latter on an unnamed tributary to Rockfish Creek.

Photo 3-76

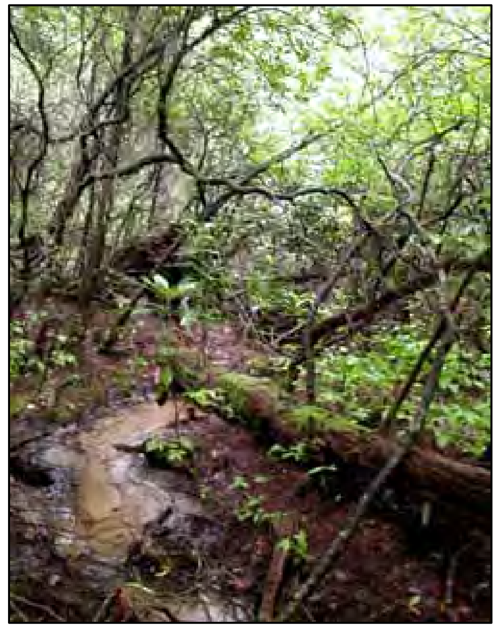


Photo 3-77

Headwater Forest. These examples of Headwater forest are located in upper Porter Creek, Beaufort County (Photo 3-76); a first-order unnamed tributary to the South Fork of the French Broad River, Transylvania County (Photo 3-77); a Headwater Forest located along a first-order unnamed tributary to Hominy Creek, Buncombe County (Photo 3-78) (this Headwater Forest occurs on a sediment delta at the head of a beaver impoundment on a first-order stream); and upslope of a Bog in the floodplain of Dry Branch, on the border of Transylvania and Henderson Counties (Photo 3-79).

Photo 3-78

Photo 3-79

3.1.16 Bottomland Hardwood Forest

Bottomland Hardwood Forests are found throughout the state in geomorphic floodplains of second-order and larger streams (see Appendix C for guidance on stream-order determinations). These wetlands are generally intermittently to seasonally inundated. Overbank flooding can be an important source of water as can groundwater and surface runoff. Overbank flooding may be less influential for Bottomland Hardwood Forests west of the Middle Atlantic Coastal Plain ecoregion (see Figure 1 and Appendix E). Bottomland Hardwood Forests along brownwater streams receive more sediment and nutrients from overbank flooding than those found along blackwater streams. This wetland type is generally characterized by ground surface relief that provides good water storage. Bottomland Hardwood Forests generally occur on mineral soils. This wetland type is dominated by a variety of hardwood tree species including various oaks (*Quercus* spp.), red maple (*Acer rubrum*), ashes (*Fraxinus* spp.), sycamore (*Platanus occidentalis*), sweetgum (*Liquidambar styraciflua*), box elder (*Acer negundo*), hackberry (*Celtis laevigata*), and American elm (*Ulmus americana*).

Reference wetlands (see Section 3.2) are available for Bottomland Hardwood Forest, but vary widely in character among different floodplain sizes and the various regions of the state. The size and extent of these wetlands are dependent on floodplain size and disturbance. While smaller-order streams will typically support narrower wetlands, these wetlands may be extensive along the length of the floodplain. Bottomland Hardwood Forest may contain Floodplain Pools and may transition up slope to Headwater Forest and down slope to Riverine Swamp Forest. In the Coastal Plain ecoregions, Bottomland Hardwood Forest often occurs in extensive mosaics with Riverine Swamp Forest. See Figure 2 for an example of how to delineate the difference between a Headwater Forest and a Bottomland Hardwood Forest at the confluence of a first-order stream and a second-order stream.

Bottomland Hardwood Forest correlates to the NCNHP types Coastal Plain Bottomland Hardwoods (Blackwater and Brownwater Subtypes), Coastal Plain Levee Forest (Blackwater and Brownwater Subtypes), Piedmont/Mountain Levee Forest, Piedmont/Mountain Bottomland Forest, Montane Alluvial Forest, and part of Piedmont/Low Mountain Alluvial Forest. Bottomland Hardwood Forest is included in the NCDCM wetland type of Bottomland Hardwood Forest. Bottomland Hardwood Forest corresponds to the HGM class Riverine (sub-classes Headwater Complex, Intermittent–Upper Perennial, and Lower Perennial). Appendix B provides a cross-reference of wetland types across three classification systems.

Photo 3-80

Photo 3-81

Bottomland Hardwood Forest. Photos 3-80 and 3-81 are examples of Bottomland Hardwood Forest located in association with unnamed tributaries to the Cape Fear River, Cumberland County; Photo 3-82 is located in the Swift Creek floodplain, Wake County; and Photo 3-83 depicts the Little Creek floodplain at the headwaters of Jordan Lake, Durham County. Vegetation in Photo 3-82 is early secondary growth, while shrub and herb growth in Photo 3-83 is sparse due to extended surface inundation resulting from management of the area as a waterfowl impoundment.

Photo 3-82

Photo 3-83

Photo 3-84

Photo 3-85

Bottomland Hardwood Forest. Photos 3-84 and 3-85 are more examples of Bottomland Hardwood Forest in Wake County. Photo 3-84 depicts a clear-cut portion of the Swift Creek floodplain, and Photo 3-85 depicts the outer edge of a floodplain on a greater than second order unnamed tributary of Little Branch. Photos 3-86 and 3-87 are examples of disturbed Bottomland Hardwood Forests located in Cumberland and Hoke County, respectively. Photo 3-86 depicts a wetland maintained as a utility line corridor abutting Rockfish Creek, and Photo 3-87 depicts an area abutting Horsepen Branch that was formerly inundated as part of a beaver impoundment.

Photo 3-86

Photo 3-87

3.2 Wetlands and Reference

An understanding of the concept of a reference wetland is crucial for the appropriate use of NC WAM. A reference wetland (or wetland in reference condition) is a discrete wetland identified as a typical, representative, or common example of that particular wetland type without, or removed in time from, substantial human disturbance.

For the purposes of NC WAM, the term "reference wetland" includes a range of biotic and abiotic characteristics within each recognized wetland type and is synonymous with "relatively undisturbed." A reference wetland indicates quality along with the presence of expected functions for each general wetland type. An appropriate reference wetland needs to be comparable to the wetland being assessed, sometimes at a finer scale of resolution than the general wetland type. The reference wetland can thus serve to indicate what Hydrology, Water Quality, and Habitat functions the wetland under evaluation would have if it were unaltered.

3.2.1 Wetlands with Reference

NC WAM considers reference wetlands to be available for all general wetland types with the exception of Pine Flat, Non-Tidal Freshwater Marsh, and some sub-types of Basin Wetland (see Section 3.1 for descriptions). Sub-types of Basin Wetland that are considered to have reference wetlands include mafic depressions and Carolina bays.

In order to properly utilize NC WAM, assessors will need to be familiar with the physiography, hydrologic regime, water quality function, typical vegetation structure and composition, and wildlife attributes for the range of reference examples in each general wetland type. Currently, the best source of information concerning the location of reference wetlands is NCNHP mapping, which documents the locations of natural communities of North Carolina. Communities documented on this map base have been identified according to Classification of the Natural Communities of North Carolina: Third Approximation (Schafale and Weakley 1990). These NCNHP wetland community designations are cross-referenced with NC WAM wetland types in the NC WAM wetland type descriptions (Section 3.1) and the wetland type cross-reference provided in Appendix B. A Geographic Information System (GIS) database (the NC WAM "Tool Box," see Section 5.1.2) provides on-site information about wetlands evaluated with the use of NC WAM. One of the resources intended to be available with this product will be the location and identification of wetlands considered to be in reference condition. Additional information provided for each reference wetland contained within the NC WAM "Tool Box" will include associated site mapping (aerial photography, topographic mapping, soils mapping), completed Field Assessment Form, Wetland Rating Sheet, and on-site photographs.

Because some of the general wetland types are heterogeneous in certain characteristics, it may be necessary to choose a site-specific reference – one that matches the site under evaluation more precisely than merely belonging to the same general wetland type. One example is Bottomland Hardwood Forest. Reference wetlands for Bottomland Hardwood Forest might be quite different among ecoregions. For example, overbank flooding is often less influential for Bottomland Hardwood Forests west of the Middle Atlantic Coastal Plain ecoregion than those east of this ecoregion. Bottomland Hardwood Forests along brownwater streams receive more sediment and nutrients from overbank flooding than examples of this wetland type found along blackwater streams. Another example is Pocosin. The Pocosin general wetland type ranges widely in characteristics: from woodlands with substantial tree canopy on mucky mineral soils to nearly treeless shrub lands on deep peats. The appropriate site-specific reference for a Pocosin with mucky mineral soil is a relatively undisturbed Pocosin with mucky mineral soil, rather than one with deep peat. Absence of trees in the case of a Pocosin with mucky, deep, peat soil would not be considered a departure from reference.

For a few rare types, condition may need to be judged on its own merits against a conceptual reference condition synthesized from multiple altered remnants of the appropriate wetland type and literature review (examples: Pine Savanna and Seep). An important environmental factor for the maintenance of Pine Savanna is fire. Some Pine Savannas currently exist in areas subject to management with controlled burns, which maintains these wetlands in reference condition. Others exist in relatively undisturbed areas where fire is suppressed, resulting in a wetland type shift toward Pine Flat or Pocosin. The assessor will need to consider the true reference condition, characterized by regular fire events, when evaluating this wetland type. Seeps usually occupy small areas and can therefore be degraded by relatively local activities. Again, an assessor will need to consider the reference condition of an undisturbed seep in the appropriate landscape when evaluating this wetland type.

3.2.2 Wetlands without Reference

Some wetlands will not have a usable reference. Pine Flat, Non-Tidal Freshwater Marsh, and some sub-types of Basin Wetland (for instance, freshwater marshes in man-made depressions) consist largely of successional wetlands for which a natural reference condition is not distinguishable. The same metrics are used by NC WAM to generate functional ratings for both wetlands with reference and wetlands without reference, so it is important that the assessor be knowledgeable concerning whether each general wetland type assessed can be evaluated relative to reference condition or not.

3.3 Intensively Managed Wetlands

Although not a true general wetland type, wetlands that are “intensively managed” include any wetland that has been severely altered or unintentionally created by humans and is maintained in a severely altered state. Intensively managed wetlands have degraded wetland functions, but the sites remain jurisdictional wetlands. These areas may include, but are not limited to, farmed wetlands and mowed wetlands within utility-line corridors. Intensively managed wetlands correspond to the NCDCM wetland types of Managed Pinelands, Human Impacted Wetlands, and Cleared Wetlands – if still jurisdictional. If an assessor determines that a specific wetland is intensively managed, NC WAM requires that the assessor document this fact on the Field Assessment Form (see pp. ix to xii), then proceed to classify the wetland.

3.4 Key to General Wetland Types

The initial step in the field application of NC WAM is to clearly identify the various wetland types found at the site to be evaluated. To this end, NC WAM uses the Dichotomous Key to General North Carolina Wetland Types (see pp. vii and viii) to assist assessors with identification.

Assessors will need to be familiar with characteristics of the general wetland types in order to properly utilize the key.

Within the key text, an underlined "and" (<u>and</u>) indicates that two or more conditions must be met to continue on a particular branch of the key. An underlined "or" (<u>or</u>) indicates that any one of multiple conditions can be met to continue on a particular branch of the key.

<u>It is important that the assessor walk the entire wetland area prior to making a determination as to the wetland type(s) present.</u> If the assessor believes a wetland can reasonably fit into more than one wetland type, the assessor may find it helpful to generate a list of wetland characteristics that fit each of the potential wetland types, or the assessor may consider rating the wetland as each potential wetland type. With this information, the assessor may use best professional judgment to determine the appropriate wetland type. The assessor should always document the decision-making process. If there is evidence suggesting that the wetland is a type other than the keyed type, the assessor should document this evidence then classify the wetland as the evidenced type.

3.4.1 Wetland Type Identification in Disturbed Areas

All wetlands should be evaluated in the context of landscape setting and recent history. Wetlands that have been subject to disturbance may be identified as degraded examples of general wetland types and/or as "intensively managed" wetlands on the Field Assessment Form. If identified as intensively managed, the subject wetland should still be identified as the appropriate general wetland type using the Dichotomous Key to General North Carolina Wetland Types.

The following rule will assist the assessor with the identification of wetland type in confusing, substantially modified, or disturbed situations.

> <u>Wetlands with alterations (man-made or natural) should generally be classified as the original, naturally occurring type if this determination can be made. However, if the full range of stable, existing, wetland parameters (vegetation, hydrology, and soils) better resembles another wetland type because of long-established, permanent alterations, it should be classified as this current, more appropriate type.</u>

The first sentence of the rule will typically allow the assessor to determine the appropriate wetland type for a disturbed wetland. The term "alteration" refers to a modification to one or more of the three wetland parameters: vegetation, hydrology, and soils. Examples of alterations not expected to result in a change in wetland type include increased stormwater inputs and clear-cuts. If a wetland has been disturbed but appears to be in a stable condition and progressing toward recovery, then the assessor should use the key to identify the wetland type based on current conditions. If a portion of a wetland has been altered, the assessor may look to nearby wetlands for guidance in determining the appropriate wetland type. If a large area, or all of a wetland, type has been altered, the assessor may look at area mapping (aerial photography, topographic mapping, soils mapping, and the NC WAM Tool Box [see Section

5.1.2]) to see if there are nearby areas with similar characteristics that may provide a clue as to the proper wetland type. If the decision between wetland types remains unclear, the assessor may choose to evaluate a wetland as both possible wetland types and use best professional judgment to determine which rating best approximates the level of function for the specific wetland (the Wetland Rating Sheet for both possible wetland types should be submitted to regulatory agencies for review). Wetlands in urban settings should be identified as the appropriate general wetland type and evaluated relative to reference examples of the general wetland type. NC WAM does not consider separate reference examples for urban wetlands.

The second sentence of the rule is used if an alteration has potentially affected all three wetland parameters and the alteration appears to be long-established and permanent. NC WAM considers the term "long-established, permanent alterations" to refer to alterations that have been ongoing for 10 or more years. In some cases, alterations or disturbances to wetlands may result in a change in wetland type. When such alterations affect all three wetland parameters to the degree that the wetland better resembles another wetland type, the assessor will need to determine if the subject wetland should be rated as a disturbed version of the pre-alteration wetland or if the subject wetland should be rated as the new, more appropriate type. Examples of alterations that may result in wetland type change include deliberately constructed, man-made impoundments/excavations and beaver impoundments. Beaver impoundments are generally not thought to result in a wetland type change in the short term (less than 10 years), but are expected to result in a wetland type change over the long term (if established for 10 years or more).

Another situation that will be encountered is man-made alterations that have unintentionally created wetlands. An example of this situation involves the placement of an underground pipeline in a floodplain that formerly did not contain wetlands. Introduction of the pipeline and associated back fill can result in a damming effect, slowing surficial drainage or impounding water long enough to result in development of wetlands. As stated above, these wetlands should be identified with the key based on their full range of stable, existing wetland parameters (vegetation, soils, and hydrology).

Examples of disturbed wetlands and confusing wetland types are provided by Photos 3-88 through 3-92.

In Photos 3-88 and 3-89, the Riverine Swamp Forest and Floodplain Pool, respectively, are subject to regular vegetation maintenance (intensive management), and even though hydrology and soils are affected, the wetlands have not stabilized as a new wetland type. It is reasonable to assume that if vegetation maintenance was terminated, these wetlands would be disturbed (at least in the short term) examples of the original wetland types. Photo 3-90 depicts a wetland on an interstream divide in the Mid-Atlantic Coastal Plain that was clear-cut and subject to severe soil disturbance approximately 10 years ago. Woody vegetation has not re-established as a dominant component since the clear-cutting. The apparently stable, existing wetland parameters appear to resemble a Non-Tidal Freshwater Marsh. However, the NC WAM wetland type key does not make Non-Tidal Freshwater Marsh an option for the interstream divide landscape position, so the assessor will need to use resources available in the field and through documentation to classify this wetland as a disturbed version of an appropriate wetland type for this landscape setting.

Photo 3-88

Photo 3-89

Photo 3-90

Photo 3-88 depicts an intensively managed utility line corridor across an unnamed tributary to the Cape Fear River, New Hanover County. Photo 3-89 depicts an intensively managed portion of the Ragsdale Creek floodplain, Buncombe County. Photo 3-90 depicts a wetland on an interstream divide that was clear-cut approximately 10 years ago.

Photo 3-91

Photo 3-92

Photo 3-91 depicts a gas line corridor across the Haw River floodplain, Rockingham County. Photo 3-92 depicts post hurricane scour pools on Ocracoke Island, Hyde County.

Photos 3-91 and 3-92 depict wetlands that have been altered to the degree that the full range of stable, existing, wetland parameters now better resemble another wetland type because of long-established, permanent alterations. Photo 3-91 depicts a gas line corridor across the floodplain of the Haw River. The floodplain intersecting this gas line corridor supports Riverine Swamp Forest. The insertion of the gas line resulted in excavation of a trench for the pipe and then replacement of the soil in the trench, resulting in a severe alteration to soil structure and ground surface slumping along the pipe line corridor. This wetland is within a geomorphic floodplain, is not a Bog, and is dominated by herbaceous vegetation, which leads the assessor to Non-Tidal Freshwater Marsh in the dichotomous key (key location II.B.ii.1).

Photo 3-92 depicts scour depressions on the sound side of Ocracoke Island following the passage of Hurricane Isabel in 2004. These areas were likely not wetlands at all prior to the hurricane, but are now considered wetlands. These wetlands are on a coastal island; in depressions surrounded by uplands; are not dominated by dense, waxy shrub species and not characterized by a peat-filled bay, which leads the assessor to Basin Wetland in the dichotomous key (key location II.A.ii.2.b).

3.4.2 Using the Dichotomous Key

Following is a discussion of decision making points used in the key to general wetland types. For guidance on determining wetland types in disturbed areas, see Section 3.4.1. An example for identifying wetland types within a delineated wetland complex is provided in Section 5.2.3.

- I. Wetland affected by lunar or wind tide, may include woody areas contiguous with tidal marsh
- II. Wetland not affected by tides

The first decision separates wetlands in terms of tidal versus non-tidal influence. The question of tidal influence is exclusive of salinity. The term "tidal" typically refers to a situation in which the water level periodically fluctuates due to the action of lunar and solar forces upon the rotating earth (Environmental Laboratory 1987). "Wind tides" refer to surface water level fluctuations due to the action of wind on the water surface. NC WAM uses the term "tidal" for wetlands subject to surface waters flushing in and out due to tidal action. For the purposes of NC WAM, lakes 20 acres or larger (examples: Lake Phelps, Lake Waccamaw, Lake Mattamuskeet) may have sufficient fetch to be considered subject to wind tides. However, this characteristic may be more likely to occur on lakes in the Coastal Plain ecoregions that are characterized by extensive shallows along the rims, as opposed to lakes in the Piedmont and Blue Ridge ecoregions that are characterized by greater depths and steeper slopes along the rims. A wetland is considered to be subject to tides even when tidal waters reach the wetland through an artificial watercourse (such as a ditch, canal, or pipe through a berm).

- I.A. Wetland affected, at least occasionally, by brackish or salt water
  - I.A.i. Dominated by herbaceous vegetation – **Salt/Brackish Marsh**
  - I.A.ii. Dominated by woody vegetation – **Estuarine Woody Wetland**
- I.B. Wetland primarily affected by freshwater
  - I.B.i. Dominated by herbaceous vegetation – **Tidal Freshwater Marsh**
  - I.B.ii Dominated by woody vegetation – **Riverine Swamp Forest**

This decision requests the assessor to determine whether or not a wetland is subject to saline waters at least occasionally. NC WAM considers brackish, estuarine, and salt water to be included in this category, which is defined by waters in which ocean-derived salts measure 0.5 parts per thousand or greater. In regards to Estuarine Woody Wetlands, "affected at least occasionally" may include being affected by saline waters due to aperiodic events such as storms (tropical cyclones, northeasters). <u>The frequency of such aperiodic events must be sufficient for salinity to have an observable effect on community biology.</u> Both Riverine Swamp Forest and Tidal Freshwater Marsh are considered to be affected by saline waters so infrequently that salinity has little to no effect on community biology. No map source has been established for this determination, so, in the absence of water chemistry data, the assessor will need to rely on site-specific evidence (such as plant species present) and best professional judgment. Some plant species common to this landscape position are intolerant of salt water (such as pond pine [*Pinus serotina*], bald cypress [*Taxodium distichum*], and gallberry [*Ilex glabra* and *I. coriacea*]) and may provide useful indicators in making this determination.

The phrase “dominated by” refers to a biological, chemical, or physical feature that exerts a controlling influence on or defines the character of a community. For the purposes of NC WAM, only living vegetation is considered in the determination of wetland type, and vegetation dominance is determined by areal coverage (or “drip line” coverage) rather than number of stems. A wetland dominated by herbaceous vegetation is characterized by greater than 50 percent coverage of herbs and less than 50 percent coverage by living woody plants. A wetland dominated by woody vegetation is characterized by greater than 50 percent coverage of living woody vegetation, regardless of the percent coverage of herbs.

See Photos 3-93 through 3-96 for examples of the decision making involved in this portion of the key.

II.A. Not in a geomorphic floodplain or a natural topographic crenulation <u>and</u> not contiguous with an open water 20 acres or larger

II.B. In a geomorphic floodplain or a natural topographic crenulation <u>or</u> contiguous with an open water 20 acres or larger

This decision requires that the assessor make a landscape position determination, rather than a determination of whether or not the wetland is affected by riparian hydrology. The term “geomorphic” is intentionally used to avoid the need for the assessor to make a determination as to whether or not a floodplain is active. Geomorphic floodplain wetlands are those that occur on the floodplain between the toes of the valley walls. Wetlands on the slope above the toe of a valley wall do not meet this criterion. Geomorphic floodplain wetlands are considered to be riparian wetlands. NC WAM does not require that there be any sign of overbank flow, or even a channel, for a wetland to be considered a riparian system. For many floodplains, especially west of the Mid-Atlantic Coastal Plain ecoregion, overbank flooding may not be an important source of wetland hydrology.

A crenulation is a linear, topographic feature that is less defined than a channel or valley and may be characterized by “v”-shaped contour lines on topographic mapping. Topographic crenulations are typically smaller-scale, localized features as opposed to larger-scale, landscape-wide features. Field observations and/or detailed mapping are very important in determining the presence or absence of a topographic crenulation. A “natural” topographic crenulation excludes man-made features. Wetlands located within a natural topographic crenulation are considered to be riparian wetlands.

The best available information should be used by the assessor in the determination of the presence or absence of a geomorphic floodplain or natural topographic crenulation, as well as the extent of these features when present (examples: USGS 7.5-minute quadrangle, <u>Li</u>ght <u>D</u>etection <u>a</u>nd <u>R</u>anging (LiDAR) mapping, best professional judgment based on on-site characteristics). Figures 3A and 3B depict the same landscape area and delineation boundaries on both a USGS 7.5-minute quadrangle background and a LiDAR terrain model background. Note that some delineated wetlands are located in the geomorphic floodplain or topographic crenulations, while some are located on the slope outside of the floodplain and topographic crenulations. In this case, wetlands located in the floodplain or in

Photo 3-93

Photo 3-94

Photo 3-93 is a wetland along the shoreline of Croatan Sound in Dare County. This wetland is affected, at least occasionally, by brackish or salt water, is dominated by herbaceous vegetation, and therefore keys out as a Salt/Brackish Marsh. Photo 3-94 is a wetland along the shore of East Lake in Dare County. This wetland is affected, at least occasionally, by brackish or salt water, is dominated by woody vegetation, and therefore keys out as an Estuarine Woody Wetland. Photo 3-95 is a wetland along the bank of Town Creek in Brunswick County, and Photo 3-96 is a wetland along the bank of Lockwood Folly River in Brunswick County. Both wetlands support species with little to no salt tolerance suggesting they are primarily affected by freshwater. The Town Creek wetland is dominated by woody vegetation and keys out as a Riverine Swamp Forest, while the Lockwood Folly River wetland is dominated by herbaceous vegetation and keys out as a Tidal Freshwater Marsh.

Photo 3-95

Photo 3-96

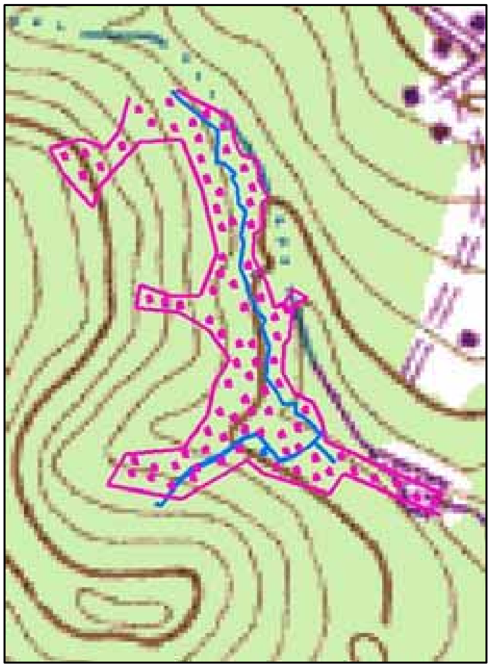


Figure 3A

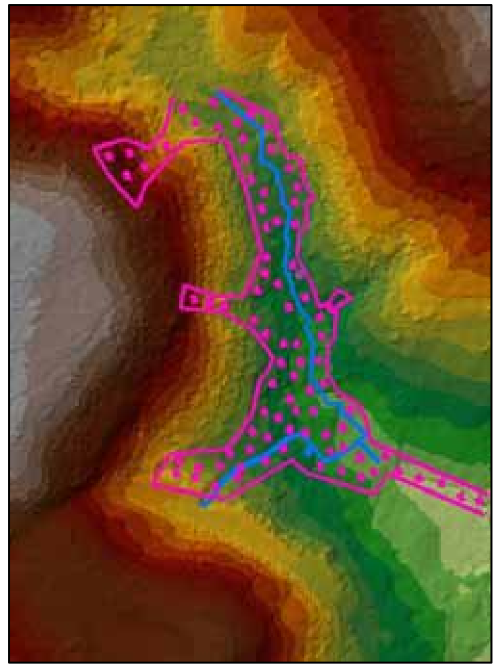


Figure 3B

Figures 3A and 3B are both depictions of an unnamed tributary to McPherson Creek, a tributary to the Cape Fear River in northern Fayetteville, Cumberland County. Figure 3A displays the unnamed tributary on a USGS 7.5-minute quadrangle base, while Figure 3B displays the unnamed tributary on a LiDAR terrain model base (both at a 1:2400 scale). Stippled areas depict a delineated wetland, while solid lines within stippled areas depict delineated tributaries.

topographic crenulations would fall into category "II.B" in the key, while slope wetlands would fall into category "II.A."

Assessors should note that the degree of resolution of remote data used will affect map determinations, but on-site observations may overrule map determinations. A further example of this point is provided in Figures 4A through 4D, which depict the same area on a USGS 7.5-minute quadrangle base and a LiDAR base.

In some areas of low topographic relief, such as much of the Mid-Atlantic Coastal Plain ecoregion, it may be difficult to determine the boundary between riparian and non-riparian wetlands. For the purposes of this example, the reader should assume that the landscape depicted in Figures 4A through 4D is all wetland. In this example, the riparian/non-riparian boundary is the upper extent of a natural topographic crenulation. Based on the resolution provided in Figure 4A, a reasonable map determination for the boundary between natural topographic crenulation and interstream flat/divide may be the 10-foot contour on the 7.5-minute quadrangle. Figure 4B depicts the resulting area of riparian wetland with yellow shading. Based on the relatively higher resolution provided by the LiDAR model base in Figure 4C, a reasonable map determination for the boundary between natural topographic crenulation and interstream flat/divide may be the upper extent of the natural topographic crenulation as clearly depicted on the LiDAR map. Figure 4D depicts the area of resulting riparian wetland with yellow shading. Again, assessors may use on-site characteristics to override a map determination.

Figure 4A

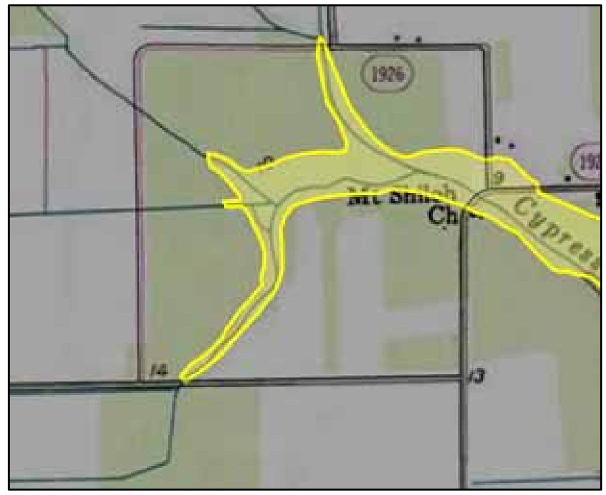


Figure 4B

Figures 4A and 4C are depictions of the same area of upper Cypress Run, a tributary to South River in Beaufort County, on a USGS 7.5-minute quadrangle base and a LiDAR terrain model base, respectively. Assuming that all of the area shown in these figures is wetland, Figures 4B and 4D depict, with hatching, the reasonable extent of riparian wetland based on the topographic resolution provided by each type of map.

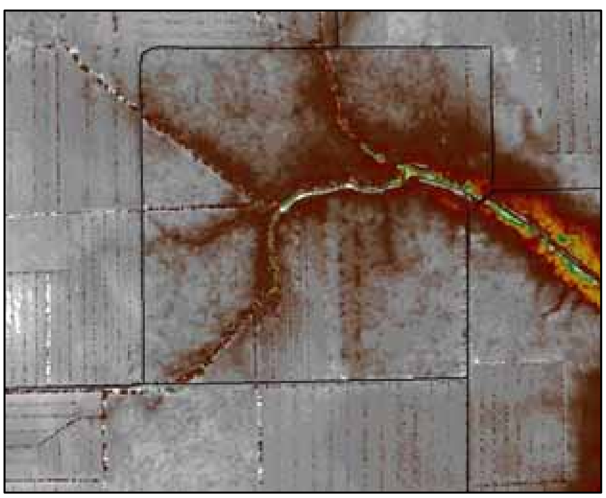


Figure 4C

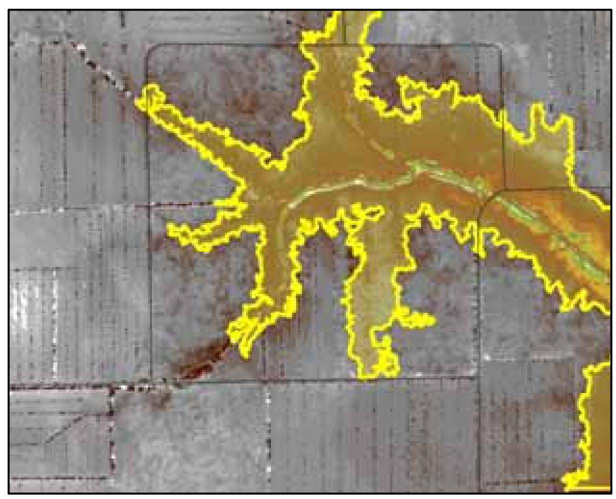


Figure 4D

In the embayed region of North Carolina, some wetland types typically found on interstream flats may occur within geomorphic floodplains and/or in close proximity to bays and tributaries. In making wetland type determinations in this region, assessors may consider remote (county soil survey descriptions or detailed data such as a LiDAR terrain model). However, familiarity with wetland type descriptions and an on-site investigation of wetland characteristics will provide the assessor the best information for making a wetland type determination.

Large open waters (20 acres or larger) are considered to impart riparian characteristics (in terms of hydrology) on contiguous wetlands due to seasonal fluctuations in water level and the potential for periodic wind tides. The size threshold has been taken from Cowardin et al. (1979). Wetlands included in II.A. may occur on interstream flats or divides, coastal islands, side slopes, ridges, saddles, and depressions, regardless of the presence of man-made conveyances (ditches, canals).

II.A.i. On side slopes – **Seep**
II.A.ii. On interstream divides <u>or</u> on a coastal island

This decision separates Seep from other wetland types located outside of a geomorphic floodplain and not in a natural topographic crenulation. Seeps typically occupy small areas located throughout the state outside of geomorphic floodplains, on sloping hillsides and valley walls, and not on flats. In many cases, the location of a Seep may be determined by an impermeable layer (such as sub-surface rock or a clay lens) that directs groundwater to the surface. Though not located in a natural topographic crenulation, surface water from a Seep may drain to a stream or riparian wetland (Headwater Forest, Bottomland Hardwood Forest, Riverine Swamp Forest, Bog, and Floodplain Pool). In the example provided by Figures 3A and 3B, wetlands depicted on the slopes outside of the geomorphic floodplain are Seeps. These Seeps drain down slope to Headwater Forest.

II.A.ii.1. Flats on interstream divides in Coastal Plain ecoregions
II.A.ii.2. In depressions surrounded by uplands anywhere in the state (mafic depressions, lime sinks, Carolina bays) or contiguous with an open water

This decision separates expansive wetlands typical of relatively flat interstream divides (Hardwood Flat, Non-Riverine Swamp Forest, Pine Flat, Pine Savanna, and some sub-types of Pocosin) from smaller, localized wetlands typically found in topographic depressions (Basin Wetland and some sub-types of Pocosin – see wetland sub-types listed under II.A.ii). A depression may be located within an interstream divide landscape position, but the key separates depressions from interstream flat wetlands by local topography and uplands on the perimeter of the wetland.

II.A.ii.1.a. Dominated by deciduous trees

- II.A.ii.1.a.i. Seasonally saturated to seasonally inundated (typically dominated by sweetgum and oaks) – **Hardwood Flat**
- II.A.ii.1.a.ii. Seasonally to semi-permanently inundated (typically dominated by cypress and black gum) – **Non-Riverine Swamp Forest**

II.A.ii.1.b. Dominated by evergreens

- II.A.ii.1.b.i. Dominated by dense, waxy shrub species (typically include gallberries, fetterbushes, honeycup, greenbriar); canopy may include pond pine, Atlantic white cedar, and bays – **Pocosin**
- II.A.ii.1.b.ii. Not dominated by dense, waxy shrub species
  - II.A.ii.1.b.ii.1. Dominated by long-leaf or pond pine and wire grass – **Pine Savanna**
  - II.A.ii.1.b.ii.2. Dominated by loblolly or slash pines – **Pine Flat**

The phrase "dominated by" refers to a biological, chemical, or physical feature that exerts a controlling influence on or defines the character of a community. For the purposes of NC WAM, vegetation dominance is considered in terms of areal coverage (or "drip line" coverage) rather than number of stems. In order to determine dominance between deciduous and evergreen trees or types of shrub species, the assessor may choose to employ the "50/20 rule." This is the recommended method for selecting dominant species from a plant community when quantitative data are available. The most abundant species (when ranked in descending order of abundance and cumulatively totaled) that exceed 50 percent of the total dominance measure for a given stratum, plus any additional species comprising 20 percent or more of the total dominance measure for that stratum, are considered dominant species for the stratum (USFWS et al. 1989).

A wetland subject to seasonal to semi-permanent inundation (Non-Riverine Swamp Forest) will be characterized by prominent surface water indicators. Specific evidence of this hydrology includes visual observation of long- to very long-duration inundation (ponding or flooding), presence of emergent vegetation, absence of ground cover in combination with prominent water marks on fixed objects, muck surface layer in combination with prominent surface water indicators, hydrogen sulfide odor, water-stained leaves that are grayish or blackish in color, algal mat or crust, surface soil cracks, presence of aquatic fauna, moss trim lines, and redoximorphic features not masked by organic material. A wetland subject to seasonal saturation to seasonal inundation (Hardwood Flat) may be characterized by less prominent evidence of the above-referenced indicators or may lack the above-referenced indicators. Vegetation composition may also be helpful in separating Non-Riverine Swamp Forest from Hardwood Flat (see Schafale and Weakley 1990). Non-Riverine Swamp Forest is often dominated by bald cypress (*Taxodium distichum*), black gum (*Nyssa biflora*), loblolly pine (*Pinus taeda*), Atlantic white cedar (*Chamaecyperis thyoides*), pond pine (*P. serotina*), tulip poplar (*Liriodendron tulipifera*), and red maple (*Acer rubrum*). The understory may vary from open to dense and include sweet bay (*Magnolia virginiana*), red bay (*Persea palustris*), ti-ti (*Cyrilla racemiflora*), fetter-bush (*Lyonia lucida*), and sweet pepperbush (*Clethera alnifolia*). Hardwood Flat is often dominated by hardwood tree species typical of bottomlands such as swamp chestnut oak (*Quercus michauxii*), laurel oak (*Q. laurifolia*), cherrybark oak (*Q. pagoda*), tulip poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), American elm (*Ulmus americana*), red maple (*Acer rubrum*), and black gum. The understory may include ironwood (*Carpinus caroliniana*), red maple, American holly (*Ilex opaca*), and pawpaw (*Asimina triloba*).

II.A.ii.2.a. Dominated by dense, waxy shrub species (typically include gallberries, fetterbushes, honeycup, greenbriar); canopy may include pond pine, Atlantic white cedar, and bays and not characterized by clay-based soils – **Pocosin**

II.A.ii.2.b. Not dominated by dense, waxy shrub species and not characterized by a peat-filled bay –**Basin Wetland**

This decision effectively separates two general wetland types that both have many possible forms. This form of Pocosin includes Carolina bay wetlands, which may vary from tall, vertically stratified pond pine woodlands, to tall, less well stratified high pocosin, to a short pocosin with little stratification. Carolina bay wetlands may or may not contain open water. Basin Wetlands include lime sink ponds, mafic depressions, and open waters less than 20 acres in size.

II.B.i. Northern Inner Piedmont or Blue Ridge ecoregions and dense herbaceous or mixed shrub/herbaceous vegetation with characteristic bog species (see wetland type description), with or without tree canopy; at least semi-permanent saturation; typically on organic or mucky soils; sphagnum moss commonly present – **Bog**

II.B.ii. Anywhere in the state and not Bog

This decision separates Bog from all other riparian wetland types. See the general wetland type description (Section 3.1.12) for more detailed characteristics used to identify the Bog wetland type.

II.B.ii.1. Dominated by herbaceous vegetation. At least semi-permanently inundated or saturated. Includes lacustrine and riparian fringe and beaver ponds with dense herbaceous vegetation; sphagnum moss scarce or absent – **Non-Tidal Freshwater Marsh**

II.B.ii.2. Dominated by woody vegetation. Trees may be present on edges or hummocks.

This decision separates Non-Tidal Freshwater Marsh from all other riverine wetland types (with the exception of Bog). The phrase "dominated by" refers to a biological, chemical, or physical feature that exerts a controlling influence on or defines the character of a community. For the purposes of NC WAM, vegetation dominance is considered in terms of areal coverage, or "drip line" coverage (rather than number of stems) of "living" vegetation in the air space over the wetland (though the plants may be rooted outside of the wetland type) as well as vegetation growing within the wetland. A small Floodplain Pool may not support woody vegetation within its boundaries, but may still be dominated by woody vegetation from the floodplain forest. If the site was a riparian forested community that has been affected by a beaver impoundment, the assessor needs to decide if the full range of current stable, existing wetland parameters (vegetation, hydrology, and soils) better resemble a marsh or a forested wetland. If the assessor is in doubt as to the keyed wetland type, the site should be rated as each likely wetland type.

II.B.ii.2.a. Localized depression; semi-permanently inundated – **Floodplain Pool**
II.B.ii.2.b Not "a"

A localized depression will likely not have a regular surface water connection to another wetland type. Examples of this are oxbows, floodplain backwaters along the toe of valley walls, and tree tip depressions. Localized depressions contiguous with other wetland types (possibly Bottomland Hardwood Forest or Riverine Swamp Forest) may often be considered a component of the contiguous wetland type.

II.B.ii.2.b.i. Less than second-order stream or in a natural topographic crenulation. Diffuse surface flow and groundwater more important than overbank flooding.
- II.B.ii.2.b.i.1 Seasonally to semi-permanently saturated and/or only Intermittently inundated – **Headwater Forest**
- II.B.ii.2.b.i.2. Seasonally to semi-permanently inundated – **Riverine Swamp Forest**

II.B.ii.2.b.ii. Second-order or greater stream or contiguous with an open water 20 acres or larger
- I.B.ii.2.b.ii.1. Intermittently to seasonally inundated (may be dominated by sweetgum, ash, sycamore, and oaks) – **Bottomland Hardwood Forest**
- I.B.ii.2.b.ii.2. Seasonally to semi-permanently inundated (may be dominated by cypress and black gums in Coastal Plain and ash, overcup oak, and elms in Piedmont and Mountains) – **Riverine Swamp Forest**

To determine stream order, an assessor needs to consider the following: 1) is the assessment area within the geomorphic floodplain of a tributary or contiguous with a natural tributary; 2) if so, is the tributary depicted on a 7.5-minute topographic quadrangle, and 3) in what ecoregion is the assessment area located. Appendix C contains two schematic diagrams to assist the assessor with understanding how to determine stream order.

The term "tributary" refers to an open conduit, either naturally or artificially created, that periodically or continuously contains moving water (examples: river, stream, ditch, canal, inter-dune swale connected to surface waters). For the purposes of NC WAM, the term "tributary" implies federal and/or state jurisdictional status. A "natural" tributary excludes man-made features (ditches, canals) outside of a natural topographic crenulation, even when man-made features appear to have "naturalized."

In most of the state, stream order should be determined by consulting blue lines on the USGS 7.5-minute quadrangle (see Appendix C, Figure C1 for an example). Wetlands in the geomorphic floodplain of a less than second-order stream or in a natural topographic crenulation fall under II.B.ii.2.b.i in the dichotomous key. When the less than second-order stream or natural topographic crenulation crosses into the geomorphic floodplain of a second-order or larger stream, the wetlands will fall under II.B.ii.2.b.ii in the dichotomous key. See Figure 2 for a depiction of this example.

For sites in the Coastal Plain ecoregions, the assessor should not incorporate blue lines in the determination of stream order when the blue lines occur outside of a natural topographic crenulation as depicted on a 7.5-minute topographic quadrangle. Blue lines outside of the natural topographic crenulation (if tributaries) are either zero-order streams or man-made ditches or canals. In the example provided in Appendix C, Figure C2 (taken from a 7.5-minute topographic quadrangle), only the blue lines depicted within the 10-foot contour should be considered when determining stream order. Based on this perspective, the confluence of first-order streams in the middle of the figure view and below the number "10" forms the second-order stream, Cypress Run. Another first-order stream joins the main branch just upstream of Mt. Shiloh Church, but Cypress Run remains a second-order stream as it passes to the right out of the figure view.

Wetland hydrology terms are derived from Cowardin et al. (1979). Headwater Forest situated high in the landscape or characterized by coarse substrate may be subject to seasonal saturation without evidence of surface inundation. Both remote and on-site evidence may be used in making the determination between "intermittently to seasonally inundated" and "seasonally to semi-permanently inundated;" however, on-site evidence is preferred. Remote sources may include county soil surveys, USFWS NWI mapping, and site-specific documentation. Aside from long-term, recorded hydrology data, on-site observations are not always conclusive (especially when access to the site is limited); even so, evidence useful in making this determination includes (but is not limited to) presence of hydric soil indicators; wetland indicator status of dominant vegetation; and presence of wetland hydrology indicators (observation of inundation, watermarks, drift deposits, sediment deposits, drainage patterns within wetlands, and water-stained leaves).

A wetland subject to seasonal to semi-permanent inundation (Riverine Swamp Forest) will be characterized by prominent surface water indicators. Specific evidence of this hydrology includes visual observation of long- to very long-duration inundation (ponding or flooding), presence of emergent vegetation, absence of ground cover in combination with prominent water marks on fixed objects, muck surface layer in combination with prominent surface water indicators, hydrogen sulfide odor, water-stained leaves that are grayish or blackish in color, algal mat or crust, surface soil cracks, presence of aquatic fauna, moss trim lines, and redoximorphic features not masked by organic material. A wetland subject to intermittent to seasonal inundation (Headwater Forest) will typically lack the above-referenced indicators but may be characterized by water marks, drift deposits, drainage patterns, and sediment deposits.

4.0 FUNCTIONAL ASSESSMENT METRICS

4.1 Introduction to Metrics

NC WAM assesses wetland condition as an alternative to direct assessment of wetland function. Wetland condition can be observed, and is more readily assessed than wetland function, which must be measured or inferred. The method of determining the condition and opportunity of a specific wetland is to answer a series of questions or **metrics** concerning 1) the observable condition of the wetland and 2) the opportunity for potential enhancement of wetland functions due to disturbance in the watershed draining to the wetland. A list of metrics specific to each general wetland type was generated by the WFAT. Metrics corresponding to wetland types with a reference standard are designed to assess the departure of wetland condition from the reference standard. All metrics for all wetland types were field tested and revised at multiple test sites representing various levels of disturbance, from relatively pristine to intensively managed. Following initial field testing, state and federal agency personnel participated in beta-testing exercises across the state concerning the applicability of metrics for all general wetland types. Beta testing included a classroom explanation of the method, field exercises, and a provision for comments by beta testers regarding the draft method. Following beta testing, metrics for each of the general wetland types were finalized.

The comprehensive metric list for all general wetland types includes 63 individual metrics. For the purpose of generating a single, relatively concise field metric evaluation form, the original 63 metrics were separated into component parts, reorganized, and condensed into the 22 “condensed” metrics (hereafter referred to as metrics) now presented on the Field Assessment Form (see pp. ix to xii). On the Field Assessment Form, each metric is presented in the form of a multiple-choice question. The selected answers, or “**descriptors**,” are then used by the NC WAM Rating Calculator (computer program) to determine wetland functional ratings.

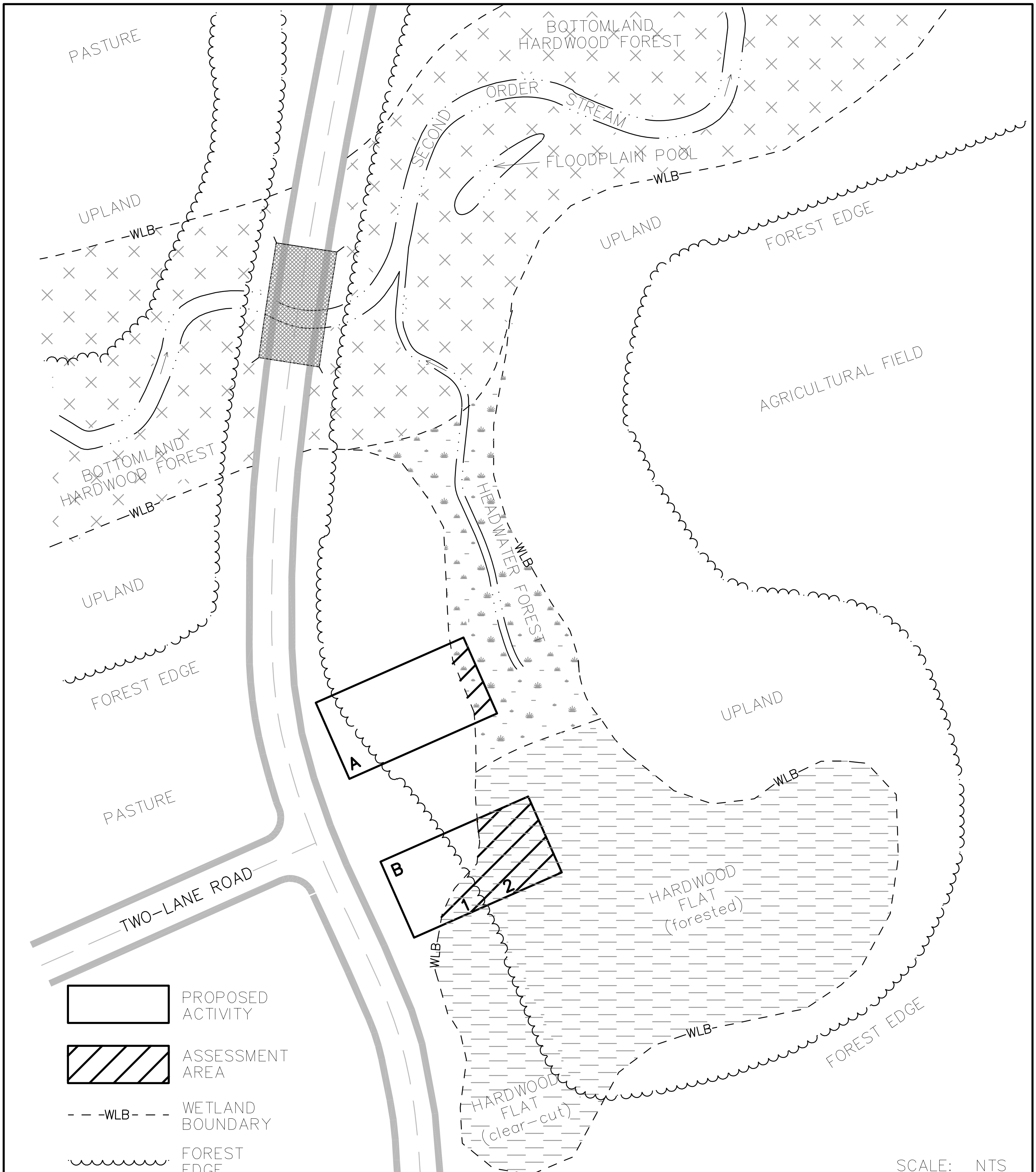
4.2 Metric Evaluation Areas

Each metric requests the assessor to evaluate field indicators within one or more specific areas. The title line for each metric on the Field Assessment Form indicates the area(s) of consideration for that metric. Five different areas may be considered: 1) assessment area, 2) wetland type, 3) forested wetland, 4) wetland complex, and 5) landscape patch. Figure 5 is referred to for illustrations of these areas in the following discussion.

4.2.1 Assessment Area

The assessment area is the defined area of a wetland type subject to the functional evaluation. Depending on circumstances, assessment area boundaries may be formed by one or more of the following.

- The limits of a proposed activity
- The limit of a single wetland type within the footprint of a proposed activity
- All uplands
- The extent of a wetland type with a homogeneous set of characteristics within the footprint of a proposed activity



NC WAM USER MANUAL

EXAMPLE WETLAND COMPLEX

FIGURE

5

A tributary flowing through a single wetland type does not form an assessment area boundary. An assessment area will never include uplands. An assessment area will never include more than one wetland type. When a project area includes a wetland type that is not homogeneous in terms of wetland parameters, an assessor will need to decide if the wetland type should be sub-divided into two or more assessment areas. As a rule of thumb, the minimum size for an assessment area should be approximately 0.1 acre, and may be larger depending on practicalities associated with the project size.

In Figure 5, the footprint of the proposed activity labeled “A” includes a Headwater Forest. The portion of this Headwater Forest that falls inside the boundaries of proposed activity A is an NC WAM assessment area (see hatched area). The footprint of the proposed activity labeled “B” includes a Hardwood Flat, a portion of which has been subject to clear-cutting and a portion of which remains in mature forest. If one or more wetland characteristics (such as vegetation structure or ground surface condition) are substantially different between these two versions of the Hardwood Flat, this wetland type will be considered separate sub-types, and an assessor will need to conduct a functional evaluation on two assessment areas: assessment area B1 and assessment area B2 in Figure 5. Another example of the determination of assessment areas for a project area is provided in Section 5.2.3.

Examples demonstrating the determination of assessment area boundaries are provided for wetlands delineated within a project area by Figures 6A and 6B and Figures 7A and 7B. In Figure 6A, the largest wetland is not affected by tides, occurs in a geomorphic floodplain, is not a Bog, is dominated by woody vegetation, is not in a localized depression, is abutting a second-order stream, and is characterized by seasonal inundation, resulting in its identification as a Bottomland Hardwood Forest (key location II.B.ii.2.b.ii.1). On-site observations confirmed that wetland characteristics within this wetland type were homogeneous, so it is identified as a single assessment area (Assessment Area 3). The two smaller wetlands are characterized as not affected by tides, not located in a geomorphic floodplain or a natural topographic crenulation, and on a side slope, resulting in their identification as Seeps (key location II.A.i). Again, on-site observations confirmed that wetland characteristics within each wetland were homogeneous, although not contiguous, so each Seep is identified as a single assessment area (Assessment Areas 1 and 2).

Figure 6B depicts a drainage flowing downhill from the top to the bottom of the view. On-site observations were used to conclude that a dam has been constructed across the upper end of this topographic feature, resulting in an impoundment fed by groundwater runoff from the slopes above the impoundment. Within the past 20 years, a portion of the dam has washed away resulting in a lowering of water elevations in the impoundment to the point that emergent vegetation now dominates the impoundment. Currently, the wetland on the slopes above the impoundment is not affected by tides, is not located in a geomorphic floodplain or a natural topographic crenulation, and is on a side slope, resulting in identification as a Seep (key location II.A.i). The Seep is homogeneous in wetland characteristics and therefore is identified as a single assessment area (Assessment Area 1). The impounded area is not affected by tides, occurs in a geomorphic floodplain, is not a Bog, and is dominated by herbaceous vegetation, resulting in its identification as a Non-Tidal Freshwater Marsh (key location II.B.ii.1). This marsh is homogeneous in wetland characteristics and therefore is identified as a single assessment area (Assessment Area 2). The wetland below the dam is characterized as not affected by tides, located within a geomorphic floodplain, not a Bog, dominated by woody vegetation, not a localized depression, abutting a less than second-order stream, and subject to seasonal to semi-permanent inundation, resulting in its identification as Riverine Swamp Forest (key location II.B.ii.2.b.ii.2). On-site observations confirmed that wetland characteristics within this wetland were homogeneous, so the Riverine Swamp Forest is identified as a single assessment area (Assessment Area 3).

Figure 6A

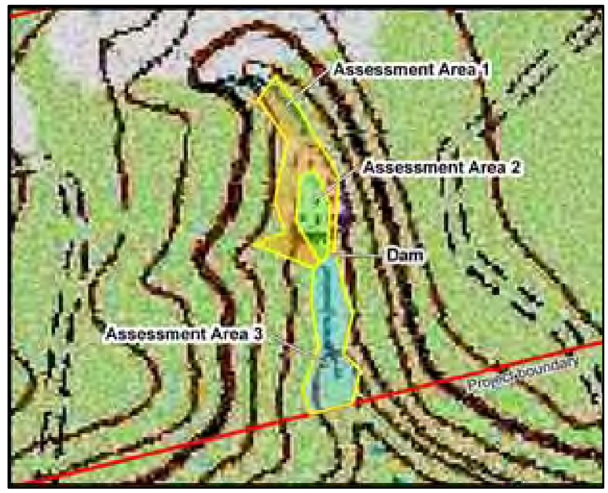


Figure 6B

Figures 6A and 6B depict delineated wetlands within a proposed roadway corridor in Cumberland County. The solid red line depicts the project boundary, and solid yellow lines depict wetland type boundaries.

Figures 7A and 7B depict the same delineated wetland within a project area on two map bases: USGS 7.5-minute quadrangle and aerial photograph. In this example, a second-order stream flows from the upper left to the bottom center of each view. The largest wetland is characterized as not affected by tides, located within a geomorphic floodplain, not a Bog, dominated by woody vegetation, not a localized depression, abutting a second-order stream, and subject to intermittent to seasonal inundation, resulting in its identification as Bottomland Hardwood Forest (key location II.B.ii.2.b.ii.1). On-site observations confirmed that wetland characteristics within this wetland were homogeneous, so the Bottomland Hardwood Forest is identified as a single assessment area (Assessment Area 1). The remaining wetland area is not affected by tides, is not located in a geomorphic floodplain or a natural topographic crenulation, and is on a side slope, resulting in identification as Seep (key location II.A.i). On-site observations found that the upper portion of the Seep is relatively undisturbed (characterized by a pine canopy and an ericaceous shrub understory), while the lower portion of the Seep, occurs within a regularly maintained sewer-line corridor. Vegetation within the portion of the Seep within the sewer-line corridor is regularly cut to the ground, resulting in dominance by dense herbaceous growth. Also, the ground surface within the sewer-line corridor is compacted and rutted by vegetation maintenance machinery. The lack of homogeneity between these two sub-types of Seep should result in an assessor sub-dividing this wetland type into two discrete assessment areas (Assessment Areas 2 and 3).

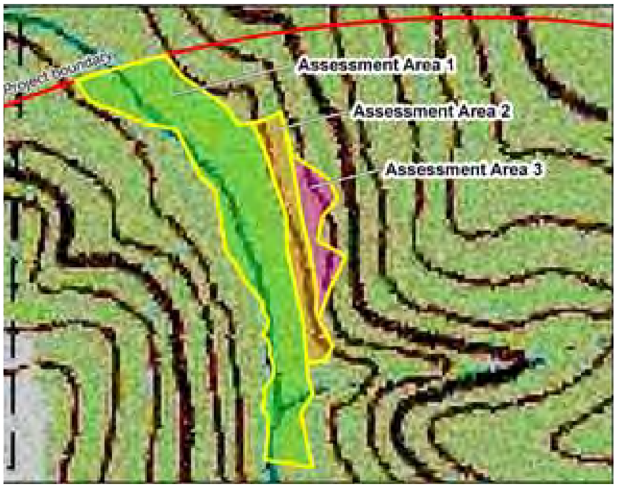


Figure 7A

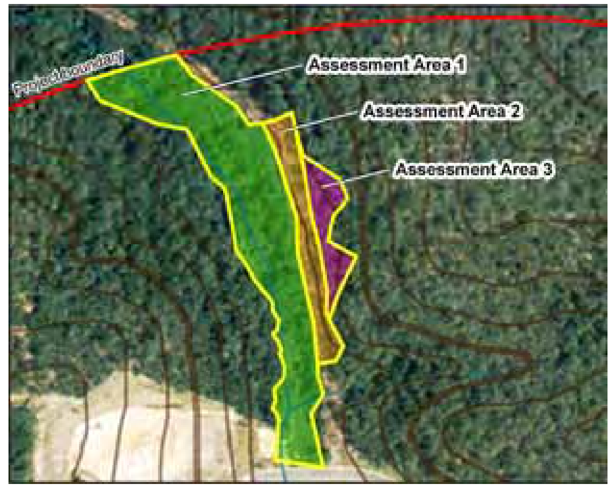


Figure 7B

Figures 7A and 7B depict the same delineated wetlands within a proposed roadway corridor in Cumberland County on USGS 7.5-minute quadrangle and aerial photography bases. The solid red line depicts the project boundary, and solid yellow lines depict assessment area boundaries.

“Assessment area” metrics focus only on the field indicators evident in the assessment area. The characteristics of any portion of wetland outside of the assessment area should not be considered when evaluating assessment area metrics.

4.2.2 Wetland Type

The wetland type is a wetland area comprised of <u>one</u> of the 16 NC WAM general wetland types, irrespective of the limits of any proposed activity. Wetland type boundaries are formed by the following.

- Another wetland type
- A wetland/natural upland boundary
- A man-made berm/causeway wider than that needed to support a two-lane road

A wetland type determination may be made based on general wetland type descriptions (see Section 3.1), with the use of the NC WAM Dichotomous Key to General North Carolina Wetland Types (see pp. vii and viii), or following guidelines provided for the identification of wetland types in disturbed areas (see Section 3.4.1). Man-made berms, supporting two-lane roads or narrower, are not boundaries for wetland type. Regarding the example provided in Figure 5 (p. 69), the two-lane road crossing the Bottomland Hardwood Forest is not wide enough to act as a boundary, so all of the Bottomland Hardwood Forest is considered a single wetland type. Similarly, in the example provided in Figure 14C (p. 115), a one-lane road crossing the Bottomland Hardwood Forest is not wide enough to act as a boundary, so all of the Bottomland

Hardwood Forest is considered a single wetland type. The maintained utility line corridor crossing the south arm of the Headwater Forest is not a wetland type boundary. The assessor should employ best professional judgment when interpreting this guidance. For instance, if a two-lane road is atop a tall causeway with a wide base resulting from the crossing of a floodplain with high valley walls, this road may be considered a wetland type boundary.

"Wetland type" metrics require the evaluation of field indicators evident throughout the entire wetland type. If wetland characteristics vary within the wetland type, the assessor will evaluate metrics based on the dominant field indicators. Using the example in Figure 5 (p. 69), a wetland type metric used in the functional evaluation of assessment area A will need to consider dominant field indicators of the entire Headwater Forest, not just the portion within the assessment area. Likewise, an assessor must determine and consider dominant field indicators for the entire Seep when evaluating wetland type metrics for the example provided by Figures 7A and 7B.

4.2.3 Forested Wetland

The forested wetland may consist of one NC WAM general wetland type or an association of two or more contiguous NC WAM general wetland types. In general, a forested wetland is characterized by over 50 percent coverage of woody vegetation that is 10 feet or taller (modified from NCDEM 1995). For the purposes of NC WAM, a forested wetland type in reference condition always supports forest. NC WAM forested wetland types include Estuarine Woody Wetland (some forms), Riverine Swamp Forest, Seep, Hardwood Flat, Non-Riverine Swamp Forest, Pocosin (some forms), Pine Savanna (some forms), Pine Flat, Basin Wetlands (some forms), Bog (some forms), Floodplain Pool, Headwater Forest, and Bottomland Hardwood Forest. Forested wetland boundaries are based on perceived barriers to forested wetland-dependent wildlife movement and include the following.

- Natural uplands
- Open water that extends across the entire width of a floodplain
- A man-made berm/causeway the width of a four-lane road or wider
- A forested wetland type that averages less than 10 feet in height and is the width of a four-lane road or wider

The assessor should employ best professional judgment when interpreting this width guidance. For instance, if a two-lane road crossing a floodplain with high valley walls is atop a tall causeway with a wide base, this causeway/berm may constitute enough of a barrier to be considered a forested wetland boundary.

Regarding the example provided in Figure 5 (p. 69), all three wetland types displayed (Bottomland Hardwood Forest, Headwater Forest, and Hardwood Flat), with the exception of the clear-cut area, comprise the forested wetland. The road depicted is a two-lane road and is therefore not considered to be a forested wetland boundary. Regarding the example provided in Figure 14C (p. 115), the four-lane road is a boundary dividing forested wetlands. This figure also displays two forested wetlands, one on each side of the four-lane road. The maintained utility corridor is narrower than a four-lane road and does not create a forested wetland boundary. The forested wetland west (left of the four-lane road) includes only the Riverine Swamp Forest and not the Non-Tidal Freshwater Marsh.

"Forested wetland" metrics typically ask broad questions (such as general sizes and widths) and are not expected to require detailed information obtained in the field. These data are best determined from the examination of maps, which may be accomplished most efficiently in the office.

4.2.4 Wetland Complex

A wetland complex may consist of one NC WAM general wetland type or an association of two or more contiguous NC WAM general wetland types. Wetland complex boundaries are based on perceived barriers to wetland-dependent wildlife movement and include the following.

- Natural uplands
- Open water that extends across the entire width of a floodplain
- A man-made berm/causeway the width of a four-lane road or wider

The assessor should employ best professional judgment when interpreting this width guidance. For instance, if a two-lane road crossing a floodplain with high valley walls is atop a tall causeway with a wide base, this causeway/berm may constitute enough of a barrier to be considered a wetland complex boundary.

Regarding the example provided in Figure 5 (p. 69), all three wetland types displayed (Bottomland Hardwood Forest, Headwater Forest, and Hardwood Flat) are considered to be part of a single wetland complex. The road depicted is a two-lane road and is therefore not considered to be a wetland complex boundary. Regarding the example provided in Figure 14C (p. 115), the four-lane road is a boundary dividing displayed wetlands into two complexes. This figure also displays two forested wetlands, one on each side of the four-lane road.

"Wetland complex" metrics typically ask broad questions (such as general sizes and widths) and are not expected to require detailed information obtained in the field. These data are best determined from the examination of maps, which may be accomplished most efficiently in the office.

4.2.5 Landscape Patch

The landscape patch is the contiguous natural habitat that includes the assessment area irrespective of the watershed of the assessment area. "Landscape patch" is used in only one metric (Field Assessment Form Metric 13; see pp. xi and 98), which concerns the area of available habitat readily accessible from the assessment area. This metric defines landscape patch boundaries as follows.

- Four-lane roads
- Regularly maintained utility-line corridors the width of a four-lane road or wider
- Urban landscapes
- Maintained fields (pasture and agriculture)

- Open water greater than 300 feet wide

In the example given in Figure 5 (p. 69), all of the forested habitats are part of a landscape patch. Again, these data may be best determined from examining maps in the office.

4.3 Guidance for Completing the Field Assessment Form

It is important that the assessor walk the entire assessment area prior to completing the Field Assessment Form (see pp. ix to xii). During this investigation, the assessor should make note of the presence of potential wetland stressors (such as roads, utility lines, maintained vegetation, septic fields, and stormwater runoff) and consider the effect of potential stressors on the subject wetland. The assessor should take notes liberally, documenting important site features and reasoning used in best professional judgment on the Field Assessment Form. A sketch map (or higher quality) indicating assessment area characteristics should be generated and attached to the completed Field Assessment Form.

4.3.1 Field Assessment Form Introductory Information

The most current version of the Field Assessment Form as of the date of generation of this User Manual is provided as pp. ix to xii at the beginning of the User Manual. The box at the top of the first page requests general information concerning the setting, time, and assessor involved in the wetland assessment.

- Wetland Site Name – name used to identify the assessed wetland site
- Wetland Type – based on use of the general wetland type key in combination with best professional judgment
- Level III Ecoregion – based on the ecoregion map provided in Appendix E
- River Basin – name of river basin
- Precipitation within 48 hours – indicate whether measurable rainfall has fallen within the past 48 hours (http://water.weather.gov/precip/ for assistance)
- Date – date of the field assessment
- Assessor Name/Organization – name and affiliation (agency, company) of the party responsible for the evaluation decisions
- Nearest Named Water Body – name of the nearest named water body as indicated on the USGS 7.5-minute quadrangle or other reliable resource
- USGS 8-Digit Catalogue Unit – provide the 8-digit catalogue unit (available from USGS 1974 and NCDWQ basinwide management plans at the following web site - http://portal.ncdenr.org/web/wq/ps/bpu)
- Latitude/Longitude (deci-degrees) – coordinates in decimal degrees to six significant figures (example: 35.123456, -79.123456)

The section entitled "Evidence of stressors affecting the assessment area" is meant to prompt the assessor to consider the overall condition of the assessment area by looking for evidence of environmental stressors. Comments provided by the assessor will be used by resource agency personnel and are not directly involved in generating the assessment ratings. The term "consider departure from reference, if appropriate, in recent past" is intended to prompt the assessor to consider whether the vegetation appears to have been disturbed within approximately the past 10 years. The bulleted list provides examples of common disturbances that are generally considered to reduce wetland function. The assessor should record whether or not the assessed wetland is intensively managed. It is important that the assessor describe in writing the observed effects of stressors within an assessment area prior to completing the Field Assessment Form.

The section entitled "Regulatory Considerations" requests that the assessor acknowledge, by selecting the corresponding box(es), known issues that apply to the assessment area that are regulated by one or more federal, state, or local natural resource agencies.

- "Anadromous fish" – The assessor should select "Anadromous fish" if there are either direct observations or documentation of the presence of anadromous fish within the assessment area or within a tributary abutting the assessment area.
- "Federally protected species or State endangered or threatened species" – The assessor should select this box if there are either direct observations or documentation of the presence of these species within the assessment area. Sources for documentation include the U.S. Fish and Wildlife Service and the N.C. Natural Heritage Program.
- "NCDWQ riparian buffer rule in effect" – The assessor should select "Riparian buffer rule in affect" only if the N.C. Environmental Management Commission (EMC) has instituted buffer rules that apply to the assessment area (located on the web at http://portal.ncdenr.org/web/wq/swp/ws/401/riparianbuffers/rules).
- "Abuts a Primary Nursery Area (PNA)" – Information concerning the identification and location of Primary Nursery Areas is available in 15A NCAC 03N 0.0104 and 15A NCAC 03R .0103, respectively. The assessor should use best professional judgment when considering if the distance between the assessment area and a designated PNA makes selection of this descriptor appropriate.
- "Publicly owned property" – Property ownership should always be established prior to an assessor making a site visit.
- "NCDCM Area of Environmental Concern (AEC) (including buffer)" – Communication with a NCDCM representative or familiarity with the most current version of the "CAMA Handbook for Development in Coastal North Carolina" (located on the web at http://dcm2.enr.state.nc.us/) will aid the assessor in determining whether the assessment area includes an AEC.
- "Abuts a tributary with a NCDWQ best usage classification of SA or supplemental classification of HQW, ORW, or Trout" – Surface water quality classifications and definitions for terms such as High Quality Waters (HQW), Outstanding Resource Waters (ORW), and Trout Waters (Trout) are available through NCDWQ stream classification schedules and other publications and can be found on-line at the following web site: http://h2o.enr.state.nc.us/bims/reports/reportsWB.html.
- "Designated NCNHP reference community" – Information concerning the location of NCNHP-designated reference communities is available through NCNHP publications such as county inventories and lists of Significant Natural Heritage Areas.
- "Abuts a 303(d)-listed stream or a tributary to a 303(d)-listed stream" – Information concerning the names of current 303(d)-listed streams is available through NCDWQ

N.C. Water Quality Assessment and Impaired Waters list located at the following website: http://portal.ncdenr.org/web/wq/ps/mtu/assessment.

The type of natural stream is important information used by the Rating Calculator for riparian wetlands. Blackwater streams are streams that generally originate in the Coastal Plain ecoregions, contain negligible amounts to no sediment, are tannic in nature, and often flow through peat-based or sandy areas. Brownwater streams generally originate in the Piedmont or Blue Ridge ecoregions and sometimes contain high amounts of clay and silt and may be turbid and brown in color. The breakdown of source of tides is used to locate wetlands in the landscape. Acknowledging that a wetland occurs on a coastal island potentially prevents a lowering of wetland rating based on size when an assessment area is confined to an island. Acknowledgement that a wetland is affected by beaver provides additional information for consideration to assessment reviewers. Important terms are defined in the Glossary of Terms (Appendix I).

Whether or not a riparian wetland assessment area experiences overbank flow during normal rainfall conditions is important in determining the wetland's function. Wetlands located abutting tributaries or other open waters may not necessarily be subject to overbank flow from those water bodies. The assessor is requested to use on-site evidence and best professional judgment to determine whether the assessment area is subject to overbank flow during normal rainfall conditions (see next paragraph for a discussion of "normal rainfall" conditions). Indicators of overbank events during normal rainfall conditions include recent sedimentation, waterlines, debris deposits, reclining vegetation, and gauge data. "Normal rainfall conditions" includes regular events such as nor'easters along the coast but is not considered to include severe, aperiodic events such as hurricanes or drought.

The U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), National Water and Climate Center provides, through its WETS tables, a normal range for monthly precipitation based on climate data collected through the National Weather Service Cooperative Network. These tables can be used in conjunction with recent rainfall data to determine if a specific site is characterized as being subject to "normal rainfall conditions" at the time of a functional assessment. The following description concerning the determination of whether a site is subject to normal rainfall conditions is taken from the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain (USACE 2008).

> Determine whether the amount of rainfall that occurred in the 2-3 months preceding the site visit was normal, above normal, or below normal based on the normal range reported in WETS tables. WETS tables are provided by the NRCS Water and Climate Center (http://www.wcc.nrcs.usda.gov/climate/wetlands.html) and are calculated from long-term (30-year) weather records gathered at National Weather Service meteorological stations. To determine whether precipitation was normal prior to the site visit, actual rainfall in the current month and previous 2-3 months should be compared with the normal ranges for each month given in the WETS table (USDA Natural Resources Conservation Service 1997, Sprecher and Warne 2000). The lower and

upper limits of the normal range are indicated by the columns labeled "30% chance will have less than" and "30% chance will have more than" in the WETS table. The USDA Natural Resources Conservation Service (1997, Section 650.1903) also gives a procedure that can be used to weight the information from each month and determine whether the entire period was normal, wet, or dry.

4.3.2 Field Assessment Form Metrics

The metric name, metric type, and metric scope are included on the metric title line. Consider metric number 1 (Metric 1) for example.

1. Ground Surface Condition/Vegetation Condition – assessment area condition metric

In this case, the assessor is to consider the assessment area when evaluating both the "ground surface condition" and "vegetation condition" components of this metric. This is a condition metric because the assessor uses it to evaluate the extent a wetland departs from full integrity with respect to these components. The metric scope will be indicated if the metric is only to be applied to certain wetland types (examples: evaluate for non-marsh wetlands only, evaluate for riparian wetlands only).

Each metric is composed of one or more questions. For each metric, the assessor is provided two or more possible answers or "descriptors." Each descriptor is accompanied by a box. The evaluation of each metric will involve the selection of one or more descriptors by checking the appropriate boxes.

Each of the 22 metrics included on the Field Assessment Form follows, along with a clarifying discussion. The Field Assessment Form is included at the beginning of the User Manual (see pp. ix to xii).

1. Ground Surface Condition/Vegetation Condition – assessment area condition metric

Check a box in each column. Consider alteration to the ground surface (GS) in the assessment area and vegetation structure (VS) in the assessment area. Compare to reference wetland if applicable (see User Manual). If a reference is not applicable, then rate the assessment area based on evidence of an effect.

GS	VS	
☐A	☐A	Not severely altered
☐B	☐B	Severely altered over a majority of the assessment area (ground surface alteration examples: vehicle tracks, excessive sedimentation, fire-plow lanes, skidder tracks, bedding, fill, soil compaction, obvious pollutants) (vegetation structure alteration examples: mechanical disturbance, herbicides, salt intrusion [where appropriate], exotic species, grazing, reduced diversity [if appropriate], hydrologic alteration)

With regard to ground surface, the assessor should consider the assessment area when evaluating this metric and should check one box in the GS column. The ground surface component addresses the departure, or alteration, from reference of the ground surface condition. Departure from reference may include roughening of the ground surface in wetlands typically characterized by little microtopography such as Headwater Forest and Pine Savanna or leveling of the ground surface in wetlands typically characterized by more microtopography such as Pocosin and Bottomland Hardwood Forest. Examples of disturbance provided in the metric wording, when found in sufficient severity and with coverage of over 50 percent of the assessment area, are anticipated to degrade ground surface habitats enough to receive descriptor "B." Evidence of local (not severe) disturbances such as small numbers of fire plow lanes or skidder trails, or shallow tire ruts are likely not sufficient evidence to receive descriptor "B." Evidence that an area has previously been ditched but now the ditches have been partially back-filled (naturally or intentionally) is sufficient to rate a "B." The metric is applicable to the Habitat function in all general wetland types and the Water Quality function in Non-tidal Freshwater Marsh, Seep, and Bog.

With regard to vegetation structure, the assessor should consider the assessment area when evaluating this metric and check a box in the VS column. The vegetation structure component addresses the departure, or alteration, from reference of the vegetation structure. The assessor should consider the following in terms of Habitat: are expected strata present, or has disturbance resulted in the elimination of one or more expected strata or the addition of one or more unexpected strata? Examples of disturbance are provided in metric wording. Vegetation removal may result in both an increase in surface storage capacity (due to surface roughening) and a reduction of water transport out of the wetland (evapotranspiration). This metric is applicable to the Habitat function in all wetland types and the Water Quality function in Seep and Bog.

The clear-cut Bottomland Hardwood Forest depicted by Photo 3-84 is characterized by descriptor "B" for both ground surface condition and vegetation condition. Descriptor "B" for vegetation condition is appropriate for the Bog being maintained (removal of woody vegetation) for the enhancement of bog turtle habitat depicted by Photo 3-61, the beaver-impacted Headwater Forest depicted by Photo 3-78, and the intensively managed (regularly mowed) Pocosin depicted by Photo 3-41.

If a wetland has undergone an alteration that has caused the full range of stable, existing wetland parameters to better resemble another wetland type, the wetland should be classified as the current, more appropriate type. In this case, the assessor needs to be careful when evaluating this metric. The assessor is now evaluating ground surface condition and vegetation condition relative to reference (if applicable) of the current wetland type, and not a potential former wetland type. For instance, if the assessment area is a former Bottomland Hardwood Forest that has been altered by a beaver impoundment so that the full range of stable, existing wetland parameters better resemble a Riverine Swamp Forest, the assessor needs to evaluate this metric relative to a reference Riverine Swamp Forest and not a reference Bottomland Hardwood Forest.

2. Surface and Sub-Surface Storage Capacity and Duration – assessment area condition metric

Check a box in each column. Consider surface storage capacity and duration (Surf) and sub-surface storage capacity and duration (Sub). Consider both increase and decrease in hydrology. Refer to the current NRCS lateral effect of ditching guidance for North Carolina hydric soils (see USACE Wilmington District website) for the zone of influence of ditches in hydric soils. A ditch ≤ 1 foot deep is considered to affect surface water only, while a ditch > 1 foot deep is expected to affect both surface and sub-surface water. Consider tidal flooding regime, if applicable.

Surf	Sub	
☐A	☐A	Water storage capacity and duration are not altered.
☐B	☐B	Water storage capacity or duration are altered, but not substantially (typically, not sufficient to change vegetation).
☐C	☐C	Water storage capacity or duration is substantially altered (typically, alteration sufficient to result in vegetation change) (examples: draining, flooding, soil compaction, filling, excessive sedimentation, underground utility lines).

This metric is a key to an accurate assessment because it is used in the evaluation of all three wetland functions. The assessor should consider the assessment area when evaluating this metric and should check one box in each column.

The surface storage capacity and duration component (Surf) is concerned with the departure, or alteration, from reference with respect to all three wetland functions in most general wetland types (the exception is Bottomland Hardwood Forest, where this metric is only used for the Habitat function). The assessor is asked to determine among the possibilities of no alteration, little alteration, or substantial alteration. The assessor should be able to determine visually if the ground surface has been disturbed enough to remove "A" as a possibility. Examples of alterations that may affect water storage capacity are provided in the metric wording. Please note that both an increase and a decrease in storage capacity are considered "alterations." The severity of evidenced alterations will be used to determine between descriptors "B" and "C." The condition and/or species composition of vegetation may provide assistance with the determination between "B" and a "C."

In order for a ditch(es) to be considered effective, it must be connected to a tributary, or other external receiving water (i.e., water must be leaving the wetland via the ditch). If a ditch is not connected to external receiving waters, it will not be considered to be effective at draining the wetland. When the assessor encounters a ditch within or near the assessment area, several tools exist to assist with the challenging decision regarding a ditch's zone of influence. These tools include groundwater monitoring data, scope and effect models, and drainage guides. It is very important to note that many ditches do not drain as far as suggested by such models or guides due to many site-specific factors including, but not limited to, variable soil textures and restrictive layers, compaction and damming effects of roads, berms, and other land disturbing activities, vegetation growth within the ditch bottom, bank sloughing and sedimentation, and the topographic setting of the ditch(es). A key indicator of the effective drainage depth of a ditch is the physical point where vegetation disappears along the side of the ditch. For example, the effective drainage of a 4-foot deep ditch exhibiting no vegetation to within 12 inches of the ground surface is equivalent to a ditch only one-foot deep. The assessor must also consider normal rainfall conditions when making this decision. An incised stream can have the same effect as a ditch by reducing wetland surface storage and retention. The cause of an alteration to assessment area surface storage capacity and duration does not necessarily have to be located within the assessment area. Again, making decisions relating to the zone of influence of a ditch is challenging, and the drainage effect is very often over estimated.

The sub-surface storage capacity and duration component (Sub) is concerned with the departure, or alteration, from reference with respect to the Hydrology and Water Quality functions. The assessor is again asked to determine among the possibilities of no alteration, little alteration, or substantial alteration. For the purposes of NC WAM, a ditch needs to exceed a foot in depth to be considered to degrade sub-surface wetland hydrology. The threshold of 1 foot for depth has been derived from the 1-foot threshold used by the USACE to determine presence of wetland hydrology (Environmental Laboratory 1987). In areas supporting histic epipedons or histisols, ditching must extend below the surface peat and into the subsoil to be considered to have an effect on sub-surface hydrology. The assessor should also consider departure from reference of sub-surface hydrology resulting from impoundment (such as surface berms, construction of underground utility lines, and beaver dams). Clear-cutting of wetlands may compact surface soils, especially if the activity occurred in winter when soils are wetter. Such compaction reduces infiltration to the sub-surface and increases surface inundation. The cause of an alteration to assessment area sub-surface storage capacity and duration does not necessarily have to be located within the assessment area. Nearby features such as a borrow pit, a large canal, or an impoundment may result in an alteration to assessment area sub-surface storage capacity and duration.

3. Water Storage/Surface Relief – assessment area/wetland type condition metric (evaluate for non-marsh wetlands only)

Check a box in each column for each group below. Select the appropriate storage for the assessment area (AA) and the wetland type (WT).

	AA	WT	
3a.	☐A	☐A	Majority of the wetland with depressions able to pond water > 1 foot deep
	☐B	☐B	Majority of wetland with depressions able to pond water 6 inches to 1 foot deep
	☐C	☐C	Majority of wetland with depressions able to pond water 3 to 6 inches deep
	☐D	☐D	Depressions able to pond water < 3 inches deep

3b.	☐A	Evidence that maximum depth of inundation is greater than 2 feet
	☐B	Evidence that maximum depth of inundation is between 1 and 2 feet
	☐C	Evidence that maximum depth of inundation is less than 1 foot

The assessor should consider the assessment area (AA) and then the wetland type (WT) separately for the 3a evaluation. Metric 3a addresses surface roughness, which indicates the amount of water that can be stored above the ground surface with respect to the Hydrology function for selected wetland types. The assessor should keep in mind the “greater than 50 percent coverage” aspect of the metric. A simple way of measuring the depth of depressions is to lay a stick (auger, shovel, or branch) across depressions (see Photo 4-1) and approximate the height of the stick above the ground surface. The optimum characteristics for this metric vary by general wetland type.

The assessor should only consider the assessment area (AA) when evaluating Metric 3b. Evidence of the height of inundation includes water marks, sediment deposits, wrack material, and drift deposits. This evaluation considers the maximum height of inundation, not a height of inundation that predominates across the assessment area.

Photo 4-1 depicts a Pocosin characterized by greater than 50 percent of the wetland with depressions able to pond water 1 to 2 feet deep (note the auger with a 3-foot shaft).

Photo 4-1

4. Soil Texture/Structure – assessment area condition metric

Check a box from each of the three groups below. Dig soil profile in the dominant assessment area landscape feature. Make soil observations within the top 12 inches. Use most recent guidance for National Technical Committee for Hydric Soils regional indicators.

4a. ☐A Sandy soil
☐B Loamy or clayey soils exhibiting redoximorphic features (concentrations, depletions, or rhizospheres)
☐C Loamy or clayey soils not exhibiting redoximorphic features
☐D Loamy or clayey gleyed soil
☐E Histosol or histic epipedon

4b. ☐A Soil ribbon < 1 inch
☐B Soil ribbon ≥ 1 inch

4c. ☐A No peat or muck presence
☐B A peat or muck presence

This metric addresses the Hydrology and Water Quality functions for forested wetland types. The assessor should consider the assessment area when evaluating this metric. The optimum characteristics for this metric vary by general wetland type.

As stated, the soil profile should be dug in the dominant landscape feature to look at the characteristic assessment area profile. Several holes may need to be excavated for the assessor to determine that this requirement has been met. Soil observations should be made within 12 inches of the surface unless best professional judgment indicates otherwise. Make note of reasoning if observations occur at a different depth.

Soil texture should be determined through use of a texture decision chart (Appendix F). Redoximorphic features are formed by the processes of reduction, translocation, or oxidation of iron and magnesium oxides. Redoximorphic features were formerly called mottles and low chroma colors. For a detailed discussion of redoximorphic features, gleying, histosoils, histic epipedons, peat, and muck, see "Field Indicators of Hydric Soils in the United States: Guide for Identifying and Delineating Hydric Soils" (see most recent guidance from the National Technical Committee for Hydric Soils [ftp://ftp-fc.sc.egov.usda.gov/NSSC/Hydric_Soils and http://soils.usda.gov/use/hydric/]). See Appendix F for directions for determining soil ribbon length.

5. Discharge into Wetland – assessment area opportunity metric

Check a box in each column. Consider surface pollutants or discharges (Surf) and sub-surface pollutants or discharges (Sub). Examples of sub-surface discharges include presence of nearby septic tank, underground storage tank (UST), etc.

Surf	Sub	
☐A	☐A	Little or no evidence of pollutants or discharges entering the assessment area
☐B	☐B	Noticeable evidence of pollutants or discharges entering the wetland and stressing, but not overwhelming the treatment capacity of the assessment area
☐C	☐C	Noticeable evidence of pollutants or discharges (pathogen, particulate, or soluble) entering the assessment area and potentially overwhelming the treatment capacity of the wetland (water discoloration, dead vegetation, excessive sedimentation, odor)

The assessor should consider the assessment area when evaluating this metric. Both surface (Surf) and sub-surface (Sub) discharge components address departure from reference for the Water Quality function of non-riparian wetlands, marshes, and Estuarine Woody Wetland. For the purposes of NC WAM, the term "pollutants" refers to substances introduced into the assessment area that adversely affect the usefulness or health of the wetland (for instance, salt may not be a pollutant in estuarine wetlands but is considered a pollutant in freshwater wetlands); the term "pathogen" refers to undesirable bacteria and viruses; the term "particulate" refers to sediment and insoluble organic matter in the water column; and the term "soluble" refers to dissolved materials from the water column (for example, nutrients that are readily water soluble, such as nitrate nitrogen).

Examples of discharges may include stormwater from a point or a non-point discharge, sediment, herbicides on road shoulders and utility line corridors, and animal waste. A key term used in this metric is the word "evidence." Evidence of discharges is almost always something the assessor can see within the assessment area, an effect within the assessment area resulting from a discharge. A cow standing in the assessment area is not evidence of a discharge, while algae in surface water receiving cow manure is evidence of an effect resulting from a discharge. A road passing by an assessment area is not evidence of a discharge, while an oily sheen in the wetland beside the road is evidence of an effect resulting from a discharge. The only time discharges do not have to be directly observed by the assessor is when they can be inferred from other sources of information. For instance, estuarine wetlands that have been given the designation of "closed shellfish bed" may be inferred to be subject to a detrimental discharge. Wetlands subject to such designations should not receive descriptor "A." Examples of evidence of discharges that may potentially overwhelm the treatment capacity of a wetland include water discoloration, dead vegetation, excessive sedimentation, and odor. For this metric, "excessive sedimentation" that may overwhelm the treatment capacity of the wetland may include both recent sediment that lacks vegetation and sediment from a past event that now supports vegetation.

"Discharge into Wetland" is an opportunity metric that accounts for or infers watershed conditions affecting the level of performance of the Water Quality wetland function. "Opportunity" can increase the amount of water quality treatment a wetland provides by increasing the amount and types of discharges to which the wetland is exposed. Opportunity only leads to increased function if the wetland has the capacity for performing additional function. In NC WAM, opportunity is used to modify the functional rating based on condition, with the combination of condition and opportunity metrics used to determine if the wetland has the capacity to respond to the opportunity.

6. Land Use – opportunity metric

Check all that apply (at least one box in each column). Evaluation involves a GIS effort with field adjustment. Consider sources draining to assessment area within entire upstream watershed (WS), within 5 miles and within the watershed draining to the assessment area (5M), and within 2 miles and within the watershed draining to the assessment area (2M).

WS	5M	2M	
☐A	☐A	☐A	≥ 10% impervious surfaces
☐B	☐B	☐B	< 10% impervious surfaces
☐C	☐C	☐C	Confined animal operations (or other local, concentrated source of pollutants)
☐D	☐D	☐D	≥ 20% coverage of pasture
☐E	☐E	☐E	≥ 20% coverage of agricultural land (regularly plowed land)
☐F	☐F	☐F	≥ 20% coverage of maintained grass/herb
☐G	☐G	☐G	≥ 20% coverage of clear-cut land
☐H	☐H	☐H	Little or no opportunity to improve water quality. Lack of opportunity may result from hydrologic alterations that prevent drainage or overbank flow from affecting the assessment area.

This metric is concerned with conditions within the watershed that may enhance the "opportunity" of the assessment area to perform the Water Quality function. "Opportunity" can increase the amount of water quality treatment a wetland provides by increasing the amount and types of discharges the wetland is exposed to. Opportunity only leads to increased function if the wetland has the capacity for performing additional function. This metric is used in the assessment of Water Quality function for riparian wetlands.

Following is a discussion of the evaluation areas used by this metric and the descriptors presented for consideration by the assessor.

Evaluation Areas (WS, 5M, and 2M)

Assessors should note the importance of the underlined conjunctions in the metric description. An "and" requires that two conditions be met - so the landscape area evaluated has to be characterized by both conditions. Note that no area outside of the watershed or catchment draining to the assessment area should be considered in this evaluation. The term "watershed draining to the assessment area" means all of the watershed area that drains to any portion of the assessment area – from the farthest point upstream in the assessment area to the farthest point downstream in the assessment area.

The assessor will need to consider three landscape areas relative to the assessment area when evaluating this metric.

1) The "WS" landscape area is the entire watershed draining to the assessment area. The WS landscape area is important to the assessment area's opportunity to dissipate water energy (the physical change sub-function of the Water Quality function).

2) The "5M" landscape area is the area that meets both of the following criteria: *within 5 miles of the assessment area boundary* and *within the watershed draining to the assessment area*. The 5M landscape area is important to the assessment area's opportunity to remove sediments and attached pollutants (the particulate change sub-function of the Water Quality function) and to remove dissolved pollutants (the soluble change sub-function of the Water Quality function).

3) The "2M" landscape area is the area that meets both of the following criteria: *within 2 miles of the assessment area boundary* and *within the watershed draining to the assessment area*. The 2M landscape area is important to the assessment area's opportunity to remove bacteria and viruses (the pathogen change sub-function of the Water Quality function). The shorter distance of concern (2 miles) placed on pathogens is due to die-off of bacteria and viruses while traveling through the system.

Figures 8A and 8B are provided as examples for making the determination of area assessed for each of the three columns of check boxes included in this metric. Following is a discussion of what landscape area should be evaluated for each column in these two examples.

In Figure 8A, the watershed draining to the assessment area (area bounded by the line labeled "watershed boundary") extends beyond 5 miles from the assessment area boundary. When selecting one or more descriptor(s) in the first column of Metric 6 (WS), the landscape area evaluated by the assessor is the entire watershed draining to the assessment area (the entire watershed as shown in Figure 8A). When selecting a descriptor in the second column of Metric 6 (5M), the landscape area evaluated by the assessor is the portion of the watershed draining to the assessment area that occurs within 5 miles of the assessment area boundary (the area characterized by any type of hatching in Figure 8A). When selecting a descriptor in the third column of Metric 6 (2M), the landscape area evaluated by the assessor is the portion of the watershed draining to the assessment area that occurs within 2 miles of the assessment area boundary (the area characterized by double hatching in Figure 8A).

In Figure 8B, the entire watershed draining to the assessment area (bounded area of double hatching) is located within 2 miles of the assessment area boundary. Therefore, the landscape area evaluated by the assessor is the same for all three columns in Metric 6.

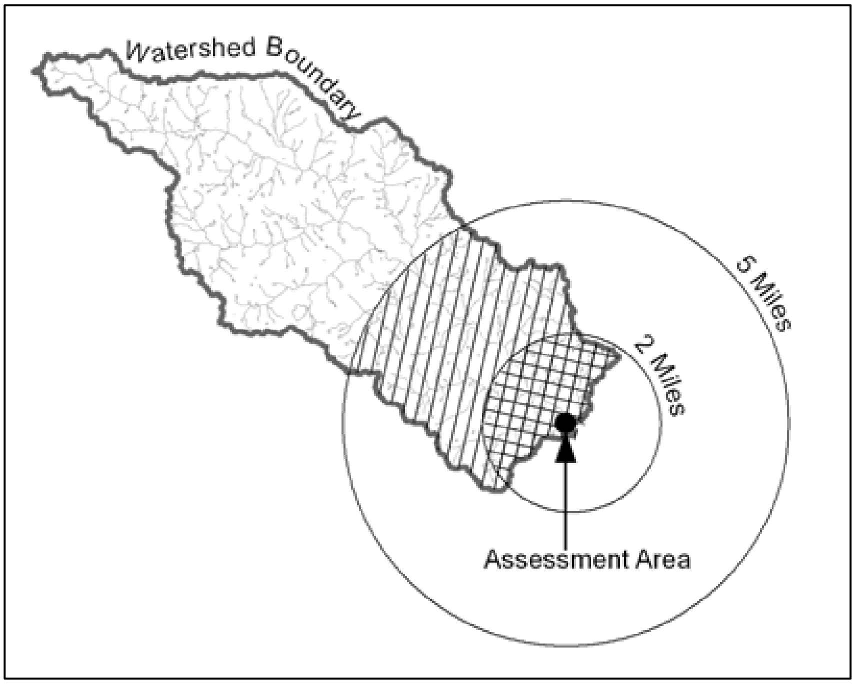


Figure 8A

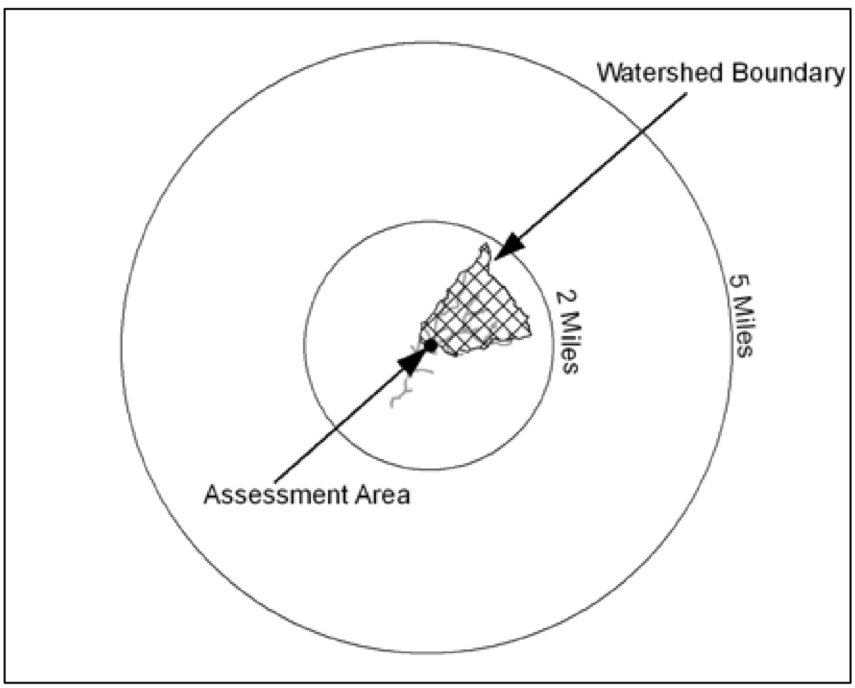


Figure 8B

Descriptors

The evaluation of this metric is expected to involve a mapping investigation. The assessor may benefit from traveling through the watershed draining to the assessment area or talking with someone with local knowledge in order to gain first-hand information for the evaluation of this metric. Sources of information that may be used by the assessor to evaluate this metric include Geographic Information System (GIS) data (made available by the county or state), aerial photography, USGS topographic mapping, county soils survey information, and land use/land cover mapping. These GIS data sources will all be characterized by a certain degree of error, and regulatory agencies acknowledge the existence of this error.

Please note that percent coverage thresholds used by metric descriptors (20% and 10%) are anticipated to be coarse estimates (not precise calculations) on the part of the assessor.

Confined animal operations are facilities associated with production of animal products through raising livestock in large numbers in a limited space, resulting in on-site concentration of animal byproducts. Confined animal operations (CAFOs) are defined by the EPA and Division of Water Quality with respect to a minimal number of livestock in a confined area. The evaluator is not required to actually count the number of animals, but rather has to make a judgment whether livestock in a confined space could result in the runoff of animal waste products to surface waters. Livestock manure is considered a “pollutant” by NC WAM. Examples of “other local, concentrated sources of pollutants” may include landfills, wastewater treatment plants, and localized concentrations of sources of livestock-derived pollutants (such as a small, intensively used pasture or local feed lot) that are situated and managed in such a way that could result in the runoff of animal waste products to surface waters.

Indications that an assessment area is not subject to watershed inputs (overbank events, upslope runoff) suggest the assessment area has little or no opportunity to provide aspects of the Water Quality function (example: a stream has been deepened and/or a berm has been established between the wetland and the stream so that overbank flooding [based on field evidence] rarely, if ever, occurs). Conversely, the presence of sedimentation, organic debris lines or piles, and reclining vegetation within the assessment area may indicate that the wetland is subject to watershed inputs.

Note that the descriptor “H” is selected for either of two extremes: 1) when a severe hydrologic modification has occurred which prevents overbank flow or overland runoff from reaching the assessment area resulting in “little or no opportunity to improve water quality” or 2) when one or more of the evaluation areas is relatively undisturbed resulting in “little or no opportunity” to improve water quality.”

7. Wetland Acting as Vegetated Buffer – assessment area/wetland complex condition metric

7a. Is assessment area within 50 feet of a tributary or other open water?
☐Yes ☐No If Yes, continue to 7b. If No, skip to Metric 8.
Wetland buffer need only be present on one side of the open water. Make buffer judgment based on the average width of wetland. Record a note if a portion of the buffer has been removed or disturbed.

7b. How much of the first 50 feet from the bank is wetland?
☐A ≥ 50 feet
☐B From 30 to < 50 feet
☐C From 15 to < 30 feet
☐D From 5 to < 15 feet
☐E < 5 feet <u>or</u> buffer bypassed by ditches

7c. Tributary width. If the tributary is anastomosed, combine widths of channels/braids for a total width.
☐≤ 15-feet wide ☐> 15-feet wide ☐ Other open water (no tributary present)

7d. Do roots of assessment area vegetation extend into the bank of the tributary/open water?
☐Yes ☐No

7e. Is the tributary or other open water sheltered or exposed?
☐Sheltered – open water width < 2500 feet and no regular boat traffic.
☐Exposed – open water width ≥ 2500 feet or regular boat traffic.

The assessor should consider the assessment area only when answering this metric. This metric addresses the Water Quality function in riparian wetlands.

“Open water” includes tributaries, natural or man-made ponds, natural or man-made lakes, estuaries, and the ocean.

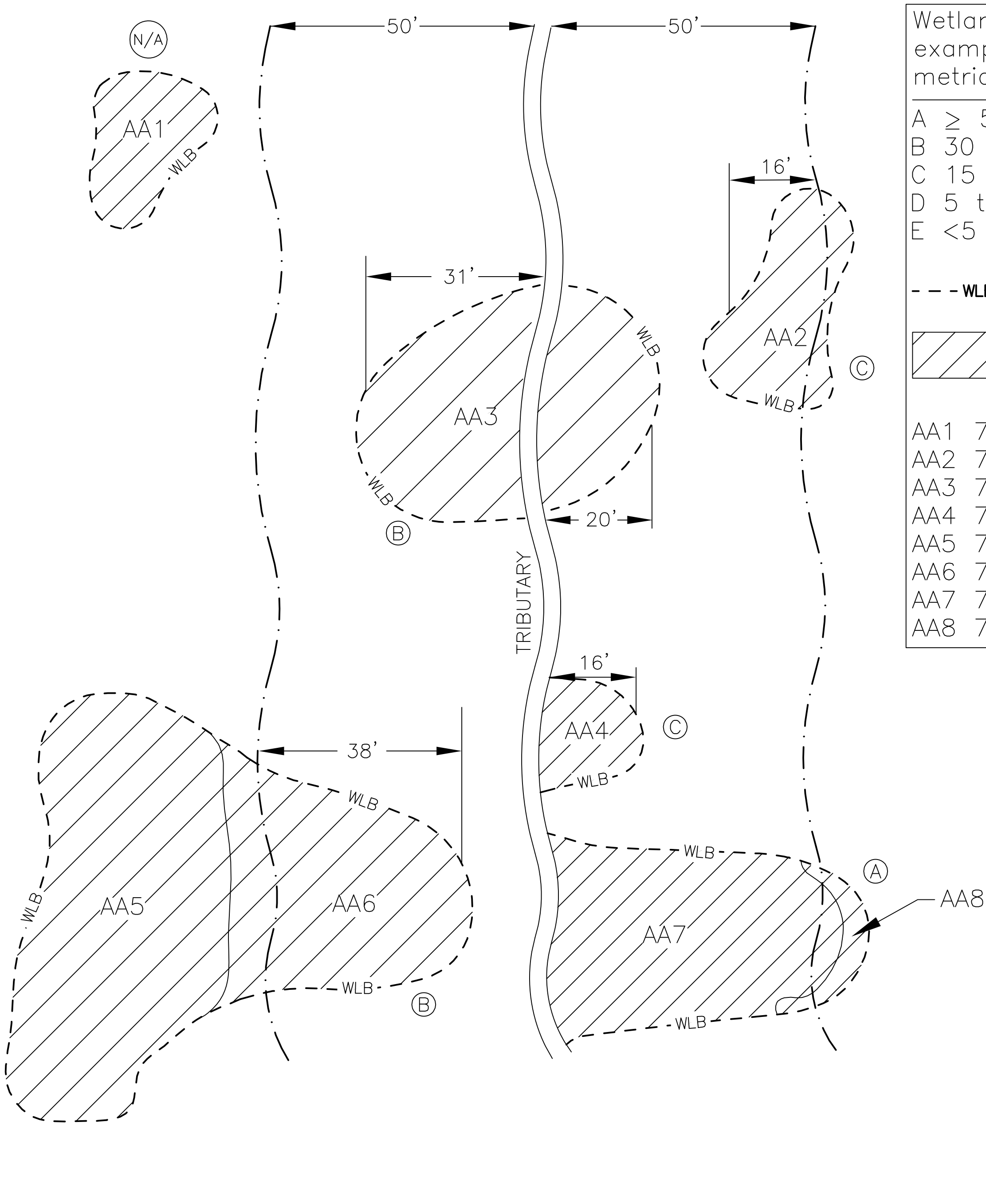
See Figure 9 for examples of how to determine wetland buffer widths. A wetland must be vegetated and within 50 feet of a tributary or other open water to be considered a buffer; therefore, the assessor must have answered “yes” to Metric 7a in order to evaluate the wetland buffer width (Metric 7b). If an assessment area is within 50 feet of a tributary or other open water, the wetland buffer width is how much of the first 50 feet from the open water bank at the assessment area is wetland. If the assessment area extends to both sides of a tributary, and the wetland buffer width is uneven between sides, the assessor should select a descriptor for the bank with greater wetland buffer width. The wetland buffer is measured from the outside banks of the outer channels of an anastomosed system. The number of options and odd intervals of the options presented in this metric are a result of thresholds for different general wetland types. Field experience has proven the following two questions to be helpful in answering Metrics 7a and 7b (see Figure 9 for guidance).

1. Does any part of the assessment area occur within 50 feet of a tributary or other open water?
2. How much of the 50 feet is wetland?

A breach in a wetland buffer does not necessarily mean the buffer is ineffective. The extent of a breach necessary to reduce buffer effectiveness is left to the assessor’s best professional judgment. Un-buffered agricultural or pastoral ditches draining to a buffered tributary are considered to be effectively bypassing the wetland buffer. Metric 7b, Descriptor E should be selected in such cases.

1. Does any part of the Assessment Area occur within 50 feet of a tributary or other open water?

2. How much of the 50 feet is wetland?



Wetland buffer width examples are based on metric 7 descriptions
A ≥ 50 feet
B 30 feet to <50 feet
C 15 to <30 feet
D 5 to <15 feet
E <5 feet
- - WLB - - WETLAND BOUNDARY
ASSESSMENT AREA
AA1 7a=No
AA2 7a=Yes, 7b=C
AA3 7a=Yes, 7b=B
AA4 7a=Yes, 7b=C
AA5 7a=No
AA6 7a=Yes, 7b=B
AA7 7a=Yes, 7b=A
AA8 7a=Yes, 7b=A

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METRIC 7 WETLAND BUFFER WIDTH GUIDANCE

FIGURE

9

Tributary width (Metric 7c) is the normal flow width, or distance of ordinary high water on one bank to ordinary high water on the opposite bank that may be determined by referring to USACE Regulatory Guidance Letter No. 05-05 (Ordinary High Water Mark Identification) for guidance (USACE 2005). If a tributary consists of multiple channels (an anastomosed or braided system), combine the channel widths to estimate the total width. If an assessed wetland occurs within 50 feet of both a tributary greater than 15 feet wide and a tributary less than or equal to 15 feet wide, the assessor should use best professional judgment in determining which tributary the wetland best serves in terms of buffer and flood-flow attenuation. “Other open water” is selected if the assessment area is within 50 feet of an open water that is not a tributary.

Roots of vegetation (both woody and herbaceous) extending into banks (Metric 7d) are considered to be an important factor in stabilizing bank sediments and preventing erosion and subsequent water quality degradation. This determination can be made based on visual assessment of roots in banks or the extent of drip-line coverage of assessment area vegetation. The assessor will need to use best professional judgment to determine when drip-line coverage is not appropriate for this metric, such as when a berm exists along the assessment area side of a tributary.

Shorelines regularly subject to waves of a height of 1 foot or more are considered to be “exposed” (Metric 7e). NC WAM considers an open-water width of 2500 feet to provide sufficient fetch for regular development of waves meeting or exceeding this threshold. Also, shorelines of open water with regular boat traffic that generates high-energy wakes are considered to be “exposed,” regardless of the open-water width. Shorelines not anticipated to be regularly subject to waves of greater than 1 foot in height are considered to be “sheltered” (Metric 7e). NC WAM considers an open-water width of less than 2500 feet to provide too little fetch for regular development of waves meeting or exceeding this threshold unless there is regular boat traffic.

Following are discussions of the evaluation of Metric 7 for example assessment areas depicted in Figure 9.

- Assessment area 1 does not occur within 50 feet of the tributary, so Metric 7a is “No.”
- Assessment area 2 occurs partially within 50 feet of the tributary, so Metric 7a is “Yes;” an average of 16 feet of the 50 feet is wetland, so Metric 7b is “C” (15 to < 30 feet); the tributary is “≤ 15 feet wide” (Metric 7c); the roots of the assessment area likely do not extend into the bank of the tributary, so Metric 7d is “No;” and the tributary is “Sheltered” (Metric 7e).
- Assessment area 3 occurs within 50 feet of the tributary, so Metric 7a is “Yes;” for the bank with the greater wetland buffer width, an average of 31 feet of the 50 feet is wetland, so Metric 7b is “B” (30 to < 50 feet); the tributary is “< 15 feet wide” (Metric 7c); the roots of the assessment area extend into the bank of the tributary, so Metric 7d is ”Yes;” and the tributary is “Sheltered” (Metric 7e).
- Assessment area 4 occurs within 50 feet of the tributary, so Metric 7a is “Yes;” an average of 16 feet of the 50 feet is wetland, so Metric 7b is “C” (15 to < 30 feet); the

tributary is “< 15 feet wide” (Metric 7c); the roots of the assessment area extend into the bank of the tributary, so Metric 7d is “Yes;” and the tributary is “Sheltered” (Metric 7e).

- Assessment area 5 does not occur within 50 feet of the tributary, so Metric 7a is “No.”
- Assessment area 6 is partially within 50 feet of the tributary, so Metric 7a is “Yes;” an average of 38 feet of the 50 feet is wetland, so Metric 7b is “B” (30 to < 50 feet); the tributary is “< 15 feet wide” (Metric 7c); the roots of the assessment area may extend into the bank of the tributary if the assessment area supports vegetation with a canopy that extends over the tributary bank, so Metric 7d may be “Yes;” and the tributary is “Sheltered” (Metric 7e).
- Assessment area 7 is partially within 50 feet of the tributary, so Metric 7a is “Yes;” all of the 50 feet is wetland, so Metric 7b is “A” (> 50 feet); the tributary is “< 15 feet wide” (Metric 7c); the roots of the assessment area extend into the bank of the tributary so Metric 7d is “Yes;” and the tributary is “Sheltered” (Metric 7e).
- Assessment area 8 is partially within 50 feet of the tributary, so Metric 7a is “Yes;” all of the 50 feet is wetland, so Metric 7b is “A” (> 50 feet); the tributary is “< 15 feet wide” (Metric 7c); the roots of the assessment area do not extend into the bank of the tributary, so Metric 7d is “No;” and the tributary is “Sheltered” (Metric 7e).

8. Wetland Width at the Assessment Area – wetland type/wetland complex condition metric (evaluate for riparian wetlands only)

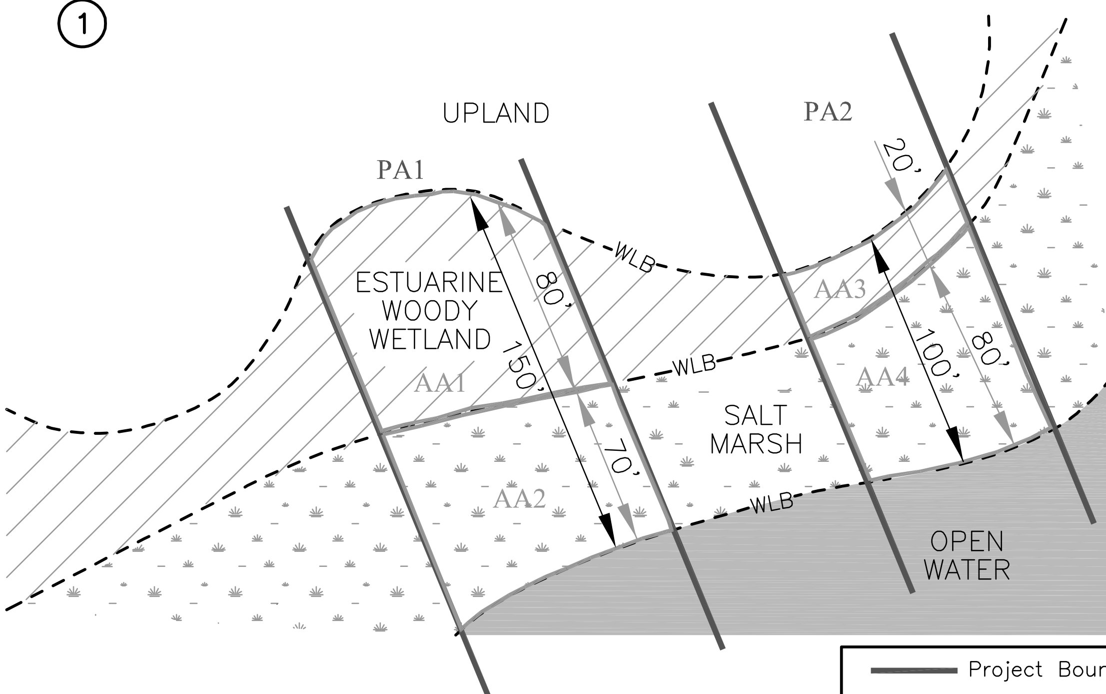
Check a box in each column. Select the average width for the wetland type at the assessment area (WT) and the wetland complex at the assessment area (WC). See User Manual for WT and WC boundaries.

WT	WC	
☐A	☐A	≥ 100 feet
☐B	☐B	From 80 to < 100 feet
☐C	☐C	From 50 to < 80 feet
☐D	☐D	From 40 to < 50 feet
☐E	☐E	From 30 to < 40 feet
☐F	☐F	From 15 to < 30 feet
☐G	☐G	From 5 to < 15 feet
☐H	☐H	< 5 feet

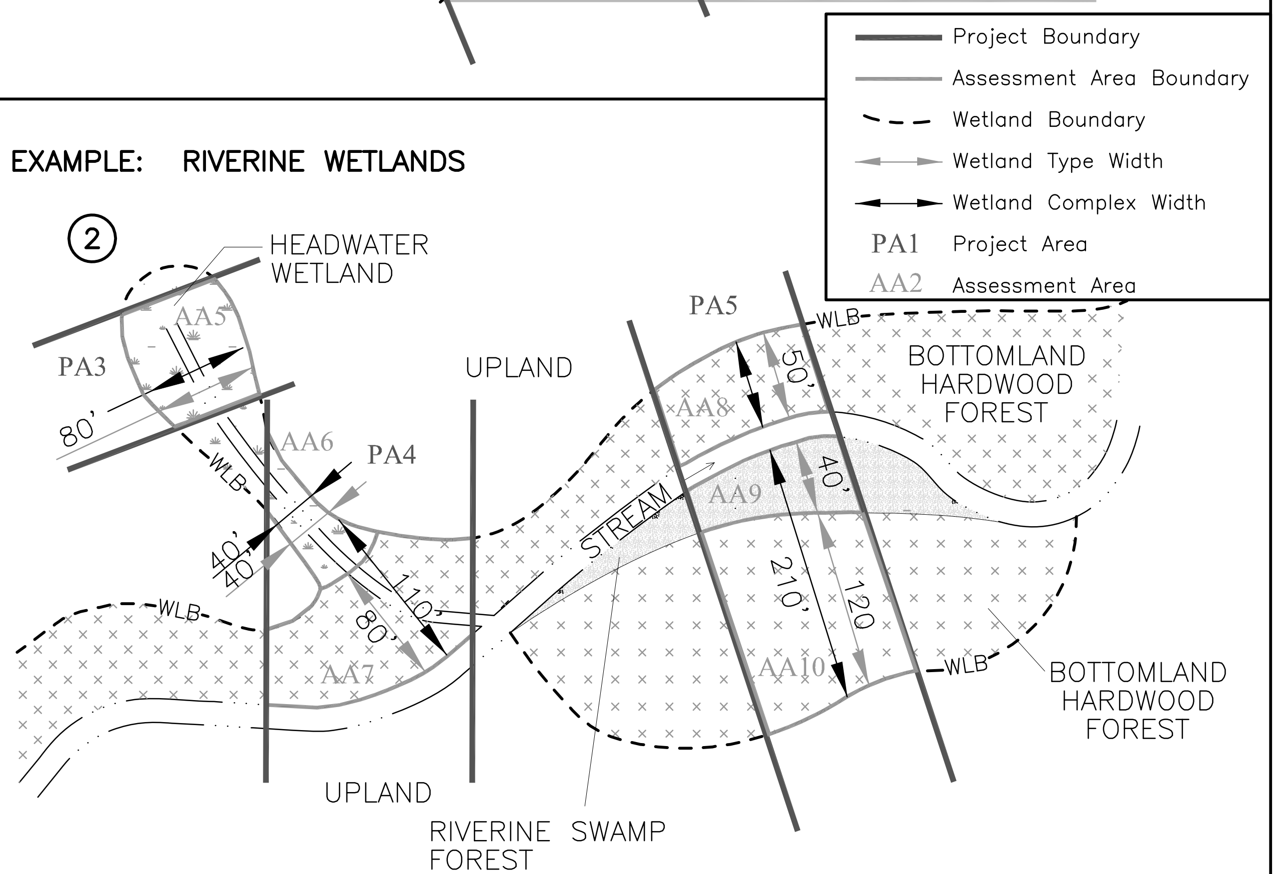
This metric is evaluated for riparian wetlands only. The assessor needs to evaluate this metric for the width of the wetland type at the assessment area (WT) and the wetland complex at the assessment area (WC). The number of options and odd intervals of the options presented in this metric are a result of thresholds for different general wetland types. This metric is used primarily in the Water Quality function and, to a lesser extent, in the Hydrology function in riparian wetlands and all marshes.

See Figure 10 for examples of how to determine wetland widths. Measure the average wetland width perpendicular to elevation contours, stream bank, or shoreline at the assessment area. In the case of a wetland extending along a lower-order stream into the geomorphic floodplain of a higher-order stream, the direction of measured width is dependent on the location of the assessment area. If the assessment area is located along the lower-order stream outside of the geomorphic floodplain of the higher-order stream (Figure 10, Assessment Area 5), wetland type width should be measured perpendicular to the elevation contours of the lower-order stream.

EXAMPLE: COASTAL WETLAND COMPLEX
(Estuarine Woody Wetland, Salt /Brackish Marsh)



EXAMPLE: RIVERINE WETLANDS



NC WAM USER MANUAL	METRIC 8 WETLAND WIDTH GUIDANCE	FIGURE 10

However, if the assessment area is located along the lower-order stream and within the geomorphic floodplain of the higher-order stream (Figure 10, Assessment Area 7), wetland type width should be measured perpendicular to the elevation contours of the channel with the dominant hydrologic influence on the assessment area (this may be the higher-order stream or the lower-order stream, and the assessor must make this determination). Measurements of wetland type width and wetland complex width should be made along the same axis (relative to slope, stream bank, or shoreline) and along the same line. The WFAT considers wetland width to be more important than wetland size with consideration to dissipation of wave energy for shoreline-fringing wetlands.

9. Inundation Duration – assessment area condition metric

Answer for assessment area dominant landform.

☐A Evidence of short-duration inundation (< 7 consecutive days)
☐B Evidence of saturation, without evidence of inundation
☐C Evidence of long-duration inundation or very long-duration inundation (7 to 30 consecutive days or more)

The assessor should consider the assessment area only when evaluating this metric. This metric addresses departure from reference for both the Hydrology and Water Quality functions of some riparian wetlands and Non-Tidal Freshwater Marsh. Wetland delineation experience is very helpful in evaluating this metric. The assessor must also rely on knowledge of the reference condition of the subject wetland, the presence or absence of specific field indicators, and best professional judgment in making this challenging decision.

Inundation is the condition in which water from any source temporarily or permanently covers a land surface and includes both flooding and/or ponding. The duration of such inundation often leaves its mark upon the landscape in the form of recognizable field indicators. The challenge to the assessor lies in interpreting this metric within areas that experience only short-term inundation or saturation.

The assessor will need to rely on on-site evidence of inundation during the growing season when possible and best professional judgment. Wetland indicator status of dominant plant species present and soil type provide the primary indications of wetland hydroperiod utilized in answering this metric. The USACE Hydrophytic Vegetation Indicator Dominance Test (50/20 Rule) is the recommended method for selecting dominant species from a plant community when quantitative data are available. "Dominance" refers strictly to the spatial extent of a species that is measurable in the field. Absolute Percent Cover is the preferred abundance measure for all species. Dominant species are chosen independently from each stratum of the community. In general, dominants are the most abundant species that individually or collectively account for more that 50 percent of the total coverage of vegetation in the stratum, plus any other species that, by itself, accounts for at least 20 percent of the total. Once this determination has been made, the assessor may then use the wetland indicator status of the dominant species to make judgments relative to the wetland hydroperiod. Information regarding vegetation indicator status may be found at https://wetland_plants.usace.army.mil. Hydric soils information may be obtained at the following web sites: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm and ftp://ftp-fc.sc.egov.usda.gov/NSSC/Hydric_Soils.

An assessor should utilize the following indicators to answer this metric:

A. Short-duration inundation (Surface water indicators weak)

- Visual observation of short-duration inundation (ponding or flooding)
- Recorded data
- Soil type
- Drainage patterns, sediment deposits, water marks, wrack material, and/or drift deposits and the absence of prominent inundation indicators listed in C. below
- Dominated by hydrophytic vegetation in conjunction with hydric soils (may include a muck surface layer), but surface water indicators will be weak
- Vegetative morphological adaptations to hydric conditions may be present (e.g., shallow roots, buttswell, buttressing, pneumatophores, hypertrophied lenticels), but surface water indicators will be weak

B. Saturation without evidence of inundation (Surface water indicators absent)

- Recorded data
- Soil type
- Oxidized rhizospheres
- Redoximorphic soil features (concentrations and depletions)
- Dominated by hydrophytic vegetation in conjunction with hydric soils (may include a muck surface layer) and the absence of surface water indicators
- Vegetative morphological adaptations may be present, but surface water indicators will be absent

C. Long-duration inundation or very long-duration inundation (Surface water indicators prominent)

- Visual observation of long-duration inundation (ponding or flooding)
- Recorded data
- Soil type
- Presence of emergent vegetation
- Absence of ground cover in combination with prominent water marks on fixed objects (see Photos 3-18, 3-21, 3-23, 3-25, 3-27, 3-37, 3-50, 3-52, and 3-83)
- Muck surface layer (surface water indicators must be prominent)
- Hydrogen sulfide odor
- Water-stained leaves (grayish or blackish in color)
- Algal mat or crust
- Surface soil cracks
- Presence of aquatic fauna (living individuals, diapausing eggs or crustacean cysts, or dead remains)
- Moss trim lines
- Dominated by FACW to OBL vegetation in conjunction with hydric soils (may include a muck surface layer in conjunction with prominent surface water indicators)

10. Indicators of Deposition – assessment area condition metric

Consider recent deposition only (no plant growth since deposition).

☐A Sediment deposition is not excessive, but at approximately natural levels.
☐B Sediment deposition is excessive, but not overwhelming the wetland.
☐C Sediment deposition is excessive and is overwhelming the wetland.

The assessor should consider only the assessment area when evaluating this metric. This metric addresses the departure from reference of the Water Quality function in forested, riparian wetland types only. The term "recent deposition" refers to sediment deposited by moving water that has not been in place long enough for vegetation to become established in it. The term "overwhelming the wetland" refers to conditions resulting in loss of vegetation components or wetland hydrology. It is assumed that the assessor will have an understanding of the amount of sediment appropriate to a particular wetland type, ecoregion, and landscape position.

11. Wetland Size – wetland type/wetland complex condition metric

Check a box in each column. Involves a GIS effort with field adjustment. This metric evaluates three aspects of the wetland area: the size of the wetland type (WT), the size of the wetland complex (WC), and the size of the forested wetland (FW) (if applicable, see User Manual). See the User Manual for boundaries of these evaluation areas. If assessment area is clear-cut, select "K" for the FW column.

WT	WC	FW (if applicable)	
☐A	☐A	☐A	≥ 500 acres
☐B	☐B	☐B	From 100 to < 500 acres
☐C	☐C	☐C	From 50 to < 100 acres
☐D	☐D	☐D	From 25 to < 50 acres
☐E	☐E	☐E	From 10 to < 25 acres
☐F	☐F	☐F	From 5 to < 10 acres
☐G	☐G	☐G	From 1 to < 5 acres
☐H	☐H	☐H	From 0.5 to < 1 acre
☐I	☐I	☐I	From 0.1 to < 0.5 acre
☐J	☐J	☐J	From 0.01 to < 0.1 acre
☐K	☐K	☐K	< 0.01 acre <u>or</u> assessment area is clear-cut

The assessor needs to evaluate this metric for the wetland type (WT), the wetland complex (WC), and the forested wetland (FW). This metric is principal to the assessment because it addresses the departure from reference of all three wetland functions and is used in the functional assessment of all general wetland types. This metric is used to assess the Water Quality function of non-riparian wetland types and the Habitat function of all wetland types. In the case of Estuarine Woody Wetland, this metric is used to assess the Hydrology function. The number of metric options and odd intervals of the metric options are the result of compiling different thresholds for different general wetland types. The "forested wetland" column will only be used if the assessment area occurs in a forested wetland type. If the assessment area is a forested wetland type that has been clear-cut, the assessor should select "K" for the "forested wetland" column.

Depending on the size of the assessment area, wetland type, and wetland complex, the evaluation of this metric may require a mapping investigation. Sources of information that may be used by the assessor to evaluate this metric include Geographic Information System (GIS) data (made available by the county or state), aerial photography, USGS topographic mapping, county soils mapping, and land use/land cover mapping. A good deal of best professional judgment may be required for this task.

12. Wetland Intactness – wetland type condition metric (evaluate for Pocosins only)

☐A Pocosin is the full extent (≥ 90%) of its natural landscape size.
☐B Pocosin is < 90% of the full extent of its natural landscape size.

The assessor should consider the wetland type when evaluating this metric. This metric addresses the departure from reference of the Habitat function for Pocosins only. A Pocosin not occupying the full extent of the mapped Pocosin soil unit will likely have suffered a disturbance that has changed a Pocosin to another wetland type or caused an area of former Pocosin to no longer be wetland. Silviculture practices may result in conversion of a Pocosin to Pine Flat or non-wetland. Agriculture, construction of roads, mining, or fill may result in a conversion of Pocosin to non-wetland.

The evaluation of this metric is expected to involve best professional judgment and a map investigation. County soils mapping may be the best source of information for estimation of “landscape size” of a Pocosin in many cases. Appendix D provides a list of soils that typically support the NC WAM Pocosin wetland type. The list includes soil series that typically support a plant community dominated by dense, waxy shrub species and that includes pond pine and/or bays. Other sources of information to be used in making this decision may include Geographic Information System (GIS) data (made available by the county or state), aerial photography, USGS topographic mapping, and land use/land cover mapping).

Figures 11A and 11B depict examples of Carolina bays that are characterized by both possible Metric 12 descriptors, respectively. In the case of Carolina bays, aerial photography may be the best method to determine the natural landscape size of the subject Pocosins.

Figures 11C through 11F depict examples of non-bay Pocosins that are characterized by both possible Metric 12 descriptors. In these cases, a digital representation of a soil mapping unit that typically supports Pocosin (Appendix D) is overlaid on a recent aerial photograph in order to determine the extent of Habitat disturbance within the estimated natural landscape size of the subject Pocosins.

Figure 11A

Figure 11B

Figure 11A depicts a Carolina bay at Suggs Mill Pond Game Land, Bladen County, that appears to be less than the full extent of its original landscape size but is likely greater than 90 percent of its natural landscape size. Figure 11B depicts a Carolina bay in Pender County that has been modified to be less than 90 percent of its natural landscape size. Figures 11C and 11D are examples of Pocosins that are greater than 90 percent of their natural landscape size. Figure 11C depicts with a white line a mapping unit of Croatan muck within the Croatan National Forest, Craven County. Figure 11D depicts with a white line a mapping unit of Murville mucky fine sand near Hooper Hill, Brunswick County.

Figure 11C

Figure 11D

Figure 11E

Figure 11F

Figures 11E and 11F are examples of Pocosins that are less than 90 percent of their natural landscape size. Figure 11E depicts with a white line a mapping unit of Belhaven muck near Scuppernong, Washington County. Figure 11F depicts with a white line a mapping unit of Dare muck near Fairfield Harbor, Craven County.

13. Connectivity to Other Natural Areas – landscape condition metric

13a. **Check appropriate box(es) (a box may be checked in each column).** Involves a GIS effort with field adjustment. This metric evaluates whether the wetland is well connected (Well) and/or loosely connected (Loosely) to the landscape patch, the contiguous naturally vegetated area and open water (if appropriate). Boundaries are formed by four-lane roads, regularly maintained utility line corridors the width of a four-lane road or wider, urban landscapes, maintained fields (pasture and agriculture), or open water > 300 feet wide.

Well	Loosely	
☐A	☐A	≥ 500 acres
☐B	☐B	From 100 to < 500 acres
☐C	☐C	From 50 to < 100 acres
☐D	☐D	From 10 to < 50 acres
☐E	☐E	< 10 acres
☐F	☐F	Wetland type has a poor or no connection to other natural habitats

13b. **Evaluate for marshes only**.

☐Yes ☐No Wetland type has a surface hydrology connection to open waters/tributary or tidal wetlands.

The assessor should consider the relative position of the wetland type in the regional landscape when evaluating Metric 13a. This metric addresses the juxtaposition of other naturally vegetated areas relative to the wetland type. This metric applies to the Habitat function of all general wetland types.

For the purposes of NC WAM, a "landscape patch" is the contiguous natural habitat that includes the assessed wetland type regardless of whether the natural habitat is located within the watershed of the assessed wetland type. "Well connected" (Well) is a term that generally refers to a wetland type that is surrounded by or adjoins a landscape patch along a substantial part of its boundary on at least one side. A wetland type is considered to be "loosely connected" (Loosely) to other habitats if connected by narrow corridors of habitat. Boundaries must present a barrier or danger to wildlife attempting to negotiate them in order to disconnect the assessment area from landscape patches. Such boundaries include four-lane roads, regularly maintained utility line corridors the width of a four-lane road or wider, urban landscapes, maintained fields (pasture and agriculture), or open water greater than 300 feet wide. The assessor may check a box in each column. If a wetland type is well connected to 15 acres and loosely connected to 200 acres, the assessor should check "D" in the "Well" column and "B" in the "Loosely' column. If a wetland type has poor or no connection to a landscape patch, the assessor may check either one or both "F" boxes. The assessor should document best professional judgment concerning the evaluation of this metric when the assessed wetland is on an island.

"Surface hydrology connection to open waters/tributary or tidal wetlands" is an important factor in the evaluation of the Habitat function in marshes. When evaluating marshes, an assessor should only consider other marsh-like areas in terms of connection to natural areas. "Marsh-like areas" include emergent herbs and shrubs with or without an interspersion of surface water. Metric 13b is concerned with the potential for movement of wildlife and fish among contiguous, suitable habitat types, and wetland types found higher in the landscape would likely not provide suitable habitat for many marsh specialists. In this sense, a "surface hydrology connection" includes any type of connection that will allow aquatic life movement. A ditch or canal is only considered to be a surface hydrology connection if it has been determined to be subject to Section 404 jurisdiction. A marsh is still considered to have a surface hydrology connection to other natural areas if culverts allow aquatic life access into and out of the marsh.

14. Edge Effect – wetland type condition metric (skip for all marshes)

May involve a GIS effort with field adjustment. Estimate distance from wetland type boundary to artificial edges. Artificial edges include non-forested areas ≥ 40 feet wide such as fields, development, roads, regularly maintained utility line corridors, and clear-cuts. Consider the eight main points of the compass.

☐A No artificial edge within 150 feet in all directions
☐B No artificial edge within 150 feet in four (4) to seven (7) directions
☐C An artificial edge occurs within 150 feet in more than four (4) directions <u>or</u> assessment area is clear-cut

The assessor should consider the wetland type when evaluating this metric. This metric addresses the departure from reference of the Habitat function for all forested wetland types. Artificial edges are barriers to travel or population expansion for some native flora and fauna, yet provide access to forest interiors for invasive and exotic fauna and flora. The listed artificial edges (permanent features such as fields, development, two-lane or larger roads [greater than 40 feet wide], utility lines wider than a two-lane road, and clear-cuts) include areas that break the structure of forested wetlands (forested uplands are not considered an artificial edge).

The eight main points of the compass comprise north, northeast, east, southeast, south, southwest, west, and northwest. Figure 12 provides a display of the eight main points of the compass and depicts two proposed activities, A and B. These activities are represented with emphasis on the issue of artificial edge. The wetland type included in proposed activity A assessment area (Headwater Forest) is characterized by artificial edge within 150 feet in only three directions (southeast, south, and southwest), resulting in descriptor "B." The wetland type included in proposed activity B assessment area (Hardwood Flat) is characterized by artificial edge within 150 feet in all directions, resulting in a descriptor of "C."

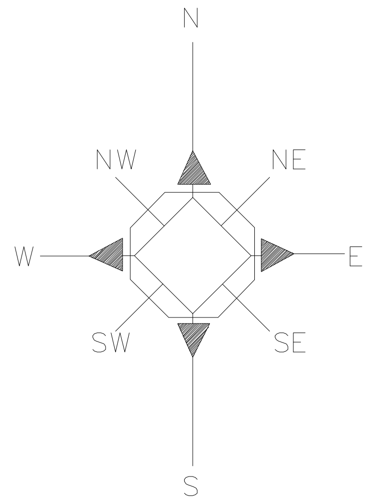
Photo 4-2

Photo 4-3

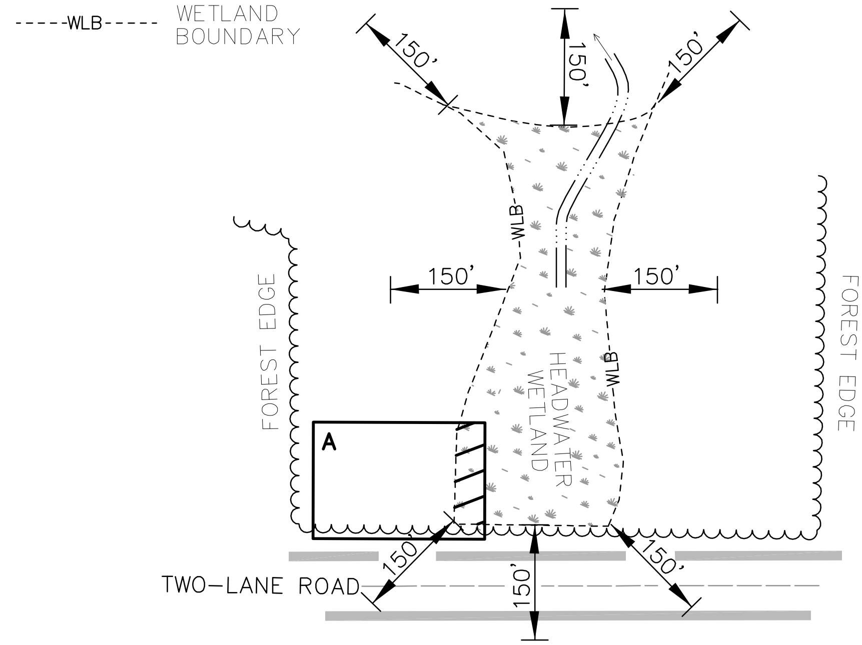
Photos 4-2, 4-3, and 4-4 are examples of artificial edges. Photo 4-2 depicts a two-lane road, Photo 4-3 depicts a single-lane road and man-made ditch (together, wider than a two-lane road), and Photo 4-4 depicts a maintained utility line corridor wider than a two-lane road. Photo 4-5 is not an example of an artificial edge because the maintained corridor is narrower than the width of a two-lane road.

Photo 4-4

Photo 4-5



EIGHT MAIN POINTS OF THE COMPASS



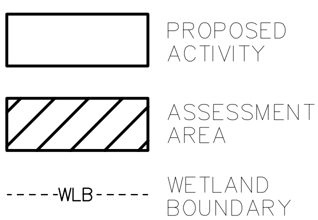
Activity A

WETLAND TYPE: HEADWATER FOREST

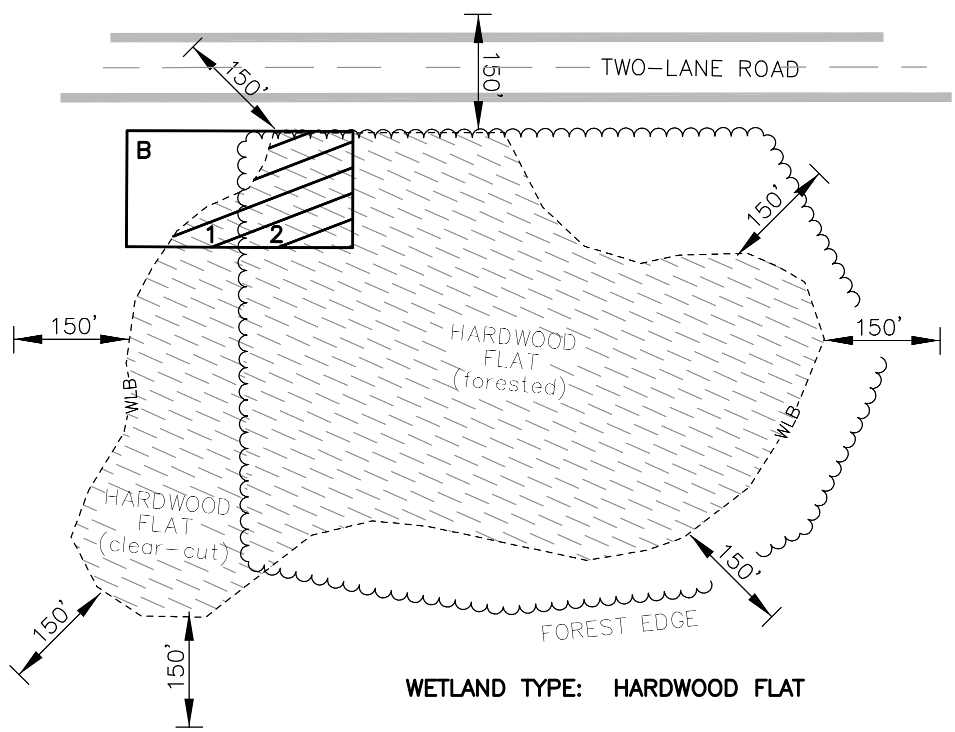
METRIC # 14=B:

No Artificial Edge Within 150 Feet In Four To Seven Directions.

SCALE: NTS



SCALE: NTS



Activity B

METRIC # 14=C:

An Artificial Edge Occurs Within 150 Feet In More Than Four Directions.

WETLAND TYPE: HARDWOOD FLAT

NC WAM USER MANUAL

METRIC 14 EDGE EFFECT DETERMINATION GUIDANCE

FIGURE

12

15. Vegetative Composition – assessment area condition metric (skip for all marshes and Pine Flat)

- ☐A Vegetation is close to reference condition in species present and their proportions. Lower strata composed of appropriate species, with exotic plants absent or sparse within the assessment area.
- ☐B Vegetation is different from reference condition in species diversity or proportions, but still largely composed of native species characteristic of the wetland type. This may include communities of weedy native species that develop after clear-cutting or clearing. It also includes communities with exotics present, but not dominant, over a large portion of the expected strata.
- ☐C Vegetation severely altered from reference in composition. Expected species are unnaturally absent (planted stands of non-characteristic species or at least one stratum inappropriately composed of a single species). Exotic species are dominant in at least one stratum.

The assessor should consider the assessment area only when evaluating this metric. This metric addresses the departure from reference of the Habitat function for all general wetland types with the exception of marshes and Pine Flat. In order to evaluate this metric, the assessor needs to be familiar with the composition of vegetation within the range of reference examples of each general wetland type. Exotic species may become established in disturbed areas, so the presence of exotic species suggests a past disturbance that resulted in a window of opportunity for establishment. A list of species considered to be exotic in North Carolina is provided in Appendix G. Although not on the list of exotics, common reed (*Phragmites australis*) is considered a non-native, invasive species in North Carolina, and presence of this species should be considered equivalent to presence of an exotic.

16. Vegetative Diversity – assessment area condition metric (evaluate for Non-Tidal Freshwater Marsh only)

- ☐A Vegetation diversity is high and is composed primarily of native species (< 10% cover of exotics).
- ☐B Vegetation diversity is low or has > 10% to 50% cover of exotics.
- ☐C Vegetation is dominated by exotic species (> 50% cover of exotics).

The assessor should consider the assessment area only when evaluating this metric. This metric is used in the Habitat function in Non-tidal Freshwater Marsh only. An estimation of percent coverage of vegetation should be made for the growing season. Exotic species usually become established in disturbed areas, so the presence of exotic species may suggest a past disturbance that resulted in a window of opportunity for establishment. A list of species considered to be exotic in North Carolina is provided in Appendix G. Although not on the list of exotics, common reed (*Phragmites australis*) is considered a non-native, invasive species in North Carolina, and presence of this species should be considered equivalent to presence of an exotic.

17. Vegetative Structure – assessment area/wetland type condition metric

17a. Is vegetation present?

☐Yes ☐No If Yes, continue to 17b. If No, skip to Metric 18.

17b. Evaluate percent coverage of assessment area vegetation **for all marshes only**. Skip to17c for non-marsh wetlands.

☐A ≥ 25% coverage of vegetation

☐B < 25% coverage of vegetation

17c. **Check a box in each column for each stratum.** Evaluate this portion of the metric **for non-marsh wetlands**. Consider structure in airspace above the assessment area (AA) and the wetland type (WT) separately.

Stratum	AA	WT	
Canopy	☐A	☐A	Canopy closed, or nearly closed, with natural gaps associated with natural processes
	☐B	☐B	Canopy present, but opened more than natural gaps
	☐C	☐C	Canopy sparse or absent
Mid-Story	☐A	☐A	Dense mid-story/sapling layer
	☐B	☐B	Moderate density mid-story/sapling layer
	☐C	☐C	Mid-story/sapling layer sparse or absent
Shrub	☐A	☐A	Dense shrub layer
	☐B	☐B	Moderate density shrub layer
	☐C	☐C	Shrub layer sparse or absent
Herb	☐A	☐A	Dense herb layer
	☐B	☐B	Moderate density herb layer
	☐C	☐C	Herb layer sparse or absent

Metric 17a should be evaluated for all wetlands. Metric 17b is used in the assessment of the Water Quality function for marshes. Metric 17c addresses the departure from reference for all three wetland functions in non-marsh wetlands.

The assessor should consider both the assessment area and the wetland type when evaluating Metric 17c. Woody structure is important in riparian wetlands for slowing flood waters and overland runoff (Hydrology function) and increasing residence time for treatment and infiltration of surface waters (Water Quality function). Woody structure, at appropriate density and stratification for specific general wetland types, is important in terms of diversity of habitats (Habitat function). The assessor should consider living vegetation in the growing season when evaluating this metric.

Definitions for "canopy," "tree," "sapling," "shrub," and "herb" can be found in the glossary (Appendix I). Woody vines should be considered in the stratum in which they occur. For example, woody vines should be classified as shrubs if they are the height of shrubs and should be classified as canopy if they are the height of trees. "Natural gaps associated with natural processes" includes large gaps resulting from natural tree fall as well as storm damage, including hurricane damage. For forested wetlands that may be characterized by a variety of structural variations (Floodplain Pool, Bog, Pine Savanna, Pocosin, Pine Flat, Seep), this metric is not used for generation of functional ratings.

Photo 3-38 depicts a Non-Riverine Swamp Forest recovering from hurricane damage. Although canopy gaps are larger than typical for reference of this wetland type, a hurricane is considered to be a natural process, and therefore "canopy closed or nearly closed, with natural gaps associated with natural processes" (descriptor "A") is an appropriate descriptor. In this same example, the mid-story/sapling layer is sparse or absent (descriptor "C"), while the shrub and herb layers are responding to increased sunlight since the hurricane, resulting in descriptors of "B" and "A," respectively, for these layers.

18. Snags – wetland type condition metric

☐A Large snags (more than one) are visible (> 12 inches DBH, or large relative to species present and landscape stability).
☐B Not A

The assessor should consider the wetland type when evaluating this metric. This metric addresses the departure from reference of the Habitat function for forested wetland types. Diameter at breast height (DBH) is the width of a plant stem as measured at 4.5 feet above the ground surface. The term "large" used in this metric should be considered relative to the species present in the assessment area (see Photo 4-6). For example: a stand of 8- to 10-inch DBH black willows (*Salix nigra*) is less than the 12-inch DBH criteria listed in the metric, but these trees are considered "large" for this species. The term "visible" means "visible within the wetland type from the assessment area." An assessor is expected to have walked the assessment area prior to conducting the functional assessment but is not expected to have searched throughout a large wetland type that may extend well outside of a given project area. "Landscape stability" refers to wetlands subject to disturbance or somehow lacking stability – such as wetlands located at stormwater outfalls or on deltas at the heads of reservoirs. More than one large snag must be visible to the assessor within the wetland type for the selection of descriptor "A." This is a "value-added metric;" selection of descriptor "A" may increase a wetland rating for Habitat, while selection of descriptor "B" will not affect the rating.

Photo 4-6

Photo 4-6 depicts both a large snag and large woody debris in a Pine Flat.

19. Diameter Class Distribution – wetland type condition metric

- ☐A Majority of canopy trees have stems > 6 inches in diameter at breast height (DBH); many large trees (> 12 inches DBH) are present.
- ☐B Majority of canopy trees have stems between 6 and 12 inches DBH, few are > 12 inch DBH.
- ☐C Majority of canopy trees are < 6 inches DBH or no trees.

The assessor should consider the wetland type when evaluating this metric. This metric addresses the departure from reference of the Habitat function for forested wetland types. DBH (diameter at breast height) is the width of a living plant stem as measured at 4.5 feet above the ground surface. For this metric, canopy tree size is a surrogate estimate for habitat diversity – with the presence of larger trees considered indicative of higher structural diversity. The term "large" used in this metric should be considered relative to the species present in the assessment area. For example: a stand of 8- to 10-inch DBH black willows (*Salix nigra*) is less than the 12-inch DBH criteria listed in the metric, but these trees are considered "large" for this species.

20. Large Woody Debris – wetland type condition metric

Include both natural debris and man-placed natural debris.

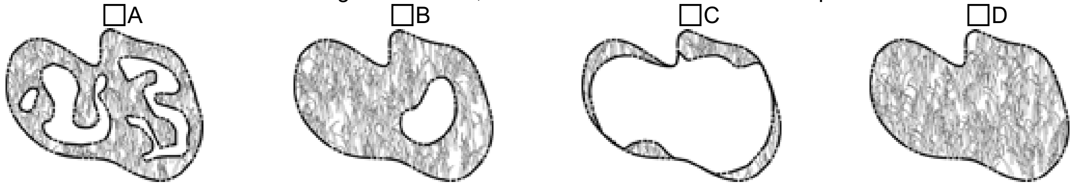
- ☐A Large logs (more than one) are visible (> 12 inches in diameter, or large relative to species present and landscape stability).
- ☐B Not A

The assessor should consider the wetland type when evaluating this metric. This metric addresses the departure from reference of the Habitat function in forested wetland types only. The term "large" used in this metric should be considered relative to the species present in the assessment area (see Photo 4-6). For example: a stand of 8- to 10-inch diameter black willow trunks are less than the 12-inch criteria listed in the metric, but these trees are considered "large" for this species. An example of woody debris being large relative to landscape position might include Estuarine Woody Wetland, a transitional wetland type that might not be expected to provide a stable enough environment to support large trees; therefore, in this wetland type, the presence of woody debris that is less than 12-inches in diameter may be evaluated with a descriptor of "A." More than one large log must be visible to the assessor within the wetland type for descriptor "A" to be appropriate. The term "visible" means "visible within the wetland type from the assessment area." An assessor is expected to have walked the assessment area prior to conducting the functional assessment but is not expected to have searched throughout a large wetland type that may extend well outside of a given project area. This is a "value-added metric;" selection of descriptor "A" may increase a wetland rating for Habitat, while selection of descriptor "B" will not affect the rating.

21. Vegetation/Open Water Dispersion – wetland type/open water condition metric (evaluate for Non-Tidal Freshwater Marsh only)

Select the figure that best describes the amount of interspersion between vegetation and open water in the growing season. Patterned areas indicate vegetated areas, while solid white areas indicate open water.

☐A ☐B ☐C ☐D



The assessor should consider the wetland type when evaluating this metric. This metric is only used in the Habitat function in Non-tidal Freshwater Marsh. Only living vegetation should be considered when evaluating this metric. The evaluation of this metric should be made for the expected condition during the growing season. This will require that the assessor employ best professional judgment when evaluating this metric outside of the growing season. Descriptor "A" depicts a relatively large area of marsh and from few to many, relatively small, scattered areas of open water. Descriptor "B" depicts a relatively large area of marsh and one or few, relatively small, concentrated areas of open water. Descriptor "C" depicts a marsh fringing a larger open water. Descriptor "D" depicts nearly complete to complete coverage of marsh. See Photos 4-7 through 4-10 for field examples of different descriptors.

Photo 4-7

Photo 4-8

Photos 4-7 through 4-10 depict Non-Tidal Freshwater Marshes in Henderson, Wake, Wake, and Brunswick counties, respectively. The first three include open water within the wetland, while the fourth includes no open water. Photo 4.7 depicts a homogenous interspersion of marsh vegetation and shallow open water – representing an example of Metric 21, descriptor "A." Photo 4-8 depicts a relatively large area of marsh and a relatively small area of shallow open water – representing an example of Metric 21, descriptor "B." Photo 4-9 depicts a narrow fringe of marsh around the perimeter of a relatively large open-water area – representing an example of Metric 21, descriptor "C." And Photo 4-10 depicts a marsh with almost complete coverage by emergent and aquatic vegetation – representing an example of Metric 21, descriptor "D."

Photo 4-9

Photo 4-10

22. Hydrologic Connectivity – assessment area condition metric (evaluate for riparian wetlands only)

Examples of activities that may severely alter hydrologic connectivity include intensive ditching, fill, sedimentation, channelization, diversion, man-made berms, beaver dams, and stream incision.

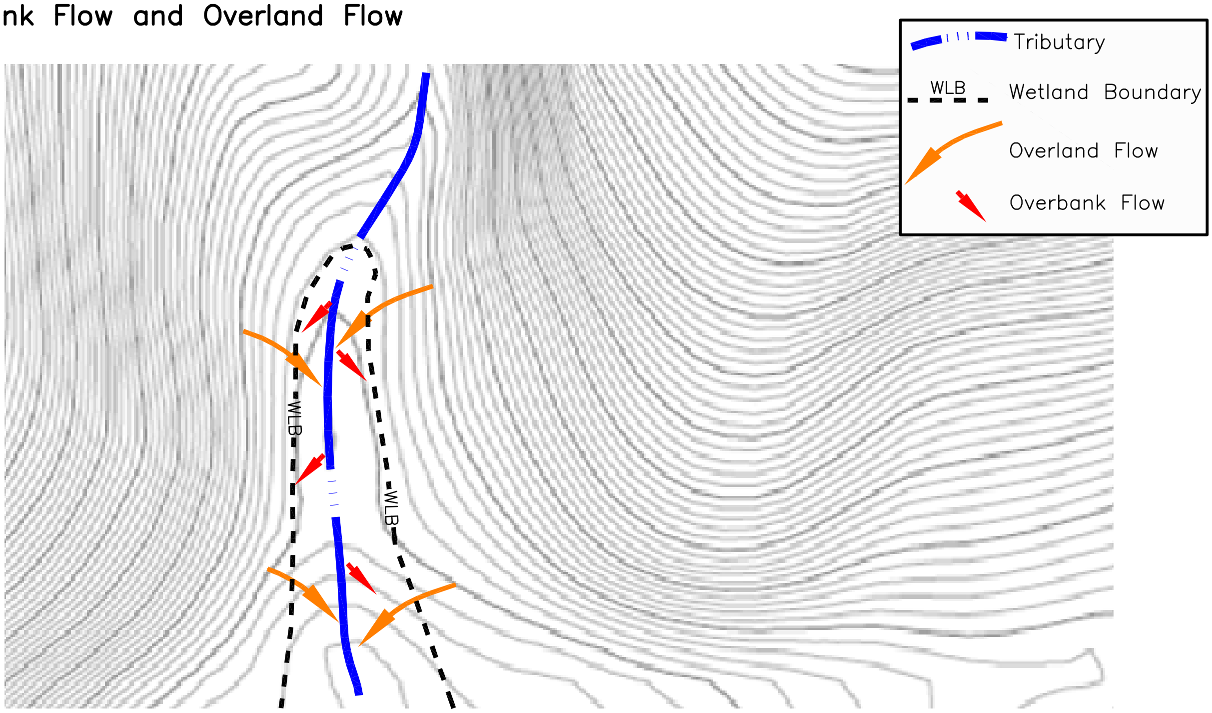
☐A Overbank and overland flow are not severely altered in the assessment area.
☐B Overbank flow is severely altered in the assessment area.
☐C Overland flow is severely altered in the assessment area.
☐D Both overbank and overland flow are severely altered in the assessment area

The status of overbank and overland flow within riparian wetlands is very important in the generation of Hydrology and Water Quality function ratings, and, therefore, the overall rating of the wetland. The assessor is urged to evaluate this question carefully. Please note that the conjunction "and" is underlined, meaning that the same condition applies to both overbank and overland flow. A substantial portion of the Hydrology and Water Quality functions in riparian wetlands is dependent on the availability of these wetlands to receive overbank flow and to receive and transport overland flow. Figure 13 provides depictions of overbank and overland flow. Overbank flow occurs when water rises in a tributary or other open water, such as a lake, until it exceeds bank elevation and spreads across the land surface outside of the banks. Indicators of overbank flow include sedimentation, drainage patterns, debris lines, reclining vegetation, and gauge data. Overland flow is water movement above and parallel with the soil surface. When considering a wetland abutting a tributary or other open water, unaltered overland flow includes surface water from contiguous uplands or wetlands and transport of surface water across the wetland to a tributary or other open water. When considering a linear wetland without a tributary or other open water, overland flow may include down-valley surface flow and down-slope surface flow from uplands. Overland flow does not assume the existence of a tributary.

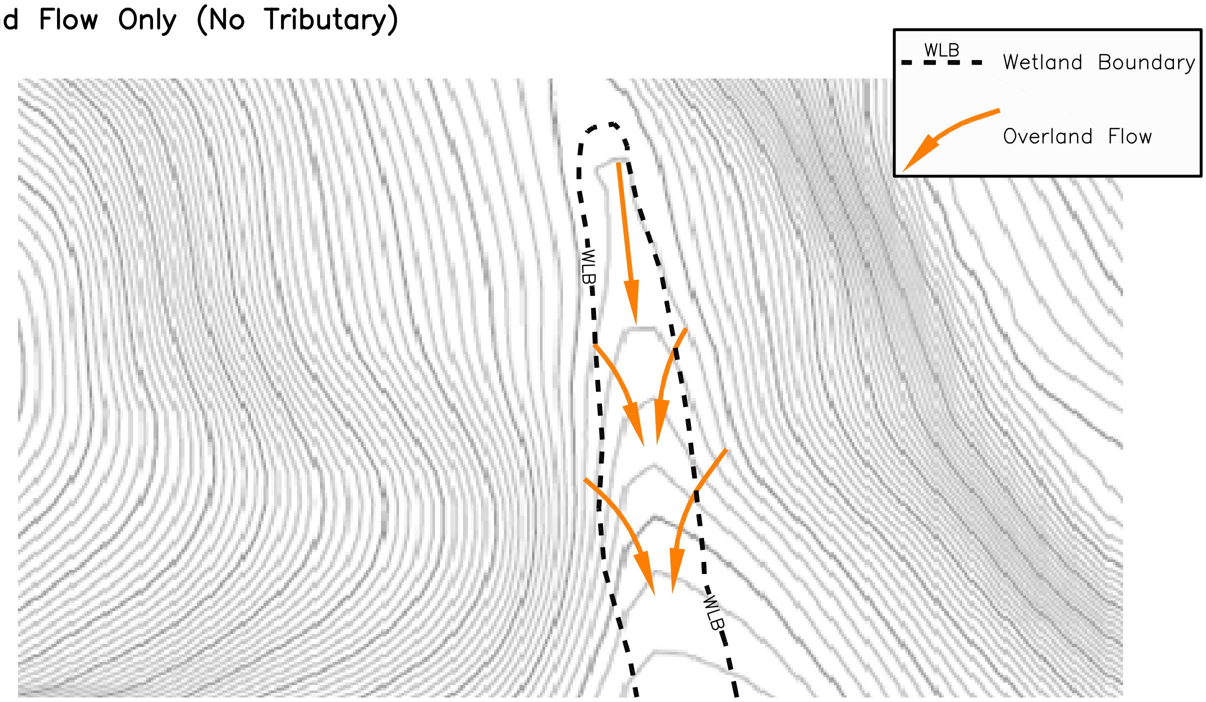
To select descriptors "B," "C," or "D," the assessor must see definitive evidence of a severe alteration to overbank flow or overland flow. Indicators of overbank or overland flow include recent sedimentation, waterlines, debris lines, reclining vegetation, and gauge data. "Overland" flow refers to surface water moving from high to low ground. Overland flow includes, but is not limited to, surface flow down valley and surface flow from upslope uplands into a geomorphic floodplain or a natural topographic crenulation.

Examples of severe alterations to overbank flow may include deeply incised tributaries and high berms or other structures between the tributary or other open water and assessment area. Examples of severe alterations to overland flow may include development such as walls or parking lots up slope of riparian wetlands or causeways across a floodplain. The cause of an alteration to assessment area overbank or overland flow does not necessarily have to be located within the assessment area.

Overbank Flow and Overland Flow



Overland Flow Only (No Tributary)



NC WAM USER MANUAL	**METRIC 22 OVERBANK and OVERLAND FLOW GUIDANCE**	FIGURE **13**

5.0 THE WETLAND ASSESSMENT PROCESS

It is crucial that the assessor become familiar with the NC WAM general wetland types and Field Assessment Form metrics in order to conduct a proper wetland assessment. Assessors will need to be familiar with the physiography, hydrologic regime, water quality function, typical vegetation structure and composition, and wildlife attributes for the range of reference examples appropriate to each general wetland type within the project area. Assessors will also need to develop a clear understanding of the intention of each metric, how the intention of each metric may change with different general wetland types, and how characteristics within each wetland type may change among different ecoregions.

An on-going objective during development of NC WAM is that on-site completion of the Field Assessment Form should take no more than 15 minutes. However, it is assumed that this 15-minute, on-site wetland assessment will be performed following a wetland boundary delineation or determination, and that during the course of the delineation/determination, the assessor will have become knowledgeable of the environmental features important to this wetland assessment method. This being the case, the assessor should have become familiar with site and regional physiography, soils, hydrology, vegetation, wetlands, and watershed activities affecting the site. The assessor should also be familiar with the proposed project in order to determine potential impact areas and identify individual assessment areas.

Completion of a wetland functional assessment will typically be a six-step process (the first three steps will likely be completed as part of a wetland boundary delineation/determination but are outlined here to maintain continuity in the discussion of information sources and methods): 1) become familiar with regional features through off-site research (mostly map analysis); 2) conduct an on-site investigation sufficient to delineate separate general wetland types; 3) make a determination of the boundaries of one or more assessment areas within the proposed project or action area; 4) conduct a rapid, on-site evaluation of each assessment area; 5) conduct an in-office map/GIS evaluation if needed (may be helpful in evaluation of Metrics 6, 11, 13, and 14) and 6) use the NC WAM Rating Calculator computer program to generate assessment ratings. Assessors are urged to document the basis for judgments on the Field Assessment Form or attach information for future reference by regulatory personnel and the public.

5.1 Background Information

5.1.1 General Information

Tools available for the assessor to become familiar with regional features may include the following.

- Aerial photography
- Topographic mapping
- County soil survey
- Wetlands mapping
- Land-use mapping
- Natural heritage element occurrence mapping from NCNHP

- NC WAM Tool Box (see description below)

Wetland assessors should examine available natural resource data prior to making the field visit. Available resources to be consulted include (but are not limited to) aerial photography, topographic mapping (USGS 7.5-minute quadrangles or more accurate mapping if available), the county soil survey, U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) maps, the N.C. Division of Coastal Management (NCDCM) wetland map (if the site to be assessed is in the Coastal Plain ecoregions), NCNHP mapping of significant natural heritage areas and reference wetlands, local municipal web-based Information Mapping System (IMS) or GIS data sets (photography, contours, zoning, parcel data, etc.), and (if available) previously conducted jurisdictional area delineations/determinations from the project vicinity. These resources should initially be viewed with an eye toward landscape/watershed scale features. Next, the assessor should consider how potential wetland characteristics of the assessment site fit into the landscape perspective. The assessor should evaluate features of interest such as wetland delineation criteria (vegetation, hydrology, and soils) and anthropogenic disturbances (roadways, impoundments, deforestation, impermeable surfaces, and storm-water sources).

5.1.2 NC WAM Tool Box

Another important tool for the wetland assessor (which utilizes much of the above-mentioned reference materials), currently under development, is a suite of GIS data layers collectively known by the working name "Tool Box." The Tool Box is intended to provide specific information concerning wetland sites previously evaluated, including locations and descriptions for reference examples of WFAT-identified wetland types. The Tool Box will contain a map of North Carolina subdivided into level III and IV ecoregions (Appendix E). Ideally, a queried ecoregion will provide the assessor with a location map of previously identified and assessed wetlands. Digital files of available natural resources information pertinent to the assessment of that wetland will be linked to each wetland assessment site - topographic mapping, aerial photography, soils mapping, NWI mapping, on-site photography, and a completed Field Assessment Form. By comparing digital data layers for the wetland area to be assessed with the reference information contained in the Tool Box, an assessor should be able to make a reasonable estimation of wetland types that may be encountered. As future assessments are performed and compiled, the Tool Box will be supplemented with the intent to expand wetland functional information for each wetland type over a range of levels of disturbance. This feature may 1) assist the assessor with identification of wetlands in substantially disturbed condition and 2) provide the assessor with a reference wetland functional rating based on a documented, previously rated wetland with a similar level of disturbance.

Information gathered during this task might be used to plan the assessor's course of travel to the wetland assessment site to maximize the assessor's knowledge and understanding concerning natural features in the region.

5.2 On-Site Investigation

This discussion assumes the assessor has conducted a wetland boundary delineation or determination (or is relying on a pre-existing wetland boundary delineation or determination) and knows that wetlands are present in a project area.

Following a delineation/determination effort that results in the identification of wetlands within a project area, an assessor will need to 1) determine if wetland stressors are present, 2) determine if more than one wetland type is present, and, if so, identify wetland type boundaries, and 3) identify assessment areas for evaluation.

5.2.1 Presence of Wetland Stressors

During the on-site investigation, the assessor should make note of the presence of wetland stressors and consider the effect of stressors on project area wetlands. Wetland stressors typically include anthropogenic activities that affect one or more wetland functions. Potential wetland stressors may include, but are not limited to, ground surface disturbances, vegetation removal or maintenance, hydrological modification (stormwater runoff, ditching), presence of infrastructure that fragments habitat (roads, utility lines), and septic fields (see Section 2.3). The assessor should be familiar with the NRCS document that describes the lateral effect of ditches in North Carolina hydric soils (see USACE Wilmington District website) to analyze the affects of ditches in hydric soils. The effect of a stressor on a wetland depends on the wetland type and size, stressor type and severity, and the amount of time the wetland has been subject to the stressor. In some cases, when given sufficient time, a wetland may adjust to one or more stressors by shifting to another general wetland type.

5.2.2 Wetland Type, Number, and Boundaries

NC WAM is designed for the assessor to consider current wetland condition during wetland type identification (not a past condition or anticipated future condition). The assessor should identify each discrete general wetland type that occurs within the project area using knowledge of the general wetland type descriptions (see Section 3.1) and the Dichotomous Key to General North Carolina Wetland Types (see pp. vii and viii and Section 3.4). It is important that the assessor walk the entire project area prior to making a wetland type determination or deciding if more than one wetland type is present. In cases where identification of the general wetland type is difficult, and a wetland appears to potentially fit into more than one general wetland type, the assessor should use best professional judgment in determining the appropriate wetland type and document the reasoning. The assessor may choose to rate an assessment area as more than one wetland type and use best professional judgment to evaluate the results.

It is important that an assessor determine all boundaries between the wetland to be assessed (assessment area) and other wetland types or uplands. If the project area contains more than one wetland type, a determination of transition boundaries will need to be made. Depending on wetland types involved, the boundary between an assessment area and other wetland types may be straightforward or problematic. When problematic, the assessor will need to use best professional judgment in boundary determination and provide written justification on the Field Assessment Form or attached map. Examples of problematic areas include 1) the boundary between Riverine Swamp Forest and Non-Riverine Swamp Forest in a large floodplain swamp system in the embayed region of the state, 2) the boundary between Headwater Forest and Bottomland Hardwood Forest in a Piedmont or Mountain floodplain at the confluence of a first-order stream with a second-order stream (see Figure 2), 3) the boundary between Pine Flat and Hardwood Flat on an interstream system in the Coastal Plain ecoregions, and 4) the boundary between an interstream wetland (examples: Pocosin, Pine Flat, Hardwood Flat) and a riparian wetland such as a Headwater Forest. The NC WAM Tool Box will provide assessors with guidance concerning these types of problems.

5.2.3 Assessment Area Identification

"Assessment area" refers to a defined area of wetland that is subject to functional evaluation using NC WAM. Boundaries of the assessment area may be determined by the boundaries of a proposed activity (the project area), wetland type boundaries, the extent of a wetland type with a specific set of characteristics in common, or an upland area. A project area may contain multiple assessment areas, each of which will be evaluated separately using NC WAM. Steps taken in determining the boundaries of one or more assessment areas include the following: 1) conduct a Section 404 jurisdictional area determination/delineation within a project area to determine wetland locations and limits, 2) identify wetland types within the project area using the NC WAM Dichotomous Key to General North Carolina Wetland Types, and 3) use landscape and wetland features to potentially separate identified wetland types into discrete assessment areas.

It is anticipated that assessors will encounter wetlands of a single type characterized by more than one level of modification or disturbance. Examples of this include 1) a Hardwood Flat transected by a regularly (or irregularly) maintained utility line corridor or 2) a Riverine Swamp Forest with a portion that has been clear-cut. The decision of whether to break these areas into separate assessment areas should be based on the assessor's best professional judgment. In general, when considering breaking a single wetland type into more than one assessment area due to a difference in wetland characteristics, the assessor may consider a minimum assessment area size of 0.1 acre (66 feet by 66 feet). This minimum size is proposed as general guidance based on project practicalities. The assessor will need to be prepared to defend this size decision when presenting NC WAM results.

Figures 14A through 14D provide an example of the process determining assessment area boundaries for a proposed roadway intersection. This example is located in the Southeastern Plains ecoregion in the Sandhills of Cumberland County. Figure 14A depicts the proposed intersection vicinity and project area boundaries on a USGS 7.5-minute quadrangle base. Note that a second-order stream (Tributary 1) flows into the project area from the north on the east side of the four-lane road (in the exhibits, the term "trib" is used for tributary). To the east, two streams (Tributaries 2 and 3) join to form a second-order stream (Tributary 4) that flows westward to a confluence with the previously mentioned second-order stream to form a third-order stream (Tributary 5) at the four-lane road crossing.

Step 1: Section 404 Jurisdictional Area Delineation

Figure 14B introduces a Section 404 jurisdictional area delineation completed for the proposed roadway intersection. A yellow boundary with internal shading depicts a delineated wetland, while blue solid lines within wetland shading depict delineated tributaries.

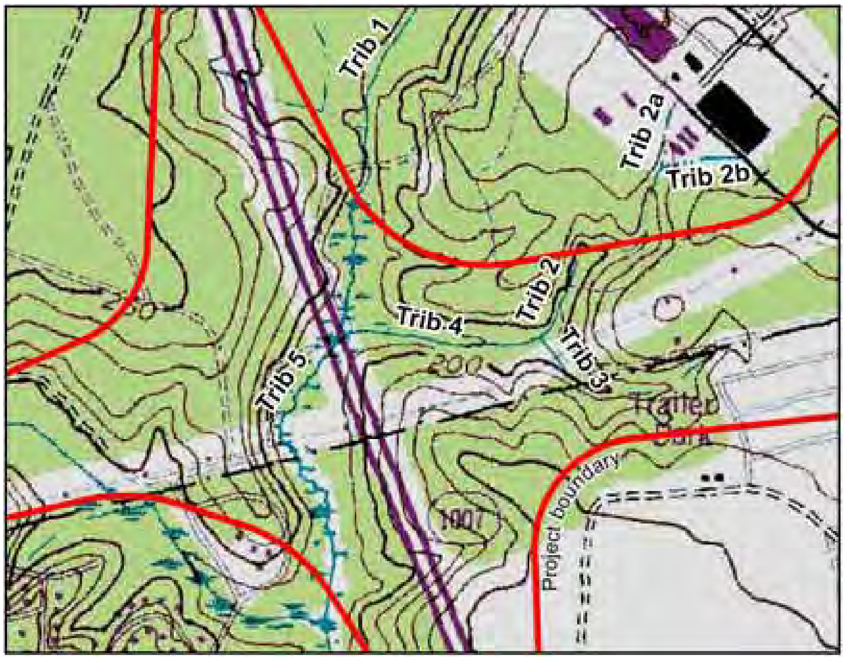


Figure 14A

Figure 14A depicts a proposed intersection vicinity and project area boundaries on a USGS 7.5-minute quadrangle base. This site is located in the Sandhills region of the Southeastern Plains ecoregion, Cumberland County. The term “Trib” refers to tributary. Figure 14B depicts a slightly zoomed-in view of the project area introduced by Figure 14A. A yellow boundary with internal shading depicts a delineated wetland; blue solid lines within wetland shading depict delineated tributaries.

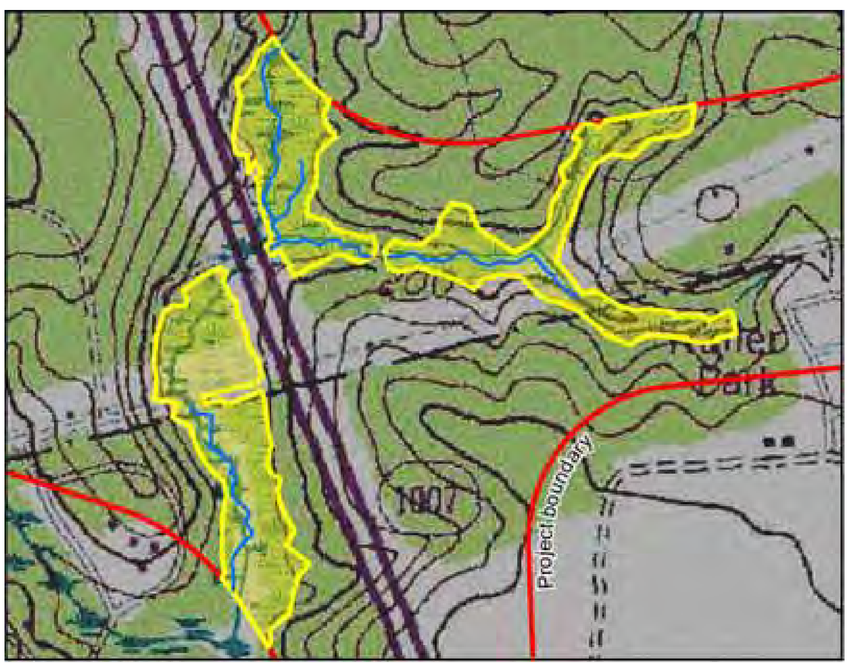


Figure 14B

Figure 14C

Figure 14C depicts general wetland types identified within the project area. Figure 14D depicts assessment areas (1 through 9) identified within the project area.

Figure 14D

Step 2: Identify General Wetland Types

Subsequent to the jurisdictional area delineation, the Dichotomous Key to General North Carolina Wetland Types (see pp. vii and viii) is used to identify general wetland types present (Figure 14C). For this example, the wetland types will be identified in the order they occur in the key.

No wetlands in this example are affected by lunar or wind tides (key location II). Only one area of delineated wetlands occurs outside of a geomorphic floodplain (key location II.A); a small wetland located on a slope above the Tributary 4. The straight topographic lines within the wetland, rather than “u” or ‘v”-shaped lines of a topographic crenulation, indicate this wetland is on a slope. The lower boundary of this wetland is the outer edge of the floodplain floor. This wetland is not in a geomorphic floodplain or a natural topographic crenulation and is located on a side slope, resulting in its identification as a **Seep** (key location II.A.i).

Tributary 5, a third-order stream, flows southward from the four-lane road, through a maintained power-line corridor, and on across the project area boundary. Maintenance of the utility corridor has resulted in disturbance within the floodplain of this tributary, and beavers have constructed a dam along the lower boundary of the maintained utility corridor. The resulting impoundment has modified wetland hydrology between the four-lane road and the beaver dam, which is currently subject to semi-permanent to permanent inundation. This hydrologic change has been in place long enough to result in a change in the wetland plant community from forested to primarily emergent herbs with a fringe of woody shrubs (the wetland vegetation is dominated by herbaceous vegetation); therefore, the hydrologic influence of the beaver impoundment on the wetland is considered to be a “long-established, permanent alteration.” The wetland associated with this beaver impoundment is located within a geomorphic floodplain, not a Bog, dominated by herbaceous vegetation, abutting a second-order or larger stream, and characterized by semi-permanent to permanent inundation, resulting in its identification as **Non-Tidal Freshwater Marsh** (key location II.B.ii.1).

The remaining delineated wetlands occur within a geomorphic floodplain, are not Bogs, are dominated by woody vegetation, and are not in a localized depression (key location II.B.ii.2.b). The 7.5-minute topographic quadrangle depicts Tributary 2 to be a second-order stream. Even though the on-site jurisdictional area delineation did not identify a tributary within this feature, information provided on the 7.5-minute quadrangle is used to determine the stream order for use in the key. The quadrangle depicts the headwaters of Tributary 2 to include two linear drainages located outside the geomorphic floodplain and not in a natural topographic crenulation (Tributaries 2a and 2b). These linear drainages are straight and located in the maintained yard of an industrial facility, providing an indication that they are man-made ditches that should not be used in determining stream order for use in the key. Based on this consideration, Tributary 2 is determined to be a first-order stream. Observations made during the field visit concluded that this wetland is characterized by intermittent inundation. So the wetland abutting Tributary 2 is within a geomorphic floodplain, is not a Bog, is dominated by woody vegetation, is not in a localized depression, is abutting a first-order stream, and is characterized by intermittent inundation, resulting in a determination that this wetland is a **Headwater Forest** (key location II.B.ii.2.b.i.1).

The 7.5-minute topographic quadrangle depicts Tributary 3 to be a first-order stream. Even though the delineated tributary does not extend to the upper end of the delineated wetland, all of the delineated wetland exhibits the same hydrological characteristic (temporary inundation). So the wetland is located within a geomorphic floodplain, is not a Bog, is dominated by woody vegetation, is not in a localized depression, abuts a first-order stream, and is characterized by intermittent inundation, resulting in a determination that this wetland is a **Headwater Forest** (key location II.B.ii.2.b.i.1). A maintained power-line corridor crosses the Tributary 3 Headwater Forest just above its confluence with Tributary 2. Within this utility corridor, the regularly maintained vegetation is dominated by saplings and shrubs – woody vegetation. Therefore this maintained wetland area remains part of the Tributary 3 Headwater Forest.

Tributary 4 forms at the confluence of Tributaries 2 and 3 and extends downstream to a confluence with Tributary 1. Since, for the purposes of NC WAM, Tributaries 2 and 3 are first-order streams, Tributary 4 is a second-order stream (see Figure 2 for guidance in determining the boundary between wetlands primarily influenced by a first-order stream and wetlands primarily influenced by a second-order stream). The wetland abutting Tributary 4 exhibits evidence of seasonal inundation downstream to the vicinity of the confluence with Tributary 1, where the wetland becomes much wetter as a result of beaver activity on Tributary 1. The wetland abutting Tributary 4 is within a geomorphic floodplain, not a Bog, dominated by woody vegetation, not in a localized depression, abutting a second-order or higher stream, and characterized by seasonal inundation, resulting in its identification as **Bottomland Hardwood Forest** (key location II.B.ii.2.b.ii.1).

Tributary 1 is a second-order stream that has been subject to the hydrologic influence of a beaver dam in the vicinity of the four-lane road crossing and the confluence with Tributary 4. The wetland abutting Tributary 1 is wholly within the beaver impoundment and is currently subject to semi-permanent to permanent inundation. This hydrologic change has been in place long enough to alter the wetland plant community to an open canopy of hydrophytic tree species and a dense undergrowth of emergent herbs (based on tree coverage, the plant community is dominated by woody vegetation); therefore, the hydrologic influence of the beaver impoundment on the wetland is considered to be a "long-established, permanent alteration." The wetland abutting Tributary 1 is within a geomorphic floodplain, not a Bog, dominated by woody vegetation, not in a localized depression, abutting a second-order or higher stream, and characterized by semi-permanent to permanent inundation, resulting in its identification as **Riverine Swamp Forest** (key location II.B.ii.2.b.ii.2).

Tributary 5, between the utility corridor beaver dam and the project area boundary, is a third-order stream, is bounded by a delineated wetland characterized by forest vegetation and semi-permanent inundation. This wetland is within a geomorphic floodplain, is not a Bog, is dominated by woody vegetation, is not in a localized depression, abuts a second-order or higher stream, and is characterized by semi-permanent to permanent inundation, resulting in its identification as **Riverine Swamp Forest** (key location II.B.ii.2.b.ii.2).

Step 3: Identify Discrete Assessment Areas

As stated earlier, boundaries of an assessment area may be determined by the boundaries of a proposed activity (the project area), wetland type boundaries, the extent of a wetland type with a specific set of characteristics in common, or an upland area. Steps 1 and 2 have resulted in the identification and delineation of wetland types based on project area boundaries, upland boundaries, and wetland characteristics (Figure 14C). The assessor should now consider each identified wetland type in turn and determine if it should be sub-divided based on variation in important characteristics such as differences in vegetation structure (clear-cutting, different age stands, thinning), hydrology (ditching, beaver impacts), and watershed disturbances that may affect the subject wetland (commercial sites, industrial sites, or highways).

The land within the boomerang-shaped Headwater Forest is relatively undisturbed and homogeneous, with the exception of a power-line corridor subject to regular vegetation maintenance (mowing) that crosses Tributary 3 and abutting wetlands just upstream of the confluence with Tributary 2. This power-line corridor is approximately 300 feet wide and supports a substantially different plant community structure from the remainder of the Headwater Forest. Therefore, the Headwater Forest should be broken into three assessment areas: the northern arm of the boomerang (Assessment Area 1), the portion of Headwater Forest within the power-line corridor (Assessment Area 2), and the southern arm of the boomerang upslope of the power-line corridor (Assessment Area 3) (Figure 14D). If on-site observations indicate that wetland characteristics are similar within Assessment Areas 1 and 3, and the area outside of the wetland type boundaries is similar for both assessment areas, the assessor may consider combining them as one assessment area. However, in this case, Assessment Area 1 contains a tributary and Assessment Area 2 does not; and although both assessment areas are near a maintained utility line corridor, Assessment Area 3 is near and downstream of a residential neighborhood, while Assessment Area 1 appears to have a wooded watershed. Because of these differences, it is reasonable to keep these areas of Headwater Forest separated as discrete assessment areas. Note that assessors will need to justify the validity of combining assessment areas.

The Seep and both Riverine Swamp Forests are characterized by relatively homogeneous wetland characteristics; therefore, each of these wetlands is considered to be a discrete assessment area (Assessment Areas 4, 7, and 9, respectively).

The Bottomland Hardwood Forest is divided into two by a causeway over a culverted tributary crossing. The causeway includes a 15-foot wide soil road. Therefore, these two wetlands are considered discrete assessment areas (Assessment Areas 5 and 6). If on-site observations indicate that wetland characteristics are similar within these two areas of Bottomland Hardwood Forest and the area outside of the wetland type boundaries was similar for both Bottomland Hardwood Forest areas, the assessor may consider combining them as one assessment area. However, assessors will need to justify the validity of combinations.

The portion of the Non-Tidal Freshwater Marsh that is subject to regular maintenance within the power-line corridor generally retains similar wetland characteristics (such as surface water hydroperiod, soils, and vegetation structure) to the non-maintained portion of this wetland, and both areas are characterized by similar features outside of the wetland type boundaries;

therefore, the entirety of the Non-Tidal Freshwater marsh is considered a single assessment area (Assessment Area 8).

Wetlands depicted in Figures 14A-D comprise two wetland complexes. In this case, wetland complex boundaries are natural uplands and a man-made berm or causeway the width of a four-lane road or wider (the causeway between the two areas of Bottomland Hardwood Forest is not a wetland complex boundary). The depicted four-lane road bridges the tributary, but no wetlands extend under the bridges; therefore, these figures depict one wetland complex east (right) of the four-lane road and a second wetland complex west (left) of the four-lane road.

Wetlands depicted in Figures 14A-D comprise two areas of forested wetland. In this case, forested wetland boundaries are a man-made berm or causeway the width of a four-lane road or wider and any wetland not dominated by forest the width of a four-lane road or wider. The maintained utility line corridor is not quite wide enough to be a forested wetland boundary; however both the four-lane road and the Non-Tidal Freshwater Marsh act as forested wetland boundaries. So, one forested wetland includes all wetlands east (right) of the four-lane road and the Riverine Swamp Forest south of (below) the Non-Tidal Freshwater Marsh is a second forested wetland.

5.3 Completion of the NC WAM Field Assessment Form

Tools needed to complete the NC WAM Field Assessment Form and associated attachments include (but are not limited to) the following.

- Soil auger or sharp-shooter shovel
- Appropriate Munsell soil color chart
- Pocket rod, or other measurement device
- Site and watershed mapping
- Global Positioning System (GPS) or other method for determining location
- Camera for recording site conditions and characteristics
- NC WAM Dichotomous Key to General North Carolina Wetland Types
- Knowledge of soil texture-by-feel analysis (Appendix F)
- Knowledge of the latest version of the Natural Resources Conservation Service/National Technical Committee for Hydric Soils (NRCS/NTCHS) “Field Indicators of Hydric Soils in the United States, Guide for Identifying and Delineating Hydric Soils.”
- Knowledge of the NRCS lateral affect of ditching guidance (see USACE Wilmington District website) to analyze the affects of ditches in hydric soils
- Knowledge of the use of NC WAM
- Plant identification manuals such as “Common Wetland Plants of North Carolina (NCDWQ 1997a)

5.3.1 Field Assessment Form

The Field Assessment Form is provided with other NC WAM forms at the beginning of the User Manual (see pp. ix to xii). Guidance for completion of the Field Assessment Form is provided in Section 4.3. <u>Completion of the Field Assessment Form should be thorough and accurate. It is important that the assessor include notes concerning wetland characteristics, especially any</u>

that might not be captured when answering the metrics on the Field Assessment Form. These forms are not only a means to a functional rating, but also a documentation of the condition of the wetland.

Information requested in the box at the beginning of the Field Assessment Form provides space for documentation of stressors affecting the assessment area, regulatory considerations, general site hydrology, and landscape position. The Field Assessment Form requests that the evaluator note evidence of various stressors on an assessment area. This particular information is not directly used in the determination of ratings but helps the assessor consider anthropomorphic impacts to the assessment area. The presence and extent of a stressor should be documented on the Field Assessment Form with consideration for the resulting departure of wetland functions from reference condition for the assessed wetland type.

When evaluating metrics, the assessor should compare the assessed wetland to a reference wetland (if appropriate). A discussion of the intention and use of Field Assessment Form metrics is included in Section 4.3. Familiarization with the watershed of the assessment area watershed and descriptions of wetland types will facilitate this process. It is essential that the assessor walk the entire assessment area prior to completing the Field Assessment Form.

5.3.2 Field Map

The assessor should attach a field map to each completed Field Assessment Form. The field map may be hand drawn or include a refined base map (USGS 7.5-minute quadrangle, county soil survey, aerial photograph, or printed-out map from a web-based geography server or local municipality IMS). The map should provide useful information for the identification of area features for evaluation by regulatory agency personnel and the public.

5.3.3 Photographs

Photographs of the assessment area taken while on-site should be attached to the completed Field Assessment Form. Attached photographs should depict typical features of the assessment area.

5.4 Generation of Functional Assessment Ratings

5.4.1 Data Analysis

Tools needed for data analysis include the following.

- Completed NC WAM Field Assessment Form and associated attachments
- NC WAM Rating Calculator computer program to generate wetland functional ratings

NC WAM utilizes a Boolean logic chain of reasoning to convert the metric evaluation results into functional ratings. The Boolean logic process was developed by the WFAT following extensive discussions regarding the possible interactions of the metrics and sub-functions. These results were re-evaluated at numerous field sites. The Boolean logic has been written into a computer program (NC WAM Rating Calculator, see Appendix H) that generates ratings for wetland metrics, sub-functions, functions, and the over-all wetland. The Rating Calculator is an Excel macro that is planned to be made available on an internet site through the N.C. Division of Water Quality.

The Boolean process proceeds by determining descriptors for metrics and then functional ratings for sub-functions, functions, and the assessment area, in sequence. Each level of function subsumes the next, effectively serving as the building blocks for the levels that follow (Table 1). For instance, of the four levels of functional assessment, the metric level has the narrowest purview. Singularly, metrics pertain to very specific aspects of the wetland, such as ground surface condition or duration of inundation. Collectively, however, metrics are organized into sub-functions. Combining the descriptors of all metrics within a particular sub-function (through the use of Boolean logic) produces a sub-function rating that offers a broader account of wetland function. Sub-functions themselves are organized into one of three wetland functions: Hydrology, Water Quality, and Habitat. The ratings generated for all sub-functions corresponding to a particular wetland function (such as the Hydrology function) are combined to produce a wetland function rating. The individual function ratings provide a still broader account of wetland function than the sub-function ratings. Ultimately, the individual wetland function ratings are combined to produce an over-all wetland rating. The over-all wetland rating is the most comprehensive of the four levels of function – an aggregate of all functional levels considered in NC WAM.

The NC WAM Rating Calculator provides a screen that approximates the Field Assessment Form. The assessor completes the form within the Rating Calculator by selecting the proper boxes and option buttons. The program generates functional ratings from the completed form. The assessor can then print a hard copy of the rating results (Wetland Rating Sheet) for the assessed wetland. An example of the Wetland Rating Sheet is provided as p. xiii at the beginning of the User Manual.

5.4.2 Final Product

The use of NC WAM is expected to result in the generation of a functional rating for each assessed wetland and the specific component functions and sub-functions of that particular wetland, as well as documentation of field conditions contributing to the ratings. The product resulting from implementation of NC WAM includes, but is not limited to, a completed Field Assessment Form (with assessor notes), a completed Wetland Rating Sheet, a site map, site photographs, and additional notes if appropriate. This product is intended to be utilized by land owners, planners, as well as, local, state, and federal regulatory agency personnel.

The Wetland Rating Sheet is comprised of five sections: general information, red-flag issues, sub-function rating summary, function rating summary, and overall wetland rating. General information at the top of the wetland rating sheet provides limited site information including wetland site name, wetland type, date of assessment, and the assessor's name and organization. Next is a list of five items of interest concerning the assessed wetland. A Yes/No toggle is provided to allow the Wetland Rating Sheet to indicate if one or more of these items has been observed during the assessment.

Table 1. Relationship of metrics, sub-functions, and functions for generation of wetland functional ratings for a Bottomland Hardwood Forest assessment area.

organization. Next is a list of five items of interest concerning the assessed wetland. A Yes/No toggle is provided to allow the Wetland Rating Sheet to indicate if one or more of these items has been observed during the assessment.

The sub-function rating summary provides ratings for all sub-functions associated with the evaluated wetland type. This summary also indicates if the assessment area has the opportunity for enhanced Water Quality function and how an existing opportunity is expected to affect Water Quality condition ratings. The function rating summary provides the function ratings resulting from a combination of sub-function ratings. This summary also indicates if the assessment area has the opportunity for enhanced Water Quality function and how an existing opportunity is expected to affect the water quality condition rating. Finally, an overall wetland rating is provided, which is a combination of the function ratings for Hydrology, Water Quality, and Habitat.

6.0 TECHNICAL RESOURCES

This version of NC WAM contains supporting information in Appendices A through I. Additional information supporting NC WAM, presented as Appendices J through M, will be made available on the internet. The contents of these additional appendices are described briefly below.

Appendix J — Relationship of Metrics, Sub-functions, and Functions for all Wetland Types. This appendix includes a table similar to Table 1 (p. 120 in the User Manual) for each wetland type. The purpose of each table is to provide a depiction of how metrics are organized into sub-functions, which are themselves organized into one of three wetland functions.

Appendix K — Field Metric Evaluation Sheets. This appendix includes the original Field Metric Evaluation Sheet developed by the WFAT for each general wetland type.

Appendix L — Cross-walk from the Field Metric Evaluation Sheets to the Field Assessment Form. This appendix depicts the relationships between the original metrics developed on the Field Metric Evaluation Sheets and the metrics presented on the current Field Assessment Form.

Appendix M — Functional Rating Boolean Logic for Each Wetland Type. This appendix provides a depiction of the Boolean logic chain of reasoning used to convert the metric evaluation results into functional ratings for sub-functions, functions, and the assessment area, in sequence.

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APPENDIX A

Abbreviations

APPENDIX A: Abbreviations

AA	Assessment Area
AEC	Area of Environmental Concern
BPJ	Best Professional Judgment
CAFOs	Confined animal operations
EEP	Ecosystem Enhancement Program
EMC	Environmental Management Commission
CAMA	Coastal Area Management Act
FW	Forested Wetland
GIS	Geographic Information Systems
HGM	Hydrogeomorphic Method
HWQ	High Quality Water
IMS	Information Mapping System
LiDAR	Light Detection and Ranging
NC-CREWS	N.C. Coastal Region Evaluation of Wetland Significance
NCDENR	N.C. Department of Environment and Natural Resources
NCDOT	N.C. Department of Transportation
NCDCM	N.C. Division of Coastal Management
NCDMF	N.C. Division of Marine Fisheries
NCDWQ	N.C. Division of Water Quality
NCEMC	N.C. Environmental Management Commission
NCNHP	N.C. Natural Heritage Program
NC WAM	N.C. Wetland Assessment Method
NCWRC	N.C. Wildlife Resources Commission
NTCHS	National Technical Committee for Hydric Soils
NWI	National Wetlands Inventory
ORW	Outstanding Resource Water
RTFM	Read the Flippin' Manual!
SA	NCDWQ best usage classification for tidal salt water
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFHWA	U.S. Federal Highway Administration
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USNMFS	U.S. National Marine Fisheries Service
USNRCS	U.S. Natural Resources Conservation Service
WC	Wetland Complex
WFAT	Wetland Functional Assessment Team
WRP	Wetlands Restoration Program
WT	Wetland Type

APPENDIX B

Cross-reference of Wetland Types

Appendix B: Cross-reference of wetland types based on NC WAM, N.C. Natural Heritage Program (Schafale and Weakley 1990), N.C. Division of Coastal Management (Sutter 1999), and Hydrogeomorphic Method Classes and Sub-classes (Brinson unpublished)

NC WAM	**NCNHP**	**NCDCM**	**HGM (class/subclass)**
Salt/Brackish Marsh	Salt Marsh Brackish Marsh Salt Flat	Salt/Brackish Marsh	Estuarine Tidal Fringe/Estuarine Lunar Estuarine Tidal Fringe/Estuarine Wind
Estuarine Woody Wetland	Salt Shrub Estuarine Fringe Loblolly Pine Forest Tidal Red Cedar Forest	Estuarine Shrub-Scrub Estuarine Forested Wetlands	Estuarine Tidal Fringe/Estuarine Lunar Estuarine Tidal Fringe/Estuarine Wind
Tidal Freshwater Marsh	Tidal Freshwater Marsh	Freshwater Marsh	Estuarine Tidal Fringe/Estuarine Lunar Estuarine Tidal Fringe/Estuarine Wind
Riverine Swamp Forest	Cypress-Gum Swamp (Blackwater subtype) Cypress-Gum Swamp (Brownwater subtype) Coastal Plain Stream Small Stream Swamp (part) Piedmont/Mountain Swamp Forest Tidal Cypress-Gum Swamp Natural Lake Shoreline	Swamp Forest	Riverine/Headwater Complex Riverine/Lower Perennial Riverine/Beaver Impounded Riverine/Human Impounded Lacustrine Fringe/Semi-permanently Flooded Lacustrine Fringe/Intermittently Flooded Lacustrine Fringe/Reservoir Estuarine Tidal Fringe/Wind
Seep	Low Elevation Seep High Elevation Seep Sandhill Seep Hillside Seepage Bog	Not identified	Slope/Organic Soil Slope/Mineral Soil
Hardwood Flat	Non-Riverine Wet Hardwood Forest Wet Marl Forest Successional versions of other types	Hardwood Flats	Flat/Mineral Soil
Non-Riverine Swamp Forest	Nonriverine Swamp Forest Peatland Atlantic White Cedar Forest Maritime Swamp Forest Maritime Shrub Swamp	Swamp Forest Maritime Forest	Depression/Isolated Groundwater Depression/Isolated Precipitation Flat/Organic Soil Flat/Mineral Soil
Pocosin	Low Pocosin High Pocosin Pond Pine Woodland Small Depression Pocosin Bay Forest	Pocosin Pine Flat (part)	Flat/Mineral Soil Flat/Organic Soil Depression/Isolated Precipitation Depression/Isolated Groundwater
Pine Savanna	Wet Pine Flatwoods Pine Savanna	Pine Flats (part)	Flat/Mineral Soil

Appendix B (continued): Cross-reference of wetland types based on NC WAM, NCNHP (Schafale and Weakley 1990), NCDCM (Sutter 1999), and HGM Classes and Sub-classes (Brinson unpublished)

NC WAM	NCNHP	NCDCM	HGM (class/subclass)
Pine Flat	Disturbed versions of the following: Nonriverine Wet Hardwood Forest Nonriverine Swamp Forest Wet Pine Flatwoods Pine Savanna	Pine Flat (Part) Managed Pineland	Flat/Mineral Soil
Basin Wetland	Vernal Pool Cypress Savanna Upland Depression Swamp Forest Upland Depression Pond Inner Dune Pond Upland Pool	Not identified possibly Swamp Forest (part) possibly Freshwater Marsh (part)	Depression/Isolated Groundwater Depression/Isolated Precipitation Depression/Human Impounded or Excavated Estuarine/Impounded
Bog	Southern Appalachian Bog (Northern subtype) Southern Appalachian Bog (Southern subtype) Southern Appalachian Fen Swamp Forest-Bog Complex (Typic subtype) Swamp forest-Bog Complex (Spruce subtype)	Not identified	Riverine/Headwater Complex Riverine/Lower Perennial Depression/Surface-connected
Non-tidal Freshwater Marsh	Piedmont/Mountain Semi-permanent Impoundment (part) Coastal Plain Semi-permanent Impoundment (part) Natural Lake Shoreline (part)	Freshwater Marsh	Riverine/Headwater Complex Riverine/Beaver Impounded Riverine/Human Impacted Lacustrine Fringe/Semipermanently Flooded Lacustrine Fringe/Reservoir Depression/Surface-connected
Floodplain Pool	Floodplain Pool	Not identified	Riverine/Headwater Wetland Depression/Surface-connected
Headwater Wetland	Piedmont Alluvial Forest Coastal Plain Small Stream Swamp (part) Streamhead Atlantic White Cedar Forest Streamhead Pocosin	Headwater Forest	Riverine/Intermittent-Upper Perennial Riverine/Headwater Complex
Bottomland Hardwood Forest	Coastal Plain Bottomland Hardwoods (Blackwater subtype) Coastal Plain Bottomland Hardwoods (Brownwater subtype) Coastal Plain Levee Forest (Blackwater subtype) Coastal Plain Levee Forest (Brownwater subtype) Piedmont/Mountain Levee Forest Piedmont/Mountain Bottomland Forest Montane Alluvial Forest Piedmont/Low Mountain Alluvial Forest (part)	Bottomland Hardwood Forest	Riverine/Headwater Complex Riverine/Intermittent-Upper Perennial Riverine/Lower Perennial

APPENDIX C

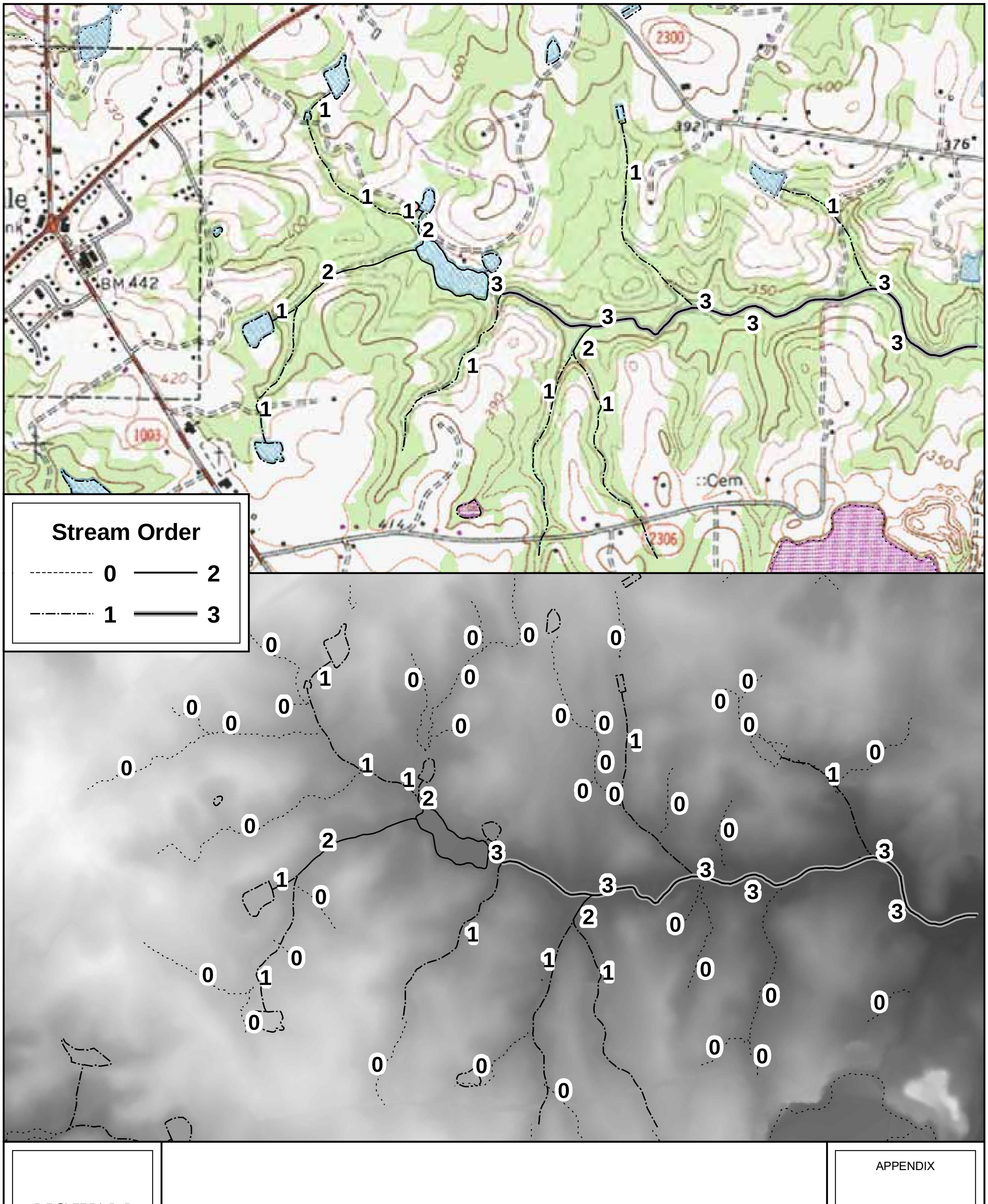
Stream Order Schematics

Appendix C: Stream Order Schematics

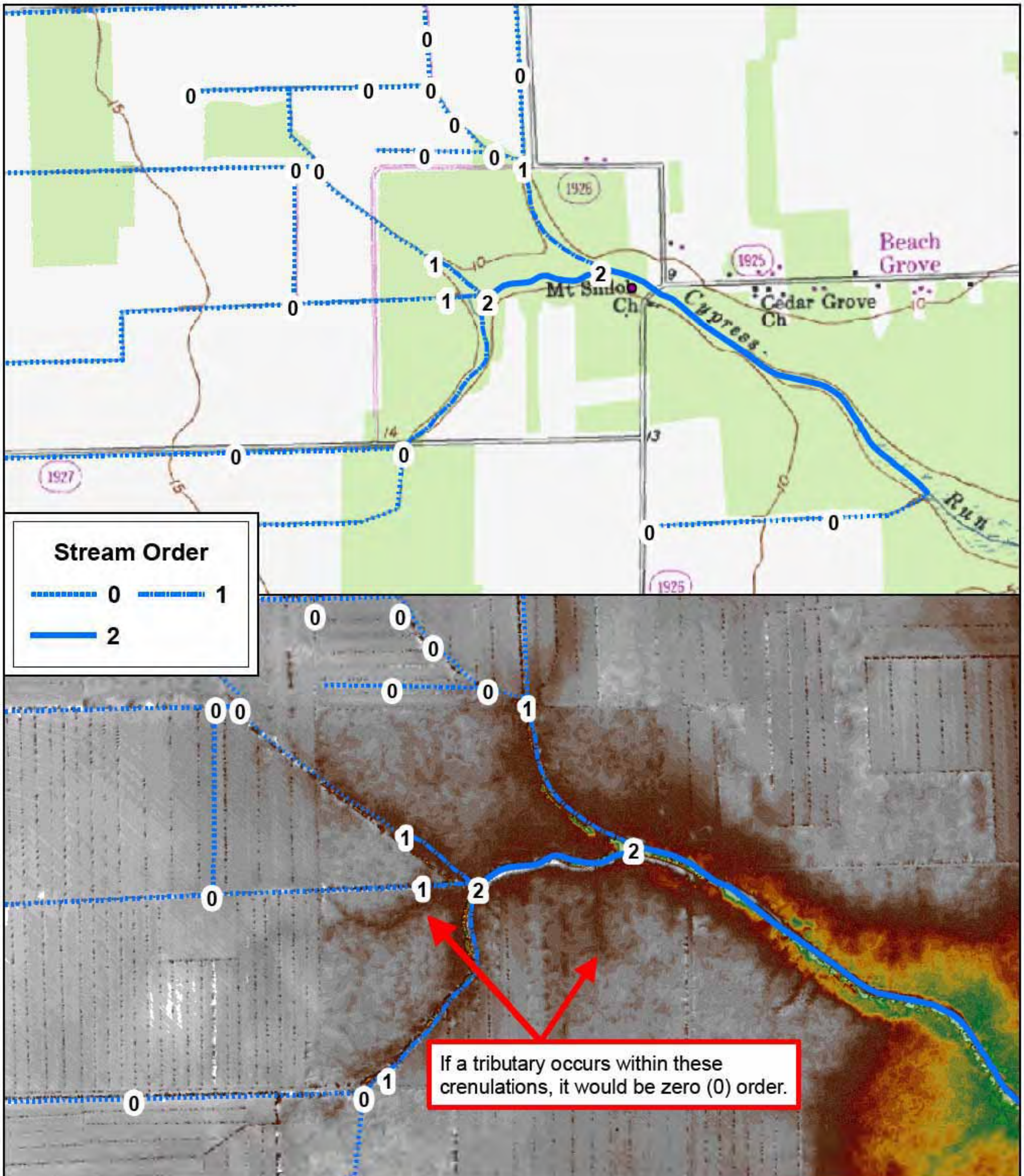
This appendix contains two schematic diagrams (Figures C1 and C2) to assist the assessor with understanding how to determine stream order. The upper and lower portions of Figure C1 depict the same area in the Piedmont ecoregion. The upper portion of the figure is based on a USGS 7.5-minute quadrangle, while the lower portion of the figure is based on LiDAR mapping of the same area. Similarly, the upper and lower portions of Figure C2 depict the same area in the Middle Atlantic Coastal Plain ecoregion. The upper portion of the figure is based on a USGS 7.5-minute quadrangle, while the lower portion of the figure is based on LiDAR mapping of the same area.

In most of the state, stream order should be determined by consulting blue lines on the USGS 7.5-minute quadrangle. A blue-line stream with no tributaries is considered a first-order stream. A segment downstream of the confluence of two first-order streams is a second-order stream. Thus, an n^{th}-order stream is always located downstream of the confluence of two $(n-1)^{th}$-order streams (Strahler 1952). Streams found on the ground but not depicted on the USGS 7.5-minute quadrangle are considered “zero-order streams.”

For sites in the Coastal Plain ecoregions, the assessor should not incorporate blue lines in the determination of stream order when the blue lines occur outside of a natural topographic crenulation as depicted on a USGS 7.5-minute topographic quadrangle. Blue lines outside of a natural topographic crenulation most likely represent man-made ditches or canals. In the example provided in the upper portion of Figure C2, only the blue lines depicted within the 10-foot contour should be considered when determining stream order. Based on this perspective, the confluence of first-order streams in the middle of the figure view and below the number “10” forms the second-order stream, Cypress Run. Another first-order stream joins the main branch just upstream of Mt. Shiloh Church, but Cypress Run remains a second-order stream as it passes to the right out of the figure view.



STREAM ORDER SCHEMATIC



NC WAM USER MANUAL

STREAM ORDER SCHEMATIC

APPENDIX

C2

APPENDIX D

Pocosin Soils

Appendix D: Soil Series that may support the NC WAM Pocosin wetland type

Series Name	Series Code	County
Belhaven muck	Bb	Beaufort
Belhaven muck	BaA	Camden
Belhaven muck	BH	Carteret
Belhaven muck	BvA	Dare
Belhaven muck	BeA	Gates
Belhaven muck	BmA	Hyde
Belhaven muck	BH	Pamlico
Belhaven muck	Ba	Tyrrell
Belhaven muck	Ba	Washington
Coxville loam	Co	Columbus
Croatan muck	Ct	Beaufort
Croatan muck	Cr	Bladen
Croatan muck	CT	Brunswick
Croatan muck	CT	Carteret
Croatan muck	CT	Craven
Croatan muck	CT	Cumberland
Croatan muck	Ct	Duplin
Croatan muck	Ct	Jones
Croatan muck	Ct	Onslow
Croatan muck	CT	Pamlico
Croatan muck	Ct	Pender
Croatan muck, freq. flooded	CT	Bladen
Dare muck	Da	Beaufort
Dare muck	DA	Carteret
Dare muck	DA	Craven
Dare muck	Da	Currituck
Dare muck	DA	Pamlico

Series Name	Series Code	County
Murville fine sand	Mu	Columbus
Murville fine sand	Mu	Lenoir
Murville fine sand	Mu	New Hanover
Murville fine sand	Mu	Onslow
Murville muck	Mu	Pender
Murville mucky fine sand	Mu	Brunswick
Murville mucky fine sand	Mu	Duplin
Murville mucky loamy sand	Mu	Craven
Murville mucky sand	Mu	Carteret
Pamlico muck	Pa	Bladen
Pamlico muck	Pc	Lenoir
Pamlico muck	Pm	New Hanover
Pamlico muck	Pm	Sampson
Pamlico muck, freq. flooded	PC	Bladen
Ponzer muck	Po	Beaufort
Ponzer muck	Po	Carteret
Ponzer muck	PO	Craven
Ponzer muck	Po	Currituck
Ponzer muck	PoA	Dare
Ponzer muck	PnA	Hyde
Ponzer muck	Po	Tyrrell
Ponzer muck	Po	Washington
Pungo muck	PuA	Camden
Pungo muck	PuA	Dare
Pungo muck	PuA	Gates
Pungo muck	PuA	Hyde
Pungo muck	Pu	Tyrrell
Pungo muck	Pu	Washington
Scuppernong muck	ScA	Hyde

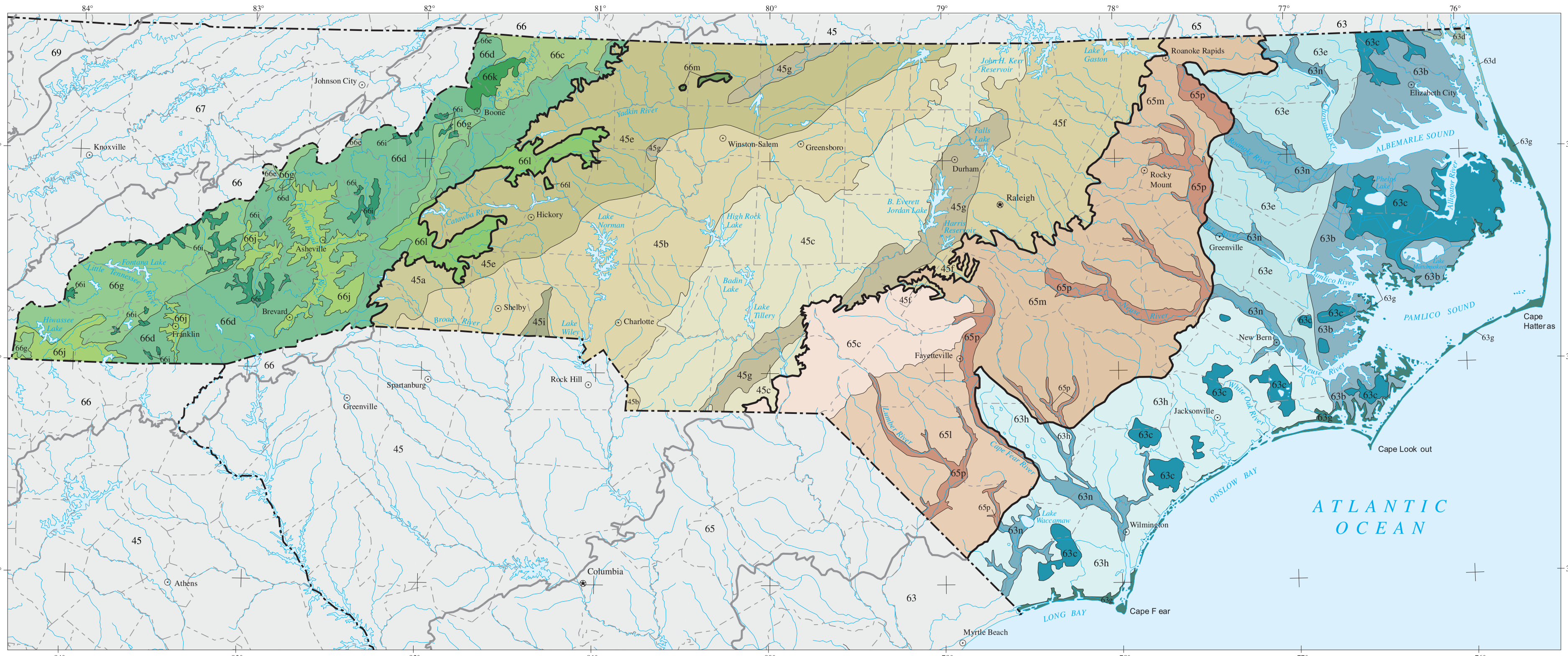
APPENDIX E

North Carolina Ecoregions

Appendix E: North Carolina Ecoregions

This map has been prepared by USEPA and many other state and federal agencies (Griffith et al. 2002). Ecoregions are depicted as either level III ecoregions (four in the state – Blue Ridge [Mountains], Piedmont, Southeastern Plains [inner Coastal Plain], and Middle Atlantic Coastal Plain [outer Coastal Plain]) or as level IV ecoregions (27 in North Carolina including such areas as the Triassic Basin, Sandhills, and New River Plateau).

Ecoregions of North Carolina



45 Piedmont
- 45a Southern Inner Piedmont
- 45b Southern Outer Piedmont
- 45c Carolina Slate Belt
- 45e Northern Inner Piedmont
- 45f Northern Outer Piedmont
- 45g Triassic Basins
- 45i Kings Mountain

63 Middle Atlantic Coastal Plain
- 63b Chesapeake-Pamlico Lowlands and Tidal Marshes
- 63c Nonriverine Swamps and Peatlands
- 63d Virginian Barrier Islands and Coastal Marshes
- 63e Mid-Atlantic Flatwoods
- 63g Carolinian Barrier Islands and Coastal Marshes
- 63h Carolina Flatwoods
- 63n Mid-Atlantic Floodplains and Low Terraces

65 Southeastern Plains
- 65c Sand Hills
- 65l Atlantic Southern Loam Plains
- 65m Rolling Coastal Plain
- 65p Southeastern Floodplains and Low Terraces

66 Blue Ridge
- 66c New River Plateau
- 66d Southern Crystalline Ridges and Mountains
- 66e Southern Sedimentary Ridges
- 66g Southern Metasedimentary Mountains
- 66i High Mountains
- 66j Broad Basins
- 66k Amphibolite Mountains
- 66l Eastern Blue Ridge Foothills
- 66m Sauratown Mountains

Level III ecoregion — County boundary
Level IV ecoregion — State boundary

SCALE 1:1 500 000

15 10 5 0 30 60 mi
30 20 10 0 60 120 km

Albers Equal Area Projection

PRINCIPAL AUTHORS: Glenn E. Griffith (NRCS), James M. Omernik (USEPA), Jeffrey A. Comstock (Indus Corporation), Michael P. Schafale (NCDENR), W. Henry McNab (USFS), David R. Lenat (NCDENR), and Trish F. MacPherson (NCDENR).

COLLABORATORS AND CONTRIBUTORS: James E. Harrison (USEPA), David L. Penrose (NCDENR), Roy L.Vick, Jr. (NRCS), Gerard McMahon (USGS), Robert Peet (UNC), Chip Smith (NRCS) and Tom Loveland (USGS).

CITING THIS MAP: Griffith, G.E., Omernik, J.M., Comstock, J.A., Schafale, M.P., McNab, W.H., Lenat, D.R., and MacPherson, T.F., 2002, Ecoregions of North Carolina, U.S. Environmental Protection Agency, Corvallis, OR, (map scale 1:1,500,000).

Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. Ecoregions are directly applicable to many state agency activities, including the selection of regional stream reference sites, the development of biological criteria and water quality standards, and the establishment of management goals for nonpoint-source pollution. They are also relevant to integrated ecosystem management, an ultimate goal of many federal and state resource management agencies.

The approach used to compile this map of North Carolina is based on the premise that ecological regions are hierarchical and can be identified through the analysis of the spatial patterns and the composition of biotic and abiotic phenomena that affect or reflect differences in ecosystem quality and integrity (Wiken 1986; Omernik 1987, 1995). These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The relative importance of each characteristic varies from one ecological region to another regardless of the hierarchical level. A Roman numeral hierarchical scheme has been adopted for different levels of ecological regions. Level I and Level II divide the North American continent into 15 and 52 regions, respectively (Commission for Environmental Cooperation Working Group 1997). At Level III, the continental United States contains 104 regions (United States Environmental Protection Agency [U.S. EPA] 2000). Level IV is a further subdivision of the Level III ecoregions. Explanations of the methods used to define the U.S. EPA's ecoregions are given in Omernik (1995), Omernik and others (2000), Griffith and others (1994, 1997), and Gallant and others (1989).

The Level III and IV ecoregions were compiled at a scale of 1:250,000 and depict revisions and subdivisions of earlier level III ecoregions that were originally compiled at a smaller scale (U.S. EPA 2000; Omernik 1987). Compilation of this map is part of a collaborative project primarily between the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), the U.S. EPA National Health and Environmental Effects Research Laboratory (NHEERL), U.S. EPA Region IV, and the North Carolina Department of Environment and Natural Resources. This project is also associated with an interagency effort to develop a common framework of ecological regions (McMahon and others 2001). Regional collaborative projects, such as this one in North Carolina where some agreement can be reached among multiple resource management agencies, are a step in the direction of attaining commonality and consistency in ecoregion frameworks for the entire nation.

Comments regarding the Level III and IV Ecoregions of North Carolina map should be addressed to Glenn Griffith, USDA-NRCS, 200 SW 35th Street, Corvallis, OR 97333, (541) 754-4465, FAX: (541) 754-4716, email: griffith.glenn@epa.gov, or to James Omernik, USGS, 200 SW 35th Street, Corvallis, OR 97333, (541) 754-4458, email: omernik.james@epa.gov.

Literature Cited:

Commission for Environmental Cooperation Working Group, 1997, Ecological regions of North America - toward a common perspective: Montreal, Quebec, Commission for Environmental Cooperation, 71 p.

Gallant, A.L., Whittier, T.R., Larsen, D.P., Omernik, J.M., and Hughes, R.M., 1989, Regionalization as a tool for managing environmental resources: Corvallis, Oregon, U.S. Environmental Protection Agency EPA/600/3-89/060, 152 p.

Griffith, G.E., Omernik, J.M., Wilton, T.F., and Pierson, S.M., 1994, Ecoregions and subregions of Iowa - a framework for water quality assessment and management: The Journal of the Iowa Academy of Science, v. 101, no. 1, p. 5-13.

Griffith, G.E., Omernik, J.M., and Azevedo, S.H., 1997, Ecoregions of Tennessee: Corvallis, Oregon, U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, EPA/600/R-97/022, 51 p.

McMahon, G., Gregonis, S.M., Waltman, S.W., Omernik, J.M., Thorson, T.D., Freeouf, J.A., Rorick, A.H., and Keys, J.E., 2001, Developing a spatial framework of common ecological regions for the conterminous United States: Environmental Management, v. 28, no. 3, p. 293-316.

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Omernik, J.M., Chapman, S.S., Lillie, R.A., and Dumke, R.T., 2000, Ecoregions of Wisconsin: Transactions of the Wisconsin Academy of Sciences, Arts and Letters, v. 88, no. 2000, p. 77-103.

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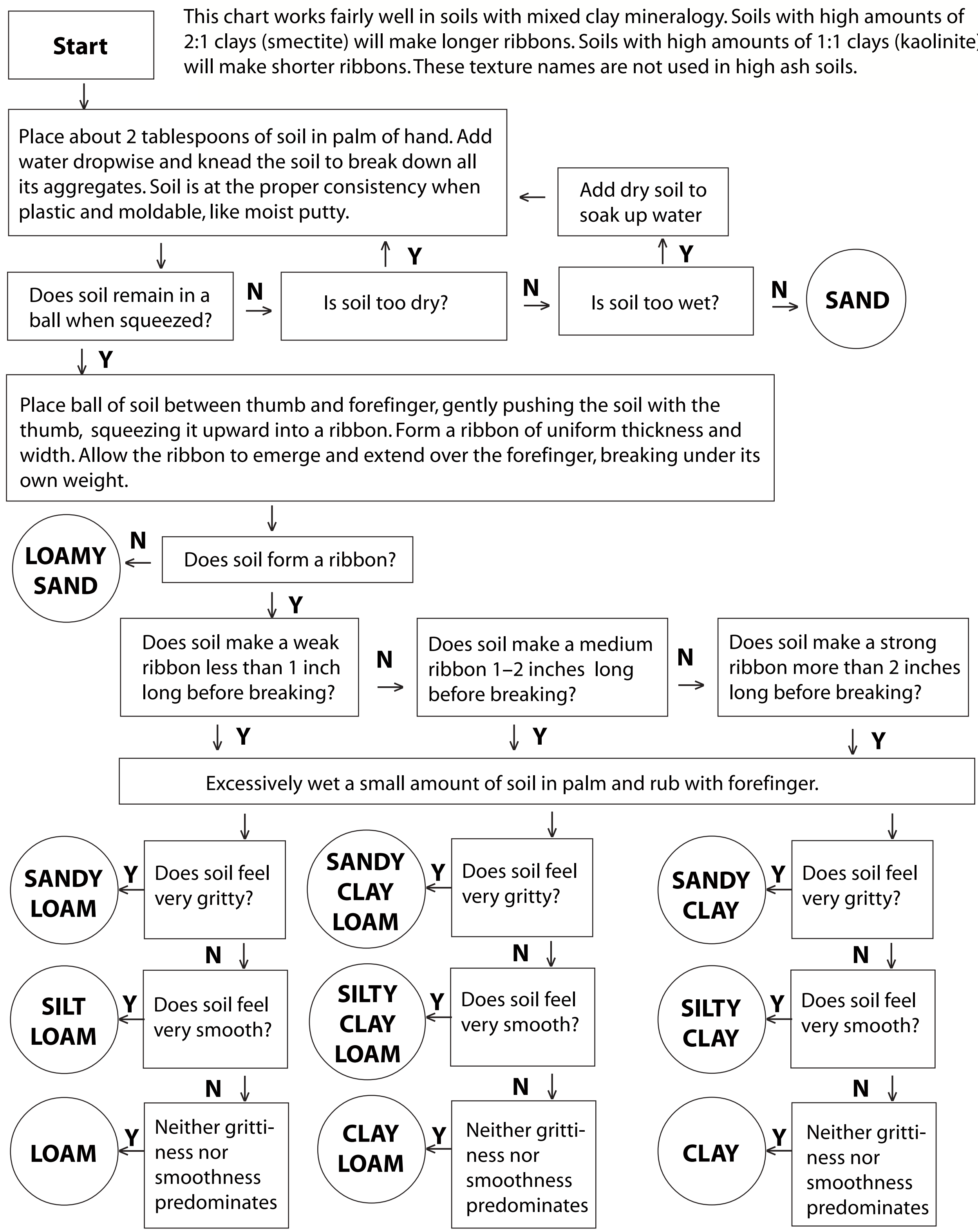
APPENDIX F

Soil Texture Decision Chart

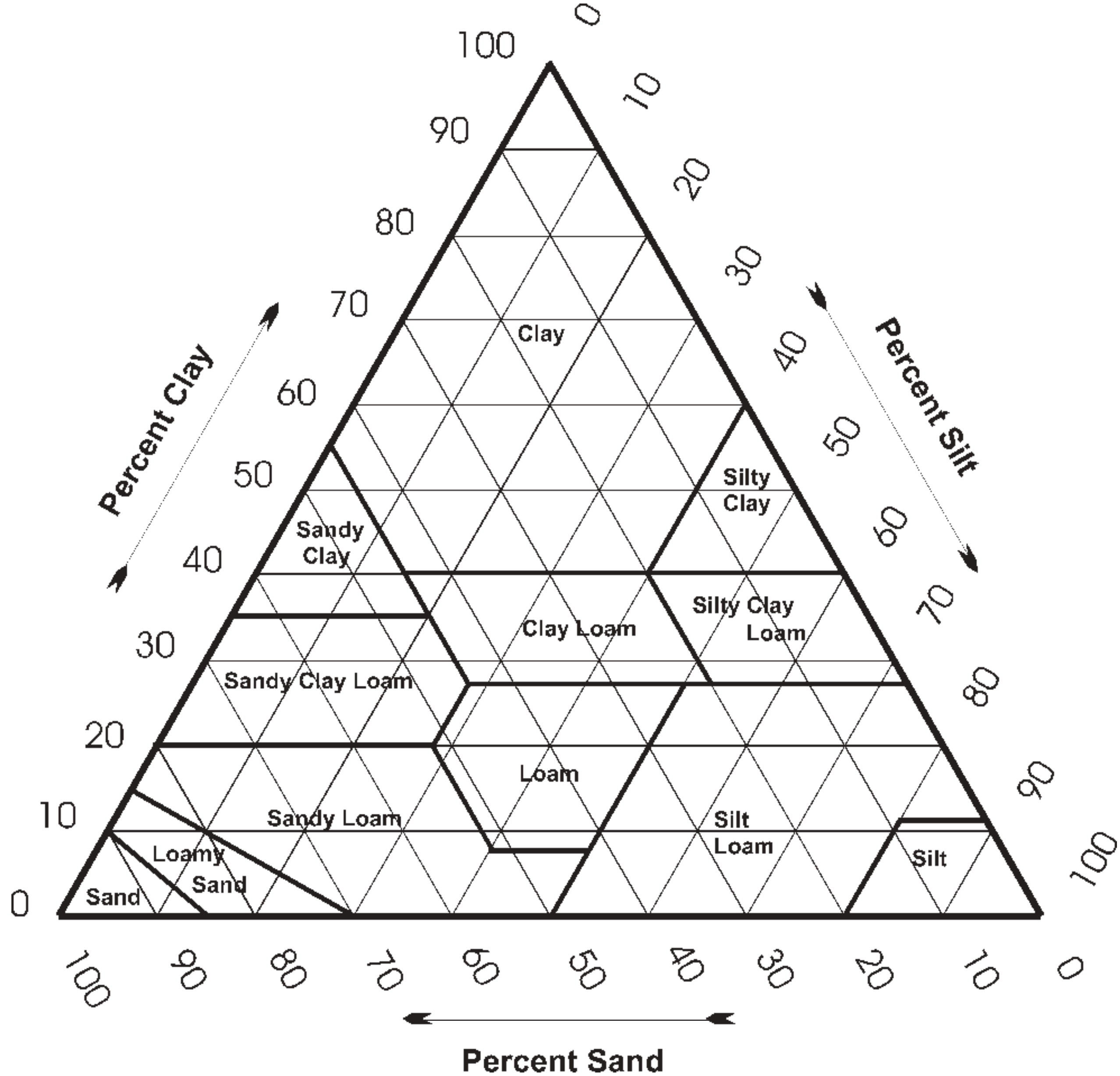
Appendix F: Soil Texture Decision Chart

This information was obtained on-line at:
http://casfs.ucsc.edu/education/instruction/tofg/download/unit_2.1b_soil_physical.pdf

Soil Texture Decision Chart



Soil Texture Triangle



APPENDIX G

North Carolina Exotic Plants

Appendix G: North Carolina Exotic Plants

This table identifies exotic, invasive plant species that have been identified by state, federal, or regional entities (as of the date of this manual) as indicated by an "X" in the three right columns. Some of the species are regulated by law.

- Plants listed under "N.C. Law" fall under North Carolina Department of Agriculture Noxious Weed Regulations (02 NCAC 48A. 1700). Sale, distribution, and conveyance of these plants are restricted within North Carolina.
- Plants listed under "U.S. Law" fall under the Federal Noxious Weed Regulations (7CFR360), compiled by the Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture. Movement or dissemination of the included species is restricted within the United States.
- Plants listed under "USFS Policy" are identified in the Southeast Exotic Pest Plant Council's Regional Invasive Exotic Plant Species List, available at: http://www.se-eppc.org/fslist.cfm. These plants are not necessarily regulated, but have been identified by public and private land managers as exotic and invasive species that pose management concerns.
- The entire list can be viewed at http://www.invasive.org/seweeds.cfm.

Scientific Name	Common Name	N.C. Law	U.S. Law	USFS Policy
Vines				
Ampelopsis brevipedunculata (Maxim.) Trautv.	Amur peppervine	-	-	X
Celastrus orbiculatus Thunb.	oriental bittersweet	X	-	X
Coronilla varia L.	purple crownvetch	-	-	X
Cuscuta spp. L.	dodder	X	X	-
Dioscorea alata L.	water yam	-	-	X
Dioscorea bulbifera L.	air yam	-	-	X
Dioscorea oppositifolia L.	Chinese yam	-	-	X
Euonymus fortunei (Turcz.) Hand.-Maz.	winter creeper	-	-	X
Hedera helix L.	English ivy	-	-	X
Ipomoea aquatica Forsskal	swamp morning-glory	X	X	-
Lonicera japonica Thunb.	Japanese honeysuckle	-	-	X
Lygodium japonicum (Thunb. ex Murr.) Sw.	Japanese climbing fern	-	-	X
Mikania cordata (Burm. f.) B.L. Robins.	heartleaf hempvine	X	X	-
Mikania micrantha Kunth	bittervine	X	X	-
Polygonum perfoliatum L.	mile-a-minute weed	X	-	X
Pueraria montana (Lour.) Merr.	kudzu	-	-	X
Tribulus terrestris L.	puncturevine	X	-	-
Wisteria floribunda (Willd.) DC.	Japanese wisteria	-	-	X
Wisteria sinensis (Sims) DC.	Chinese wisteria	-	-	X
Shrubs or Subshrubs		-	-	
Berberis thunbergii DC.	Japanese barberry	-	-	X

Scientific Name	Common Name	N.C. Law	U.S. Law	USFS Policy
Elaeagnus pungens Thunb.	thorny olive	-	-	X
Elaeagnus umbellata Thunb.	autumn olive	-	-	X
Lespedeza cuneata (Dum.-Cours.) G. Don	Chinese lespedeza	-	-	X
Ligustrum japonicum Thunb.	Japanese privet	-	-	X
Ligustrum lucidum Ait. f.	glossy privet	-	-	X
Ligustrum sinense Lour.	Chinese privet	-	-	X
Ligustrum vulgare L.	European privet	-	-	X
Lonicera fragrantissima Lindl. & Paxton	sweet breath of spring	-	-	X
Lonicera maackii (Rupr.) Herder	Amur honeysuckle	-	-	X
Lonicera morrowii Gray	Morrow's honeysuckle	-	-	X
Lonicera tatarica L.	Tatarian honeysuckle	-	-	X
Ludwigia uruguayensis Camb.) Hara	Uruguayan primrose-willow	X	-	-
Lycium ferrocissimum Miers	African boxthorn	X	X	-
Melastoma malabathricum L.	Malabar melastome	X	X	-
Mimosa diplotricha C. Wright ex Sauvalle	giant sensitive plant	X	X	-
Mimosa pigra L.	catclaw mimosa	X	X	X
Nandina domestica Thunb.	sacred bamboo	-	-	X
Polygonum cuspidatum Sieb. & Zucc.	Japanese knotweed	-	-	X
Rosa multiflora Thunb. ex Murr.	multiflora rose	-	-	X
Rubus fruticosus L.	shrubby blackberry	X	X	-
Rubus moluccanus L.	wild blackberry	X	X	-
Spiraea japonica L. f.	Japanese meadowsweet	-	-	X
Parasitic and Epiphytic Plants				
Orobanche minor Smith	small broomrape	X	X	-
Orobanche ramosa L.	broomrape	X	X	-
Orobanche spp. L.	broomrape	-	X	-
Striga asiatica (L.) Kuntze	Asiatic witchweed	X	X	-
Striga gesnerioides (Willd.) Vatke	cowpea witchweed	X	X	-
Striga spp. Lour.	witchweed	X	X	-
Hardwood Trees		-	-	
Ailanthus altissima (P. Mill.) Swingle	tree of heaven	-	-	X
Albizia julibrissin Durazz.	mimosa	-	-	X
Elaeagnus angustifolia L.	Russian olive	-	-	X
Melaleuca quinquenervia (Cav.) Blake	melaleuca	X	X	-
Prosopis spp. L.	mesquite	X	X	-
Triadica sebifera (L.) Small	tallow tree	-	-	X
Grass or Grasslike Plants				
Arthraxon hispidus (Thunb.) Makino	small carpgrass	-	-	X
Avena sterilis L.	animated oat	X	X	-
Bromus inermis Leyss.	smooth brome	-	-	X

Scientific Name	Common Name	N.C. Law	U.S. Law	USFS Policy
Chrysopogon aciculatus (Retz.) Trin.	golden false beardgrass	X	X	-
Digitaria abyssinica (A. Rich) Stapf	African couchgrass	X	X	-
Digitaria velutina (Forsk.) Beauv.	velvet fingergrass	X	X	-
Eragrostis curvula (Schrad.) Nees	weeping lovegrass	-	-	X
Imperata brasiliensis Trinius	Brazilian satintail	X	X	-
Imperata cylindrica (L.) Beauv.	cogongrass	X	X	X
Ischaemum rugosum Salisbury	murainagrass	X	X	-
Leptochloa chinensis (L.) Nees	Asian sprangletop	X	X	-
Lolium arundinaceum (Schreb.) S.J. Darbyshire	tall fescue	-	-	X
Microstegium vimineum (Trin.) A. Camus	Nepalese browntop	-	-	X
Miscanthus sinensis Anderss.	Chinese silvergrass	-	-	X
Nassella trichotoma Hackel ex Arech.	serrated tussock grass	X	X	-
Oryza longistaminata A. Chev. & Roehr.	longstamen rice	X	X	-
Oryza punctata Kotzchy ex Steud.	red rice	X	X	-
Oryza rufipogon Griffiths	brown-beard rice, Wild red rice	X	X	-
Paspalum scrobiculatum L.	kodomillet	X	X	-
Pennisetum clandestinum Hochst. ex Chiov.	kikuyugrass	X	X	-
Pennisetum macrourum Trinius	African feathergrass	X	X	-
Pennisetum pedicellatum Trinius	Kyasuma grass		X	-
Pennisetum polystachyon (L.) Schultes	mission grass	X	X	-
Phleum pratense L.	timothy	X	-	-
Rottboellia cochinchinensis (Lour.) W.D. Clayton	itchgrass	X	X	-
Saccharum spontaneum L.	wild sugarcane	X	X	-
Setaria pumila pallidifusca (Schumacher) B.K. Simon	yellow bristlegrass	X	X	-
Sorghum halepense (L.) Pers.	Johnsongrass	-	-	X
Urochloa panicoides Beauvois	liverseed grass	X	X	-
Forbs / Herbs		-	-	-
Aeginetia spp. L.	Aeginetia, Bunga	X	X	-
Ageratina adenophora (Spreng.) King & H.E. Robins.	crofton weed	X	X	-
Alectra spp. Thunb.	alectra	X	X	-
Alliaria petiolata (Bieb.) Cavara & Grande	garlic mustard	-	-	X
Allium vineale L.	wild garlic	-	-	X
Asphodelus fistulosus L.	onionweed	X	X	-
Carduus acanthoides L.	spiny plumeless thistle	X	-	-
Carduus nutans L.	musk thistle	X	-	X
Carthamus oxyacantha Bieb.	wild safflower	X	X	-
Cirsium arvense (L.) Scop.	Canada thistle	X	-	X

Scientific Name	Common Name	N.C. Law	U.S. Law	USFS Policy
Cirsium vulgare (Savi) Ten.	bull thistle	-	-	X
Commelina benghalensis L.	tropical spiderwort	X	X	-
Crassula helmsii A. Berger	swamp stonecrop	X	-	-
Crupina vulgaris Cass.	common crupina	X	X	-
Drymaria arenarioides Humboldt & Bonpland	sandwort drymary	X	X	-
Emex australis Steinhall	three-cornered jack	X	X	-
Emex spinosa (L.) Campdera	devil's thorn	X	X	-
Galega officinalis L.	goat's rue	X	X	-
Heracleum mantegazzianum Sommier & Levier	giant hogweed	X	X	-
Homeria spp. N/A	cape tulip	X	X	-
Hygrophila polysperma (Roxb.) T. Anders.	miramar weed	X	X	-
Kummerowia striata (Thunb.) Schindl.	Japanese clover	-	-	X
Limnophila sessiliflora (Vahl) Blume	Asian marshweed	X	X	-
Lythrum salicaria L.	purple loosestrife	X	-	X
Monochoria hastata (L.) Solms	arrowleaf false pickerelweed	X	X	
Monochoria vaginalis (Burm. f.) K. Presl ex Kunth	heartshape false pickerelweed	X	X	-
Polygonum caespitosum Blume	oriental ladysthumb	-	-	X
Rorippa sylvestris (L.) Bess.	creeping yellowcress	X	-	-
Salsola vermiculata L.	shrubby Russian thistle	X	X	-
Solanum torvum Swartz	turkey berry	X	X	-
Solanum viarum Dunal	tropical soda apple	X	X	X
Spermacoce alata Aublet	winged false buttonweed	X	X	-
Stachys floridana Shuttlw. ex Benth.	Florida hedgenettle	X	-	-
Tridax procumbens L.	coatbuttons	X	X	-
Verbena brasiliensis Vell.	Brazilian vervain	-	-	X
Cactus		-	-	-
Opuntia aurantiaca Lindley	Jointed prickly pear, Tiger pear	X	X	
Aquatic				
Alternanthera philoxeroides (Mart.) Griseb.	alligatorweed	-	-	X
Alternanthera sessilis (L.) R. Br. ex DC.	sessile joyweed	X	X	-
Azolla pinnata R. Brown	feathered mosquitofern	X	X	-
Caulerpa taxifolia (Vahl) C. Agardth	Mediterranean clone of caulerpa	X	X	-
Egeria densa Planch.	Brazilian waterweed	-	-	X
Eichhornia azurea (Swartz) Kunth	anchored water hyacinth	X	X	-
Eichhornia crassipes (Mart.) Solms	common water hyacinth	X	-	X
Hydrilla verticillata (L. f.) Royle	hydrilla	X	X	X
Lagarosiphon major (Ridley) Moss	oxygen weed	X	X	-

Scientific Name	Common Name	N.C. Law	U.S. Law	USFS Policy
Myriophyllum spicatum L.	Eurasian watermilfoil	X	-	X
Ottelia alismoides (L.) Pers.	duck-lettuce	X	X	-
Pistia stratiotes L.	water lettuce	-	-	X
Sagittaria sagittifolia L.	Hawaii arrowhead	X	X	-
Salvinia auriculata Aublet	eared water-moss	X	X	-
Salvinia biloba Raddi	giant salvinia	X	X	-
Salvinia herzogii de la Sota	giant salvinia	X	X	-
Salvinia molesta D. S. Mitchell	giant salvinia	X	X	X
Solanum tampicense Dunal	wetland nightshade	X	X	-
Sparganium erectum L.	exotic bur-reed	X	X	-
Trapa natans L.	water chestnut	X	-	-

APPENDIX H

NC WAM Rating Calculator User Guide

Appendix H: NC WAM Rating Calculator User Guide

H-1.0 Introduction

Wetland functional ratings are generated by processing wetland assessment data collected on the NC WAM Wetland Assessment Form through a Boolean logic sequence. Each of the 16 general wetland types has its own unique and rather extensive Boolean logic sequence. While it is possible to generate functional ratings by manually processing wetland assessment data, the effort would be time consuming and, due to the complicated nature of the Boolean logic, potentially prone to miscalculation. To reduce processing time and ensure proper processing of assessment data, the Wetland Functional Assessment Team (WFAT) directed the development of the NC WAM Rating Calculator.

The NC WAM Rating Calculator consists of a pair of Microsoft Excel worksheets designed to resemble the NC WAM Wetland Assessment Form and the NC WAM Wetland Rating Sheet. The purpose of the Rating Calculator is to automate the wetland rating process. Wetland assessment data collected in the field is input into the Rating Calculator. The computer program imbedded within the Rating Calculator passes the assessment data through the wetland-specific Boolean logic chain to produce functional ratings. Instructions for use of the Rating Calculator with pre-Excel 2007 versions and Excel 2007 follow.

H-2.0 Rating Calculator Instructions

H-2.1 Setting Excel's Macro Security

The Rating Calculator is a Microsoft Excel workbook customized with macros (computer programming code). Excel has a macro security feature that regulates the use of macros within the program. Prior to opening the Rating Calculator, Excel's macro security needs to be set to allow the operation of macros. The procedure for setting Excel's macro security differs between pre-Excel 2007 versions and Excel 2007. Please follow the appropriate instructions below.

H-2.1.1 Microsoft Excel prior to 2007

To set the macro security pre-Excel 2007 versions, start the Excel program and access the Security dialog from the Tools menu (Tools > Macros > Security). Select the Medium level of security from the Security Level tab and click OK. Next, select the Trusted Publishers tab and check the Trust access to Visual Basic Project checkbox (Figure H-1). Close the Excel program.

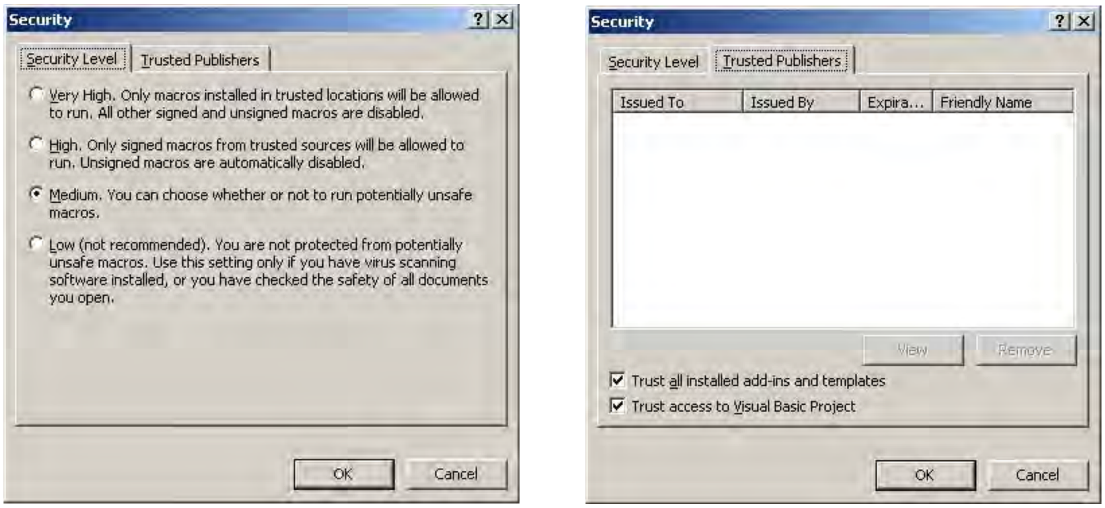


Figure H-1. Set the Excel macro Security Level to Medium and select Trust access to Visual Basic Project.

H-2.1.2 Microsoft Excel 2007

A security warning is prompted when the NC WAM Rating Calculator is opened in Excel 2007. The warning is displayed on the left side of the Excel window, just below the Ribbon (see Figure H-2). The accompanying text indicates that content within the Rating Calculator workbook – in this case, the Rating Calculator macro – has been disabled. Enable Rating Calculator functionality by selecting the Options button (denoted by a red arrow in Figure H-2). Select the Enable this content option from the Microsoft Office Security Options dialog (see Figure H-2).

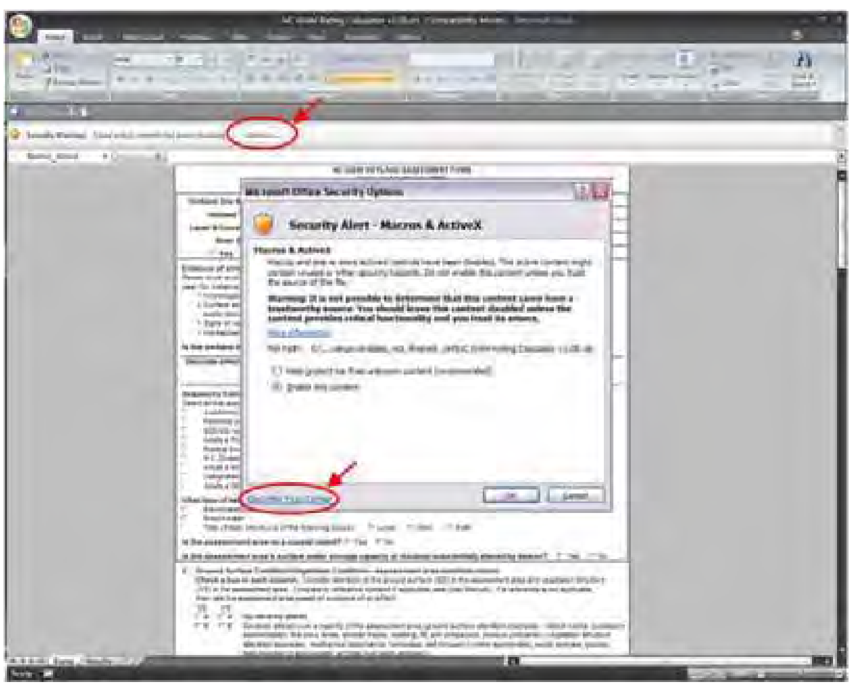


Figure H-2. Enable the NC WAM Rating Calculator functionality.

Next, open the Trust Center dialog by selecting the Open the Trust Center link (denoted by a red arrow) located in the bottom left corner of the Microsoft Office Security Options dialog. Select the Macro Settings tab from the option panel on the left side of the dialog. Two macro settings need to be configured here. First, select the Disable all macros with notification option. Second, place a check in the Trust access to VBA project object model box (see Figure H-3). Close the Trust Center and Microsoft Office Security Options dialogs. Close Excel entirely.

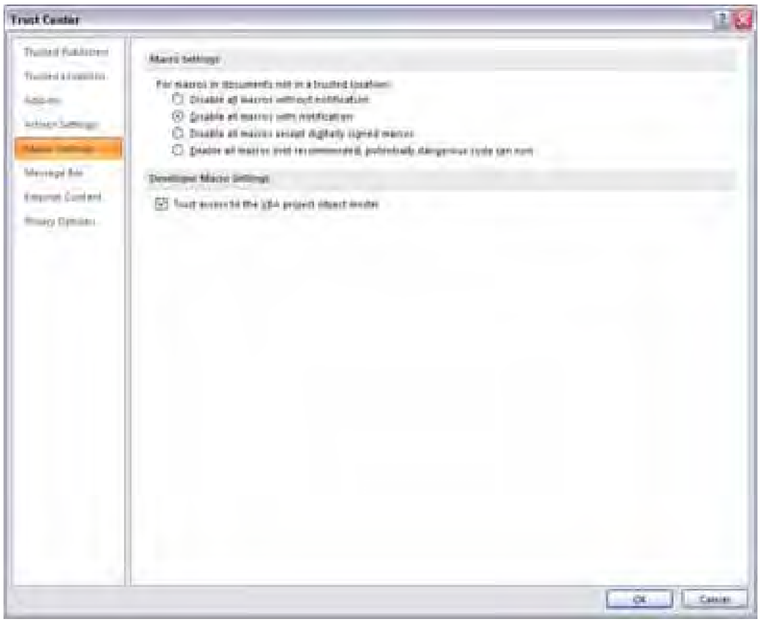


Figure H-3. Additional security settings are configured in the Trust Center dialog.

H-2.2 Opening the Rating Calculator

The Rating Calculator is opened like a typical Excel file – by either double-clicking the Rating Calculator file or by using the Open function available in Excel's File menu (File > Open). Open the Rating Calculator using one of the described methods.

H-2.1.1 Microsoft Excel prior to 2007

Upon opening the Rating Calculator, a dialog appears indicating that the file contains macros. Click Enable Macros to continue opening the file. The Rating Calculator may take a few moments to initialize. The initialization procedures are complete and the form ready to operate when the mouse cursor is no longer an hourglass. This step will need to be repeated each time the Rating Calculator is opened.

H-2.1.2 Microsoft Excel 2007

Open the NC WAM Rating Calculator workbook. Dismiss the security warning by selecting the Options button and selecting the Enable this content option from the Microsoft Office Security Options dialog (Figure H-2). This step will need to be repeated each time the Rating Calculator is opened.

H-2.2 Rating Calculator Contents

The Rating Calculator has two worksheets: the Form worksheet and the Results worksheet. The Form worksheet is a replication of the NC WAM Field Assessment Form and the Results worksheet is a replication of the NC WAM Wetland Rating Sheet. Wetland assessment data collected in the field are transcribed from the NC WAM Wetland Assessment Form onto the Form worksheet. The resulting functional ratings are presented on the Results worksheet.

Use the Form and Results tabs located in the bottom left-hand corner of the Rating Calculator screen to toggle between the two worksheets (Figure H-4). Click the Form tab to display the Form worksheet and the Results tab to display the Results worksheet. The operation of both worksheets is described below.

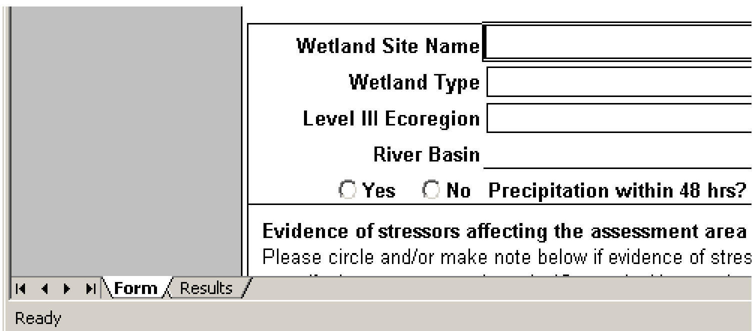


Figure H-4. Use the Form and Results tabs to toggle between the respective worksheets.

H-2.2.1 Form Worksheet

The Form worksheet is displayed when the Rating Calculator opens. The Form worksheet contains all components of the NC WAM Wetland Assessment Form; each metric as well as the general wetland information and notes sections are represented. Several different types of user interfaces are used for inputting the wetland assessment data: text fields, combo boxes, option buttons, and checkboxes.

Text fields provide space for information to be typed in via the keyboard. General wetland information, such as the wetland site name, assessor name, stressor notes, and wetland notes are input into text fields (Figure H-5). Information is input into text fields by clicking on a specific text field with the mouse and then typing with the keyboard. Click in the white space on the form to exit the text field.

Three combo boxes are used in the general wetland information section of the Form worksheet to specify the assessed wetland type, ecoregion of occurrence, river basin. The Wetland Type combo box lists the 16 general wetland types in NC WAM (Figure H-5). The Level III Ecoregion combo box lists the four level III ecoregions that occur in North Carolina (Figure H-5). Lastly, the River Basin combo box lists the 17 river basins of North Carolina. The combo boxes are used by clicking the arrow on the right side of the combo box and selecting the appropriate entry from the dropdown list. Both the wetland type and ecoregion are required information for calculating wetland functional ratings.

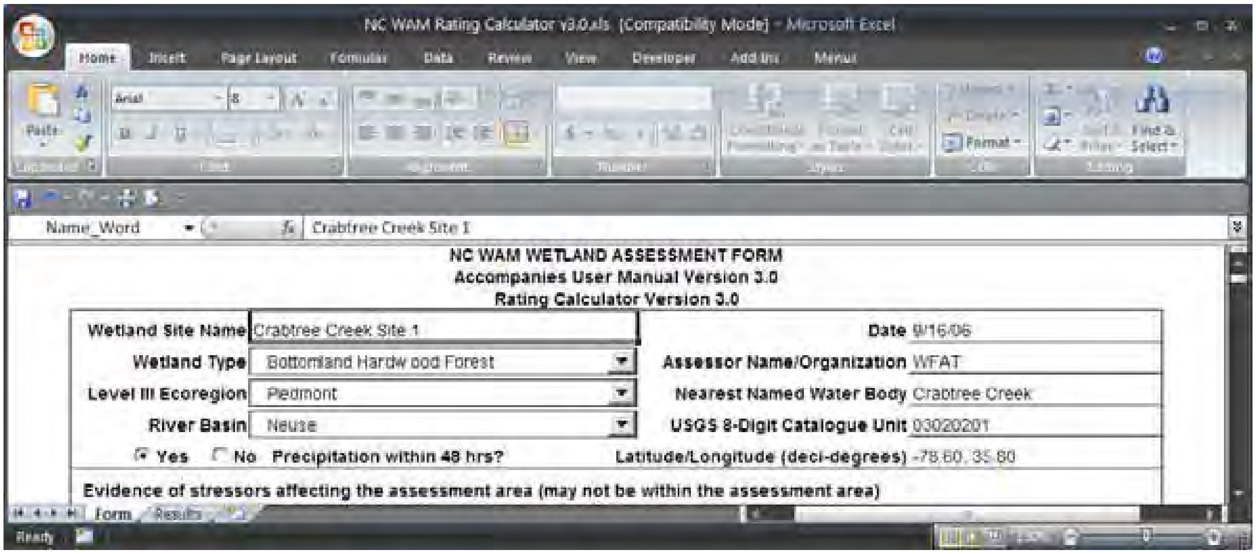


Figure H-5. Text field and combo box items on the Form worksheet.

Option buttons and checkboxes are used throughout the Form worksheet to record the selection of metric descriptors, regulatory considerations, and stream types, among other items (Figure H-6). Option buttons are used to select mutually exclusive items. Consider Metric 9 (Inundation Duration) for example (see NC WAM Field Assessment Form provided at the beginning of the User Manual). The three descriptors of Metric 9 are mutually exclusive; the inundation duration condition denoted by descriptor "A" can only occur absent the conditions described by descriptors "B" and "C," and vice versa. On the other hand, checkboxes are used for inclusive items. For instance, the land use conditions described in Metric 6 (Land Use) are not necessarily exclusive of each other; multiple land use conditions may occur within the same watershed. The same is true for the regulatory considerations in the general wetland information section. Using checkboxes for inclusive scenarios, as is the case for Metric 6, allows multiple items to be selected at once.

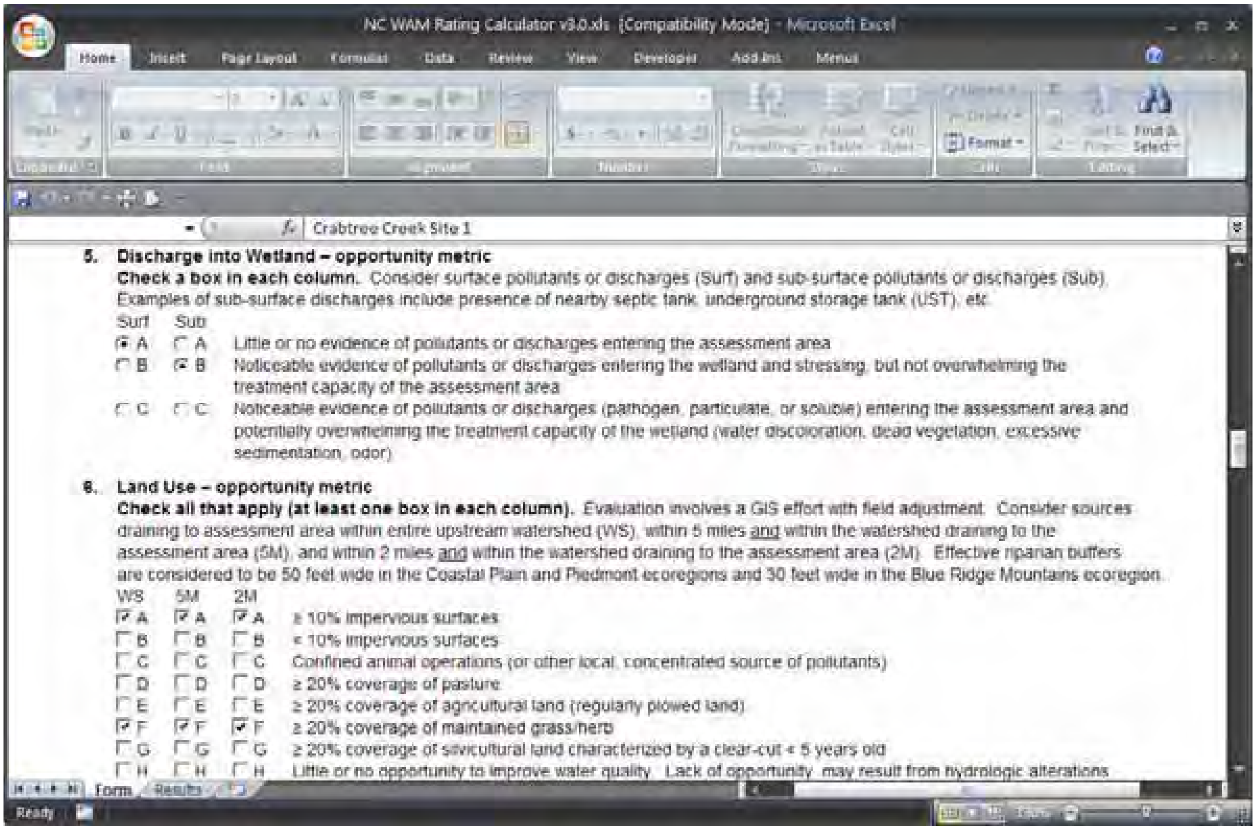


Figure H-6. Option buttons are used in metric number 5 for exclusive descriptors and checkboxes in metric number 6 for inclusive descriptors.

H-2.2.2 Results Worksheet

The Results worksheet, the second worksheet in the Rating Calculator, displays general wetland information and calculated functional ratings in the same format found on the NC WAM Wetland Rating Sheet. The Results worksheet does not allow for user input, but simply displays the wetland ratings as calculated. The general wetland information, such as wetland site name and wetland type, is automatically transferred from the general wetland information provided on the Form worksheet.

H-2.3 Generating Functional Ratings

The process of calculating wetland functional ratings with the Rating Calculator is relatively simple: complete the NC WAM Field Assessment Form depicted in the Form worksheet by selecting the metric descriptors that apply to the assessed wetland. To be thorough, general wetland information, such as the wetland site name and date, should be completed as well. As each metric is completed, the Rating Calculator automatically calculates the functional ratings for the sub-functions and functions that the metric pertains to. The calculated functional ratings are output to the Results worksheet. The rating for a particular sub-function, the Hydrology Surface Storage and Retention sub-function for instance, is displayed after metric descriptors have been provided for all metrics applicable to the sub-function. An overall wetland rating is generated only after metric descriptors have been provided for all metrics applicable to the specified wetland type.

The Rating Calculator operates dynamically, meaning that wetland functional ratings are automatically calculated after each change in the metric descriptors, wetland type, or ecoregion. For instance, the Rating Calculator could be completed for a Piedmont Bottomland Hardwood Forest – metric descriptors provided for all necessary metrics and all functional ratings calculated. If a metric descriptor is changed for any metric, the Rating Calculator will automatically recalculate the functional ratings. If it were determined, after ratings calculation, that the wetland type should be revised from Bottomland Hardwood Forest to Riverine Swamp Forest, all that would be required to recalculate the functional ratings is to select the new wetland type (Riverine Swamp Forest) from the Wetland Type combo box on the Form worksheet.

The wetland type and ecoregion are required information for all wetland assessments. Functional ratings cannot be generated until a wetland type and ecoregion are selected in the Wetland Type and Level III Ecoregion combo boxes. In fact, the Rating Calculator produces a message with instructions to specify the wetland type and ecoregion if metric descriptors are selected beforehand. In addition, the functional assessments of the Bottomland Hardwood Forest and Riverine Swamp Forest wetland types require a stream type (blackwater or brownwater) to be specified. Again, the Rating Calculator produces a message with instructions to provide a stream type if a Bottomland Hardwood Forest or Riverine Swamp Forest assessment is attempted without first specifying the stream type.

H-2.4 Viewing the Results

The Results worksheet can be viewed at any point in completing the Field Assessment Form on the Form worksheet by selecting the Results tab. The Results worksheet displays functional ratings for the sub-functions and functions completed to that point. For instance, if only metrics pertaining to the Habitat Physical Structure sub-function have been completely specified, then only the Habitat Physical Structure sub-function rating will be displayed on the Results worksheet.

As previously stated, the Results worksheet displays functional ratings and general wetland information without allowing any user input. The functional ratings presented are determined by the imbedded macros, while the general wetland information is transferred from the Form worksheet. If no general wetland information is provided on the Form worksheet, then none will be presented on the Results worksheet.

A total of 11 Hydrology, Water Quality, and Habitat sub-functions are presented on the NC WAM Wetland Rating Sheet and, consequently, the Results worksheet. Only a sub-set of the 11 sub-functions will apply to a given general wetland type. For instance, the Water Quality Pollution Change sub-function does not pertain to riverine wetlands such as Bottomland Hardwood Forest or Riverine Swamp Forest. In such cases, “NA” will appear in place of a sub-function rating to indicate that the sub-function is not applicable to the selected general wetland type (see Figure H-7).

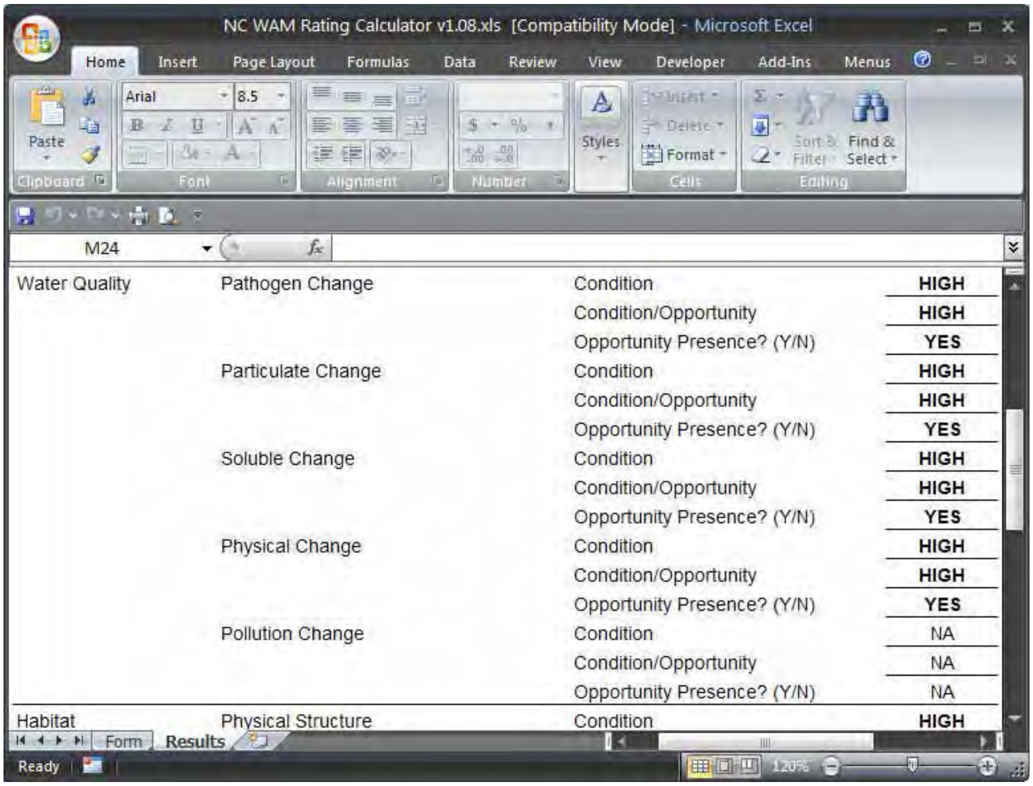


Figure H-7. Sub-functions not applicable to a given general wetland type are indicated by an "NA" on the Results worksheet.

H-2.5 NC WAM Menu

Beyond the user interfaces described above for the Field Assessment Form worksheet (Section H-2.2.1), the Rating Calculator also includes an NC WAM dropdown menu. The NC WAM menu is a customized dropdown menu that provides access to the Rating Calculator "Clear" and "Write to Word" functions. In pre-Excel 2007 versions, the NC WAM menu is located in the Menu Bar (Figure H-8). In Excel 2007, the NC WAM dropdown is located on the Add-Ins tab of the Ribbon (Figure H-9).

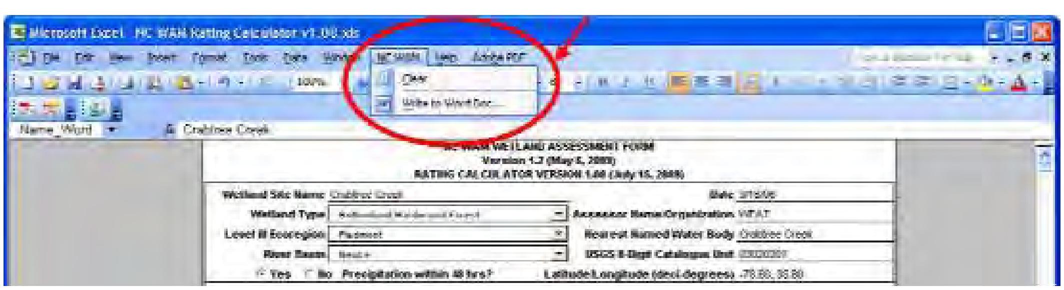


Figure H-8. In pre-Excel 2007 versions, the NC WAM menu is accessed from the Menu Bar.

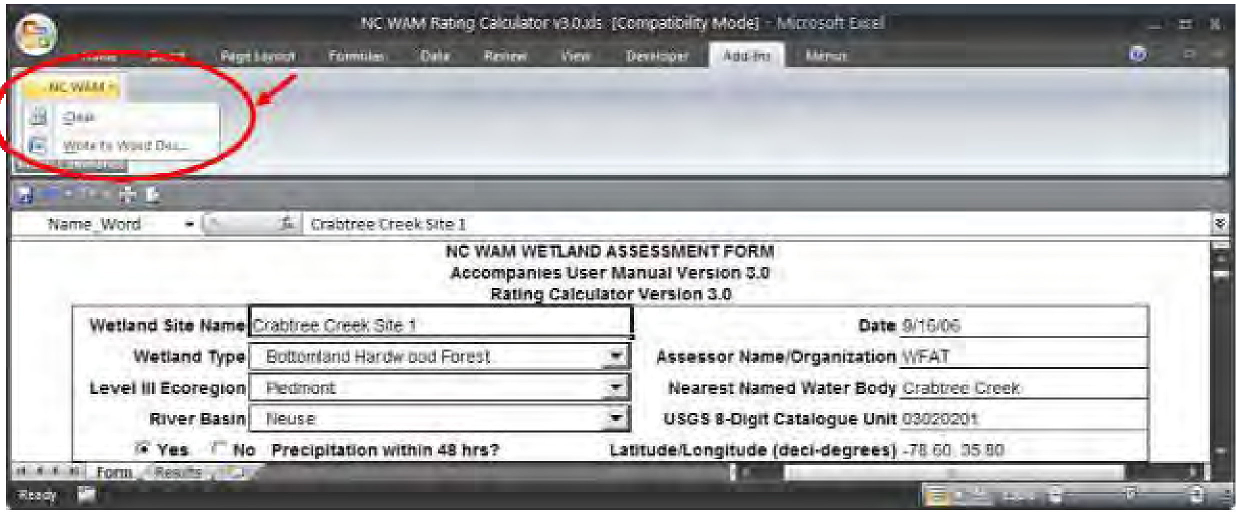


Figure H-9. In Excel 2007, the NC WAM menu is accessed from the Add-Ins tab on the Ribbon.

H-2.5.1 Clear Function

The “Clear” function clears all contents of the Form and Results worksheets including general wetland information, metric descriptor selections, and functional ratings. This function allows a new functional rating calculation to be started on clean Form and Results worksheets. To access the Clear function, select Clear from the NC WAM menu (NC WAM > Clear).

H-2.5.2 Write to Word Function

The “Write to Word” function (NC WAM > Write to Word) compiles the contents of the Form and Results worksheets into a single Microsoft Word document. Like the Rating Calculator, the resulting Word document is formatted to include both the NC WAM Field Assessment Form and the NC WAM Wetland Rating Sheet. All items from the Form worksheet, such as general wetland information and metric descriptor selections, are transferred to the corresponding locations in the NC WAM Field Assessment Form of the Word document. All items on the Results worksheet are transferred to the corresponding locations in the NC WAM Wetland Rating Sheet of the Word document.

The Rating Calculator Excel file is distributed with the WetlandTemplate.dot file. The Write to Word function requires the WetlandTemplate.dot file to operate. The WetlandTemplate.dot file is a Microsoft Word template file used by the Write to Word function to reconstruct the formatting of the NC WAM Wetland Assessment Form and the NC WAM Wetland Rating Sheet. While not necessary, it is recommended that the WetlandTemplate.dot file reside in the same directory as the Rating Calculator Excel file. If the WetlandTemplate.dot file is not stored in the same directory as the Rating Calculator when the Write to Word function is accessed, a dialog will appear asking for the location of the WetlandTemplate.dot file to be specified.

To initiate the Write to Word function, select Write to Word from the NC WAM menu (NC WAM > Write to Word). The Save As dialog appears. Navigate to the desired directory of the new Word document and provide a file name. Click Save. The Write to Word function transfers the contents of the Form and Results worksheets to the newly created Word document.

The Word document created by the Write to Word function is a digital record of the wetland assessment. This is in contrast to the Rating Calculator itself, which is designed primarily as wetland functional rating calculator and is not intended to be a storage bin for wetland assessments. Compared to the Rating Calculator, the Word document created by the Write to Word function has a smaller file size and the contents are easier to incorporate into reports or other documents.

H-3.0 Conclusion

The extensive Boolean logic developed by the WFAT for each of NC WAM's 16 general wetland types have conveniently been encoded into the NC WAM Rating Calculator. By linking the Boolean logic to an intuitive user interface that resembles the NC WAM Field Assessment Form, the Rating Calculator expedites the conversion of wetland assessment data to functional ratings by eliminating the arduous and error-prone task of manual processing. The Rating Calculator can export a completed wetland assessment – general wetland information, metric description selections, functional ratings, etc. – to a Word Document for storage or integration into reports. In all, the Rating Calculator provides a quick, user-friendly means of processing wetland assessment data collected using NC WAM, while at the same time ensuring the integrity of the data processing.

APPENDIX I

Glossary of Terms

Appendix I: Glossary of Terms

50/20 rule (for "dominant" vegetation) – This is the recommended method for selecting dominant species from a plant community when quantitative data are available. "Dominance" refers strictly to the spatial extent of a species that is measurable in the field. Absolute Percent Cover is the preferred abundance measure for all species. Dominant species are chosen independently from each stratum of the community. In general, dominants are the most abundant species that individually or collectively account for more that 50 percent of the total coverage of vegetation in the stratum, plus any other species that, by itself, accounts for at least 20 percent of the total (USFWS et al. 1989).

Agriculture (land use) – Agriculture is considered to be a land use wherein the ground surface is regularly plowed and planted with row crops.

Air space – The space extending upward above an area of the earth's surface to the lower ionosphere (modified from Webster's New World Dictionary, Third College Edition, 1988).

Alteration – NC WAM considers an "alteration" to be a change from reference in a wetland. Alterations typically degrade one or more wetland functions. See also "disturbed/disturbance."

Anadromous fish – According to the NCDWQ, this term refers to fish that spend their adult life at sea, but swim up-river to fresh water spawning grounds to reproduce. Examples include shad, herring, and striped bass (http://www.enr.state.nc.us/html/a_-_terms.html). According to the National Marine Fisheries Service, the term "anadromous" refers only to those fish that spawn in freshwater and live most of their lives in salt water. This term is often used interchangeably with "diadromous." The term 'diadromous' refers to any fish that migrates between saltwater and freshwater (http://www.nmfs.noaa.gov/habitat/habitatprotection /anadromousfish.htm).

Anastomosing (braided) channels – A multiple channel system in which channels disconnect and reconnect typically found in situations characterized by low slope or depositional fans.

Area of Environmental Concern (AEC) – Within 20 designated coastal counties, an area designated by the Coastal Resources Commission (CRC) as being a particularly fragile or critical resource of state-wide concern. AECs are organized into four categories: the Estuarine and Ocean System, the Ocean Hazard System, Public Water Supplies, and Natural and Cultural Resource Areas. AECs are the foundation of the CRC's permitting program for coastal development, as administered by the N.C. Division of Coastal Management (NCDCM 2001).

Artificial edge – see Edge effect/artificial edge.

Assessment area – This term, also known as "wetland assessment area," refers to a defined area of wetland that is subject to functional evaluation using the North Carolina Wetland Assessment Method (NC WAM). Depending on circumstances, assessment area boundaries may be formed by one or more of the following: the limit of a proposed activity, another wetland type, uplands, or the extent of a wetland type with a specific set of wetland characteristics in common (see Section 4.2.1 of the User Manual for examples). Assessment area condition metrics are those concerned only with the portion of wetlands included within the defined assessment area, regardless of the location of general wetland type boundaries. Assessment areas will generally be limited to a minimum size of 0.1 acre.

Benefit(s) (wetland) – Within NC WAM, a benefit may be one of several wetland functional products provided by identified wetland sub-functions. For instance, the wetland function of Hydrology is considered to comprise two sub-functions: surface storage and retention and sub-surface storage and retention. Benefits of surface storage and retention include energy dissipation, reduction in runoff volume, and reduced flow velocities; and benefits of sub-surface storage and retention include attenuation of peak flows and maintenance of base flow.

Best Professional Judgment (BPJ) – Utilization of accumulated experience in a given field to make a decision appropriate to the specific wetland at hand. NC WAM attempts to be as specific as possible, but the variability of wetlands and limited quantitative knowledge of some metrics make it necessary to rely on BPJ in many instances.

Blackwater streams – Streams that generally originate in the Coastal Plains (Middle Atlantic Coastal Plain and Southeastern Plains ecoregions) and contain negligible amounts to no sediment, are tannic in nature, and often flow through peat-based or sandy areas (NCDWQ 1997a). These streams are often black in color but are not turbid like brownwater streams.

Blue Ridge level III ecoregion – This ecoregion occurs within generally the same footprint as the Blue Ridge physiographic province (see Figure 1 and Appendix E for ecoregion map). The Blue Ridge ecoregion includes the mountainous portion of the old Appalachians Highland and varies in character from narrow ridges to hilly plateaus to more massive mountainous areas with high peaks. This ecoregion occurs on metamorphic rocks with minor areas of igneous and sedimentary geology (Griffith et al. 2002).

Blue Ridge physiographic province –This physiographic province is synonymous with Blue Ridge level III ecoregion (see Figure 1 and Appendix E).

Boolean logic – 1) This is a method of converting logical expressions into mathematical form and is based on a binary approach, processing only two objects at a time. 2) A deductive logical system usually applied to classes in which, under the operations of intersection and symmetric difference, classes are treated as algebraic quantities. Boolean logic is the basis of the algorithms converting the field metrics of NC WAM into functional ratings.

Brackish water – Waters typically found in the upper extent of estuaries and the lower reaches of large rivers. These waters typically have a saline content of greater than 0.5 parts per thousand. This is a term used by NC WAM to refer to estuarine waters at the lower end of the salinity concentration scale.

Braided (anastomosing) channels – See Anastomosing (braided) channels

Brownwater streams – Streams that generally originate in the Piedmont or Blue Ridge ecoregions of North Carolina (NCDWQ 1997a). These streams often contain high amounts of clay and silt and are therefore often turbid and brown in color.

Buffer (see also "riparian buffer" and "wetland buffer") – A buffer is a vegetated area abutting an open water that reduces runoff and non-point source pollution and attenuates flood flows by decreasing water flow velocity. This facilitates the settling, trapping and uptake of chemical pollutants (such as nitrogen and phosphorus) and sediment (http://www.enr.state.nc.us/html/b_-_terms.html). NC WAM considers optimum wetland buffer widths to be 50 feet (measured perpendicular to a surface water) in the Coastal Plain and Piedmont ecoregions and 30 feet wide (measured perpendicular to a surface water) in the Blue Ridge ecoregion. The wetland buffer width measurement referred to in Field Assessment Form Metric 7 requires the assessor to determine if an assessment area is within 50 feet of a tributary or other open water, and if so, how much of the first 50 feet perpendicular to the bank is wetland.

Buttressing – Enlarged trunks developed in tree species (example: bald cypress [*Taxodium distichum*]) in response to frequent inundation (Environmental Laboratory 1987).

Buttswell – Buttswell, or butt swell, is an expansion of the lower end of the tree trunk and beyond the usual stump flare found in all species. Buttswell is a natural development, apparently activated by wetness of the site (http://forest.mtu.edu/research/hwbuck/hardwood_defects/butt_swell.html).

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

Carolina bay – NC WAM considers Carolina bays to be elliptical landscape features that range in surface character from concave and supporting interspersed open water and vegetation to convex and supporting vegetation on a bed of accumulated organic matter.

Channel – A channel is a natural water-carrying trough cut vertically into low areas of the land surface by erosive action of concentrated flowing water or a ditch or canal excavated for the flow of water (15A NCAC 02B .0233 (2)(a)).

Chroma – The relative purity or saturation of a color; intensity of distinctive hue as related to grayness; one of the three variables of color (Environmental Laboratory 1987).

Class SA waters – A NCDWQ classification for the highest quality tidal salt waters. These are surface waters that are used for shell fishing for market purposes and meet the current sanitary and bacteriological standards as adopted by the Commission for Health Services (15A NCAC 02B .0221).

Clear-cut – A term which describes a regeneration method of timber harvesting in which all suitable trees within a designated area are removed while leaving ground material in place, along with stumps and usually some woody debris. For the purposes of NC WAM, assessors should consider an area to be clear-cut if a timber harvest has occurred and the regenerating woody vegetation is less than 10 feet tall on average.

Coastal island – An island surrounded by salt, estuarine, or brackish water.

Coastal Plain ecoregions – Term used within the NC WAM User Manual to collectively refer to the Middle Atlantic Coastal Plain and Southeastern Plains level III ecoregions.

Coastal Plain physiographic province – The Coastal Plain is a physiographic province that includes all areas extending eastward from the fall line/fall zone to the ocean. It consists of the areas with surface geology consisting of Cretaceous and younger sedimentary rocks and unconsolidated sediments. This physiographic province includes the Middle Atlantic Coastal Plain and Southeastern Plains level III ecoregions – as well as the Sandhills level IV ecoregion (see Figure 1 and Appendix E).

Coleoptile – The tubular, protective sheath which surrounds the young shoot in the germinating grass seed (Webster's New World Dictionary, Third Edition 1988).

Condition metric – This type of metric is a measurement of the extent to which a wetland departs from full wetland functional integrity. In other words, a condition metric is any metric that is based on the inherent capacity of a wetland to perform functions. NC WAM uses condition as a surrogate for function because "condition" can be observed while "function" must be inferred.

Confined animal operations – Facilities associated with production of animal products through raising livestock in large numbers in a limited space, resulting in concentration of animal byproducts in on-site locations. Confined animal operations (CAFOs) are defined by the EPA and Division of Water Quality with respect to a minimal number of livestock in a confined area. The evaluator is not required to actually count the number of animals, but rather has to make a judgment as to whether livestock in a confined space could result in the runoff of animal waste products to surface waters. Precise definitions of CAFOs can be found at http://portal.ncdenr.org/c/document_library/get_file?uuid=980eb3c5-56a7-4f45-bbad-6de12d0acd0f&groupId=38364.

Connectivity to other natural areas – A concept utilized by the Habitat wetland function that refers to the absence or presence and type of fragmentation, and barriers to migration (both biotic [animals and plants] and abiotic [water and nutrients]) into and out of a specific wetland system.

Contiguous – NC WAM considers this term to mean "touching or joining at the edge or border."

Cotyledon – The first single leaf or one of the first pair of leaves produced by the embryo of a flowering plant or any of various similar structures found in conifers (Webster's New World Dictionary, Third Edition 1988).

Crenulation – A crenulation is a linear, topographic feature that is less defined than a channel or valley and may be characterized by "v"-shaped contour lines on topographic mapping. Crenulations are typically smaller-scale, localized features as opposed to larger-scale, landscape-wide features. Also see "reentrant." Field observations and/or detailed mapping are very important in determining the presence or absence of a topographic crenulation. Man-made crenulations are not considered "natural." Wetlands located within a natural topographic crenulation are considered to be riparian wetlands.

Decimal degrees – This term refers to "decimal degrees" (or "deci-degrees") the expression of a latitude or longitude in degrees only (not minutes and seconds), typically written to six significant figures (example: 35.123456).

Dendritic channels – A multiple channel system in which the channels do not reconnect. The large-scale drainage pattern in most places in North Carolina is dendritic, with lower-order streams flowing into higher-order streams.

Dense – This term refers to vegetation structure and is used by NC WAM to characterize mid-story/sapling, shrub, and herb strata (Metric 17). Any of these three strata is considered to be dense when that stratum alone is characterized by 70 percent or more areal coverage.

Deposition/sedimentation – This term refers to the settling out and accumulation of eroded soil material (sediment) that has been transported into a wetland or open-water system by moving water. "Recent deposition" is defined as not supporting new plant growth.

Depression – NC WAM uses this term to refer to concave landscape features and Carolina bays supporting wetlands.

Descriptor – On the NC WAM field assessment form, each metric is in the form of a multiple-choice question that provides from one to several possible answers. The answer or answers selected by an assessor are referred to as "descriptors." The descriptors are used by NC WAM to determine functional ratings for a wetland.

Development – Any land disturbing activity that adds to or changes the amount of impervious or partially impervious cover on a land area or that otherwise decreases the infiltration of precipitation into the soil (15A NCAC 02B .0202). Also, development is considered to include a vegetation-disturbing activity resulting in breaks in the natural community structure sufficient to result in creation of an artificial edge (removing natural vegetation for a width of greater than or equal to 40 feet).

Diameter at Breast Height (DBH) – The width of a plant stem as measured at 4.5 feet above the ground surface (Environmental Laboratory 1987).

Discharge – For the purposes of NC WAM, this term refers to a substance that is released into a wetland. A discharge may be liquid or solid and may have a point or a non-point source. Note that this is not the same definition provided by the U.S. Army Corps of Engineers.

Disturbed/disturbance – NC WAM considers an area to be disturbed when it has been altered, or changed from its natural or reference condition. Disturbance typically reduces a wetland's ability to perform one or more functions. A wetland with little to no apparent disturbance is likely a fully functional wetland

Ditch, deep – A "ditch" or "canal" is a man-made channel, other than a modified natural tributary, constructed for drainage purposes. Ditches are typically dug through interstream divide areas. A ditch or canal may have flows that are perennial, intermittent, or ephemeral and may exhibit hydrological and biological characteristics similar to perennial or intermittent tributaries (15A NCAC 02B .0233(2)(d)). To be effective, a ditch must have an outlet (the ditch must eventually connect to an open water). A "deep" ditch has been excavated at a sufficient depth to potentially affect both surface and sub-subsurface storage and retention. For the purposes of NC WAM, a "deep" ditch typically exceeds 1 foot deep in mineral soils. If a soil has an organic surface layer, a "deep" ditch will extend into the underlying mineral soil layer.

Ditch, shallow – A "ditch" or "canal" is a man-made channel, other than a modified natural tributary, constructed for drainage purposes. Ditches are typically dug through interstream divide areas. A ditch or canal may have flows that are perennial, intermittent, or ephemeral and may exhibit hydrological and biological characteristics similar to perennial or intermittent tributaries (15A NCAC 02B .0233(2)(d)). To be effective, a ditch must have an outlet (the ditch must eventually connect to an open water). A "shallow" ditch has been excavated to a depth sufficient to potentially affect surface water storage and retention, but is not deep enough to affect sub-surface storage and retention. For the purposes of NC WAM, a "shallow" ditch typically does not exceed 1 foot deep in mineral soils. If a soil has an organic surface layer, a "shallow" ditch will not extend into the underlying mineral soil layer.

Dominant/dominated by/predominance – A biological, chemical, or physical feature that exerts a controlling influence on or defines the character of a community (modified from Environmental

Laboratory 1987). For example: 1) one or a few species of trees may "dominate" a forest canopy, making up the majority of the tree cover; 2) vegetation of the lower Albemarle Sound may be considered to be dominated by salt or brackish water even though the introduction of salt or brackish water occurs on an irregular basis. See the 50/20 rule for an explanation of dominant vegetation. For the purposes of NC WAM, only living vegetation is considered when determining vegetation dominance, and vegetation dominance is considered in terms of areal coverage (or "drip-line" coverage) rather than number of stems. A wetland dominated by herbaceous vegetation is characterized by greater than 50 percent coverage of herbs and less than 50 percent coverage by living woody plants. A wetland dominated by woody vegetation is characterized by greater than 50 percent coverage of living woody vegetation, regardless of the percent coverage of herbs.

Drip-line coverage – The drip line of a plant is the outer edge of foliage when looking down on the plant from above. The drip-line coverage of a plant, or a group of plants, is the areal coverage of the plant or group of plants that is bounded by the drip-line.

Ecological domain – Ecological domain refers to the characteristic group from which reference wetlands are selected. For instance, Pocosins may be found on mineral soils or organic soils. A reference for a mineral soil Pocosin will be drawn only from the ecological domain of mineral soil Pocosins.

Ecoregion – Ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. The delineation of ecoregions is based on the premise that ecological regions are hierarchical and can be identified through the analysis of spatial patterns and compositions of biotic and abiotic phenomena that affect or reflect differences in ecosystem quality and integrity. These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. A Roman numeral hierarchical scheme has been adopted for different levels of ecological regions (Griffith et al. 2002). NC WAM primarily uses level III ecoregions (see Figure 1 and Appendix E) because of the ease in translation between these units and the standard physiographic provinces. The Coastal Plain physiographic province contains the Middle Atlantic Coastal Plain and Southeastern Plains level III ecoregions; the Piedmont physiographic province roughly equals the Piedmont level III ecoregion; and the Blue Ridge physiographic province roughly equals the Blue Ridge ecoregion. NC WAM sometimes refers to level IV ecoregions (see Appendix E), subsets of level III ecoregions.

Edge effect/artificial edge – (see Field Assessment Form Metric 14) Edge effect is the alteration of physical environment and ecological function that results from a boundary between two contrasting kinds of vegetation. Of particular concern is the effect of artificial clearings bordering forests. These artificial edges increase weedy plant growth and increase the activity of certain predators and nest parasites for some distance into the forest from the edge. Certain species (forest interior species) are particularly harmed by artificial edges. A maintained corridor less than or equal to the width of a two-lane road is generally not considered to be an artificial edge. A maintained corridor greater than 40 feet wide is usually considered to be an artificial edge. Edge effect is evaluated as a metric for the Habitat wetland function.

Embayed region – A portion of the Middle Atlantic Coastal Plain ecoregion in northeastern North Carolina and adjacent Virginia. The embayed region is characterized by the prominence of drowned river valleys that form large sounds and many bays. The land in the embayed region is universally low and flat, and most is partly drained. This region contains the largest acreage and proportion of wetlands in the state (NCDWQ 1997b).

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

Estuarine water – Waters semi-enclosed by land but with at least partial access to the open ocean and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The estuarine system extends landward to where ocean-derived salts measure less than 0.5 parts per thousand during a period of average annual flow and seaward to the ocean (Cowardin et al. 1979). Brackish water, as used by NC WAM, is a subset of estuarine water at the lower end of the salt concentration (the vicinity of just over 0.5 parts per thousand).

Excessive – This modifier refers to sediment deposition in NC WAM Field Assessment Form Metric 10. Sediment deposition is considered to be excessive when it appears to be occurring at more than a natural rate.

Exotic species/exotics – (see Field Assessment Form Metric 15) This designation includes species that are not indigenous to a region – intentionally or accidentally introduced and often persisting (USACE 2006). See Appendix G for a list of species considered to be exotic in North Carolina. While numerous exotic species occur in North Carolina, the emphasis for NC WAM is on those species that are invasive, with the ability to become abundant in natural or disturbed wetlands and displace or prevent recovery of native species.

Exposed areas (with reference to marshes abutting/adjacent to open water) – (see Field Assessment Form Metric 7) Shorelines anticipated to be regularly subject to waves of a height of 1 foot or more are considered to be "exposed." NC WAM considers an open water width of 2500 feet to provide sufficient fetch for regular development of waves meeting or exceeding this threshold. Also, shorelines abutting open water with regular boat traffic that generates high-energy wakes are considered to be "exposed." "Sheltered areas" are the opposite of "exposed areas."

Fall line – The fall line or fall zone is a narrow zone encompassing a change in topography that separates the Piedmont and Coastal Plain physiographic provinces. Within this zone, the uplift of the Piedmont and Blue Ridge physiographic provinces has resulted in accelerated erosion, which, in turn, has resulted in a band of rapids and steep-sided valleys (Beyer 1991).

Few – "Few" is a relative term used in this assessment to indicate an amount less than 25 percent of the total.

Federally protected species – Species with federal classifications of Endangered or Threatened are protected under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.). Endangered status refers to "any species that is in danger of extinction throughout all or a significant portion of its range," and Threatened status refers to "any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (16 U.S.C. 1532).

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

Floodplain, geomorphic – See "geomorphic floodplain."

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

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

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

Forest – For the purposes of NC WAM, a forest is a plant community characterized by over 50 percent coverage of (dominated by) woody vegetation that is 10 feet high or taller.

Forested wetland – Forested wetland may consist of one NC WAM general wetland type or an association of two or more contiguous NC WAM general wetland types. NC WAM forested wetland types include Estuarine Woody Wetland (some forms), Riverine Swamp Forest, Seep, Hardwood Flat, Non-Riverine Swamp Forest, Pocosin (some forms), Pine Savanna (some forms), Pine Flat (some forms), Basin Wetlands (some forms), Bog (some forms), Floodplain Pool, Headwater Forest, and Bottomland Hardwood Forest. Forested wetland boundaries typically are formed by natural uplands, open water that extends across the entire width of a floodplain, a man-made berm/causeway the width of a four-lane road or wider, and a forested wetland type that averages less than 10 feet in height and is the width of a four-lane road or wider.

Freshwater – Waters containing less than 0.5 parts per thousand of ocean-derived salts (Cowardin et al. 1979).

Function – The normal activities or actions that occur in wetland ecosystems, or simply, the things that wetlands do. Wetland functions result directly from the characteristics of a wetland ecosystem and the surrounding landscape, and their interaction. The term is used primarily as a distinction from values. The term "values" is associated with society's perception of ecosystem functions. Functions occur in ecosystems regardless of whether or not they have values (definition modified from USACE 2006). According to 33 CFR Part 332, “functions” refers to the physical, chemical, and biological processes that occur in ecosystems.

Functional assessment – The process by which the capacity of a wetland to perform a function is measured or estimated (definition modified from USACE 2006).

Functional rating – See “rating.”

Geographic Information System (GIS) – A computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically, a GIS is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature (e.g. roads). Each feature is linked to a position on the graphical image of a map.

Geomorphic floodplain – A valley formed in the past by floods that extended to the valley walls. For the purposes of NC WAM, a geomorphic floodplain is a topographic feature and, for any number of reasons, may no longer be subject to periodic flooding. Geomorphic floodplain wetlands are those that occur in the area between the toes of the valley walls, and include

Bottomland Hardwood Forest, Riverine Swamp Forest, Headwater Forest, Floodplain Pool, Bog, and Non-Tidal Freshwater Marsh.

Gleyed – A soil condition resulting from prolonged soil saturation, which is manifested by the presence of bluish or greenish colors through the soil mass or in mottles (spots or streaks) among other colors. Gleying occurs under reducing soil conditions resulting from soil saturation, by which iron is reduced predominantly to the ferrous state (Environmental Laboratory 1987).

Groundwater – Groundwater is water occurring beneath the ground surface under saturated conditions (modified from 15A NCAC 02L .0102(11) (see also Flow, groundwater).

Groundwater discharge – Water originating from an aquifer that flows to the surface (USACE 2006).

Groundwater inflows – Flow of water received by a wetland or some other area as a result of groundwater discharge via lateral seepage or upward movement (USACE 2006).

Groundwater recharge – Flow of water from an area that contributes to an aquifer. Most upland areas contribute to groundwater recharge (USACE 2006).

Growing season – The growing season has begun on a site in a given year when two or more different non-evergreen vascular plant species growing in the wetland or surrounding areas exhibit one or more of the following indicators of biological activity: a) emergence of herbaceous plants from the ground, b) appearance of new growth from vegetative crowns, c) coleoptile/cotyledon emergence from seed, d) bud burst on woody plants, e) emergence or elongation of leaves of woody plants, and f) emergence or opening of flowers. A one-time observation of biological activity during a single site visit is sufficient. The end of the growing season is indicated when woody deciduous species lose their leaves and/or the last herbaceous plants cease flowering and their leaves become dry or brown, generally in the fall due to cold temperatures or reduced moisture availability (modified from USACE 2008).

Guidance for Rating the Values of Wetlands in North Carolina: Fourth Version – Guidance generated in 1995 by the N.C. Division of Environmental Management (NCDEM 1995) and intended for use with freshwater wetlands to assist regulatory agencies in making determinations concerning the values of wetlands.

Habitat – The environment occupied by individuals of a particular species, population, or community (Environmental Laboratory 1987). The provision of terrestrial and aquatic habitat is considered by NC WAM to be one of the three primary functions of wetlands.

Herb – A non-woody plant, including herbaceous vines, regardless of size (modified from USACE 2008).

Herbaceous/herb layer – A vegetation stratum that consists of all herbaceous (non-woody) plants, including herbaceous vines, regardless of size and woody species less than approximately 3 feet in height (modified from USACE 2008).

High Quality Waters (HQW) – Waters rated by the state as excellent based on biological and physical/chemical characteristics as determined by NCDWQ monitoring or special studies, and are accordingly classified by the Environmental Management Commission (NCDEM 1995).

Histic epipedon – A thick (8- to 16-inch) soil layer at or near the surface that is saturated for 30 consecutive days or more during the growing season in most years and contains a minimum of 20 percent organic matter when no clay is present or a minimum of 30 percent organic matter when 60 percent or greater clay is present (see "Field Indicators of Hydric Soils in the United States: Guide for Identifying and Delineating Hydric Soils" [most recent guidance from the National Technical Committee for Hydric Soils - http://soils.usda.gov/use/hydric/]).

Histosols – Soils that have organic soil material in more than half of the upper 32 inches or that are of any thickness if overlying rock or fragmental materials have interstices filled with organic soils materials (see "Field Indicators of Hydric Soils in the United States: Guide for Identifying and Delineating Hydric Soils" [most recent guidance from the National Technical Committee for Hydric Soils - http://soils.usda.gov/use/hydric/]).

Hydric soil – A soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part that favor the growth and regeneration of hydrophytic vegetation (Environmental Laboratory 1987).

Hydrologic regime – The distribution and circulation of water in an area, on average, during a given period including normal fluctuations and periodicity (USACE 2006).

Hydrology – The science dealing with the properties, distribution, and circulation of water (USACE 2006). Also, Hydrology, the provision of surface and near-surface water, is considered by NC WAM to be one of the three primary functions of wetlands.

Hydroperiod – This term refers to the depth, duration, seasonality, and frequency of flooding (USACE 2006).

Hydrophytic (vegetation) – This term refers to plant life growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content (Environmental Laboratory 1987).

Hypertrophied lenticels – Some plant species produce enlarged lenticels on the stem in response to prolonged inundation or soil saturation. These are thought to increase oxygen uptake through the stem during such periods (Environmental Laboratory 1987). A lenticel is an opening on the root or stem of a woody plant through which air is admitted to underlying tissues (Dictionary of Biology 1971).

Impervious surface – A surface where water infiltration is impeded by impermeable materials on top of the soil (examples: concrete, asphalt, roof tops) (NCDEM 1995).

Inner Coastal Plain – This physiographic area is synonymous with the Southeastern Plains level III ecoregion (see also) (see Figure 1 and Appendix E for ecoregion maps). This area consists of irregular plains with broad interstream areas.

Intensively-managed wetlands – Any wetlands that have been severely altered or unintentionally created by humans and are maintained in a severely altered state. These areas may include, but are not limited to, farmed wetlands and mowed wetlands around development and in utility line corridors.

Intermittently inundated (flooded) – The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation (Cowardin et al. 1979).

Interstream flat/divide – This term refers to the geographic position in the landscape for a wetland that is found between two or more tributaries. Usually the interstream flat or divide does not have natural channels, although ditches may now connect this area to natural tributaries. This term includes ridges and saddles in the Piedmont and Blue Ridge ecoregions.

Interstream wetlands – A term referring to wetland types typically not found in a geomorphic floodplain, not within a natural topographic crenulation, and not associated with an open water greater than or equal to 20 acres in size (see NC WAM wetland type key). Interstream wetlands include the following NC WAM general wetland types: Seep, Hardwood Flat, Non-Riverine Swamp Forest, Pocosin, Pine Savanna, Pine Flat, and Basin Wetland. Assessors should remember that there are exceptions to most rules. For instance, these listed wetland types may occur in geomorphic floodplains within the embayed region of the state.

Inundation – A condition in which water from any source temporarily or permanently covers a land surface (Environmental Laboratory 1987). This term is inclusive of flooding and ponding. See also intermittently inundated, long-duration inundation, seasonally inundated, semi-permanently inundated, and very long-duration inundation. For NC WAM, this term concerns inundation during the growing season.

Landscape patch – The contiguous natural habitat that includes the assessed wetland type regardless of whether the natural habitat is located within the watershed of the assessed wetland type. Landscape patch boundaries are formed by four-lane roads, urban landscapes, pasture and agricultural fields, or open water greater than 300 feet wide.

Landscape position – This term refers to the location of a wetland in the watershed. Headwater wetlands, for example, are in the upper reaches of a watershed abutting/adjacent to zero- to first-order streams as depicted on USGS 7.5-minute topographic quadrangles, while bottomland systems are typically lower in the watershed abutting/adjacent to larger (second- or higher-order) streams and rivers.

Land Use: Agriculture – Agriculture is considered to be a land use wherein the ground surface is regularly plowed and planted with row crops.

Land Use: Pasture – Pasture is considered to be a land use wherein the ground surface is maintained in grasses and herbs to provide forage for livestock. Hay fields, which typically are not plowed, would be considered in this category.

Large woody debris – (see Field Assessment Form Metric 20) This term refers to woody material found on the ground surface. The term “large” typically refers to woody material greater than 12 inches in diameter. Large woody debris serves to slow surface water flows, contain surface inundation, and provide animal habitat. The source of large woody debris (natural debris or man-placed natural debris) is immaterial to NC WAM. The term “man-placed natural debris” excludes large woody debris characterized by modifications that have reduced its value to the natural environment such as paint, creosote, salt treated, pressure treated, etc.

Level III ecoregion – See “ecoregions.”

Level IV ecoregion – See “ecoregions.”

Localized depression – This term refers to a relatively small, concave feature in the ground surface with boundaries that make it distinct from its surroundings. “Localized depression” is used in the NC WAM key to separate Floodplain Pool from Riverine Swamp Forest, Bottomland

Hardwood Forest, and Headwater Forest. The term "depression" is not size limiting and is used in the NC WAM key to separate Basin Wetlands and some Pocosins from other wetland types.

Long-duration inundation or saturation – (see the User Manual discussion of Field Assessment Form Metric 9 for more details) This term refers to an inundation class in which the period of flooding or ponding for a single event ranges from 7 to 30 consecutive days during the growing season (U.S. Department of Agriculture Natural Resources Conservation Service National Soil Survey Handbook, title 430-VI [Online]. Available: http://soils.usda.gov/technical/handbook). Evidence of long-duration inundation may be provided by recorded data, soil type, vegetation wetland indicator status, presence of emergent vegetation, lack of ground cover in combination with water marks on fixed objects (see User Manual Photos 3-18, 3-21, 3-23, 3-25, 3-27, 3-37, 3-50, 3-52, and 3-83), silt- or water-stained leaves (turned grayish or blackish due to extended inundation), algal mat or crust, presence of aquatic fauna, a sparsely vegetated concave surface, and moss trim lines on trees (partially from USACE 2007).

Long-established, permanent alteration – This term refers to a wetland alteration that has remained on-going, and will likely remain so for the foreseeable future (examples: deliberately constructed, man-made impoundments/excavations and floodplains inundated by beaver activity). A modified wetland is considered to be characterized by a "long-established, permanent alteration" if it is currently in a stable condition. Beaver impoundments are considered to be long-established when in existence for at least 10 years.

Loosely connected – (see Field Assessment Form Metric 13) Wetlands considered to be loosely connected include narrow corridors of natural habitat or broader connections through unnatural habitats through which wildlife may pass, such as pine plantations or mosaics of cropland and woodland.

Mafic depression – For the purposes of NC WAM, "mafic depression" is a sub-type of Basin Wetland. Mafic depression is also a subset of the N.C. Natural Heritage Program community Upland Depression Swamp Forest (Schafale and Weakley 1990). Mafic depressions occur over mafic igneous or metamorphic rock on interstream divides and are surrounded by upland. Characteristic clay soils slow drainage and result in wetland hydrology that ranges from saturation to intermittent to seasonal inundation. Mafic depressions typically support a closed tree canopy, sparse shrubs, and scattered ground cover.

Maintained fields – This term refers to land that is actively maintained (mowed, plowed, sprayed with pesticides and/or herbicides) in a relatively open state (examples: agricultural row crops, pasture, sod farm, orchard, Christmas-tree farm, nursery tree farm).

Majority – "A majority of" is a relative term used in this assessment to indicate an amount greater than or equal to 50 percent of the total.

Many – "Many" is a relative term used in this assessment to indicate an amount between 25 and 50 percent of the total.

Marsh – This term refers to semi-permanently to permanently flooded or saturated wetlands that are dominated by herbaceous vegetation (NCDEM 1995).

Medium-density residential (land use) – This term refers to residential development characterized by between 10 and 30 percent impervious surfaces for the purposes of NC WAM.

Metric – An environmental variable used as a surrogate indicator in the process of determining the level of function a wetland is currently performing. Field metric ratings may involve direct measurement or best professional judgment.

Microtopographic relief – This term refers to the depressional storage capacity of a wetland that results from to subtle changes (generally less than 1 foot) on the soil surface (NCDEM 1995). For the purposes of this assessment, relatively shallow man-made depressions, such as skidder ruts, are given equal consideration with natural depressions.

Middle Atlantic Coastal Plain level III ecoregion – This ecoregion occurs in the eastern portion of the Coastal Plain physiographic province and includes the tidewater area and the associated bottoms of large rivers (see Figure 1 and Appendix E for ecoregion maps). NC WAM considers this ecoregion to be synonymous with the Outer Coastal Plain. The Middle Atlantic Coastal Plain ecoregion consists of low elevation, flat plains, with many swamps, marshes, and estuaries underlain by unconsolidated sediments. Poorly drained soils are common, and the region has a mix of coarse and finer textured soils compared to the ecoregion to the west (Southeastern Plains) (Griffith et al. 2002).

Mineral soil – A mineral soil consists predominantly of, and has its properties determined predominantly by, mineral matter usually containing less than 20 percent organic matter (Environmental Laboratory 1987).

Moderate – This term refers to vegetation structure and is used by NC WAM to characterize mid-story/sapling, shrub, and herb strata (Metric 17). Any of these three strata is considered to be moderate when that stratum alone is characterized by between 10 and 69 percent areal coverage.

Most – "Most" is a relative term used in this assessment to indicate an amount greater than 50 percent of the total.

Mottles/mottled – These terms refer to spots or blotches of different color or shades of color interspersed within the dominant color in a soil layer, usually resulting from the presence of periodic reducing soil conditions (Environmental Laboratory 1987). See also "redoximorphic features."

Mountains physiographic province – See Blue Ridge level III ecoregion.

Muck – An organic soil material in which virtually all of the organic material is decomposed, not allowing for identification of plant forms (see "Field Indicators of Hydric Soils in the United States: Guide for Identifying and Delineating Hydric Soils" [most recent guidance from the National Technical Committee for Hydric Soils - http://soils.usda.gov/use/hydric/]).

Mucky mineral soil – Mineral soil with a mucky modified mineral layer 4 inches or more thick starting within the upper 6 inches of the soil (see "Field Indicators of Hydric Soils in the United States: Guide for Identifying and Delineating Hydric Soils" [most recent guidance from the National Technical Committee for Hydric Soils - http://soils.usda.gov/use/hydric/]). Muncell book – A compilation of color charts used to determine the hue, value, and chroma of soils.

National Technical Committee for Hydric Soils (NTCHS) Indicators – Field Indicators of Hydric Soils in the United States: Guide for Identifying and Delineating Hydric Soils is a guide to help identify and delineate hydric soils in the field throughout the country. The most recent version can be found on-line at http://soils.usda.gov/use/hydric/. Field Indicators of Hydric Soils in the

Mid-Atlantic United States is an attempt to provide a regionalized guide to help identify and delineate hydric soils in the field within the Mid-Atlantic region.

Natural gaps – This term refers to gaps that may form in a forest canopy when trees fall as a result of "natural processes" such as lightning strikes, disease, and storms. Large, widespread canopy gaps, even to the point of canopy loss, due to fire (as in the case of Pine Savannas) or hurricane damage are considered natural gaps.

Natural habitat patch – This term refers to the entire naturally vegetated area around a wetland assessment area.

Natural topographic crenulation (see Crenulation)

Natural tributary – The term "tributary" refers to a natural, man-altered, or man-made open water that carries flowing water (examples: river, stream, ditch, canal, inter-dune swale connected to surface waters). A "natural" tributary excludes man-made features (ditches, canals) outside of a natural topographic crenulation, even when man-made features appear to have "naturalized."

Non-point source discharge – Pollution sources that do not have a single point of origin or are not introduced to a receiving tributary from a specific outlet. Examples of non-point sources of pollutants include farms, urban areas, residential developments, construction sites and forests. Non-point source pollution is generally carried into the water from the land by stormwater runoff (http://www.enr.state.nc.us/html/n_-_terms.html).

Non-riparian wetlands – For the purposes of NC WAM, a term referring to wetland types typically found in a landscape position meeting the following criteria: not in a geomorphic floodplain and not within a natural topographic crenulation nor associated with an open water greater than or equal to 20 acres in size (see NC WAM wetland type key). Non-riparian wetlands include the following NC WAM general wetland types: Seep, Hardwood Flat, Non-Riverine Swamp Forest, Pocosin, Pine Savanna, Pine Flat, and Basin Wetland.

Normal rainfall conditions – The U.S. Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), National Water and Climate Center provides, through its WETS tables, a normal range for monthly precipitation based on climate data collected through the National Weather Service Cooperative Network. These tables can be used in conjunction with recent rainfall data to determine if a specific site is characterized as being subject to "normal rainfall conditions" at the time of a functional assessment. WETS tables are provided by the NRCS Water and Climate Center (http://www.wcc.nrcs.usda.gov/climate/wetlands.html).

N.C. Scope and Effect Guide (for ditching in hydric soils) – A guide developed by the USDA to provide fast, uniform, and relatively accurate information on the effects of drainage ditches on soil saturation (the lateral effect of a drain in a given hydric soil) (this information is made available on the USACE Wilmington District web site).

Northern Inner Piedmont level IV ecoregion – Located in the western Piedmont level III ecoregion (Appendix E), the Northern Inner Piedmont level IV ecoregion is rolling to hilly and has higher elevations, more rugged topography, and more monadnocks or mountain outliers than other areas of the Piedmont (Griffith et al. 2002).

Nuisance species – Species of plants that detract from or interfere with a mitigation project, such as most exotic species and those indigenous species whose populations proliferate to abnormal proportions (USACE 2006).

Open water – This term includes tributaries, natural or man-made ponds, natural or man-made lakes, estuaries, and the ocean (See Field Assessment Form Metric 7).

Opportunity metric – WFAT implemented this type of metric to account for or infer watershed conditions that affect the level of performance of a wetland function. "Opportunity" can increase the amount of pollutant removal or hydrological amelioration a wetland provides by increasing the amount of pollutants or altered hydrology the wetland is exposed to. Opportunity only leads to increased function if the wetland has the capacity for performing additional function. In NC WAM, opportunity is scored as a modification to the score based on condition, with the combination of condition and opportunity metrics used to determine if the wetland has the capacity to respond to the opportunity.

Organic soil – A soil is classified as an organic soil when it is 1) saturated for prolonged periods and has more than 30 percent organic matter if the mineral fraction is more than 50 percent clay, or more than 20 percent organic matter if the mineral fraction has no clay; or 2) never saturated with water for more than a few days and having more than 34 percent organic matter (Environmental Laboratory 1987).

Outer Coastal Plain – This physiographic area is synonymous with the Middle Atlantic Coastal Plain level III ecoregion (see also) (see Figure 1 and Appendix E for ecoregion maps). This area consists of low elevation, flat plains, with many swamps, marshes, and estuaries underlain by unconsolidated sediments.

Outstanding Resource Waters (ORW) – Unique and special waters of exceptional state or national recreational or ecological significance that require special protection to maintain existing uses and are accordingly classified by the Environmental Management Commission (NCDEM 1995).

Overbank flow – Overbank flow occurs when water rises in a tributary until it exceeds bank elevation and spreads across the land surface outside of the banks. Indicators of overbank flow include sedimentation, drainage patterns, debris lines, reclining vegetation, and gauge data. See User Manual Figure 13 for a graphic depiction.

Overland flow – Overland flow is water movement above and parallel with the soil surface (USACE 2006). Overland flow does not assume the existence of a channel; overland flow may include down-valley surface flow and down-slope surface flow from uplands. See User Manual Figure 13 for a graphic depiction.

Particulate Change – A sub-function under the water quality function of wetlands. Particulate change refers to the ability of a wetland to remove sediment and insoluble organic matter from the water column.

Pasture (land use) – Pasture is considered to be a land use wherein the ground surface is maintained in grasses and herbs to provide forage for livestock. Hay fields, which typically are not plowed, would be considered in this category.

Pathogen Change – A sub-function under the water quality function of wetlands. Pathogen change refers to the ability of a wetland to remove undesirable bacteria and viruses from the human environment.

Peat – A fibric organic soil material that has virtually all of the organic material allowing for identification of plant forms (USDA 2005).

Physiographic province – A physiographic province is a region in which all parts are similar in geologic structure and in which has consequently had a unified geomorphic history; a region whose pattern of relief features or landforms differs significantly from that of contiguous regions (www.webref.org/geology). The Coastal Plain physiographic province contains the Middle Atlantic Coastal Plain and Southeastern Plains level III ecoregions; the Piedmont physiographic province roughly equals the Piedmont level III ecoregion; and the Blue Ridge physiographic province roughly equals the Blue Ridge level III ecoregion.

Physical Change – A sub-function under the water quality function of wetlands. Physical change refers to the ability of a wetland to dissipate the energy of flowing water in order to prevent erosion.

Piedmont level III ecoregion – This ecoregion occurs within generally the same footprint as the Piedmont physiographic province (see Figure 1 and Appendix E for ecoregion maps). The Piedmont ecoregion is considered to be the non-mountainous portion of the old Appalachians Highland by physiographers and comprises a transitional area between the mostly mountainous ecoregions of the Appalachians to the west and the relatively flat Southeastern Plains to the east. The Piedmont is a complex mosaic of Precambrian and Paleozoic metamorphic and igneous rocks with moderately dissected irregular plains and some hills. The soils tend to be finer-textured than in the Coastal Plain ecoregions (Griffith et al. 2002).

Piedmont physiographic province – The Piedmont physiographic province extends westward from the fall line (or fall zone) to the Blue Ridge escarpment. This physiographic province occurs generally within the same footprint as the Piedmont level III ecoregion (see Figure 1 and Appendix E).

Pneumatophores – Modified roots that may serve as respiratory organs in plant species subjected to frequent inundation or soil saturation (Environmental Laboratory 1987).

Point source discharge – A stationery location or fixed facility from which pollutants are discharged or emitted. Also, any identifiable source of pollution such as a pipe, ditch, or ship (http://www.enr.state.nc.us/html/p_-_terms.html).

Pollutant – According to the NCDWQ, a pollutant is generally any substance introduced into the environment that adversely affects the usefulness or health of a resource (http://www.enr.state.nc.us/html/p_-_terms.html). According to the USACE, the following items are considered pollutants: dredged spoil, solid waste, incinerator residue, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials not covered by the Atomic Energy Act, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into water (Section 404(b)(1) Guidelines, 40 CFR Section 230.3). NC WAM accepts both definitions and adds both point source and non-point source discharges of stormwater. NC WAM considers salt to be a pollutant in freshwater wetlands.

Ponded - A condition in which water stands in a closed depression (no outlet). Water may be removed only by percolation, evaporation, and/or transpiration (USACE 2006).

Prevalent – Abundant, but not necessarily the most abundant.

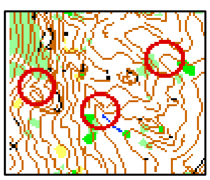
Primary Nursery Area (PNA, coastal) – This term refers to tidal salt waters that provide essential habitat for the early development of commercially important fish and shellfish and are so designated by the Marine Fisheries Commission (15A NCAC 02B .0202).

Primary nursery areas (PNA, inland) – This term is defined in 15A NCAC 10C .0502 as those areas inhabited by the embryonic, larval, or juvenile life stages of marine or estuarine fish or crustacean species due to favorable physical, chemical, or biological factors.

Rating (functional rating) – NC WAM generates an overall functional rating for each wetland type within an assessment area. In addition, ratings are generated for component wetland functions (Hydrology, Water Quality, and Habitat) and sub-functions (variable dependent on general wetland type) of each assessed wetland. Ratings are provided as "High," "Medium," or "Low" relative only to other wetlands of the same type. Each sub-function is evaluated using a unique set of field indicators presented as questions or metrics on a field assessment form. The assessor selects the appropriate answer(s), or descriptor(s), for each metric. The descriptors are converted by a computer program into a functional rating for each metric. Metric ratings are combined to generate sub-function ratings. Metric combinations are carried out using a weighting scheme that reflects the relative importance of the metric to wetland sub-functions to generate sub-function ratings. Likewise, sub-function ratings are combined to generate function ratings, and wetland function ratings are combined to yield an overall wetland functional rating.

Redoximorphic features – Features formed by the processes of reduction, translocation, or oxidation of iron and magnesium oxides. Formerly called mottles and low chroma colors (see "Field Indicators of Hydric Soils in the United States: Guide for Identifying and Delineating Hydric Soils" [most recent guidance from the National Technical Committee for Hydric Soils - http://soils.usda.gov/use/hydric/]).

Reentrant – A reentrant appears on a topographic map as a U or V shape in the contour lines, pointing upward into a hillside rather than sticking out of the hill (as would a spur) (see illustration). A reentrant is a small valley, the center of which would collect water and funnel it downhill. This portion of a map includes several reentrants, three of which are circled. The west-most is a small, v-shaped reentrant, while the two eastern examples are broad and somewhat shallow. Also see "crenulation."



Regulatory agencies – For the purposes of NC WAM, this term refers to agencies involved with environmental permitting, whether a permit authorizer or a commenting agency.

Reference domain – The geographic area (such as an ecoregion or physiographic province) from which reference wetlands are selected. A reference domain may or may not include the entire geographic area in which a wetland type occurs (USACE 2006).

Reference (wetland/condition) – A reference wetland (or wetland in reference condition) is a discrete wetland identified and judged by an interdisciplinary team as being a typical, representative, or common example of that particular wetland type without or removed in time from substantial human disturbance. WFAT recognizes that the term "reference wetland" includes a range of biotic and abiotic characteristics within each recognized wetland type and considers "reference" to be synonymous to "relatively undisturbed." An appropriate reference wetland needs to be of a comparable type to the wetland being assessed, sometimes at a finer resolution than the general wetland type level of condition. For instance, Pocosins may occur on mineral soils or organic soils, and an appropriate reference wetland for a mineral soil Pocosin will be one found on mineral soils.

Riparian buffer – A riparian buffer is a vegetated area abutting an open water that reduces runoff and non-point source pollution and attenuates flood flows by decreasing water flow velocity. This facilitates the settling, trapping and uptake of chemical pollutants (such as nitrogen and phosphorus) and sediment (http://www.enr.state.nc.us/html/b_-_terms.html).

Riparian wetlands – Wetland types typically found in one or more of the following landscape positions: in a geomorphic floodplain; in a natural topographic crenulation; contiguous with an open water greater than or equal to 20 acres in size (anticipated to be subject to seasonal fluctuations in water table); or subject to tidal flow regimes, excluding Salt/Brackish Marsh (see NC WAM wetland type key). Riparian wetlands include the following NC WAM general wetland types: Estuarine Woody Wetland, Tidal Freshwater Marsh, Riverine Swamp Forest, Bog, Non-Tidal Freshwater Marsh, Floodplain Pool, Headwater Forest, and Bottomland Hardwood Forest.

RTFM – "Read the flippin' manual" (when spoken, frequently followed by an emphatic "baby").

Saline waters – NC WAM considers brackish, estuarine, and salt water to be included in this category; any waters in which ocean-derived salts measure 0.5 parts per thousand or greater.

Salt water (marine system) – Water typically influenced by the ebb and flow of lunar tides in which salinities exceed 30 parts per thousand (Cowardin et al. 1979).

Sandhills – The Sandhills level IV ecoregion is a subset of the Southeastern Plains level III ecoregion. This area occurs in the southwestern portion of the Southeastern Plains and is characterized by unconsolidated, sandy soils deposited by erosional forces during the Pleistocene epoch.

Sandy soil – A soil material that contains 85 percent or more of sand (https://www.soils.org/publications/soils-glossary). This term refers to soils that have a USDA texture of loamy fine sand and coarser (see "Field Indicators of Hydric Soils in the United States: Guide for Identifying and Delineating Hydric Soils" [most recent guidance from the National Technical Committee for Hydric Soils - http://soils.usda.gov/use/hydric/]).

Sapling – A woody plant approximately 20 feet or more in height and less than 3 inches diameter at breast height (DBH) (modified from USACE 2008).

Saturation/saturated soil condition – A condition in which all easily drained voids (pores) between soil particles in the root zone are temporarily or permanently filled with water to the soil surface at pressures greater than atmospheric (USACE 2006). Evidence of saturation without inundation may be provided by presence of facultative or water-tolerant plant species in conjunction with wetland soils and the absence of surface water indicators.

Seasonally inundated (flooded) – Surface water is present for extended periods, especially early in the growing season, but is absent by the end of the growing season in most years. When surface water is absent, the water table is often near the land surface (Cowardin et al. 1979).

Seasonally saturated – The substrate is saturated to the surface for extended periods during the growing season, but surface water is seldom present.

Seep – Seeps are areas semi-permanently to permanently saturated by ground water discharge and are underlain by mineral or organic soils (USACE 2006). For the purposes of NC WAM, these areas are typically found on sloping hillsides where impervious layers force ground water to the surface. Groundwater-fed areas in geomorphic floodplains or headwater wetlands are placed in other general wetland types.

Sedimentation/Deposition – This term refers to the deposition or accumulation of eroded soil material (sediment) that has been transported into a wetland or open-water system by moving water.

Semi-permanently inundated (flooded) – Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface (Cowardin et al. 1979).

Semi-permanently saturated – The substrate is saturated to the surface, but surface water is seldom present, throughout the growing season in most years (Cowardin et al. 1979).

Severely – A descriptive term used to emphasize the extent to which an event affects an object or the environment – in this case, having enough substance to make an extreme difference. When this term is used in NC WAM, it is typically followed with descriptive examples.

Sheltered areas (with reference to marshes abutting/adjacent to open water) – (see Field Assessment Form Metric 7) Shorelines anticipated to be regularly subject to waves of less than 1 foot in height are considered to be "sheltered." NC WAM considers an open water width of less than 2500 feet to provide too little fetch for regular development of waves meeting or exceeding this threshold. Also, shorelines abutting open water without regular boat traffic that generates high-energy wakes are considered to be "sheltered." "Exposed areas" are the opposite of "sheltered areas."

Short-duration inundation – (see the User Manual discussion of Field Assessment Form Metric 9 for more details) This term refers to a situation in which the period of inundation for a single event ranges less than 7 consecutive days during the growing season. Evidence of short-duration inundation may be provided by visual observation of inundation (ponding or flooding), recorded data, soil type, and dominant vegetation wetland indicator status (see also long-duration inundation). The NC WAM use of the term "short-duration inundation" encompasses the inundation duration ranges of "extremely brief" (0.1 to 4 hours), "very brief" (4 to 48 hours), and "brief" (2 to 7 days) as defined by the following reference: U.S. Department of Agriculture, Natural Resources Conservation Service. 2007. National Soil Survey Handbook, title 430-VI [Online]. Available: http://soils.usda.gov/technical/handbook.

Shrub – Woody plants approximately 3 to 20 feet in height (modified from USACE 2008).

Snag – A standing dead tree or part of a dead tree from which at least the leaves and smaller branches have fallen; often called stumps if less than 20 feet tall (www.enr.state.nc.us/html/s_-_terms.html). Snags are typically vertical. Dead trees that have fallen over but are not lying on the ground are not considered snags.

Soil ribbon – Ability to form a soil ribbon eliminates sand and loamy sand as soil texture possibilities in a texture-by-feel analysis. To make a soil ribbon, place a ball of soil between thumb and forefinger, gently push the soil with the thumb, and squeeze it upward into a ribbon. The length of a soil ribbon is related to the amount of clay in the soil. Longer ribbons indicate relatively higher clay content, while shorter ribbons indicate relatively lower clay content.

Soluble Change – A sub-function under the water quality function of wetlands. Soluble change refers to the ability of a wetland to remove and hold dissolved materials from the water column. An example of soluble pollutants is nutrients that are readily water soluble, such as nitrate nitrogen.

Southeastern Plains level III ecoregion – This ecoregion occurs in the western portion of the Coastal Plain physiographic province and includes the Sandhills level IV ecoregion (see Figure 1 and Appendix E for ecoregion maps). This ecoregion, with the exception of the Sandhills, is considered synonymous with the Inner Coastal Plain. The Southeastern Plains ecoregion consists of irregular plains with broad interstream areas. The Cretaceous- or Tertiary-age sands, silts, and clays of the region contrast geologically with the older metamorphic and igneous rocks of the Piedmont to the west. Elevations and relief are greater than in the Middle Atlantic Coastal Plain to the east. Tributaries in this area are relatively low gradient and sandy bottomed (Griffith et al. 2002).

Sparse – This term refers to vegetation structure and is used by NC WAM to characterize mid-story/sapling, shrub, and herb strata (Metric 17). Any of these three strata is considered to be sparse when that stratum alone is characterized by less than 10 percent areal coverage.

Stable condition – A wetland is considered to be in stable condition when the three primary criteria (vegetation, soils, and hydrology) have not recently changed and are not currently in a state of change relative to conditions under which the wetland was established. A wetland in stable condition is one that has the ability to react to a disturbing force by maintaining or reestablishing position or form.

Strahler stream order – A simple method of classifying stream segments based on the number of tributaries upstream. A stream with no tributaries (headwater stream) is considered a first-order stream. A segment downstream of the confluence of two first-order streams is a second-order stream. Thus, an n^{th}-order stream is always located downstream of the confluence of two $(n-1)^{th}$-order streams (Strahler 1952). See Appendix C for a schematic diagram of stream order.

Stream – A stream can be described as flowing surface water in a channel resulting from storm flow (increased stream flow resulting from the relatively rapid runoff of precipitation from the land as interflow [rapid, unsaturated, subsurface flow], overland flow, or saturated flow from raised near-surface water tables close to the stream), base flow (low flow resulting from delayed discharge of ground water into the stream between rainfall events), or a combination of both storm flow and base flow, and contributions of discharge from upstream tributaries as storm flow or base flow, if present (http://portal.ncdenr.org/web/wq/swp/ws/401/waterresources/streamdeterminations)

Stream order (see also Strahler stream order) – Stream order is generally determined by consulting blue lines on the USGS 7.5-minute (1:24,000) quadrangle and calculating the order number using the Strahler method. See Appendix C for a schematic diagram of stream order. The assessor should consider both intermittent and perennial streams when making a stream order determination (ephemeral channels are not included in the determination). For the purposes of NC WAM, a zero-order stream is a stream that is found on the ground but is not shown on the most recent version of the USGS 7.5-minute (1:24,000) quadrangle. Also for the purposes of NC WAM, an assessor should not necessarily count blue-line ditches in the Middle Atlantic Coastal Plain ecoregion as first-order streams. In this region, only streams within topographic crenulations or geomorphic floodplains should be used to determine stream order. In this situation, the best mapping source available (7.5-minute quadrangle, LiDAR) may be used for the determination of stream order.

Stressor – A typically anthropogenic activity that affects one or more wetland functions by altering the wetland from reference condition. The response of a wetland to a stressor depends on wetland type, size, and severity of the stressor. Examples of stressors may include nutrient enrichment/eutrophication, organic loading and reduced dissolved oxygen, contaminant toxicity, acidification, salinization, sedimentation/burial, turbidity/shade, vegetation removal, thermal alteration, dehydration, inundation, fragmentation of habitat (Adamus and Brandt 1990), and soil disturbance. Stressors are anticipated to always degrade the condition of a wetland; but, to some extent, stressors may benefit the opportunity of some water quality functions.

Sub-function – This term refers to the supporting but distinct components of each of the three designated wetland functions as determined by WFAT. Hydrology sub-functions include 1) surface storage and retention and 2) sub-surface storage and retention; Water Quality sub-functions include 1) particulate change, 2) soluble change, 3) pathogen change, 4) physical change, and 5) pollution change; and Habitat sub-functions include 1) habitat physical structure, 2) vegetation composition, 3) landscape patch structure, and 6) uniqueness.

Substantially – This is a descriptive term used to emphasize the extent to which an event affects an object or the environment – in this case, having at least enough substance to make a difference. When this term is used in NC WAM, it is typically followed with descriptive examples.

Surface Water Classifications – Designations applied to surface waterbodies, such as streams, rivers, and lakes, defining the best uses to be protected within the waters (examples: swimming, fishing, drinking water supply) (http://www.enr.state.nc.us/html/s_-_terms.html).

Tidal – This term typically refers to a situation in which the water level periodically fluctuates due to the action of lunar and solar forces upon the rotating earth (Environmental Laboratory 1987). “Wind tides” refer to water table fluctuations due to the action of wind on the water surface. For the purposes of NC WAM, open waters greater in size than 20 acres may be considered to be subject to wind tides.

Toe-of-the-slope – This term refers to the point at the bottom of the outer floodplain slope where the slope meets the floodplain floor.

Topographic crenulation (see Crenulation)

Treatment capacity (of a wetland) – This term refers to a wetland’s ability to treat pollutants, entering the wetland through either surface or sub-surface discharges. For the purposes of NC WAM, the level of capacity is not as important as evidence of a discharge and evidence that the wetland’s treatment capacity is being exceeded by the discharge.

Tree – Any woody plant greater than or equal to 3 inches in diameter at breast height (DBH) and greater than 20 feet in height (modified from USACE 2008).

Tributary – The term “tributary” refers to an open conduit, either naturally or artificially created, that periodically or continuously contains moving water (examples: river, stream, ditch, canal, inter-dune swale connected to surface waters). For the purposes of NC WAM, the term “tributary” implies federal and/or state jurisdictional status. A “natural” tributary excludes man-made features (ditches, canals) outside of a natural topographic crenulation, even when man-made features appear to have "naturalized."

Trout waters (Tr) – This term refers to an NCDWQ supplemental classification intended to protect freshwaters for natural trout propagation and the survival of stocked trout. To receive a Tr classification, the proposed open water must have conditions that will sustain and allow for trout propagation and survival of stocked trout on a year-round basis (15A NCAC 2B .0200).

Underground Storage Tank (UST) - A tank located all or partially underground that is designed to hold chemical solutions, gasoline, or other petroleum products (www.enr.state.nc.us/html/u_-_terms.html).

Upland – This term refers to terrestrial areas not subject to Section 404 jurisdiction and not considered to be isolated wetlands.

Urban landscapes – This term refers to wetlands and uplands in urban/suburban settings characterized by intensive management such as grass lawns and suburban yards.

Value – Value refers to the benefits, goods, and services that result from wetland functions. For example, one function of many wetlands is the storage of surface water; the value of that function is to reduce flood damage. Value may be increased by the location of a wetland within a watershed whereby the wetland has an increased opportunity to provide a particular function.

Very long duration inundation (flooding) – (see the User Manual discussion of Field Assessment Form Metric 9 for more details) A duration class in which the length of a single inundation event is equal to or greater than 30 consecutive days during the growing season (U.S. Department of Agriculture Natural Resources Conservation Service National Soil Survey Handbook, title 430-VI [Online]. Available: http://soils.usda.gov/technical/handbook).

Water quality – Descriptive or quantitative conditions of water, usually in reference to physical, chemical, and biological properties, and usually from the perspective of society's use.

Watershed – The NCDWQ (and NC WAM) considers the watershed to be the entire land area contributing surface drainage to a specific point (15A NCAC 02B .0200). The USACE uses the term "catchment" to refer to this same concept.

Water table – Water table is the surface of the saturated zone below which all interconnected voids are filled with water and at which the pressure is atmospheric (15A NCAC 02L .0102(27).

Well connected (wetland) – (see Field Assessment Form Metric 13) This term generally refers to a wetland surrounded by or adjoining a natural habitat patch along a substantial part of its boundary on at least one side.

Wetland(s) – "Wetlands" are areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (33 CFR 328.3(b)).

Wetland assessment area – See Assessment area

Wetland assessment form –This form is used by NC WAM to document conditions within an assessment area during a rapid field assessment. Information recorded on this form is used to generate a functional rating of an assessed wetland.

Wetland buffer - A buffer is a vegetated area abutting an open water that reduces runoff and non-point source pollution and attenuates flood flows by decreasing water flow velocity. This facilitates the settling, trapping and uptake of chemical pollutants (such as nitrogen and phosphorus) and sediment (http://www.enr.state.nc.us/html/b_-_terms.html). NC WAM considers optimum buffer widths to be 50 feet wide (measured perpendicular to a surface water) in the Coastal Plain and Piedmont ecoregions and 30 feet wide (measured perpendicular to a surface water) in the Blue Ridge ecoregion. The wetland buffer width measurement referred to in Field Assessment Form Metric 7 requires the assessor to determine if an assessment area is within 50 feet of a tributary or other open water, and if so, how much of the first 50 feet perpendicular to the bank is wetland.

Wetland complex – The wetland complex may consist of one NC WAM general wetland type or an association of two or more contiguous NC WAM general wetland types. Wetland complex boundaries typically are formed by natural uplands, open water that extends across the entire width of a floodplain, or a man-made berm/causeway the width of a four-lane road or wider.

Wetland delineation/determination – The U.S. Army Corps of Engineers defines wetland determination as "the process or procedure by which an area is adjudged a wetland or nonwetland" (Environmental Laboratory 1987). For the purposes of NC WAM, both wetland delineation and wetland determination are terms that indicate that a wetland/upland boundary has been identified properly according to guidance provided in the Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987).

Wetland Functional Assessment Team (WFAT) – An interagency (federal and state) team sponsored by NCDENR, NCDOT, and USACE and tasked with developing a rapid wetland functional assessment methodology for the state of North Carolina. WFAT was formed in 2003 and released the NC WAM product in mid-2007.

Wetland functional rating – See "rating."

Wetland Indicator Status – The U.S. Fish and Wildlife Service (USFWS) has compiled a National List of Plant Species that Occur in Wetlands (Reed 1988 or current list). In this list, each species has been given an indicator status that reflects the probability of the species occurring in a wetland versus a non-wetland across the entire distribution of the species and another indicator status that reflects the same probability within a regional range (for example, the U.S. Southeast).

Wetland type – The wetland type is a wetland area comprised of one of the 16 NC WAM general wetland types, irrespective of the limits of any proposed activity. Wetland type boundaries are formed by another wetland type, a wetland/natural upland boundary, and a man-made berm/causeway wider than that needed to support a two-lane road. A wetland type determination may be made based on general wetland type descriptions, with the use of the NC WAM Dichotomous Key to General North Carolina Wetland Types, or following guidelines provided for the identification of unique or problematic wetland types.

Zero-order stream – This term refers to a tributary that is not shown on a USGS 7.5-minute topographic quadrangle.

Appendix C

USGS Marker Horizon Installation Procedures

SOP 5: Establishing and Sampling Marker Horizons

Version 1.00 (January 2015)

The following table lists all changes that have been made to this Standard Operating Procedure (SOP) since the original publication date. Any recommended or required changes added to the log must be complete and concise and promptly brought to the attention of the Project Leader. The Project Leader will review and incorporate all changes, officially complete the revision history log, and change the date and version number on the title page. For complete instructions, refer to SOP #10: Revising the Protocol or SOPs.

Revision History Log:

New Version #	Previous Version #	Revision Date	Author (full name, title, affiliation)	Location in Document and Description of Change	Reason for Change

Establishing Marker Horizons

This SOP provides detailed instructions for establishing and sampling marker horizons. Both the marker horizon and SET techniques measure soil processes occurring in a wetland, shallow pond or water body. The SET measures wetland elevation change incorporating both surface and subsurface processes (including deposition, erosion, decomposition, root growth, etc.). Marker horizons measure deposition due primarily to surface processes (deposition and erosion).

Three to four marker horizons (Figure 5.1) are typically established in conjunction with the first SET measurements at a sample station (SOP #4). Following installation, marker horizons are normally sampled at the same time SET measurements are taken. Two commonly used techniques for sampling marker horizons will be described in detail (cryogenic coring and cutting plugs).

Figure 5.1. Establishing marker horizons at an SET sample station (Dipper Harbour, NB, Canada).

1. Supplies:

   a. Marker Horizon (50 lb. bags) - There are many materials which can be used to create a marker horizon. Brick dust, Grog, Sand, Kaolin, glitter and varieties of feldspar clay are all suitable for marker horizons. Feldspar clay (Figure 5.2) is the recommended marker material to use in wetlands and shallow water habitats. It is a brilliant white powdered material which forms a cohesive layer once it gets wet and is easily distinguishable from the surrounding sediment. Feldspar typically comes in 50 lb. bags and be purchased from a pottery supply warehouse. There are many types of feldspar clay. Check with a local vendor to see what is available. About 6 feldspar marker horizons can be established from a single bag.

      Be aware that any marker horizon may quickly disappear in high energy and low energy areas. In high energy sites, the marker may get washed away due to tidal and wave energy. In low energy areas, the marker never gets buried, and will wash away or get disturbed. Bioturbation, by burrowing crabs or other organisms, can also be a problem affecting the longevity of a horizon. Marker horizons will more than likely disappear over time and new marker horizons may need to be added in the future.

b. Stakes (½” PVC, 3/8” Fiberglass or ½” Rebar) – Stakes are used to mark the boundaries of the sample station and the marker horizon plots. The plot is typically 50cm x 50cm and is marked with 2 or 4 stakes. Stakes are about 2-4' in length. Longer stakes may be needed if working in soft sediments or a shallow pond.

c. Trash can (32 Gallon/120 liter) with bottom cut off – Needed if installing marker horizons in shallow water.

Figure 5.2. Feldspar clay (50 lb. bag).

d. Respirator – Feldspar clay should not be inhaled so a high quality respirator is essential when establishing the marker horizons. A respirator is not needed when sampling plots.

e. Square frame (50 cm x 50 cm) – This is the guide for laying marker horizons on the wetland surface. Typically constructed from ½” PVC pipe or aluminum clothes line wire.

2. Instructions for installation

Marker horizon plots are typically established when taking the first (baseline) SET readings.

a. Three or four marker horizon plots are deployed around the sample station (figure 5.3, 5.4). Plots are usually placed near the RSET mark and are accessed from the same platform used for SET measurements (see SOP #2) or from outside the perimeter of the sample station. There should be plenty of space around the sample station to add additional plots if the initial plots disappear. NEVER put a new marker horizon plot on top of an existing one

b. Select where to establish the marker horizon plots. Figure 5.4 shows common locations for marker horizons in a sample station using a temporary or square platform (see SOP 2).

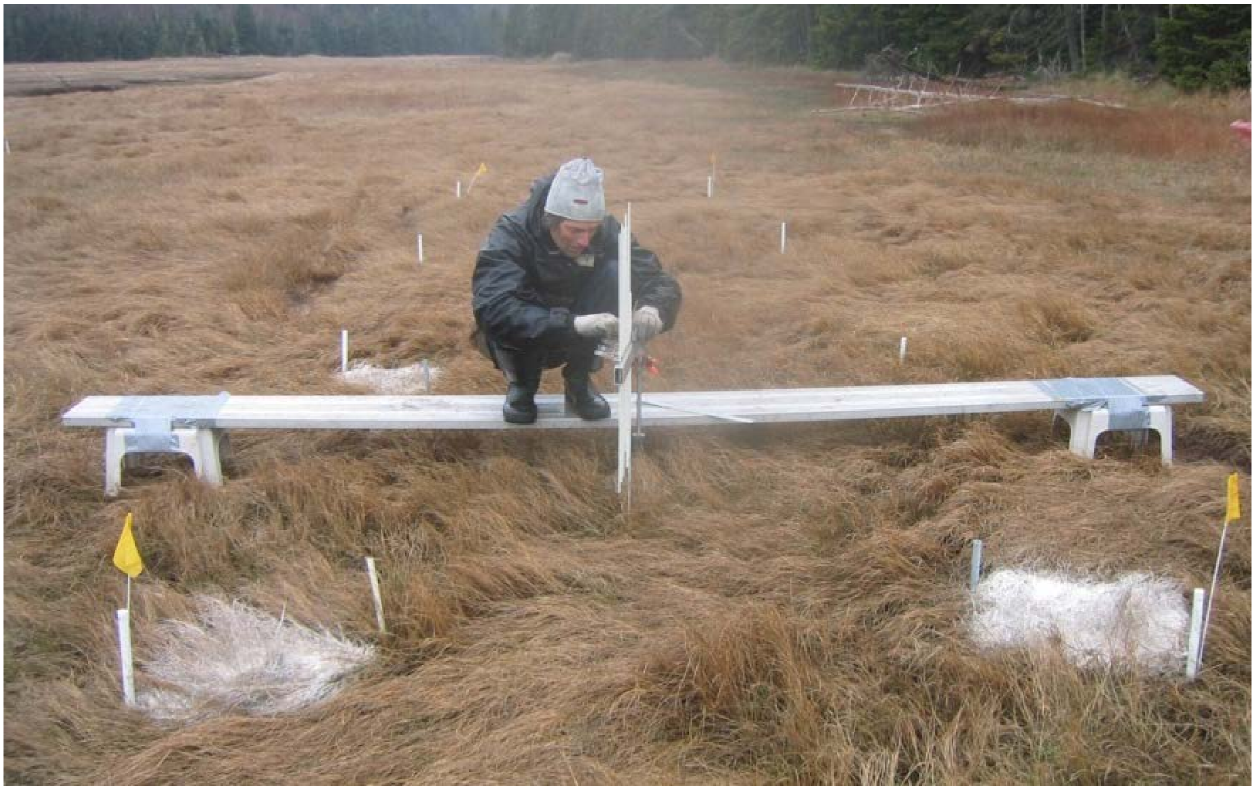


Figure 5.3. Three feldspar plots (Dipper Harbour, NB, Canada).

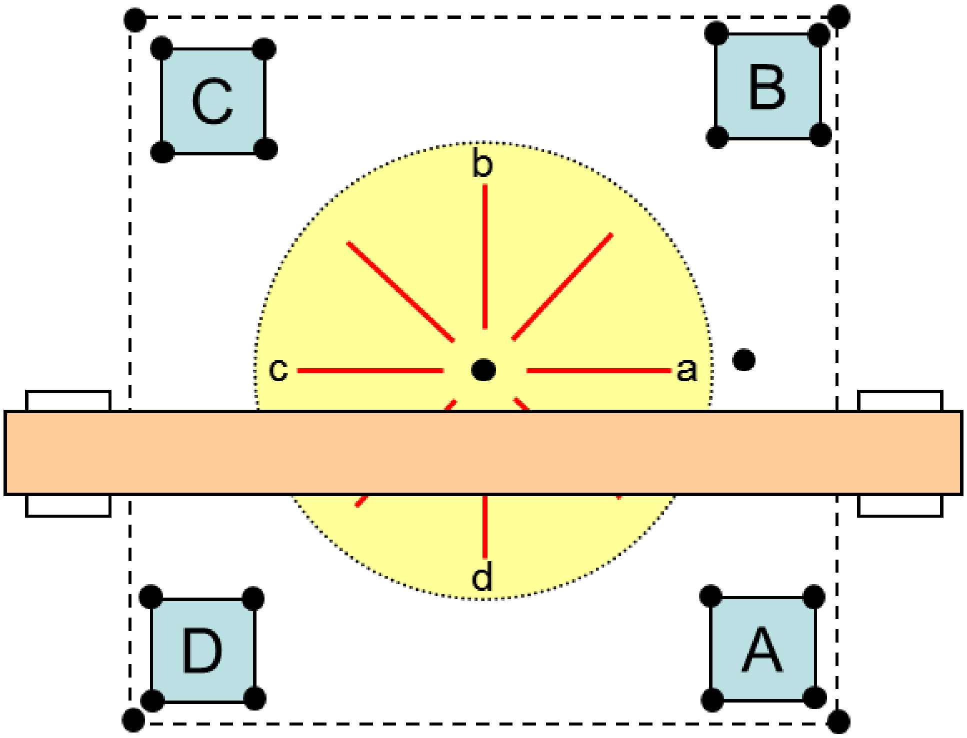


Figure 5.4. Common marker horizon locations (blue Squares) when using a square or temporary sampling platform. Yellow circle = SET measurement area.

c. Make a wire or PVC frame to approximate the size of the marker horizon plot, which is normally 50 cm x 50 cm (0.25 m^2 – Figure 5.5). Lay the frame on the wetland surface. If establishing layers in a pond or on a flooded wetland, use trash cans with the bottom cut off to define the plot (circular) and aid in establishing the horizon by confining the feldspar (Figure 5.6). It helps to push the trash can into the surface a small amount to keep the feldspar from leaking out the sides.

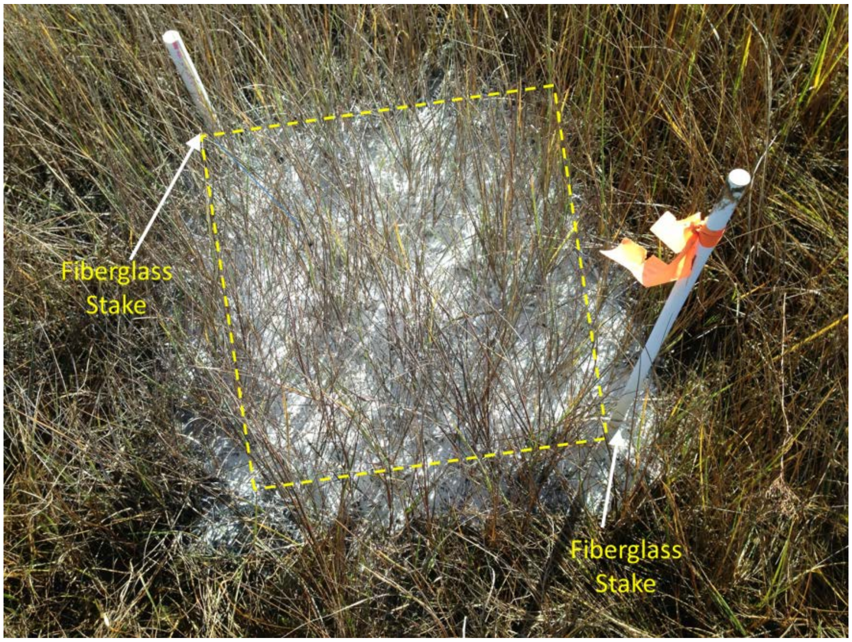


Figure 5.5. Feldspar marker horizon plot with two stakes.

Figure 5.6. Feldspar marker horizon plots established using trash cans in a shallow pond with about 8" (20 cm) of water (Delta NWR, Venice, LA USA).

d. Spread the marker on the marsh surface or into the trash can using a small plastic cup (8 oz., 230 ml). A single 50 lb. bag should provide about 6 plots (50 cm x 50 cm x 0.5 cm) using about 8 lbs. of feldspar per plot. Exact measurement is not necessary. Approximately 12-14 cups of feldspar are used. If there is water on the surface of the wetland, and a trash can is being used, wait at least 10-15 minutes to allow the feldspar inside to settle to the bottom (Figure 5.6, 5.7). Carefully remove the can when finished.

Figure 5.7. Feldspar marker horizon after removing the trash can (Delta NWR, Venice, LA USA).

e. Mark the plots with 2 or 4 stakes. If the plot is vegetated, use a stake to knock the feldspar off the vegetation and onto the wetland surface (Figure 5.8).

Note: The marker horizon will hopefully get buried and the stakes are used to find the plot in the future. If the site is periodically burned, consider using rebar or fiberglass stakes to mark the plots. PVC stakes will not survive a fire.

f. Be sure to draw a detailed map in the data book showing the relative locations of the feldspar plots in case the PVC stakes are lost or destroyed.

Appendix D

Solonist Transducer Installation Procedures

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More Info | Instructions | Get Quote

Quick Start Guide

Levelogger 5 Series

Get Quote

High Quality Groundwater and Surface Water Monitoring Instrumentation

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Installing the Software

To begin using your Levelogger, download the newest version of Levelogger Software and User Guide by visiting: www.solinst.com/downloads/

Installing the Hardware

Connect your datalogger to a computer using either the Optical Reader (Desktop Reader 5 or Field Reader 5) or PC Interface Cable.

Desktop Reader 5

Field Reader 5

Optical Readers

L5 Direct Read Cable

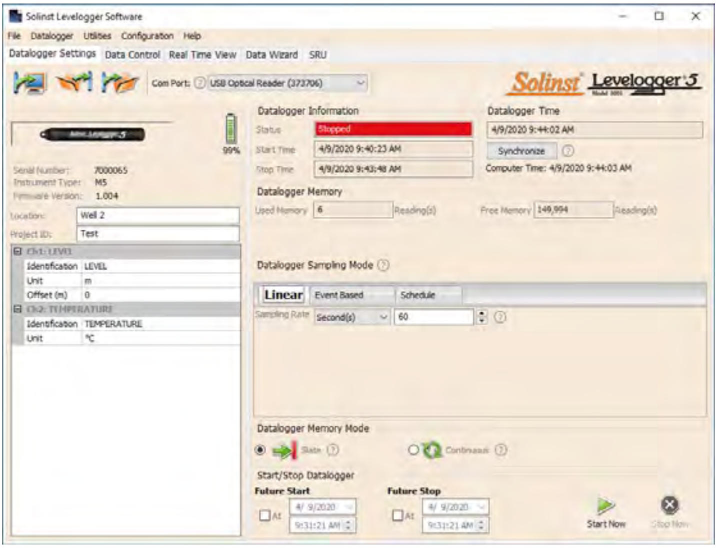
PC Interface Cable

Programming the Levelogger

Note: Ensure the Levelogger is operating with the latest firmware, and that you are using the latest software. Visit the Solinst website (www.solinst.com/downloads/) or use the update notifications in the software for assistance. If older Levelogger versions are used, refer to our Compatibility Chart on the Downloads page.

1. Connect the Levelogger to the communications device and start the software.
2. Select the appropriate Com Port for the connected communications device from the centre drop-down menu.
3. Click the 'Retrieve Settings from Levelogger' icon. This will retrieve and display information about the connected datalogger, and any current programmed settings. 
4. You can now customize the Levelogger including your Project ID, Location, Sampling Mode and Rate, and Future Stop and Start times.

Tip: If a number of Leveloggers are to be programmed with identical inputs, clicking the 'Save Default Settings' icon will create a template.



Datalogger Settings Window

Note: Clicking on the (?) in the software will provide you with a short explanation of that feature, e.g. Com Port, Slate Mode, Time Synchronization, etc.

Rainlogger 5 Programming

The Rainfall Calibration Constant 'value' of the tipping bucket rain gauge used with the Rainlogger is required when programming the Rainlogger 5. Consult the Levelogger User Guide for more information on programming the Rainlogger 5.

Levelogger 5 LTC Calibration

Before deploying your Levelogger 5 LTC, be sure to calibrate the instrument. To begin calibration, open the 'Conductivity Cal' tab and follow the steps provided. Consult the Levelogger User Guide for more information, or view the LTC Calibration Video on our YouTube Channel: https://www.youtube.com/user/SolinstCanadaLtd

Starting and Stopping the Levelogger

Note: Levelogger 5 Junior and Rainlogger 5 do not have the Future Stop function.

1. If desired, enter a Future Start and/or Future Stop Time. To start logging immediately, do not fill in a future start time and click the 'Start Now' icon.

Note: When the 'Start' icon is selected, a window will pop-up to indicate how much memory is available. Selecting "Yes" ignores the message and starts the datalogger immediately. Selecting "No" gives you the chance to access the 'Data Control' tab to download and/or delete data files using the 'Download and Delete Files' option, to free-up memory.

2. When "Yes" is selected, all settings are applied to the Levelogger and it will start logging at the specified time.
3. To stop the Levelogger immediately, click the 'Stop Now' icon.

Tip: The 'future start' and 'future stop' options are ideal for synchronizing the data collection of multiple Leveloggers and Barologgers.

Downloading and Working with Data

1. Click the 'Data Control' tab to access the 'Data Control' window. This window is laid out in three sections: Levelogger settings, tabular data, and graphical data.
2. To download the data from a connected Levelogger, select the 'Download Data from Levelogger' icon. There are four options for downloading data. They are: All Data, Append Download, Partial Download and Download and Delete Files. The data will be presented in both tabular and graphical format.

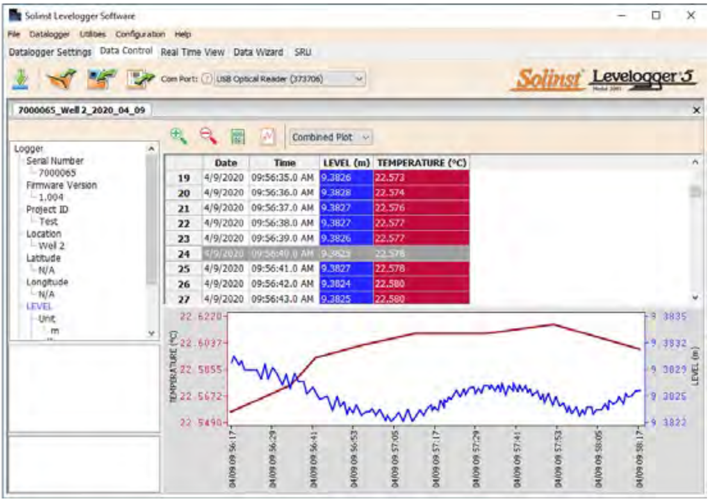
Note: The default directory for downloaded and saved data is in the 'Data' folder: <C:\Program\Files\Solinst\Levelogger 4_6\Data>. Data is saved as a .xle data file.

3. To save data, click the 'Save Data' icon and input desired name for the saved file.
4. To export the file for use in other software, click the 'Export' icon. The file can be exported to a *.csv or *.xml file.

Note: To change the default directory for downloaded data, use the 'Configuration' menu at the top of the software window. Select 'Application Settings' and input or navigate to a different folder destination. Click 'OK'.

Tip: The *.csv and *.xml file formats are supported and can be imported by most spreadsheet and database programs.

The data graph can be exported to a *.bmp file or a *.png file by clicking File > Export >Graph.



Data Control Window

DataGrabber 5

Connect a DataGrabber 5 to an in-field Levelogger via an L5 Direct Read Cable or L5 Threaded or Slip Fit Adaptor, and transfer data to a USB key.

Solinst Readout Unit (SRU)

Connect an SRU to an in-field Levelogger via an L5 Direct Read Cable or L5 Threaded or Slip Fit Adaptor to display instant water level readings, Levelogger status, save a real-time logging session, and download data to the SRU memory.

Real Time View

Real Time View provides on-screen measurement as data is being recorded by the connected datalogger. A view rate is set independently of the logging period of the Levelogger and does not interfere with internal logging taking place. To take a reading at any specific time, click ✓ and that reading will be added to the displayed data. The data can be exported and saved.

Compensate the Data

Click the 'Data Wizard' tab to open the 'Data Wizard' window. In this window the 'Wizard' will guide you through Barometric Compensation, Manual Data Adjustments, and Parameter Adjustments on your open data files. There are two convenient options; Basic or Advanced compensation. This allows you to choose just one, two, or all three types of compensation. Multiple Levelogger files can be barometrically compensated at once, using one open Barologger file.

Tip: 'Manual Data Adjustment' allows you to use manual water level measurements to adjust your data to depth to water readings.

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Levelogger Field Measurement

Levelogger 5 Ranges

Each model of Levelogger is rated for a specific submergence depth (Table 1). The choice of model largely depends on the accuracy of the water level required and the submergence depth. The selection, however, should be based on the maximum anticipated water level fluctuation.

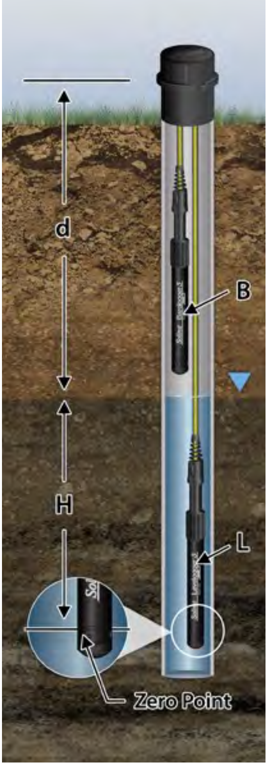
Model	Submergence Depth	Accuracy
Barologger	Air only	± 0.05 kPa
M5	5 m (16.4 ft.)	± 0.3 cm (0.010 ft.)
M10	10 m (32.8 ft.)	± 0.5 cm (0.016 ft.)
M20	20 m (65.6 ft.)	± 1 cm (0.032 ft.)
M30	30 m (98.4 ft.)	± 1.5 cm (0.064 ft.)
M100	100 m (328.1 ft.)	± 5 cm (0.164 ft.)
M200	200 m (656.2 ft.)	± 10 cm (0.328 ft.)

Table 1 – Levelogger 5 Ranges

Measurement Fundamentals

Leveloggers **(L)** measure the total pressure acting on a transducer at their zero point/sensor. The total pressure is caused by the column of water lying above the Levelogger pressure sensor AND the barometric (atmospheric) pressure acting on the water surface. To compensate for barometric pressure fluctuations and get true height of water column measurements **(H)**, a Barologger **(B)** is required, i.e.:

Levelogger Reading (L) – Barologger Reading (B)
=
Height of Water Column (H)



Verifying Readings

The best recommendation is to compare barometrically compensated Levelogger data **(H)** with a manually measured depth to water level value **(d)** (using a Water Level Meter).

Tip: To adjust all readings in your Levelogger file to depth to water below a well casing **(d)**, record a manual water level measurement using a water level meter. This reading should correspond in date and time with an actual Levelogger recording. Use this as a reference datum in the Manual Data Adjustment option in the Levelogger Software Data Wizard.

Note: The Levelogger 5 can withstand over-pressurization of 2 times the intended range, e.g. a Model M10 can accommodate a fluctuation of 20 meters or 60 feet and still record pressure. However, over-range accuracy is not guaranteed.

A single Barologger 5 can be used to compensate all Leveloggers on site, within a 30 km/20 mile radius and with every 300 m (1000 ft.) change in elevation. Ensure that your Barologger will start logging within at least 3 hours of your Levelogger start time.

Levelogger Field Notes

Tip: It is recommended to take a manual water level measurement before installing a Levelogger, shortly after installation, periodically during your monitoring interval, and at the end of your measurement period. Use these measurements to verify Levelogger readings, and for data adjustments later on. Ensure you take manual readings as close in time as possible to a scheduled Levelogger reading.

Before Deployment

Before deployment, make sure you do the following:

- Program your Levelogger, using Levelogger Software, with the correct project identification, memory mode, sampling regime, time, etc.

Note: It is useful to synchronize the times of all Leveloggers and Barologgers being used for the same project.

- Set a future start time, or start the Levelogger if deploying on a wireline/Kevlar cord (Leveloggers can be started after deployment if using an L5 Direct Read Cable)
- Determine borehole depth to ensure the Levelogger does not touch the bottom of the well (avoid submergence in sediment)
- Determine the minimum and maximum expected water levels, as Leveloggers must remain submerged for the entire monitoring period, and Barologgers must not be submerged
- Use a Solinst Model 101 or 102 Water Level Meter to take a manual depth to water measurement that will be used to verify Levelogger readings

Note: If you are using an old style Direct Read Cable with a Levelogger 5 Series datalogger, you will need to use an L5–Edge DRC Adaptor.

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Wireline/Cord Deployment **Direct Read Deployment**

Deployment

- Deploy your Levelogger and Barologger using an L5 Direct Read Cable for down-well communication, or use an inexpensive wireline or Kevlar cord.

> **Note:** For information on other types of installations, see the latest Levelogger User Guide.

- Install the Barologger in a similar thermal environment as the Levelogger
- The Barologger should be suspended beyond the frost line and deep enough to avoid large temperature fluctuations
- Ensure the Barologger location is vented to atmosphere

After Deployment

After deployment, make sure you do the following:

- Take a manual depth to water measurement after the well has stabilized (approximately 10 minutes)
- Take another manual depth to water measurement just before removing the Levelogger from the well

Well Caps

The Model 3001 2" (or 4" with Adaptor) Well Cap Assembly provides a secure method of installing your Levelogger using wireline/Kevlar cord or L5 Direct Read Cables. A Support Hanger Bracket is available for supporting and organizing down well wires or cords, or for coiling extra L5 Direct Read Cable lengths.

In-field Communication

If you have installed your Levelogger using wireline/Kevlar cord, you can communicate with your Levelogger via a Field Reader 5 or Desktop Reader 5 and Levelogger Software on a laptop PC.

If you have installed your Levelogger using an L5 Direct Read Cable, you can communicate with your Levelogger via a PC Interface Cable and Levelogger Software on a laptop PC, using a Levelogger 5 App Interface and the Solinst Levelogger App on your mobile device, or connect an SRU or a DataGrabber 5, without removing the Levelogger from the well.

Field Reader 5

Desktop Reader 5

PC Interface Cable

Levelogger 5 App Interface

SRU

DataGrabber 5

Note: An L5 Threaded or Slip Fit Adaptor can be used to directly connect a Levelogger to a Levelogger 5 App Interface, SRU or DataGrabber 5.

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Maintenance

As with any monitoring project, you should select the proper equipment and determine a maintenance schedule based on the environment specific to your application.

Maintenance tips include:

- Inspect regularly, and replace the o-ring at the optical end of the Levelogger if damaged
- Clean the optical eye of the Levelogger with a clean, soft cloth or cotton swab
- Rinse the Levelogger body using a mild, non-residual, non-abrasive household cleaner
- Use a very soft-plastic bristled brush, if needed, to clean the Levelogger body
- Do not insert any object through the circulation holes at the sensor end of the Levelogger
- See the Levelogger User Guide Maintenance Section if simple household cleaners are not sufficient for certain issues, such as hard water build up
- Clean Levelogger 5 LTC conductivity sensor pins before calibration and before/after deployment—see the Solinst Levelogger User Guide
- Stop the Levelogger from recording before storing
- Store Leveloggers with the installation cap on and in the case they were originally provided in
- Store Leveloggers in above-freezing conditions
- Read our Technical Bulletin "Ensuring Proper Use and Maintenance of Leveloggers"

Note: A Solinst Biofoul Screen can be used to protect the Levelogger 5 from biofouling on the pressure sensor, and the conductivity cell of a Levelogger 5 LTC.

Note: All Leveloggers should be deployed and stored with the installation cap or L5 Direct Read Cable attached. This prevents unnecessary battery drainage and protects the optical eye.

Troubleshooting Guide

Levelogger Software:

1. You must have administrator privileges to install software on a computer.
2. The Windows 10 Operating System supports Levelogger Software.

Communication Errors:

"Port Cannot Open", "Check Com Port"

1. Reason: Software was started before USB device was connected to computer.
   Solution: Restart computer, connect USB device, start software.
2. Reason: Incorrect Com Port is selected in Com Port selection menu.
   Solution: Check the Com Port location for the installed device, by accessing the 'Device Manager' (through the Control Panel), and selecting the "Ports" section. This will state the Com Port the device is installed on.
3. Reason: Another device shares the same Com Port or is causing a communication conflict.
   Solution: Ensure that software for PDA or other devices, which automatically synchronize, are disabled. Ask your system administrator for assistance.

"Communication Time-Out", "Communication Error"

1. Reason: Levelogger, Direct Read Cable, or communications device has failed.
   Solution:
   a) Narrow down the failure by using a different Levelogger, Direct Read Cable, or another communications device.
   b) Clean the optical eye/lens on the Levelogger and Optical Reader (Desktop Reader 5 or Field Reader 5), or L5 Direct Read Cable, with a soft cloth.
   c) Check that the communication cable is connected to the same Com Port that is chosen in the upper middle of the Levelogger Software window.
   d) Try using a different computer, to see if this is the cause of the problem.
   e) If using a laptop (especially in conjunction with a Direct Read Cable) your Com Port may not be powered adequately to receive/transmit data. Try using a desktop computer to test this.
   f) If problem persists, contact Solinst.

Frequently Asked Questions

(Also see https://www.solinst.com/products/dataloggers-and-telemetry/3001-levelogger-series/levelogger-faq/levelogger-faq.php)

How can I protect my Levelogger from corrosive or marine environments?

The Levelogger 5 and Levelogger 5 LTC have a corrosion resistant coating. In harsher chemical environments, you can protect the Levelogger using a thick membrane balloon (e.g. helium) filled with non-corrosive/non-toxic fluid (tap water). As pressure changes, the fluid encasing the dataloggers will transmit the pressure differential to the datalogger's pressure transducer, without exposing it to corrosive conditions. Continual monitoring is recommended to assess the effectiveness of the protection at your site.

How do I install my Levelogger in a surface water application?

For installations within rivers, streams, wetlands, lakes and watershed or drainage basin monitoring, the shallow pressure range (M5) Levelogger 5 or Levelogger 5 Junior should be considered. For installation in streams or rivers, stilling wells can be constructed which shield the instrument from the water turbulence. Alternatively, Leveloggers can be lowered into a protective pipe or casing and then attached to a permanent fixture such as a bridge, pier or hand driven marker/rod.

How do I protect my Levelogger from freezing?

To avoid icing/freezing and transducer damage, the easiest method is to lower the transducer to a point in the water column below the frost line or ice formation depth. In water bodies such as shallow streams, wetlands or ponds where icing/freezing may penetrate to the bottom, install the Levelogger in a vented stilling well imbedded into the bottom of the water body beyond the frost line.

If this is not possible, place the Levelogger inside a thick membrane balloon filled with a non-toxic, non-corrosive anti-freeze solution or saltwater solution. Place the balloon in a section of perforated, 30 mm (1.25") ID pipe and install the datalogger in the monitored water. The antifreeze solution will protect the Levelogger from ice expansion at the pressure transducer, yet transmit any pressure and temperature fluctuations that occur.

How do I protect my Levelogger from biofouling?

Use the Solinst Model 3001 Biofoul Screen.

Is Levelogger maintenance required?

Yes, consult the Solinst Technical Bulletin "Ensuring Proper Use and Maintenance of Leveloggers" to maintain the long life of your instrument, based on the monitoring environment specific to your application.

Solinst Canada Ltd. 35 Todd Road, Georgetown, Ontario Canada L7G 4R8
Tel: +1 (905) 873-2255; (800) 661-2023 Fax: +1 (905) 873-1992
E-mail: instruments@solinst.com **www.solinst.com**

Appendix E

Van Essen CTD Diver Installation Procedures

PRODUCT MANUAL

CTD-Diver® – DI28x Series

Contact details:

Van Essen Instruments B.V.
Delftechpark 20, 2628 XH Delft

Netherlands

Tel: +31 (0)15 275 5000

Van Essen Instruments - Canada
219 Labrador Drive, Suite 201, Waterloo

ON, Canada N2K 4M8

Tel: +1 226-791-6499

Van Essen Instruments - USA
4561 Greer Circle, Suite 100, Tucker

GA, United States 30083

Tel: +1 520-203-3445 (US West)

Tel: +1 678-983-2818 (US East)

Internet: www.vanessen.com

Support: diver@vanessen.com

The presence of the Waste Electrical and Electronic Equipment (WEEE) marking on the product indicates that the device is not to be disposed via the municipal waste collection system of any member state of the European Union. For products under the requirement of WEEE directive (2012/19/EU), please contact your distributor or local Van Essen Instruments B.V. office for the proper decontamination information and take back program, which will facilitate the proper collection, treatment, recovery, recycling, and safe disposal of the device.

CE COMPLIANCE STATEMENT (EUROPE)

We hereby declare that the device(s) described below are in conformity with the directives listed. In the event of unauthorized modification of any devices listed below, this declaration becomes invalid.

Type: Datalogger
Product Model: CTD-Diver (DI281, DI282, DI283, DI284)

Relevant EC Directives and Harmonized Standards:

1999/5/EC R&TTE Directive for Radio and Telecommunications Terminal Equipment in accordance to annex III to which this directive conform to the following standards:

Low Voltage Directive per EN60950-1 (2006)+A11 (2011) for Product Safety testing standard for "Information Technology Equipment"

EMC Directive EN 301 489-1 V1.8.1 / EN 301 489-17 V1.3.2 Electromagnetic emission and immunity for "Information Technology Equipment"

2014/30/EU Electromagnetic Compatibility directive, as amended by EN61326-1:2013

The product(s) to which this declaration relates is in conformity with the essential protection requirements of 2014/30/EU Electromagnetic Compatibility directive. The products are in conformity with the following standards and/or other normative documents:

EMC: Harmonized Standards: EN 61326-1:2013 Lab Equipment, EMC

IEC61000-6-3:2007 Emission standard for residential, commercial and light-industrial environments
IEC61000-4-2:2009 Electrostatic discharge immunity test
IEC61000-4-3:2006 Radiated, radio-frequency, electromagnetic field immunity test
IEC61000-4-4:2012 Electrical fast transient/burst immunity test
IEC61000-4-5:2006 Surge immunity test
IEC61000-4-6: 2014 Immunity to conducted disturbances, induced by radio-frequency fields
IEC61000-4-11:2004 Voltage dips, short interruptions and voltage variations immunity tests

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The items comply with all applicable Essential Requirements of the Directives.

Contents

1 Introduction

The CTD-Diver® is a compact, groundwater monitoring instrument for continuously measuring level, temperature and electrical conductivity in groundwater, surface water, and industrial waters. The data collected can be used to manage water resources, estimate hydraulic conductivity and other aquifer conditions. Examples of applications are:

- monitor potable water recharge areas for water supply,
- monitor tailings ponds, dewatering activities and water supply levels of mines,
- general site investigations for construction, and
- contaminant plume monitoring on spill sites, remediation sites, chemical storage facilities, landfill sites and hazardous waste storage sites.

The CTD-Diver is an easy-to-use datalogger featuring state-of-the-art electronics , a robust high precision pressure sensor for long term accuracy and a platinum 4-electrode conductivity sensor. The absolute pressure sensor requires minimal maintenance and re-calibration.

The CTD-Diver is a datalogger housed in a cylindrical casing with a suspension eye at the top. The suspension eye can be unscrewed and is designed to install the CTD-Diver into the monitoring well. The suspension eye also protects the optical connector. The electronics, sensors and battery are installed maintenance-free into the casing. The CTD-Diver is not designed to be opened.

The name of the datalogger, the model number, the measurement range and the serial number are identified on the side of the CTD-Diver. This information is etched using a laser and is consequently chemically neutral and not erasable.

1.1 About this Manual

This manual contains information about Van Essen Instruments' CTD-Diver with part number DI28x, see section 2.5, an instrument designed to measure groundwater levels, temperature and electrical conductivity.

This chapter contains a brief introduction to the CTD-Diver's measurement principles. Chapter 2 contains the technical specifications for the CTD-Diver as well as guidelines for Diver maintenance. Chapter 3 covers the deployment of Divers. This includes programming the Diver with the Diver-Office software. Subsequently, installation of Divers in monitoring wells and in surface water is discussed. There are three appendices that describe the use of Divers at varying elevation, the Diver communication protocol and a list of CTD-Diver accessories.

1.2 Operating Principle

The CTD-Diver is a datalogger designed to measure water pressure, temperature and conductivity. Measurements are subsequently stored in the CTD-Diver's internal memory. The CTD-Diver consists of a pressure sensor designed to measure water pressure, a temperature sensor, a 4-electrode conductivity sensor and a battery that powers the electronics that takes and stores the measurements. The CTD-Diver is an autonomous datalogger that can be programmed by the user. The CTD-Diver has a completely sealed inert ceramic enclosure. The communication between CTD-Divers and Laptops/field devices is based on optical communication.

The CTD-Diver measures the absolute pressure. This means that the pressure sensor not only measures the water pressure, but also the air pressure pushing on the water surface. If the air pressure varies, the measured water pressure will thus also vary, without varying the water level. The air pressure can be measured by a Baro-Diver and subsequently be used in the Diver-Office software to convert the CTD-Diver pressure readings into water level data.

1.3 Measuring Water Level

The CTD-Diver establishes the height of a water column by measuring the water pressure using the built-in pressure sensor. As long as the CTD-Diver is not submerged in water it measures atmospheric pressure, just like a barometer. Once the Diver is submerged this is supplemented by the water's pressure: the higher the water column the higher the measured pressure. The height of the water column above the Diver's pressure sensor is determined based on the measured pressure.

To measure these variations in atmospheric pressure a Baro-Diver is installed for each site being measured. The barometric compensation for these variations in atmospheric pressure can be done using the Diver-Office software, see www.vanessen.com for a free download. It is also possible to use alternative barometric data such as data made available online.

The barometrically adjusted water values can be related to a reference point such as the top of the monitoring well or Mean Sea Level (MSL) or any other vertical reference datum.

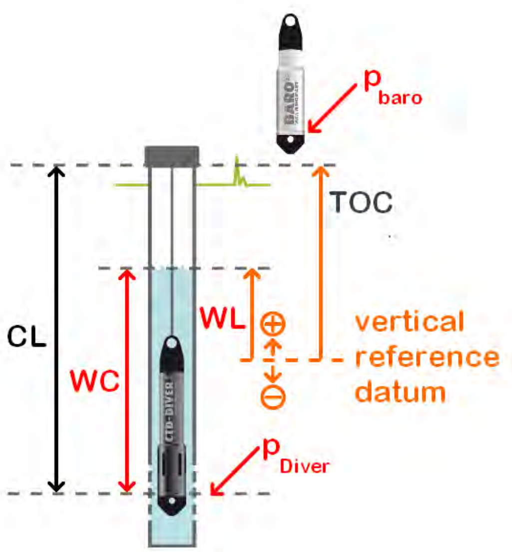
1.3.1 Converting Diver Data into Water Level

This section explains how to calculate the water level in relation to a vertical reference datum using the CTD-Diver and Baro-Diver's measurements.

The figure below represents an example of a monitoring well in which a CTD-Diver has been installed. In this case we are therefore interested in the height of the water level (WL) in relation to the vertical reference datum. If the water level is situated above the reference datum it has a positive value and a negative value if it is situated below the reference datum.

The top of casing (TOC) is measured in relation to the vertical reference datum and is denoted in the diagram below as TOC. The CTD-Diver is suspended with a cable with a length CL. If the cable length is not exactly known, it can be calculated from a manual measurement as described in section 1.3.2.

The Baro-Diver measures the atmospheric pressure (p_{baro}) and the CTD-Diver measures the pressure exerted by the water column (WC) above the CTD-Diver and the atmospheric pressure (p_{Diver}).



The water column (WC) above the CTD-Diver can be expressed as:

$$\mathrm{WC} = 9806.65\,\frac{p_{\mathrm{Diver}} - p_{\mathrm{baro}}}{\rho \cdot g} \tag{1}$$

where p is the pressure in cmH_2O, g is the acceleration due to gravity (9.80665 m/s^2) and ρ is the density of the water (1,000 kg/m^3).

The water level (WL) in relation to the vertical reference datum can be calculated as follows:

$$\mathrm{WL} = \mathrm{TOC} - \mathrm{CL} + \mathrm{WC} \tag{2}$$

By substituting WC from equation (1) in equation (2) we obtain:

$$\mathrm{WL} = \mathrm{TOC} - \mathrm{CL} + 9806.65\,\frac{p_{\mathrm{Diver}} - p_{\mathrm{baro}}}{\rho \cdot g} \tag{3}$$

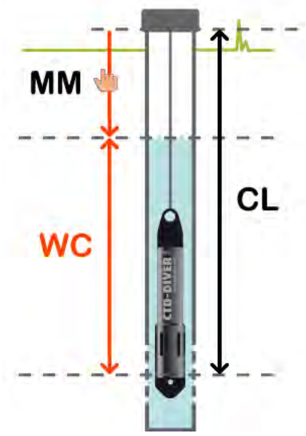
1.3.2 Calculating the Cable Length from a Manual Measurement

If the cable length is not exactly known, it can be determined using a manual measurement, see the figure below. The manual measurement (MM) is taken from the top of casing to the water level. The value of the water level is positive unless, in exceptional circumstances, the water level is situated above the top of casing.

The cable length can now be calculated as follows:

$$\mathrm{CL} = \mathrm{MM} + \mathrm{WC} \tag{4}$$

where the water column (WC) is calculated based on the measurements taken by the CTD-Diver and the Baro-Diver.



Notes:

- If the pressure measured by the CTD-Diver and the Baro-Diver is measured at different points in time, it is necessary to interpolate. The Diver-Office software automatically performs this interpolation.
- It is possible to enter manual measurements into the Diver-Office software. The software subsequently automatically calculates the cable length.

Example

The top of casing is measured to be 150 cm above the Mean Seal Level (MSL): TOC = 150 cm. The cable length is not exactly known and therefore a manual measurement is taken. It turns out to be 120 cm: MM = 120 cm.

The CTD-Diver measures a pressure of 1,170 cmH_2O and the Baro-Diver measures a pressure of 1,030 cmH_2O. Substituting these values into equation (1), results in a water column of 140 cm above the Diver: WC = 140 cm.

Substituting the values of the manual measurement and the water column in equation (4) results in the following cable length: CL = 120 + 140 = 260 cm.

The water level in relation to MSL can now be easily calculated using equation (2): WL = 150 – 260 + 140 = 30 cm above MSL.

1.4 Measuring Temperature

All Divers measure the groundwater temperature. This can, for example, provide information about groundwater flows.

The temperature is measured using a semiconductor sensor. This sensor not only measures the temperature, but also uses the value of the temperature at the same time to compensate the pressure sensor and electronics for the effects of temperature to ensure the best possible performance.

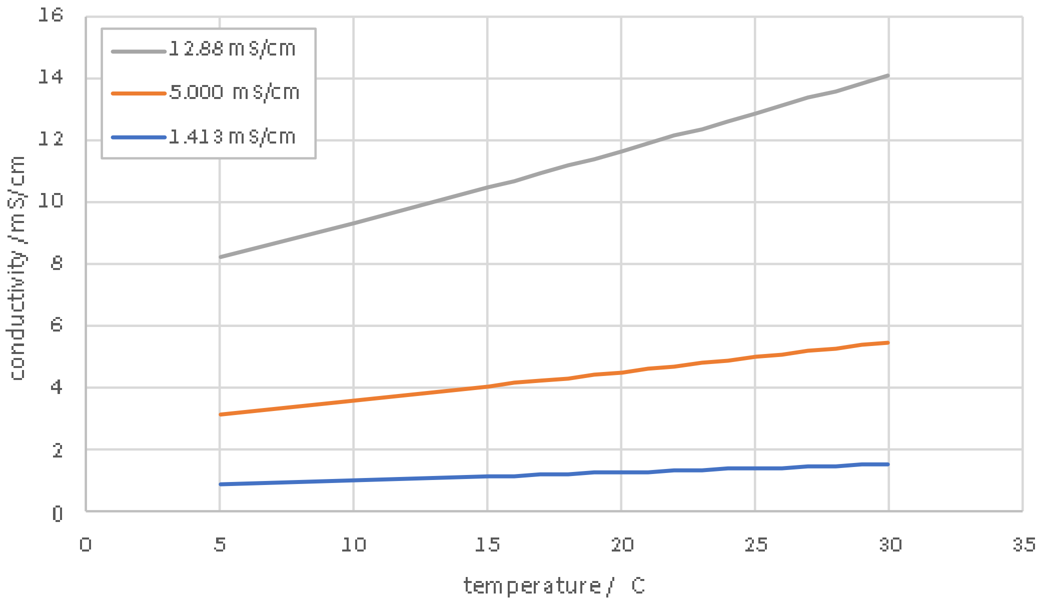
1.5 Measuring Conductivity

In addition to water levels and temperature, the CTD-Diver also measures the water's electrical conductivity in milli Siemens per centimeter (mS/cm). A change in conductivity may be caused by for example changes in water flow or increasing/decreasing pollution or salinization.

The conductivity is measured using a 4-electrode measuring cell. This type of measuring cell is relatively insensitive to sensor fouling, thus keeping maintenance to a minimum. *The measuring cell combined with the selected measurement method results in an electrolysis-free measurement system.*

The CTD-Diver measures the conductivity of a solution. The CTD-Diver can be programmed to measure either the true conductivity or the specific conductivity. The specific conductivity is defined as the conductivity as if the temperature is 25 °C. This setting must be programmed prior to starting the CTD-Diver.

The conductivity of a liquid depends on the type of ions in the liquid and to a significant degree on the liquid's temperature. This dependency is indicated on the packaging of the calibration solution. The diagram below displays the conductivity as a function of temperature for three different calibration liquids. The specified value of the calibration liquid is the conductivity of the liquid at 25 °C.



As a rule of thumb, it can be assumed that conductivity varies by 2% for each 1 °C change in temperature. This means that a calibration solution rated 5 mS/cm (at 25 °C) has a conductivity of approximately 4 mS/cm at 15 °C.

The table below lists several typical conductivity values for various types of water.

Type	Conductivity [mS/cm]
Tap water	0.2 – 0.7
Groundwater	2 - 20
Seawater	50 - 80

1.5.1 Specific Conductivity

The specific conductivity of an electrolyte solution is defined as the conductivity if the solution is at a certain – reference – temperature. The specific conductivity is an indirect measure of the presence of dissolved solids such as chloride, nitrate, phosphate, and iron, and can be used as an indicator of water pollution.

The following equation is used for calculating the specific conductivity K_{Tref} from the measured conductivity K.

$$K_{Tref} = \frac{100}{100+\theta(T-T_{ref})} \cdot K \quad (5)$$

where:

K_{Tref} = Specific conductivity at T_{ref}

K = Conductivity at T

T_{ref} = Reference temperature (25 °C)

T = Sample temperature

θ = Temperature coefficient (1.91 %/°C)

The temperature coefficient used in the CTD-Diver is 1.91 %/°C and the reference temperature is 25°C. The setting to measure conductivity or specific conductivity can be programmed into the CTD-Diver by the user.

1.6 CTD-Diver Model

The Diver models described in this manual are from the DI28x Series: the CTD-Diver. The CTD-Diver measures absolute pressure, temperature and conductivity.

CTD-Diver

This Diver is manufactured using a zirconia (ZrO_2) casing with a 22 mm diameter. The CTD-Diver can store a maximum of 144,000 measurements (date/time, pressure, temperature and conductivity) in its working memory and 144,000 measurements in its backup memory.

The CTD-Diver samples pressure, temperature and conductivity and has the following measurement options:

- Fixed length intervals in fixed length or continuous memory.
- Average values.
- Pre-programmed or user-defined pump tests.
- Event-based. The CTD-Diver only stores measurements once the user-adjustable variation limit set for the conductivity measurement is exceeded.

The CTD-Diver is available in the following pressure ranges: 10 m, 50 m, 100 m and 200 m.

1.7 Factory Calibration Procedure

Each CTD-Diver is calibrated for pressure, temperature and conductivity:

1. First the CTD-Diver is individually calibrated and tested at several temperature and pressure values to ensure superior performance. The CTD-Diver is calibrated for the lifetime of the instrument, as long as it is used within its specified range.
2. Then the conductivity sensor is individually calibrated and tested at several conductivity values. The factory calibration is stored permanently in the CTD-Diver.

A calibration certificate is available upon request.

2 Technical Specification

2.1 General

There are four CTD-Diver models with different pressure ranges for pressure, temperature and conductivity measurements. The table below lists the general specifications of the CTD-Diver.

Diameter	Ø 22 mm
Length (incl. suspension eye)	~ 135 mm
Weight	~ 95 grams
Materials	
Casing	Ceramic (zirconia ZrO_2)
Pressure sensor	Piezoresistive ceramic (alumina Al_2O_3)
Conductivity sensor	4-electrode with platinum electrodes
Suspension eye	Nylon PA6 glass fiber reinforced (30%)
nose cone	ABS
O-rings	Viton®
Communication	
Interface	Optically separated
Protocol	Serial RS232, a limited set of commands is available as specified in Appendix II
Memory capacity	288,000 measurements
working	144,000 measurements
backup	144,000 measurements
Memory	Non-volatile memory. A measurement consists of date/time, pressure, temperature, and conductivity Continuous and fixed length memory
Battery life*	Up to 10 years, depending on use
Theoretical battery capacity	2 million measurements + 1000× full memory readouts + 2000× programming
Clock accuracy	Better than ± 1 minute per year at 25 °C
	Better than ± 5 minutes per year within the operating temperature range
CE marking	EMC in accordance with the 89/336/EEC directive Basic EN 61000-4-2 standard
Emissions	EN 55022 (1998) + A1 (2000) + A2 (2003), Class B
Immunity	EN 55024 (1998) + A1 (2000) + A2 (2003)

* The CTD-Diver is always in stand-by when not making a measurement. The power consumption of the integrated battery is dependent on the temperature and usage.
If the CTD-Diver is used, stored or transported for extended periods of time under high temperature, this will adversely affect the life of the battery. The battery's capacity at lower temperatures is reduced, but this is not permanent. This is normal behavior for batteries.
Excessive programming, high frequency sampling and data reading will reduce the battery capacity.

** The accuracy of the clock is highly dependent on temperature. The clock is actively compensated for temperature variations.

2.2 Environmental

Ingress protection	IP68, 10 years continuously submerged in water at 200 m

2.3 Transportation

Suitable for transportation by vehicles, ships and airplanes in the supplied packaging.

Resistance to vibration	In accordance with MIL-STD-810.
Mechanical shock test	In accordance with MIL-STD-810, for light-weight equipment
Temperature	-20 °C to 80 °C (affects battery life)

2.4 Temperature

Measurement range	-20 °C to 80 °C
Operating Temperature (OT)	0 °C to 50 °C
Accuracy (max)	± 0.2 °C
Accuracy (typical)	± 0.1 °C
Resolution	0.01 °C
Response time (90% of final value)	3 minutes (in water)

2.5 Pressure

The specifications for water pressure measurements vary by CTD-Diver model. The specifications below apply at operating temperature.

	DI281	DI282	DI283	DI284	Unit
Water column measurement range	10	50	100	200	mH_2O
Accuracy (max)	± 2.0	± 10.0	± 20.0	± 40.0	cmH_2O
Accuracy (typical)	± 0.5	± 2.5	± 5.0	± 10.0	cmH_2O
Long-term stability	± 2	± 10	± 20	± 40	cmH_2O
Resolution	0.2	1	2	4	cmH_2O
Display resolution	0.058	0.192	0.358	0.716	cmH_2O
Overload pressure	15	75	150	300	mH_2O

2.5.1 Water Column Measurement Range

The height of water above the CTD-Diver that can be measured.

2.5.2 Accuracy (maximum)

Accuracy is the proximity of measurement results to the true value. The algebraic sum of all the errors that influence the pressure measurement. These errors are due to linearity, hysteresis and repeatability. During the CTD-Diver calibration process a CTD-Diver is rejected if the difference between the measured pressure and the applied pressure is larger than the stated accuracy.

2.5.3 Accuracy (typical)

At least 68% of the measurements during the calibration check are within 0.05% FS of the measurement range.

2.5.4 Long-term Stability

The stability of the measurement over a period of time when a constant pressure is applied at a constant temperature.

2.5.5 Resolution

The smallest change in pressure that produces a response in the CTD-Diver measurement.

2.5.6 Display Resolution

The smallest increment in pressure that the CTD-Diver can measure.

2.5.7 Overload Pressure

The pressure at which the CTD-Diver pressure sensor will catastrophically fail.

2.6 Conductivity

Measurement range*	30 mS/cm	120 mS/cm	300 mS/cm
Accuracy**	±2% of reading with a minimum of 20 µS/cm		
Resolution	1 µS/cm	4 µS/cm	10 µS/cm

* User adjustable

** Undefined when reading > 120 mS/cm

2.7 Sample Interval and Methods

The minimum and maximum sample interval plus the various sample methods available for the CTD-Diver are listed below.

Sample interval	1 sec to 99 hours
Sample methods	• Fixed length intervals in fixed length or continuous (ring) memory. • Average values over a specified period. • Pre-programmed pump tests or user-defined pump tests (no backup memory). • Event-based. In this case the CTD-Diver only stores measurements once the variation limit set for the conductivity measurement is exceeded. This variation limit is user adjustable (no backup memory).

2.7.1 Fixed

When this method is selected, the CTD-Diver will take and store samples in regular time intervals.

For example, with a 10-second fixed record interval, the CTD-Diver will take a measurement every 10 seconds on all channel settings and then store these values in internal memory, with the date and time.

For the CTD-Diver there are two methods for storing data:

- Fixed Length Memory – The CTD-Diver will take measurements at a sample interval set by the user, for example every hour. When the number of samples reaches 144,000, i.e. the memory is full, the CTD-Diver stops measuring.
- Continuous Memory – The CTD-Diver will take measurements at a preset sample interval data. When the memory fills up, new samples begin overwriting the oldest records.

2.7.2 Averaging

When programmed with the Averaging Sample method, the CTD-Diver samples data at a specified "fast" rate (Sample Interval) and then stores an average of these values at the specified averaging rate (Record Interval).

Example

Record Interval: 1 hour

Sample Interval: 1 Minute

When programmed and started with these settings, the CTD-Diver will read a sample every minute, and record an average of the samples every 1 hour.

For surface water applications it is recommended using the averaging sampling method. This way the effects of waves are 'averaged out'.

2.7.3 Event Based

When you select this method, the CTD-Diver compares each conductivity sample to the last stored conductivity sample and calculates a difference. A new sample is only stored when:

- The difference exceeds the specified difference (percentage) from the last stored sample on the conductivity measurement.
- If no samples were stored for the past 250 samples.

If you select this method, the Variation field will be displayed. In the Variation field, specify the appropriate difference threshold. Enter this difference as a percentage of the total conductivity range. The percentage must lie between 0.1% and 25%.

Example

The conductivity range is set to 120 mS/cm, the Variation field is set to 2% and the sample interval is set to 30 seconds. A new sample will be stored when it deviates more than 120 × 2% = 2.4 mS/cm from the previously stored sample.

The CTD-Diver is started at 12:00:00. It will immediately record a sample (pressure, temperature and conductivity). The recorded conductivity is 23 mS/cm. After 30 seconds, the CTD-Diver takes a new sample: the conductivity is 23.5 mS/cm. This sample will not be recorded, because the difference is 0.5 mS/cm, which is less than 2.4 mS/cm.

Also, for the next 249 samples the difference is less than 2.4 mS/cm, so no samples are recorded. However, when the 250^{th} sample is taken, it is recorded (at 14:05:00) regardless the difference.

2.7.4 Pumping Tests

The CTD-Diver can be programmed with a pumping test logging scheme. Generally, the logging interval is short at the start and increases when the pumping tests progresses.

There are two pre-programmed pumping tests available for the CTD-Diver. These are as listed in the two tables below. In addition, user-defined pumping tests can be programmed in the CTD-Diver.

A pumping test is defined by a base sample interval (from 1 second to 99 hours) and up to 10 different logging steps. For each step the number of samples that must be taken must be set plus the Interval Multiplier (1 to 250). The interval between two successive samples is equal to the Base Sample Interval multiplied by the Interval Multiplier. For example, if the Base Sample Interval is 3 seconds and the Interval Multiplier is 5, then the sampling interval is 15 seconds. Note: The Base Sample Interval is equal for all steps.

Aquifer Log Scale Test - 3 Day

Base Sample Interval: 1 second

Step	Number of samples	Interval multiplier	Interval between samples	Duration
1	600	1	1 seconds	10 minutes
2	1080	5	5 seconds	90 minutes
3	5400	10	10 seconds	15 hours
4	136920	30	30 seconds	47 days

Aquifer Log Scale Test - 2 Month

Base Sample Interval: 5 seconds

Step	Number of samples	Interval multiplier	Interval between samples	Duration
1	120	1	5 seconds	10 minutes
2	270	4	20 seconds	90 minutes
3	900	12	60 seconds	15 hours
4	1800	60	5 minutes	150 hours
5	140910	240	20 minutes	1957 days

3 CTD-Diver Installation and Maintenance

3.1 Introduction

In practice the CTD-Diver is suspended in a monitoring well and the Baro-Diver is installed at the surface for recording barometric pressure. Atmospheric pressure data must be used to compensate the pressure measurements recorded by the CTD-Diver for variations in atmospheric pressure. In principle, a single Baro-Diver is sufficient for an area with a radius of 15 kilometers depending on terrain conditions. Also see *Appendix I – Use of CTD-Divers at Varying Elevations*. A 10-meter change in elevation is the equivalent of a barometric pressure change of approx. 1 cmH2O or 1 mbar.

The following sections describe how to install the CTD-Diver and Baro-Diver.

3.2 Configuring and Reading the CTD-Diver

A CTD-Diver must be programmed with the desired sample method, sample interval, and monitoring point name before it is deployed. The CTD-Diver can be programmed, started, stopped and its data read using the Diver-Office software. The latest version of Diver-Office can be downloaded for free from www.vanessen.com. Once the software is installed, a CTD-Diver can be connected to the computer through a USB Reading Unit (part no AS330), a Smart Interface Cable (part no. AS346) or the Diver-Gate(M) (part no. AS345).

3.2.1 Configuring a CTD-Diver

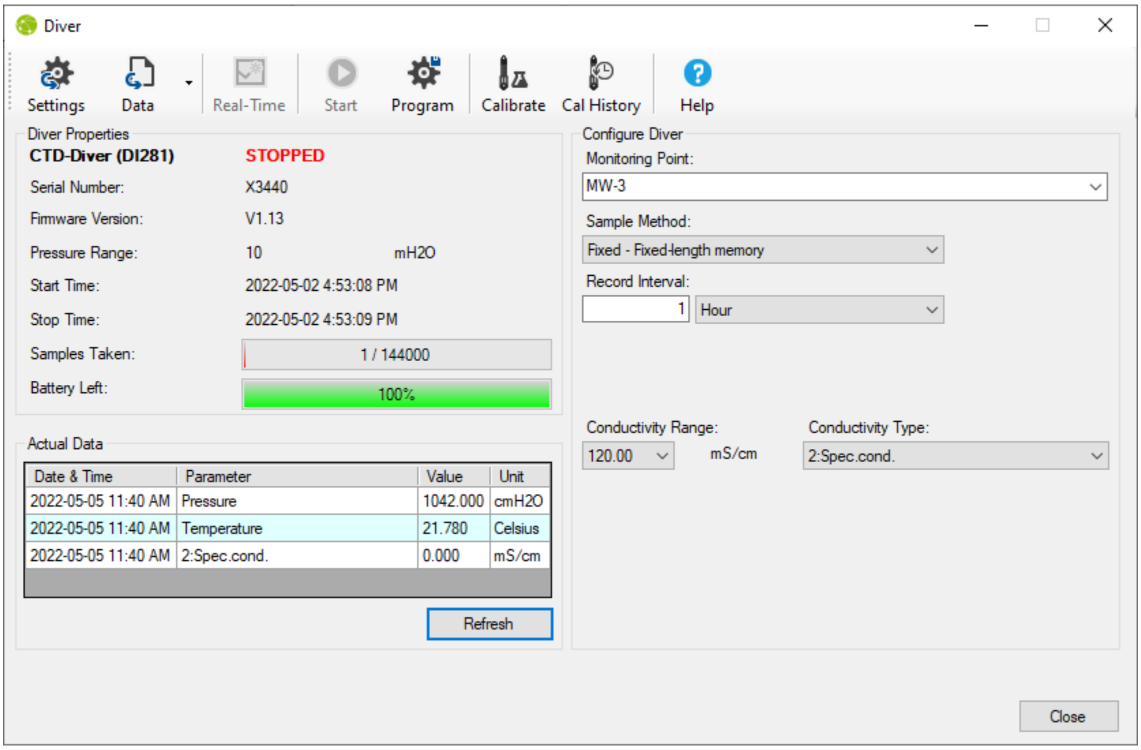
Open the Diver-Office software and click the Diver button to open the Diver window. See the image below for an example where the following settings were entered:

- monitoring point name: “MW-3”,
- sample method: “Fixed – Fixed-length memory”,
- record interval: 1 hour,
- conductivity range: 120 mS/cm,
- conductivity type: specific conductivity.

After entering the settings, the Diver must be programmed by clicking the Program button.

The conductivity range can be set to 30, 120 or 300 mS/cm. Select the range corresponding to the expected measurement values. A higher range reduces the resolution of the measurements. When the actual measurement value exceeds the conductivity range, then stored value is clipped to the maximum value.

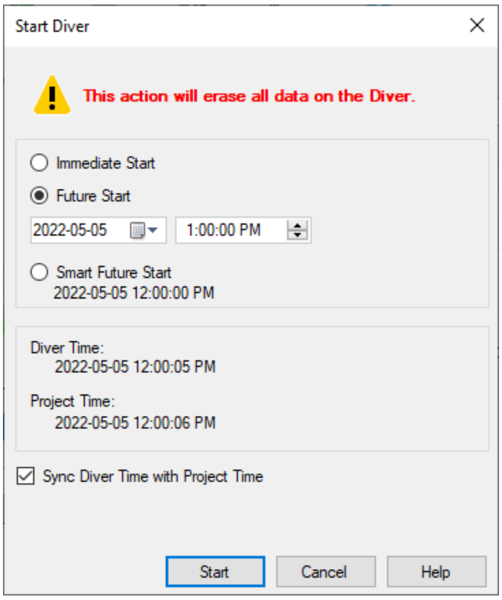
Set the conductivity type to the desired type. See section *1.5.1 Specific Conductivity* for more details.



Once the settings are successfully programmed into the CTD-Diver the Start button will be enabled. Clicking the Start button opens the Start Diver dialog as shown below. Here you can select from the following three start methods:

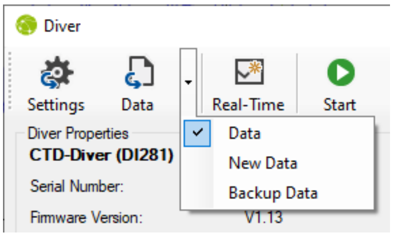
- Immediate Start - Select this option to start the CTD-Diver immediately. Upon clicking [Start], the Diver will begin to take and record samples, as defined in the CTD-Diver settings
- Future Start - Select this option to start the CTD-Diver at a specified time in the future. Use the date and time boxes to enter the desired future start time.
- Smart Future Start - This option is useful in situations where you want to stop the CTD-Diver, download its data and then continue collecting data at the specified sample interval.

After selecting the desired start method, click the [Start] button to save the start settings to the CTD-Diver.



3.2.2 Reading Data from a CTD-Diver

Click the Data button to download data from the CTD-Diver. Click the down arrow next to the Data button to change the mode/type of data download:



Depending on the sample interval the following 3 options are available:

- Data - download all the data recorded by the Diver.
- New Data - download only newly recorded data (since the last data download). This option is not available when the sample interval is 5 seconds or less.
- Backup Data - download data from the previous monitoring session.

During the data download the progress is indicated by a progress bar. Once the data has been downloaded it will be exported if this option is selected in the Project Settings. Subsequently, the program will jump to the tree view where the downloaded time series will be selected and a graph/table of the data will be shown.

3.3 Installation in a Monitoring Well

CTD-Divers are normally installed below the water level/table in a monitoring well. The depth at which a CTD-Diver can be suspended depends on the instrument's measurement range. Further information about the CTD-Diver's range is contained in the chapter 2 *Technical Specification*.

First determine the length of the non-stretch suspension cable (part no MO500) based on the lowest groundwater level. Provide for the required additional length for attaching the cable to the suspension eye of the Diver and at the upper end when you cut the wire to size.

Next use cable clips (part no MO310) to attach the ends of the cable to the monitoring well's end cover and the Diver's suspension eye, respectively.

To determine the distance of the pressure sensor in the monitoring well requires the precise length of the cable to be known, to which the distance to the location of the pressure sensor in the Diver must be added to obtain the overall effective cable length. This is depicted in the diagram below.

It is also possible to install the CTD-Diver with a communication cable (part no AS2xxx). This cable allows you to readout the CTD-Diver at the top of the monitoring well by using a Smart Interface Cable (part no AS346).

Note that in small diameter wells the installation and removal of the CTD-Diver may affect the water level.

3.4 Installation in Surface Water

If a CTD-Diver is used in surface water, it is important that there is sufficient circulation around the CTD-Diver's sensors.

Sedimentation, algae and plant growth should be minimized as much as possible to ensure the CTD-Diver measures the surrounding water level.

Position the CTD-Divers deep enough so that they remain below a possible ice layer.

A steel protective cover that can be locked should be used to prevent vandalism or theft of the CTD-Diver.

CTD-Divers can also be used to indirectly measure discharge. In such a case, the CTD-Diver can be installed in a monitoring tube/screen next to a weir.

3.5 Use of CTD-Divers at Varying Elevation

CTD-Divers can be used at any elevation ranging from 300 meters below sea level to 5,000 meters above sea level. Appendix I contains further information on the use of CTD-Divers at varying elevation.

3.6 Use in Seawater

The CTD-Diver is an excellent choice for use in semi-saline water/seawater. The CTD-Diver has a ceramic casing that does not corrode and is inert to most substances.

3.7 Biofouling

Biofouling is the undesirable accumulation of microorganisms, plants, algae, or animals on wetted structures. This is especially prominent in surface water monitoring in warm environments. Biofouling causes an algal growth on the electrodes of the CTD-Diver. This may affect the conductivity readings and increases the need for maintenance. Removing the biological materials from the electrodes can be damaging over a prolonged period and increase time spent in the field.

The Diver Copper Shield (part no AS350) protects the CTD-Diver from biofouling and reduces maintenance cost. There are many methods that can be used to prevent and remove the bioaccumulations. However, these methods can be expensive and detrimental to the environment. The Diver Copper Shield is a copper coil shield specifically designed to significantly reduce the growth of algae on the electrodes. Thus, reducing the need for maintenance and reducing the time spent on site.

3.8 CTD-Diver Maintenance

The CTD-Diver casing can be cleaned with a soft cloth. Calcium and other deposits can be removed by soaking the CTD-Diver in commercially available acidic cleaner (such as cleaning vinegar) and/or sodium bicarbonate (commonly known as baking soda or bicarbonate of soda).

Notes:

- Only use diluted acidic solutions if the CTD-Diver has severe build-up of, for example, lime scale and other cleansers are not effective.
- Never use any hard brushes, abrasives or sharp objects for cleaning the CTD-Diver and always rinse it properly with clean water after cleaning, particularly near the flow-through openings. Do not use any powerful jets. This could damage the pressure sensor.

3.9 User Conductivity Calibration

3.9.1 Introduction

The conductivity sensor is, in contrast to the pressure and temperature sensor, sensitive to pollution and fouling. Therefore, it is recommended to check the sensor regularly. A simple verification consists of two steps. First, take the CTD-Diver out of the well and shake it dry. Then take an actual reading, the reading should be 0 mS/cm. The reading may be slightly higher if the conductivity sensor is not completely dry. Second, immerse the CTD-Diver in a conductivity calibration solution. Ensure, that there are no air bubbles trapped inside the conductivity measurement cell. Take another actual reading and compare with the value of the calibration solution.

Note: If the CTD-Diver is set to read Conductivity (and not Specific Conductivity), ensure that the reading is corrected for temperature.

If the deviation is greater than the specified accuracy it is recommended to recalibrate the CTD-Diver. It is important to note that this calibration should be performed in an environment with a stable temperature. It is necessary to make use of good reference fluids and clean tools in order to perform a proper and reliable recalibration.

The conductivity accuracy specification of the CTD-Diver for the full 0-120 mS/cm measurement range can only be achieved if the CTD-Diver is calibrated at all four calibration points: 1.413; 5.000; 12.88 and 80.00 mS/cm.

If you choose to use the CTD-Diver in a specific application, you may decide to perform the calibration on 1 or 2 points. This means that the CTD-Diver meets the specifications in that measurement range. The CTD-Diver may deviate somewhat from the specifications outside the calibrated measurement range.

Example: If the CTD-Diver is used in a measurement range of 2-3 mS/cm, perform the user calibration at 1.413 and/or 5.000 mS/cm. The CTD-Diver will consequently be within the specifications for the 1.413 to 5 mS/cm measurement range.

If the user calibration is later carried out at the four calibration points, then the CTD-Diver will once again meet its specifications for the full measurement range.

Note: When the CTD-Diver has not been used for an extended period take the following steps prior to calibration. Program the CTD-Diver with a one-minute sample interval and start the CTD-Diver. Immerse the CTD-Diver in tap water for at least 24 hours.

Important: Prior to each reference measurement and/or calibration, the CTD-Diver must be thoroughly rinsed in demineralized water. After it has been rinsed it may not be touched by bare hands since the reference liquid can easily become contaminated by residual contaminants and/or residual salts left on hands. This invalidates a reference measurement/calibration since the reference has become distorted. This effect is highest at the low conductivity values.

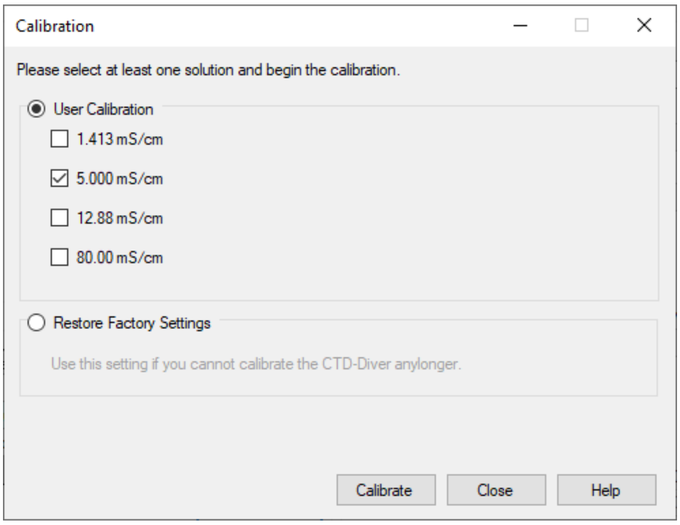
Erroneous or improper calibration can negatively affect the accuracy of the CTD-Diver.

Cleanliness during calibration is especially important. All salt residues adhering to the CTD-Diver will negatively affect the accuracy of the calibration liquid. Therefore, a calibration solution may never be used twice.

Temperature differences, between the conductivity solution and the CTD-Diver, may also cause errors (extended acclimatization is required).

3.9.2 Perform a User Calibration

To calibrate a CTD-Diver, open the Diver-Office software and click the Diver button to open the Diver window. Click the **Calibrate** button located in the **Diver** dialog toolbar. This button is only visible when a CTD-Diver is connected and only enabled when the logging status of the CTD-Diver is stopped. Upon clicking the **Calibrate** button, the following dialog will display.



Select the check boxes next to the calibration solutions that will be used to calibrate the CTD-Diver. Click the Calibrate button to begin calibrating the CTD-Diver.

Next, you will be prompted to immerse the CTD-Diver in the selected solution. Click OK to continue. If you are using multiple solutions, you will be prompted to calibrate from the lowest to the highest concentration.

Diver-Office will then calibrate the CTD-Diver according to the specified solutions. It is important to keep the CTD-Diver connected until the success message appears. If the calibration fails:

- check to make sure you are using the appropriate calibration solution,
- ensure that the CTD-Diver is connected securely to the Reading Unit,
- ensure that the CTD-Diver's sensors are submerged in the solution.

3.9.3 Restore Factory Settings

Select this option to reset the CTD-Diver calibration to its factory settings. This option can be useful if you are experiencing difficulties calibrating the CTD-Diver.

When this option is selected, click the Calibrate button to perform the reset.