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Wetlands and Wetland Restoration

Recommendations of the Wetland Expert Panel for the incorporation of non-tidal wetland best management practices (BMPs) and land uses in the Phase 6 Chesapeake Bay Watershed Model

Chesapeake Bay Program

Science. Restoration. Partnership.

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Prepared for

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Executive Summary

The Wetlands Expert Panel convened in late 2014 to provide recommendations on how natural wetlands and implementation of wetland best management practices (BMPs) should be represented in the Phase 6 Chesapeake Bay Watershed Model (CBWM). Based on their cumulative understanding and best professional judgment of the wetland literature and wetland restoration, including past reports and recommendations presented to the Chesapeake Bay Program (CBP), the following overarching conclusions and recommendations are detailed in this report:

- Wetlands provide significant and unique water quality benefits compared to other land use/land cover classes, specifically by reducing excess nutrients and sediment, and therefore should be considered explicitly in the Phase 6 watershed model.
- Similar to unmanaged forests, undisturbed, natural wetlands are unlikely to generate excess nutrient and sediment loads. Few studies, however, report wetlands as sole contributions because these unique landscape features tend to occur as transition zones between upland and aquatic habitats. As such, the panel recommends that the Phase 6 model set wetland loading rates equal to forest loading rates.
- There is strong evidence that wetlands naturally filter ground- and surface waters but that effectiveness varies widely based on hydrologic connectivity to up-gradient 'contaminant' sources and to down-gradient regional waterways, and on wetland condition. Quantifying wetland water quality benefits, however, remains challenging based on available information. To address this need, the panel proposed a simple framework to predict the potential for different types of natural, undisturbed or restored wetlands to intercept, transform, and reduce excess nutrient and sediment loads, given physiographic setting and position of the wetland in the watershed.

Key findings and considerations in the panel's recommendations include the following:

- The hydrogeologic setting, including geology, topography, land use, and climate conditions, together with position in the watershed influence the hydroperiod (i.e., timing, duration, magnitude, and frequency of saturation as well as the rate of water table change) and the relative importance of ground- and surface-water sources. Resulting hydrologic fluxes control the potential for wetlands to intercept and treat contaminated waters.
- Connectivity to contaminant sources strongly influences water quality benefits. If up-gradient sources are lacking or contaminated waters by-pass a wetland (e.g., through concentrated flow channels or deep groundwater), limited retention and associated water quality benefits will occur.
- In addition to hydrologic fluxes, natural and anthropogenic influences on water quality affect nutrient fluxes and wetland retention capacities. In particular, effects on pH, redox, as well as carbon availability strongly influence N and P transformations in wetlands; human land and water management often artificially influences these environmental controls significantly.

The panel's scientific review is described in Chapter 4 of this report in detail, followed by Chapter 5 that describes the panel's land use and BMP recommendations. In late 2015 the WQGIT accepted the panel's recommendations for including two nontidal wetland land uses in the Phase 6 CBWM: Floodplain and Other. In late 2016 the panel provided its recommendations for the wetland restoration BMP documented in this report. A future expert panel is recommended for a more detailed review of the nutrient and sediment reduction benefits associated with three other wetland BMP categories: wetland creation (establishment), wetland enhancement, and wetland rehabilitation. All four BMP categories are now available for annual BMP progress reporting in the Phase 6 CBWM, but the reductions associated with creation, enhancement and rehabilitation are temporary values agreed to by the Wetland Workgroup. As a result of the panel's work, the Phase 6 CBWM explicitly simulates acres of nontidal wetlands and includes four categories of wetland BMPs that provide a framework for improved tracking and reporting of diverse implementation efforts moving forward.

The panel was formed in coordination with the Wetland Workgroup and Habitat Goal Implementation Team, and followed the procedures and expectations outlined in the Water Quality Goal Implementation Team's (WQGIT's) *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model*[1] or "BMP Protocol."

[1] http://www.chesapeakebay.net/publications/title/bmp_review_protocol

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List of acronyms used in this report

AgWG	Agriculture Workgroup
BMP(s)	Best Management Practice(s)
CBP	Chesapeake Bay Program
CBPO	Chesapeake Bay Program Office
CWP	Center for Watershed Protection
CBWM	Chesapeake Bay Watershed Model
GIT	Goal Implementation Team
HGIT	Habitat Goal Implementation Team
HGM	Hydrogeomorphic
N	Nitrogen
NRCS	Natural Resources Conservation Service (USDA)
NWI	National Wetlands Inventory
P	Phosphorus
SPARROW	SPAtially Referenced Regressions On Watershed Attributes
STAC	Scientific and Technical Advisory Committee (CBP)
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USDA-NRCS	U.S. Department of Agriculture, Natural Resource Conservation Service
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WEP	Wetlands Expert Panel
WIP(s)	Watershed Implementation Plan(s)
WQGIT	Water Quality Goal Implementation Team
WTWG	Watershed Technical Workgroup

Chapter 1. Charge and membership of the expert panel

With the signing of the Chesapeake Watershed Agreement in 2014, Chesapeake Bay Program (CBP) partners committed to the following outcome for wetlands: 85,000 acres of created or reestablished wetlands, and 150,000 additional acres of enhanced wetlands by 2025. Additionally, partners committed to protect 225,000 acres of wetlands under the Protected Lands Outcome that seeks to protect a total of two million acres of valuable lands by 2025, relative to a 2010 base year. The 2014 wetland goals revise a long-standing commitment by Bay partners to wetland restoration, enhancement and preservation as indicated by wetland goals in previous Bay Agreements.

The current Phase 5.3.2 Chesapeake Bay Watershed Model (CBWM) does not recognize the additional water quality benefits that wetlands provide compared to upland forests; nor does the model recognize that wetland function depends on landscape position *and* condition. These issues were first addressed in a 2007 Scientific and Technical Advisory Committee (STAC) workshop (STAC, 2008), that evaluated the nutrient and sediment processing efficiencies of wetlands, but the limited literature search and data used at the time was inadequate to recommend substantive changes to the way wetlands are modeled by the partnership (credited as forest). A STAC workshop held in March 2012 by the Maintaining Healthy Watershed Goal Implementation Team (GIT) included identification and mapping of new land use classes, one of which is “other wetlands” (STAC, 2012). This recommendation in the workshop report also states, “The potential value of identifying additional new land use classes that also demonstrate a greater functional capacity for retaining nutrients and sediments should be evaluated.” A second recommendation from this workshop indicated that loading rates associated with the new land use classes should be estimated based on spatially explicit landscape attributes that include directional connectivity, multi-direction flow fields, and flow path analysis (STAC, 2012).

Given these priority needs, the Habitat Goal Implementation Team’s Wetlands Workgroup recommended that a Wetlands Expert Panel (WEP) be convened to (1) review and make recommendations to refine the existing wetland restoration best management practice (BMP) definitions and load reductions represented in the Phase 5.3.2 Chesapeake Bay Watershed Model (CBWM), and; (2) make recommendations to define wetlands as a separate land use classification as part of the CBWM Phase 6.0 update, applicable to all land uses. The panel, which convened in Fall 2014, operates under the Scope of Work described below in addition to the Water Quality Goal Implementation Team’s *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model*. Appendix F summarizes locations in the report where elements of the BMP Protocol and Scope of Work are addressed.

- Wetland Restoration BMP: The expert panel will review the current wetland restoration BMP definition and efficiencies in the model and evaluate recent research on nitrogen, phosphorus, and sediment retention rates of wetlands to determine how they may be improved and/or refined. For example, the expert panel will review all new science and research regarding wetland enhancement and rehabilitation that has been performed since the 2007 STAC wetlands workshop. The panel will determine whether the science supports development of wetland enhancement/rehabilitation BMP efficiencies for nitrogen, phosphorus, and sediment retention; if so, the panel will provide recommendations for the appropriate efficiencies for wetland enhancement/rehabilitation as a BMP.

- Review the current CBWM assumptions to simulate the impact of wetland restoration BMPs to agricultural land uses and recommend how practice(s) should be represented in the CBWM version 5.3.2 and make recommendations for Phase 6.
- Provide a definition, describe the geographic boundary, and determine any qualifying conditions needed prior to receiving nutrient and/or sediment pollutant load reductions.
- Define the proper units that local governments will report practice implementation to the State to incorporate into the CBWM.
- Recommend procedures for reporting, tracking and verifying any recommended wetland upgrade credits over time.
- Critically analyze any unintended consequence associated with the credit and any potential for double or over-counting of the credit

In addition to review of the wetland BMP, the expert panel was asked to evaluate and make recommendations for including wetlands as a land use classification in the Phase 6 CBWM update. This assessment was limited to determine: 1) if there is sufficient evidence to support a wetland land use different from the forested land use based on loading rates in the CBWM; and 2) what categories for wetland land uses could be supported by the literature (e.g., floodplain, emergent, high marsh, low marsh, tidal, etc.). Currently, the loading rate for wetlands is the same as the forest land use in the CBWM. The panel was tasked to seek guidance from the Land Use Workgroup, Watershed Technical Workgroup, Agricultural Workgroup, and other Chesapeake Bay partners, as needed, in its assessment of the data. The panel was instructed to provide these recommendations to the Chesapeake Bay Program Office's (CBPO) Water Quality GIT for inclusion in the 2017 midpoint assessment of the modeling tools.

The panel members and other participants engaged during the panel's deliberation are outlined in Table 1 below. The panel was facilitated by the Center for Watershed Protection (CWP) from its launch until February 2015 and was transitioned to Virginia Tech for the remainder of their work beginning in May 2015. The panel wishes to acknowledge Neely Law and the CWP for the extensive groundwork they provided to the panel and their continued willingness to provide input after they were no longer coordinating the panel. Tetra Tech provided contractual support to the panel, primarily in the form of literature reviews described in this report, as well as assistance in preparation of the report documentation.

Table 1. Wetlands Expert Panel membership and other participants.

Name	Role (post-CWP)	Organization
Erin McLaughlin	Panel member	Maryland Department of Natural Resources (MD DNR), Wetland Work Group Co-Chair
Steve Strano	Panel member	Natural Resource Conservation Service (NRCS)
Judy Denver	Panel member	U.S. Geological Survey (USGS)
Ken Staver	Panel member	Wye Research and Education Center
Kathy Boomer	Panel member	The Nature Conservancy
Pam Mason	Co-Chair	Virginia Institute of Marine Science
Dave Davis	Panel member	Virginia Department of Environmental Quality (VA DEQ)
Jeff Hartranft	Panel member	Pennsylvania Department of Environmental Protection (PA DEP)
Ralph Spagnolo	Co-Chair	U.S. Environmental Protection Agency (USEPA) Region 3
Jeff Thompson	Panel member	Maryland Department of Environment (MDE)
Tom Uybarreta	Panel member	USEPA Region 3
Quentin Stubbs	Panel member	USGS, CBPO
Rob Brooks	Panel member	Pennsylvania State University
Dr. Jarrod Miller	Panel member	University of Maryland (UMD) Extension
Michelle Henicheck	Panel member	VA DEQ
Denise Clearwater	Panel member	MDE
Panel support		
Jeremy Hanson	Panel Coordinator	Virginia Tech, CBPO
Jennifer Greiner	HGIT Coordinator	US Fish and Wildlife Service (USFWS), CBPO
Hannah Martin	Support	Chesapeake Research Consortium (CRC), CBPO
Kyle Runion	Support	CRC, CBPO
Aileen Molloy	Support	Tetra Tech
Jeff Sweeney	CBPO Modeling and WTWG rep	USEPA CBPO
David Wood	CBPO Modeling rep	CRC, CBPO
Peter Claggett	GIS Support	USGS, CBPO
Brian Benham	VA Tech Project Director	Virginia Tech
Additional panel guest participants: Ken Murin (PA DEP), Kristen Saacke-Blunk (Chesapeake Bay Agricultural Workgroup former Co-Chair), Anne Wakeford (West Virginia Department of Natural Resources) Previous participants who contributed previously and are no longer active (post-CWP): Brian Needelman (UMD), Tom Jordan (Smithsonian Environmental Research Center), and Robert Kratochvil (UMD) Other individuals the panel wishes to acknowledge for providing valuable input or services to the panel: Neely Law (Center for Watershed Protection), Bill Stack (Center for Watershed Protection),		

The panel met 21 times over the course of more than 24 months, including two face-to-face meetings in the Annapolis area.

Additional context for the expert panel

Wetland restoration is an important BMP within the state Watershed Implementation Plans (WIPs), which call for approximately 83,000 acres of implementation within the Bay watershed. The Chesapeake Bay Program currently defines the Phase 5.3.2 agricultural wetland restoration best management practice (BMP) as:

Reestablishment (restore)—Manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former wetland. Results in a gain in wetland acres.

Establishment (create)—Manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist on an upland or deepwater site.

Results in a gain in wetland acres.

The literature search for this practice focuses only the water quality benefits that restored and natural wetlands provide and literature on the wildlife and mitigation wetlands are not considered.

A more broad-based definition is provided by the CBPO when wetland area or drainage area is unreported:

Agricultural wetland restoration activities reestablish the natural hydraulic condition in a field that existed before the installation of subsurface or surface drainage. Projects can include restoration, creation and enhancement acreage. Restored wetlands can be any wetland classification including forested, scrub-shrub or emergent marsh.

There are other issues related to landuse/landcover in the Bay and watershed models that complicate credit for wetlands. Currently in the Phase 5.3.2 CBWM, wetlands are simulated the same as forests, meaning the Phase 5 “forest” land use includes both wetland and upland forest areas. Many suggest that the enhanced denitrification potential from saturated wetland soils support an approach wherein the wetland land use receives a higher credit compared to the forested land use.

Literature Cited

STAC (Scientific and Technical Advisory Committee). 2008. *Quantifying the Role of Wetlands in Achieving Nutrient and Sediment Reductions in Chesapeake Bay*. Publication 08-006. Annapolis, MD.

STAC. 2012. The role of natural landscape features in the fate and transport of nutrients and sediment. STAC Report 12-04. Edgewater, MD. http://www.chesapeake.org/pubs/293_2012.pdf

Chapter 2. Definitions of terms used in the report

There are many terms associated with wetlands that often have specific technical, scientific or regulatory meanings. To reduce confusion it must be emphasized that this panel report and any unique definitions described herein apply in contexts relevant to the Chesapeake Bay Program and associated efforts of its partners, e.g., as related to tracking/reporting purposes for annual BMP progress reporting toward Chesapeake Bay Total Maximum Daily Load (TMDL) targets. This section is not a comprehensive glossary, as many terms and concepts (e.g., hydric soils, wetland hydrology, etc.) are used in this report in a context generally consistent with widely accepted or established definitions (i.e., national guidance or manuals from the USACE, USEPA, USFWS, USDA-NRCS or other government or academic entities). A glossary is provided for the reader as Appendix E. Definitions provided in this section are only applicable to this report and its subsequent incorporation with the Chesapeake Bay Program partnership modeling tools and other partnership efforts to track progress toward outcomes and targets under the Watershed Agreement or the Chesapeake Bay TMDL.

Effectiveness estimate refers to the estimated pollutant reduction for a BMP as defined by an expert panel or the Chesapeake Bay Program partnership. The reduction for a BMP is often described as a percent (%) reduction that is applied to specific land use(s) or source of loads in the CBP partnership modeling tools; when expressed as a percent reduction, the effectiveness estimate is often referred to as an **efficiency**. An effectiveness estimate can also be defined in other ways, such as an absolute load reduction (e.g., in pounds (lbs) or pounds per unit area of the given pollutant).

Existing wetlands or **natural wetlands**. For the purposes of this report these terms are used to refer to wetlands that are currently present as wetlands in the landscape or were present in land use data used for calibration of the Phase 6 CBWM.

Former wetland or **historic wetland**. For purposes of this report, a former wetland is a site where available evidence suggests that a functional wetland previously existed. Examples of evidence include, but are not limited to: aerial photographs, prior delineations, historical maps, and forensic soil analysis.

Degraded wetland. The term “degraded” is subjective. Assessment methods can be used to determine whether a particular resource is degraded, based on the chosen threshold(s). Best professional judgment may also be used to identify degraded resources in situations where appropriate assessment methods are not available. For purposes of this report, “degraded wetland” refers to a wetland area that does not meet one or more threshold(s) set by the entity assessing the wetland (likely a state agent). The assessment may not be limited to water quality. Specific thresholds or assessment methods are outside the scope of this panel and will be set based on the applicable local, state or federal guidance or regulations.

There are some BMPs already approved by the CBP partnership that can be confused with wetland practices described by this panel. These other CBP-approved BMPs are not within the purview of this panel’s recommendations as they have already been reviewed and approved by the CBP partnership:

- **Constructed stormwater wetlands or wet ponds** – if engineered and designed for stormwater purposes, should be reported under the existing CBP-approved urban BMP, Wet Ponds and Wetlands. Or, in an agriculture context, constructed wetland structures that treat or capture barnyard runoff as part of a treatment train may be eligible under the future recommendations of the ongoing panel for agriculture stormwater structures.

- **Riparian tree plantings** – follow the definitions and protocols for the riparian forest buffer BMPs. For qualifying projects, the total reduction combines the land use change from the previous land use to forest, and also applies a percent effectiveness value to the upland area.

- **Living shoreline projects** – follow the definitions and protocols for the shoreline management BMP. For qualifying projects, the reduction is calculated based on the four protocols defined by the Shoreline Management panel.

- **Regenerative Stormwater Conveyances** (RSC's) – dry channel RSC projects can be reported using the existing stream restoration BMP (Protocol 4 – Dry Channel RSC as a retrofit). The TN, TP and TSS reductions for Protocol 4 are calculated using the adjustor curves developed by the retrofits BMP panel.

- **Urban Stream restoration** – any natural channel design, regenerative stormwater conveyance (wet-channel), legacy sediment removal or other restoration project that meets the qualifying conditions set by the Stream Restoration Expert Panel (2014). The Stream Restoration Expert Panel defined three protocols that can be used to determine the nutrient and sediment load reduction for a qualifying stream restoration project: Protocol 1 – Prevented Sediment; Protocol 2 – Instream Denitrification, and; Protocol 3 – Floodplain Reconnections. Protocol 3 may be particularly relevant for wetland projects that include connection of the wetland to the waterway creating the opportunity for treatment of water delivered from the upstream watershed via stream flooding. Care must be taken to avoid double counting.

Defining wetland best management practices for the Phase 6 modeling tools

There is a wide range of actions and practices that can be implemented to restore, create, enhance or rehabilitate wetlands in the Chesapeake Bay watershed. The Wetlands Expert Panel was asked to define BMPs for the Phase 6 Chesapeake Bay Watershed Model that the jurisdictions will then be able to report in their annual progress run submissions. The panel discussed various wetland practices and categories of practices to develop a scheme that allows for a relatively simple approach to report and credit wetland BMPs in Phase 6. After much discussion it is clear that there will always be some ambiguous projects that may be labeled as different things by different practitioners, so the panel strove to provide guidance that will allow the jurisdictions and CBP to better understand when a project should be reported as restoration-reestablishment, creation, enhancement, or rehabilitation for CBP purposes (Table 2). While it is impossible for the panel to pre-emptively clarify every ambiguous project that may arise in the future, the panel's recommendations will hopefully reduce confusion and simplify the reporting process.

Restoration of floodplain wetlands may be eligible for BMP credit under the CBP-approved protocols for Stream Restoration.[2] The reporting entity should work closely with their jurisdictional agency to consider other crediting protocols in conjunction with the recommendation from this panel. It is possible that crediting protocols from the wetland expert panel recommendations are combined with other crediting protocols to account for reductions from floodplain restorations. However, a specific area and management action reported for credit under one BMP should not be reported a second time under a different BMP. Careful consideration of the protocols to avoid double counting reduction estimates is the responsibility of jurisdictional and reporting entities. The statements and procedures outlined in this Expert Panel Report are intended to supplement existing jurisdictional requirements. Nothing in the Expert Panel Report shall affect jurisdictional regulatory and other legal requirements.

Table 2 is a guide to the four categories of wetland BMPs considered by the Wetlands Expert Panel for incorporation into the Chesapeake Bay Program (CBP) partnership's Phase 6 Chesapeake Bay Watershed Model (CBWM) for annual progress runs. The table also provides information as to how each category will be tracked towards Watershed Agreement outcomes in addition to the annual progress runs for TMDL purposes. **The examples in the right-hand column are not intended to be comprehensive – nor limiting or restrictive – as some projects or practices could count under a different category depending on the design, site location, or other specific factors of the project. The table is intended to help clarify how a type of practice is most likely to be categorized under the Panel's Phase 6 BMP definitions.** The categories in Table 2 are not presented in any particular order or hierarchy.

Table 2. Proposed categories for wetland BMPs on agricultural land in the Chesapeake Bay Program's Phase 6 Chesapeake Bay Watershed Model.

Proposed BMP Category	**Proposed CBP Definition (for Phase 6 CBWM)**	**CBP will count the BMP acres as…**	**Practice and Project Examples**
Restoration	Re-establish The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former wetland.	Acreage gain *(toward Watershed Agreement outcome of 85,000 acre wetland gain <u>and</u> in Phase 6 annual progress runs)*	Restore hydrology to prior-converted agricultural land (cropland or pasture); elevate subsided marsh and re-vegetate; ditch plugging on cropland; Legacy Sediment Removal NRCS Practice 657
Creation	Establish (or Create) The manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist at a site.	Acreage gain *(toward Watershed Agreement outcome of 85,000 acre wetland gain <u>and</u> in Phase 6 progress runs)*	Modifications to shallow waters or uplands to create new wetlands. Placement of fill material or excavation of upland to establish proper elevations for wetlands; Hydrologic measures such as impoundment, water diversion

[2] I.e., floodplain reconnection, legacy sediment removal, and other types of restoration projects that interact with the stream channel (e.g., wetland bench/active floodplain, Rosgen, Natural Channel Design)

Proposed BMP Category	Proposed CBP Definition (for Phase 6 CBWM)	CBP will count the BMP acres as...	Practice and Project Examples
			and/or excavation of upland to establish nontidal wetlands NRCS Practice 658
Enhancement	Enhance The manipulation of the physical, chemical, or biological characteristics of a wetland to heighten, intensify, or improve a specific function(s).	Function gain *(toward 150,000 acre outcome* *and* *Phase 6 annual progress runs)*	Flood seasonal wetland for waterfowl benefit; regulate flow velocity for increased nutrient uptake; NRCS Practice 659
Rehabilitation	Rehabilitate The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions to a degraded wetland.	Function gain *(toward 150,000 acre outcome* *and* *Phase 6 annual progress runs)*	Restore flow to degraded wetland; ditch plugging in a forested wetland area; moist soil management*; invasive species removal; floodplain reconnection; re-establishing needed vegetation on cropland with wetland hydrology; native wetland meadow planting; May include some NRCS Code 657 practices. *Moist soil management should only be counted if there are predominantly native wetland plants; and site can sustain itself as wetland without active management, meaning whether water control structure is operated or not.

There are other wetland activities that occur in the watershed to preserve wetlands, or for regulatory purposes of compensatory mitigation. These types of activities are wholly outside the scope of this expert panel and are not reported for annual progress submissions toward TMDL targets. The types of voluntary restoration, creation, or enhancement of wetlands as summarized in Table 2 should not be confused with wetland preservation or regulatory wetland mitigation. For clarification purposes to benefit the reader, Table 3 provides basic descriptions of these activities. Wetland preservation may not be a BMP for purposes of annual progress reporting, but it is still a vital activity that is part of the protection goal in the 2014 Chesapeake Bay Watershed Agreement. Compensatory wetland mitigation is tracked by state and federal agencies, but is not part of annual tracking and reporting toward TMDL progress or Watershed Agreement outcomes. All regulatory and voluntary actions are important for protecting wetland resources in the region.

Table 3. Descriptions of wetland activities that are not counted towards TMDL progress.

Activity	Basic description	CBP will count the BMP acres as...	Examples, if applicable
Preservation	Protect (or Preserve) Acquisition of land or easements of at least 30 years' duration	Neither acreage nor function *(will track toward protection goal)*	Non-mitigation acquisitions; easements of 30+ years duration
Compensatory mitigation	Not applicable for CBP Watershed Agreement and Chesapeake Bay TMDL purposes. 33CFR Part 332 (2008) defines compensatory mitigation as "the restoration (re-establishment or rehabilitation), establishment (creation), enhancement, and/or in certain circumstances preservation of aquatic resources for the purposes of offsetting unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved."	Not applicable for CBP purposes. Compensatory mitigation projects are not reportable or creditable for Chesapeake Bay TMDL purposes.	Not applicable for CBP purposes

Chapter 3. Background on wetlands and wetland BMPs in the Chesapeake Bay Watershed

The critical role of wetlands in the Chesapeake Bay ecosystem was recognized in the 1987 Chesapeake Bay Agreement, the 1989 Chesapeake Bay Wetlands Policy, Directive 97-2, Wetlands Protection and Restoration Goals, the Chesapeake 2000 Agreement, and the 2014 Chesapeake Watershed Agreement.

Scientific studies of wetland function provide increasingly powerful evidence of the efficiency of wetlands in filtering surface-water runoff and shallow groundwater. In the Chesapeake Bay watershed, the retention of nutrients and sediment by wetlands contributes to ambient and downstream water quality improvements. Wetlands reduce flooding and erosion in nontidal areas by trapping and slowly releasing surface water. In coastal areas, wetlands help buffer the shoreline from damaging erosive forces. Wetlands also provide essential habitat for a wide variety of plant, fish and wildlife species.

While wetlands represent a relatively small portion of the total watershed, they are an essential component of the Chesapeake Bay ecosystem for the reasons stated above. Efforts are underway to more accurately map wetlands throughout the full 64,000 square mile watershed, but it has been estimated there are approximately 900,000 acres of nontidal wetlands in the watershed (Tiner, 1987).[3] Nontidal wetlands represent about 86% of the total wetlands in the Bay region, while tidal wetlands account for approximately another 282,291 acres as of 2010, according to the CBP.[4]

Overview of wetland BMPs currently implemented in the watershed

A wide range of federal, state, local, academic, extension and nonprofit partners are engaged in efforts to restore, enhance and protect wetlands throughout the watershed. These efforts include headwater restorations, stream corridor riparian restoration, and floodplain reconnections. Restoring degraded wetlands is also important to enhancing wetland function. For example, a common wetland restoration practice is returning hydrology to ditched areas that are currently forested. Upon restoration of hydrology and soil saturation, denitrification is expected to increase, thereby functioning as a BMP reducing nitrogen load in the watershed. Since these projects often restore hydrology and possibly the wetland footprint, they are often given the name wetland rehabilitation and occasionally given credit. Common types of projects include floodplain reconnection (through various methods – breaching spoil berms, bringing up the stream bed, grading down the floodplain); and ditch plugs in forested wetlands to restore "natural" groundwater table/reduce the effects of the ditch on the water table, among others.

[3] This is an estimate based on acreage of inland wetlands, excluding freshwater ponds, in Tiner 1987 (Tiner, R.L. 1987. *Mid-Atlantic Wetlands: A Disappearing Natural Treasure*. U.S. Fish and Wildlife Service and U.S. Environmental Protection Agency). Acres of wetlands in the Phase 6 CBWM may be different as it will include National Wetland Inventory (NWI) and other more recent data from the jurisdictions.

[4] http://www.chesapeakebay.net/indicators/indicator/tidal_wetlands_abundance

Under the Phase 5.3.2 definition for the wetland restoration BMP, most of the acres reported in annual progress runs are associated with U.S. Department of Agriculture (USDA)-NRCS cost-share practices. There are many other funding sources and implementing partners, however, and partners continue to improve their data collection efforts to more fully account for all wetland-related BMP implementation in the region. Available implementation data from the jurisdictions' most recent annual BMP progress reports is summarized in Table 4 below. Table 5 summarizes cumulative wetland restoration by state as reported to the CBP from 2010 to 2014.

Table 4. Acres of wetland restoration reported by jurisdictions in annual progress runs.

	1985 Calibration	2009	2010 Progress	2011 Progress	2012 Progress	2013 Progress	2014 Progress	2015 Progress
DE	0	287	439	588	2,694	2,697	2,699	2,717
MD	0	7,716	8,249	8,614	9,037	9,260	9,284	9,729
NY	0	5,214	5,578	6,217	6,217	6,278	6,307	6,320
PA	77	3,002	3,874	3,875	3,875	3,857	3,858	3,985
VA	0	213	213	411	420	420	452	452
WV	0	203	203	203	203	203	208	220
Total	77	16,617	18,538	19,890	22,428	22,715	22,808	23,423

Note: Reported under Phase 5.3.2 definition for the BMP, in acres.
Source: BayTAS Summary BMPs report, February 2016.

Table 5. Restoring wetlands on agricultural lands, cumulative acreage by state (2010-2014).

State	Acres
Maryland	1,568
Pennsylvania	874
Virginia	239
West Virginia	5
New York	1,093
Delaware	2,412

Source: CBP indicators: http://www.chesapeakebay.net/indicators/indicator/restoring_wetlands, Accessed 2/9/2016, last updated 7/8/2015

All data summarized in Table 4 and Table 5 reflect established, rehabilitated, or re-established wetlands on agricultural lands reported to date for BMP credit. These wetlands are considered functional and of benefit since they provide increased wetland habitat, among other services. Although partners report information for wetlands establishment or re-establishment on urban lands, these data are not included in Table 5 because a myriad of project proponents complicates consistent and accurate data collection across the Bay region and some projects (such as urban stormwater ponds) are established for the sole purpose of stormwater capture and are of limited habitat value. Since rehabilitation does not have a credit efficiency assigned in the CBP modeling tools, rehabilitation records included in the above table are incomplete as not all projects have been reported for credit.

Background on the Phase 6 Watershed Model

At the time of this report, the Phase 6 Chesapeake Bay Watershed Model is undergoing development and beta calibrations. The final calibration will occur in 2017. The Water Quality and Sediment Transport Model (aka the estuarine model) will simulate tidal wetlands given the dominance of their direct interactions with the tidal water column over their interactions with runoff from upland areas. Nontidal wetlands will be simulated as two new land uses[5] in the Phase 6 Watershed Model based on the recommendations described in this report (see Chapter 5), which were previously discussed and approved by the CBP partnership in the fall of 2015.

Figure 1 below illustrates how various components of the Phase 5.3.2 modeling structure are related. Though specific aspects of data inputs, Scenario Builder, the Watershed Model, and the Estuarine Model will be updated for Phase 6 based on cumulative partnership feedback and recommendations, the overall structure and data flow will remain similar.

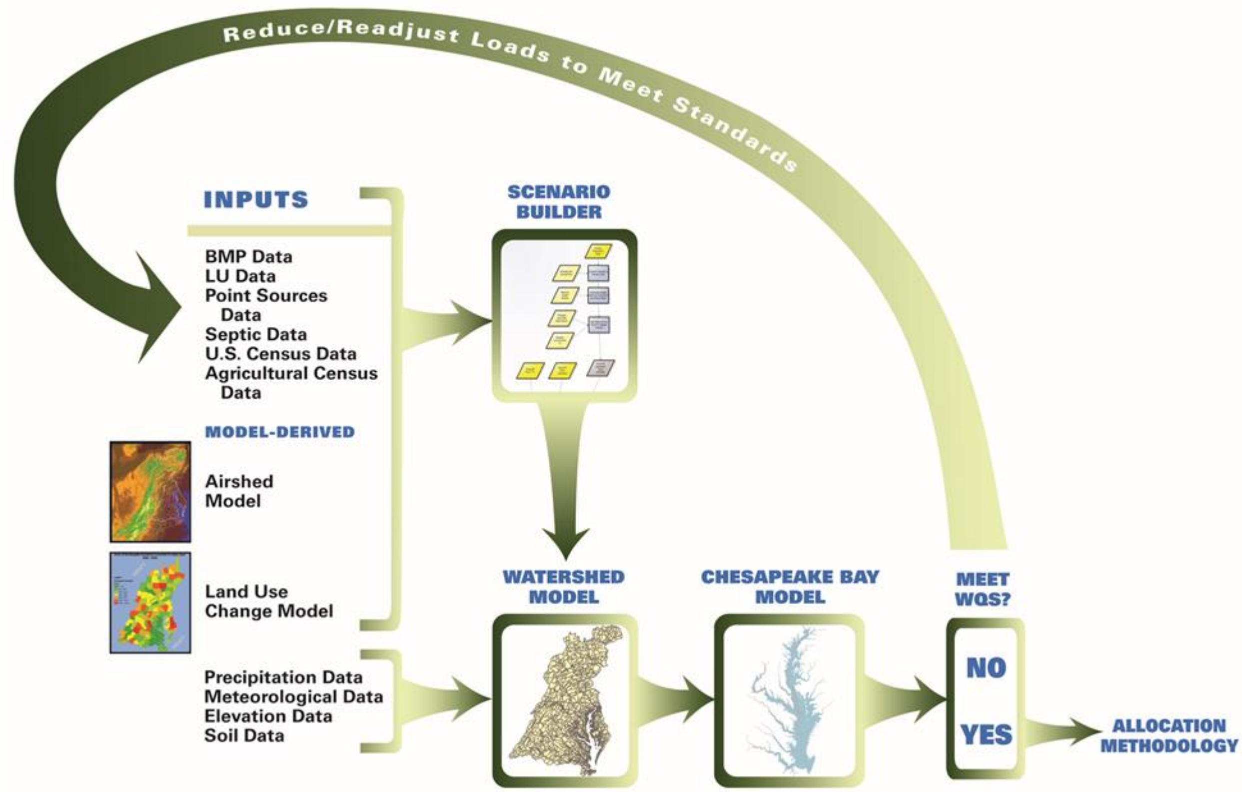


Figure 1. Conceptual diagram of Phase 5.3.2 Watershed Model and related modeling tools.

[5] The two wetland land uses are Nontidal – Floodplain and Nontidal – Other (Non-Floodplain). Or simply, Floodplain and Other.

Chapter 4. Review of available science – Nontidal wetland effects on water quality: an updated landscape perspective

Advancing a conceptual model to explain how wetland water quality and habitat benefits vary across space and time.

Predicting water quality and habitat benefits of wetlands across regional scales requires a systematic understanding of how hydrogeologic factors and watershed position combine to influence wetland form and function (Bedford, 1999). Hydrogeologic frameworks emphasize the importance of climate, surface relief and slope, thickness and permeability of soils, and the geochemical and hydraulic properties of underlying geologic materials (Winter, 1988, 1992). Stream classifications describe systematic changes and hydrologic interactions along the river corridor, from headwater reaches and associated wetlands to delta ecosystems (e.g., Brinson, 1993a; Church, 2002; Rosgen, 1994; Vannote et al., 1980). Hydrogeomorphic (HGM) frameworks combine these conceptual models to describe how wetland hydrodynamics and hydrologically-influenced geochemical variables vary across space and time (Brinson, 1993b; Brooks et al., 2014; Euliss et al., 2004); thus when the HGM framework is presented in the context of a physiographic setting, it provides a compelling basis to capture variability in wetland function and to predict water quality benefits of different wetland types within a region. Accordingly, the panel combined these frameworks to describe how biogeochemical processes affecting transport and delivery of excess nutrients and sediment might vary in wetlands across the Chesapeake Bay watershed. Results build on the work of Lowrance et al. (1997) by emphasizing linkages between wetland function and watershed position, given physiographic setting.

The hydrogeologic setting controls ground- and surface-water interactions and the role of wetlands as nutrient and sediment sinks, sources, and transformers (Winter, 1999). In upland areas, depth to bedrock, soil infiltration capacity, and topographic relief strongly influence the amount of runoff and the rate at which it is delivered to waterways versus infiltration to the shallow groundwater system. Shallow bedrock and steep terrain typical of mountainous ridge and valley regions result in rapid runoff rates, narrow stream/river corridors, and wetlands development primarily in valley bottoms. Steep upland land surfaces can cause erosion and transport of sediment and phosphorus from eroded soils to streams. In contrast, deep, unconsolidated sedimentary deposits across flat terrains, such as those defining much of the Coastal Plain, allow development of broad, expansive wetlands along entire stream networks. The relative influence of surface runoff versus infiltration controls the quantity and rate at which contaminants of concern are delivered to down-gradient wetlands. In addition, the physio-chemical structure of a contaminant strongly influences delivery mechanisms. For example, while phosphorus and sediments are transported primarily through overland processes, nitrogen primarily enters streams in the form of nitrate dissolved in groundwater.

Where productive shallow groundwater systems develop, the potential for wetlands to capture excess nitrate depends on the thickness of the surficial aquifer above a confining layer (e.g., fine-grain, clay stratum, consolidated hardpan, or capstone bedrock) and the resulting hydrologic connectivity with wetland soils. This stratigraphy determines the potential for nitrate-enriched groundwater to flow through reduced, organic-rich wetland sediments ideal for denitrification or to bypass these reactive zones (Hill et al., 2004; Vidon and Hill, 2004a, 2006). Phosphorus retention depends on physical factors affecting erosion and deposition as well as hydrochemical conditions affecting phosphorus chemistry. Flat open areas typical of valley bottoms and bottom lands slow flow velocities and allow sedimentation. Steep relief enhances erosion and transport of sediment and phosphorus to streams, especially where sandy loam soils occur.

Consideration of watershed position can further expand the basis for evaluating how wetland function varies across space and time (Brinson, 1993a). Stream classifications describe variation in hydrobiological function in positions along a stream network, recognizing systematic changes as headwater streams converge ultimately to form large-order rivers (e.g., Brinson, 1993a; Church, 2002; Rosgen, 1994; Vannote et al., 1980). Most describe the 'riverine landscape' to include the open water channel zone, headwater wetlands, and adjacent riparian or floodplain zones. In less disturbed systems, the relative importance of overland flow, groundwater contributions, and surface water inundation changes systematically along this up-stream to downstream continuum:

- Upland areas include the majority of a watershed and are defined as where stream channels connect directly to hillslopes and where sediment mobilized on upland slopes moves directly into the stream channel at the slope base (Church, 2002). In these areas, headwater wetlands, including many depressional, sloping, and riparian wetlands, provide important nutrient, sediment and carbon sinks (Church, 2002; Cohen et al., 2016). Uplands are groundwater recharge areas where soils and surficial sediments are permeable.
- Upland valley regions refer to portions of the stream network that function primarily as transfer zones (Church, 2002). These low-order streams tend to have the greatest capacity to transport sediments downstream (i.e., stream power; Bagnold, 1966) and have limited in-stream biota (Church, 2002). These reaches also have the greatest frequency of adjacent sloping wetlands where advective groundwater flow controls water table position and the delivery of nutrients (Devito et al., 1999).
- The main valley forming the "backbone" of the drainage system accumulates alluvial materials along the channel and within adjacent floodplains due to much lower gradients (Church, 2002). Here, "sediment recruitment and onward transfer become purely consequences of erosion of the streambed and banks", with the former dominating further upstream and depositional processes becoming increasingly important downstream toward the distal end of stream networks (Church, 2002).

Combining the underlying principles of hydrogeology and stream classification, Brooks et al. (2011) refined a hydrogeomorphic (HGM) classification of wetlands (Brinson, 1993b) for the

Mid-Atlantic Region (MAR), including the entire Chesapeake Bay watershed. The model broadly includes flats, depressions, and slope wetlands; lacustrine fringe, riverine floodplains, and tidal and nontidal fringe wetlands. Importantly, the authors recognized distinct patterns in the distribution and hydrologic characteristics of wetlands across major physiographic provinces of the region (e.g., Ator et al., 2005; Cole and Brooks, 2000), including the Appalachian Plateau, Appalachian Ridge and Valley, Piedmont and Coastal Plain (see Figure 2). Each of the major wetland classes described below can occur in the different physiographic provinces, but the distribution and predominant geochemical controls vary across that space. Wetlands are most common in the relatively flat Coastal Plain followed by the Piedmont, and occur less frequently in the other physiographic provinces (See Box 1, Table 6). While information presented herein provides a generalized framework to better account for wetland water quality functions within a TMDL framework, it is critical to recognize that the water quality services provided by an individual wetland strongly depends on hydrologic connectivity with sources of excess nutrients and sediment.

Flats develop where a combination of flat topography and slow infiltration results in precipitation accumulation at the surface. Accordingly, seasonal water tables and short-term weather patterns including evapotranspiration, primarily influence water table dynamics. In the Chesapeake Bay watershed, flats tend to occur on Coastal Plain interfluves (higher ground between two watercourses in the same drainage system) (Brinson, 1993b). They are particularly common along the central topographic high of the Delmarva Peninsula between the Chesapeake Bay watershed and the Delaware Bay and Atlantic Ocean drainages in the poorly drained soils of the Outer Coastal Plain. While flats sustain denitrifying conditions, these wetland sediments often do not intercept nitrate-enriched groundwater (Denver et al., 2014) or capture large quantities of surface overland flow because of their location along watershed drainage divides and small contributing areas. However, interception may occur where drainages drop down into flats at lower topographical positions within the watershed.

Depressional wetlands occur in topographic hollows and are controlled mainly by precipitation runoff, evapotranspiration, and also local interflow. Typically, these small wetlands lack surface water inlets or outlets. They form in areas up-gradient of headwater reaches and thus can provide important areas of focused groundwater recharge. The small contributing areas often limit external supply of nutrients (Craft and Casey, 2000), however, because of their high ratio of perimeter to surface area and their frequent distribution across the landscape, depressional wetlands initially intercept surface runoff, thus providing important deposition areas (Cohen et al., 2016). Where these wetlands are located in agricultural fields, they can intercept and denitrify nitrate in or potentially entering groundwater (Denver et al, 2014). Areas with prior-converted cropland and hydric soils that are former depressional wetlands also can be areas of denitrification when soils are saturated. Further, low surface connectivity reduces exports to mitigate impacts on downstream waters, and retention rates are relatively high (Craft and Casey, 2000). Low pH (4 to 5.5) due to the predominant influence of precipitation, limits production and decomposition especially during wet seasons. Within the Chesapeake Bay watershed, depressional wetlands include the Delmarva Bays of the Outer Coastal Plain and ridge top wetlands of the Appalachian Ridge and Valley.

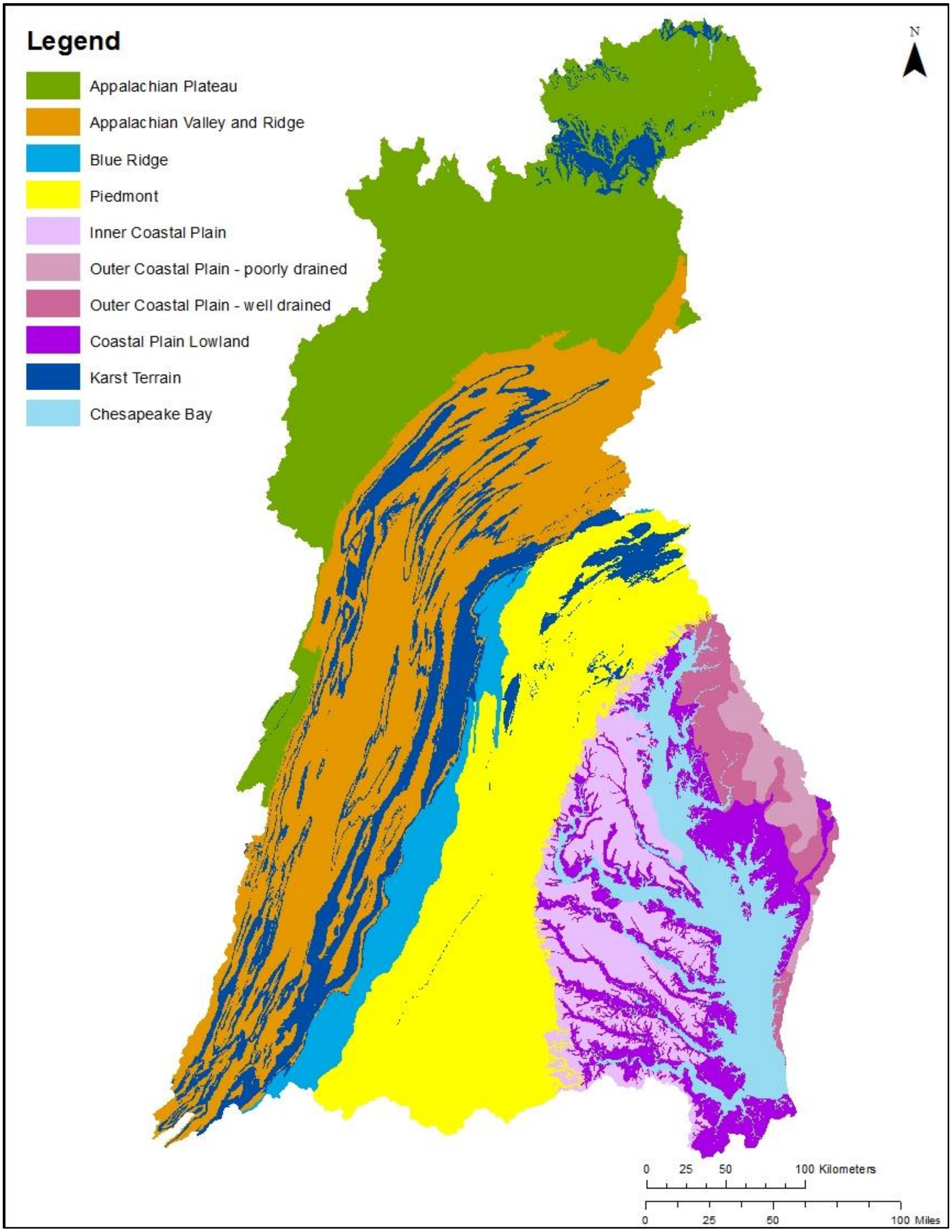


Figure 2. Physiographic settings in the Chesapeake Bay Watershed.

Map generated by Quentin Stubbs, USGS. Modified from Brakebill and Kelley (2000).

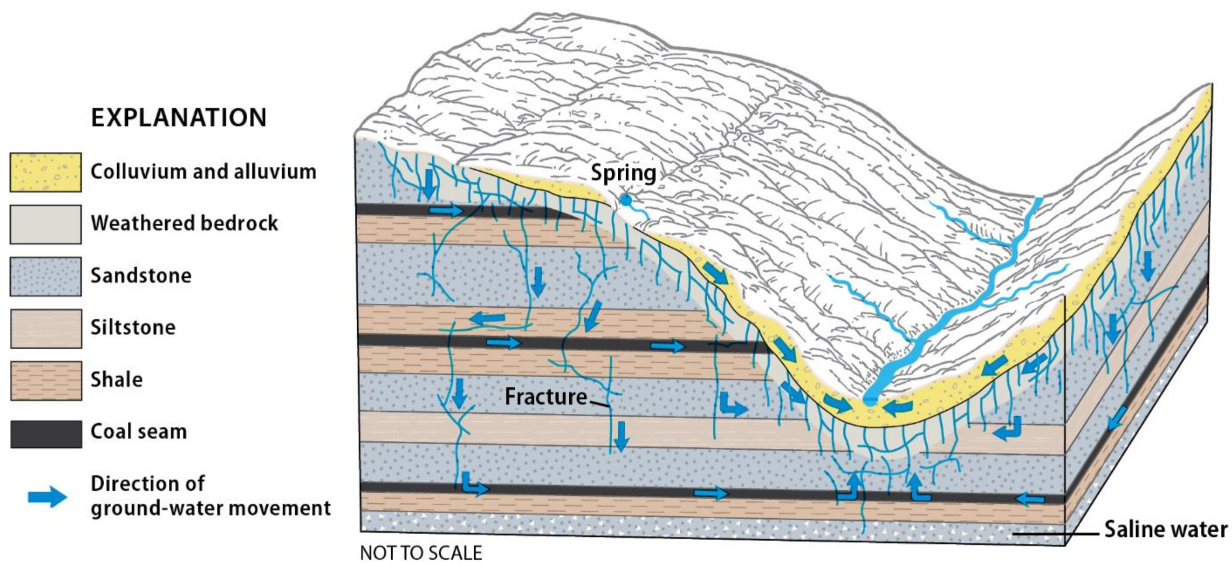
Sloping wetlands, including riparian corridors, often occur in association with headwater reaches where geologic discontinuities or breaks in topographic slope result in groundwater discharge to the land surface. As a result, the water table remains near the land surface (within 10 cm), and the plant rooting zone effectively is permanently saturated (Almendinger and Leete, 1998). Groundwater flow tends to occur in one direction, in relation to topographic gradients. Although saturated conditions retard decomposition and often result in the development of organic-rich peat soils, supplies of oxic, nitrate-rich groundwater and generally neutral pH create biogeochemically active areas especially conducive to removing excess nitrogen (Gu et al., 2008; Hill and Cardaci, 2004; Schipper et al., 1993; Vidon and Hill, 2004b). These wetlands have the highest reported denitrification rates, although sub-oxic conditions also can enhance phosphorus availability and exacerbate downstream eutrophication, especially where human impacts have altered water chemistry (Boomer and Bedford, 2008; Dupas et al., 2015; Lucassen et al., 2004; Smolders et al., 2010; Verhoeven et al., 2008). Where surficial aquifer thickness is significantly greater than the depth of associated anoxic wetland sediments, contaminated groundwater can bypass sloping wetlands and limit natural filter treatment (Bohlke and Denver, 1995; Puckett, 2004; Tesoriero et al., 2009).

Riverine floodplains occur adjacent to waterways where overbank storm flow provides the dominant water source (Brinson, 1993b). These surface-water driven systems generally have more variable water level fluctuations related to season and storm events compared to other wetland types, and also greater external supplies of nutrients. As a result nutrient availability, primary production, and decomposition rates are higher, especially where forested wetlands establish stabilizing root systems. In addition, groundwater inflows from the local contributing area sustain water quality functions similar to sloping wetlands.

The Importance of Physiographic Setting

The form and distribution of wetlands strongly depend on climate and physiographic setting. Defining characteristics including topographic relief and geology strongly influence the relative importance of runoff vs infiltration, where near-surface groundwater and surface water interactions support wetland development, and also land use history. Together, these factors influence the distribution of different wetland types and the potential delivery of excess nutrients and sediment to these wetland systems. The Chesapeake Bay watershed can be divided into five major physiographic regions with additional sub-classes to summarize key characteristics that predominantly influence the form and function of wetlands throughout each sub-region (see Figure 2). For purposes of this report nine physiographic settings are discussed; these nine areas are cross-referenced in Appendix C (Table C3) with the Phase 6 CBWM HGMRs. The distribution of wetlands varies widely across these physiographic regions.

The Appalachian Plateau extends across the most remote areas from the Bay, including the New York portion of the Bay watershed, across more than half of western Pennsylvania, and through the westernmost areas of Maryland and Virginia. The region is characterized by overlaying, consolidated sandstone mudrock and carbonate sedimentary rocks that are flat-lying to gently folded, but highly fractured, especially in more weathered units closer to the land surface (Figure 3; modified from Trappe Jr. and Horn, 1997). In the unglaciated subregions which includes much of the Appalachian Plateau in the Bay watershed, the region includes highly dissected waterways with adjacent slopes covered by thin accumulations of regolith; therefore, most precipitation runs to streams and only a small portion infiltrates to the groundwater system (Trappe Jr. and Horn, 1997). About 5% of the land area is wetlands, most of which are in floodplains in wide valleys and topographic lows formed upstream of erosion resistant bedrock stream contacts (Figure 4; modified from Fretwell et al., 1996). Depression and sloping wetlands also occur where permeable, water-bearing strata outcrop dissected valley walls to sustain groundwater fed springs (Figure 4; modified from Fretwell et al., 1996). In the glaciated regions of northern Pennsylvania and New York, depressional wetlands occur in association with glacial moraine deposits (Fretwell et al., 1996). The average dissolved solids concentration is 230 milligrams per liter with a median pH of 7.3. Contaminated waters, notably from coal mining, generally are acidified and have higher concentrations of iron, manganese, sulfate, and dissolved solids, all of which can strongly influence nutrient biogeochemistry. Limited development and agriculture in the region reduces the risk of contamination by excess nutrients and sediment.



Modified from Harlow, G.E., Jr., and LeCain, G.D., 1993, Hydraulic characteristics of, and ground-water flow in, coal-bearing rocks of southwestern Virginia: U.S. Geological Survey Water-Supply Paper 2388, 36 p.

Figure 3. Topography and shallow fracture systems determine groundwater movement in the aquifers of the Appalachian Plateaus. Water infiltrates weathered bedrock and moves mostly through near-surface fractures; some water moves in a steplike fashion vertically along deeper fractures and horizontally through fractured sandstone or coal beds. Because of the absence of deep groundwater circulation and regional flow systems, saline water is at shallow depths. Glacial deposits present in northern parts of the CB Watershed (northern Pennsylvania and New York) are not depicted.
Modified from Trappe Jr. and Horn, 1997.

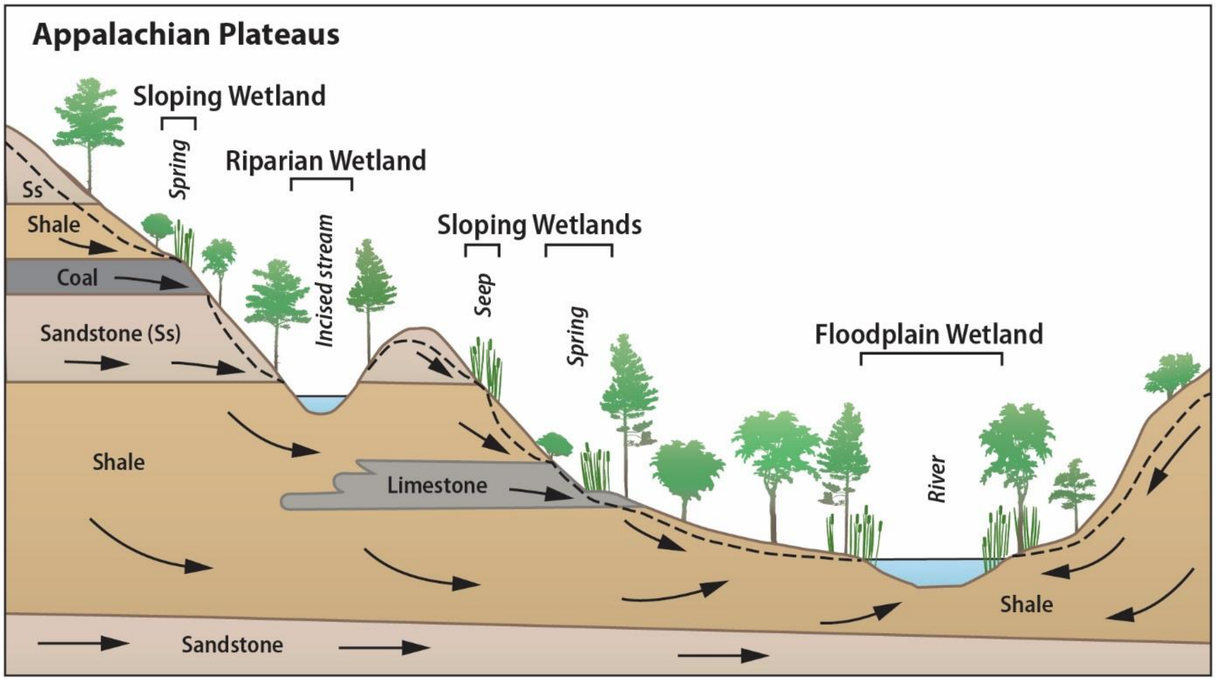


Figure 4. Depiction of sloping, floodplain, and riparian wetlands across the Appalachian Plateau. Depressional wetlands, while not depicted in this conceptual diagram, can occur in this landscape, especially where glacial moraine deposits exist.
Modified from Fretwell et al., 1996.

The **Appalachian Ridge and Valley** province is defined by alternating, distinctly linear valleys and ridges that trend southwest from northern New Jersey to northern Georgia and Alabama. This includes areas of central Pennsylvania, Maryland and Virginia in the Chesapeake Bay region. Similar to the Appalachian Plateau, bedrock consists mostly of sandstone, shale, and carbonate, with some locally important coal-bearing units (Trappe Jr. and Horn, 1997). The stratum underlying the region’s distinct topography, however, are highly deformed and folded and also more fractured (Trappe Jr. and Horn, 1997). In addition to the steep terrain, valley floor bottoms tend to have deeper accumulations of regolith. Groundwater generally flows through ever-larger, subsurface conduits, until discharging at springs (Figure 5, modified from Trappe Jr. and Horn, 1997). Three types of springs occur within the region (Trappe Jr. and Horn, 1997), including 1) contact springs where a water-bearing unit and underlying aquitard emerge at the land surface; 2) impermeable rock springs fed by fractures, joints or bedding planes in rocks; and 3) tubular springs that from where solution channels emerge. The latter are common in carbonate-rich, karst regions, described below in more detail. Wetlands cover less than 3% of the land in this region. Water chemistry also is similar to resources across the Appalachian Plateau, although more variable and slightly more dilute: the average dissolved-solids concentration is 115 mg/L and median pH is 7.4. Contaminated sources of water are generally from mining in the ridge areas; in the valleys, especially in areas underlain by carbonate rocks (see karst section), high nitrate concentrations from agricultural sources are common.

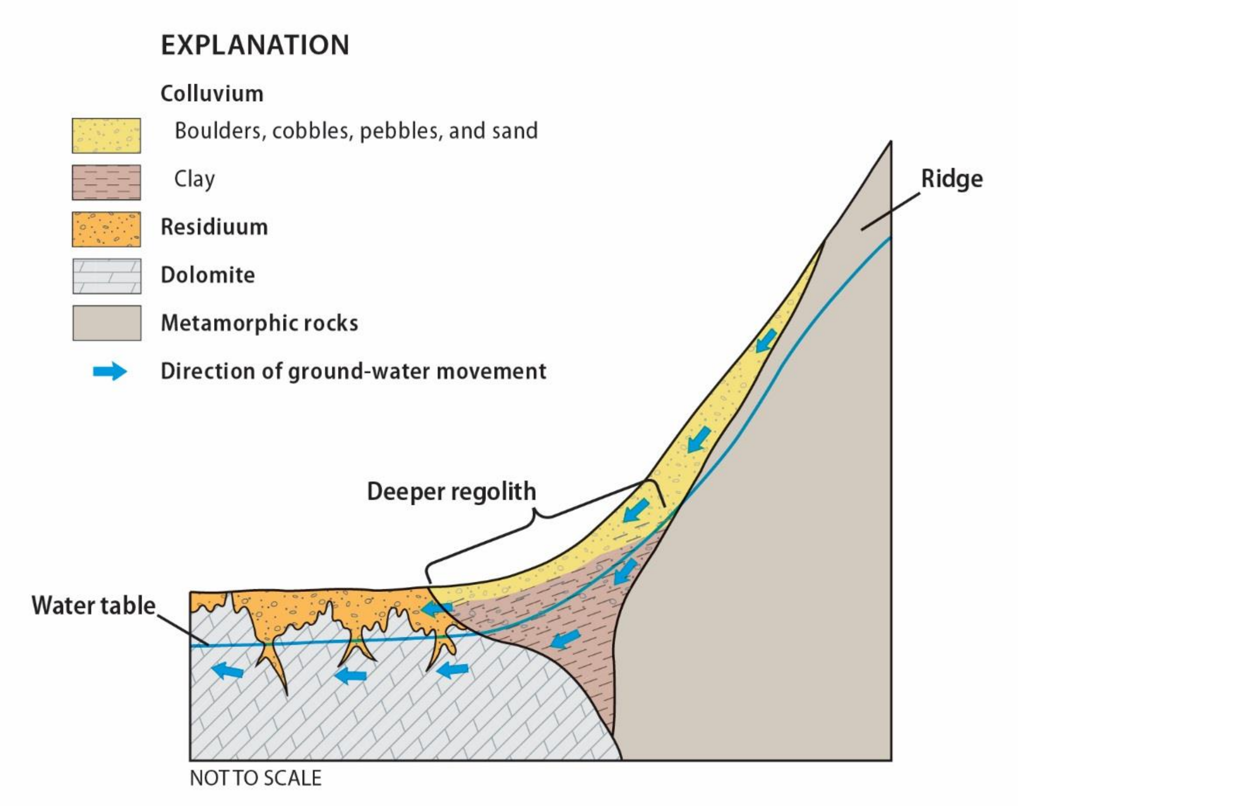


Figure 5. Thick wedges of colluvium on the lower flanks of ridges store large quantities of water that subsequently move into aquifers in the valleys. The colluvium commonly contains perched bodies of groundwater that are separated from the main water table by clay confining units.
Trappe Jr. and Horn, 1997, Modified from Nutter, L.J., 1974a, Hydrogeology of Antietam Creek Basin: U.S. Geological Survey Journal of Research, v. 2, p. †249-252.

The **Blue Ridge Province** is characterized by its surrounding steep, mountainous slopes and numerous streams that feed into a broad valley with heavy rolling terrain, and deeply incised, fast flowing streams (Trappe Jr. and Horn, 1997). Underlying bedrock consists of highly faulted, folded, and fractured crystalline and siliciclastic bedrock (Denver et al., 2010). As a result, the groundwater system is unique to the sedimentary aquifers typical of other physiographic provinces in the region (LeGrand, 1988). Deep groundwater moves mainly through bedrock fractures. A mix of unconsolidated materials, which varies greatly in thickness, composition, and grain size, lays over top, resulting in highly variable hydraulic properties. The regolith is more permeable than the bedrock (Trappe Jr. and Horn, 1997), and groundwater flow generally is constrained to the unconfined aquifer. Flowpaths are relatively short, from recharge areas in uplands to local streams and springs; baseflow contributes more than 50% of annual stream discharge (Denver et al., 2010). Wetlands occupy less than 1% of the region.

The **Piedmont** has similar geology to the adjacent Blue Ridge Province, but is distinguished by its low, gently rolling hills and moderate relief. To the east, the Fall Line demarcates where deeply weathered igneous and metamorphic rocks often exposed in the Piedmont are covered by unconsolidated sediments characteristic of the Coastal Plain. With its hilly terrain and shallow upland soils (less than 1 m thick) with slow infiltration rates, the Piedmont is predominantly an erosive environment (Markewich et al., 1990). Groundwater occurs in unconfined conditions, in the bedrock fractures or in the overlying mantle of weathered regolith (Johnston, 1964). For more than 200 years, extensive forest clearing, agriculture, and milling operations have contributed significantly to the naturally deep valley floor deposits (Lowrance et al., 1997; Walter and Merritts, 2008). As a result of natural and anthropogenic processes, the river-scape is entrenched or channelized through legacy sediments more than other regions in the Chesapeake Bay watershed (Donovan et al., 2015). Baseflow supplied by the unconfined aquifer ranges between 50 and 75% of watershed discharge (Lowrance et al., 1997). Wetlands typically are small and spring-fed, associated with slope changes in riparian or bedrock fracture zones (Fretwell et al., 1996). Where connected and functioning, floodplain wetlands also provide significant nutrient and sediment trapping capacities (Schenk et al., 2013, Hupp et al., 2013). Overall, wetlands cover about 4% of the land area. Dissolved solids concentrations in natural waters of the Piedmont average 120 mg/L with a median pH of 6.7.

Carbonate deposits (karst terrain) in the Appalachian Plateau, Ridge and Valley, and Piedmont Provinces provide unique karst features that influence regional hydrology and the distribution of wetlands. Chemical dissolution of the bedrock creates a network of tunnels, caves, and related features that significantly increase groundwater transmissivity (Figure 6, modified from Trappe Jr. and Horn, 1997). Rapid groundwater drainage limits extensive wetland development (Fretwell et al., 1996). Limestone outcrops, however, discharge calcium-bicarbonate rich waters that create unique groundwater fed wetland habitats and also uniquely influence wetland water chemistry. Ancient sink holes associated with subterranean karst network support depressional wetlands that typically are not directly connected by surface water flows to regional water ways, but may be connected through spring discharge in other areas.

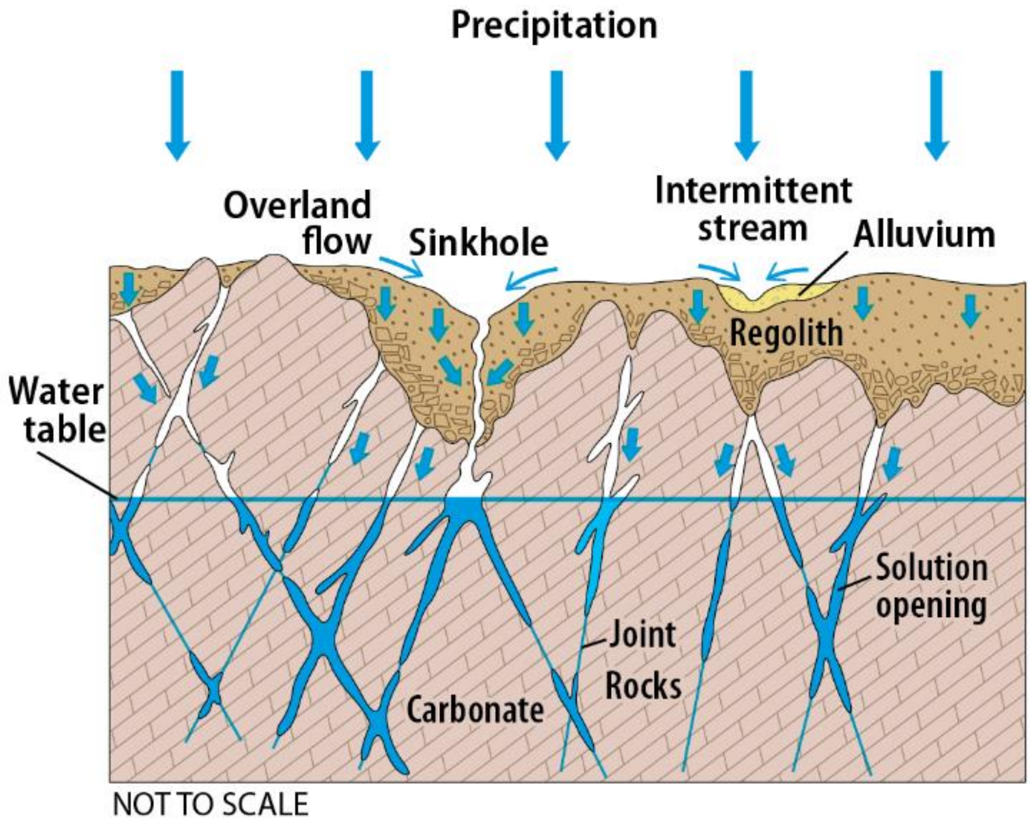


Figure 6. Thick wedges of colluvium on the lower flanks of ridges store large quantities of water that subsequently move into aquifers in the valleys. The colluvium commonly contains perched bodies of groundwater that are separated from the main water table by clay confining units.
Trappe Jr. and Horn, 1997, Modified from Nutter, L.J, 1973, Hydrogeology of the carbonate rocks, Frederick and Hagerstown Valleys: Maryland Geological Survey Report of Investigations 9, 70.

The **Coastal Plain** describes the broad wedge of unconsolidated sediments that occurs along the Atlantic Ocean coastline (See Figure 7). Within the Chesapeake Bay watershed, the Coastal Plain deposits extend from the land surface, at the Piedmont Fall Line, on the Chesapeake Bay's western shore, to a depth of more than 8,000 feet closer to the Atlantic coastline (Debrewer et al., 2007). The region can be divided into three sub-areas with distinctly different trends in wetland distributions and functions. Previous mapping of the Coastal Plain has shown the Western and Eastern Shores to have similar hydrogeomorphic features (Bachman et al., 1998) but that classification does not adequately describe wetland features and functions and has been modified herein and is shown in Figure 7. The Inner Coastal Plain includes areas west of the Chesapeake Bay characterized by gently rolling hills and incised streams. This area has the lowest percentage of wetlands (5%) compared to other Coastal Plain subregions. On the Eastern Shore, the Outer Coastal Plain includes poorly drained divides and well-drained regions (wetlands cover about 15% of the land area). In interior areas depressional wetlands and expansive flats form on poorly drained soils along watershed divides. In these areas, wetlands occupy 34% of the land area. In well drained inland areas between the inland poorly drained soils and the Coastal Lowlands, narrow bands of palustrine wetlands occupy less than 5% of the land area but provide riparian and floodplain functions. The Coastal Plain lowlands include low-lying areas on both sides of Chesapeake Bay that occur generally within 25 feet of sea level. Here, the flat terrain and shallow regional water-table depth results in broad, unconstrained channels and expansive backwater areas (e.g., slacks or bottom-bottomland hardwood forests). These riverscapes are characterized by continuous inundation mainly driven by seasonal conditions rather than storm events, and limited directional flow (Brooks et al., 2014). Precipitation, runoff from upland areas, and groundwater from local and regional aquifer discharge also can contribute significantly to bottomland wetland water budgets (Fretwell et al., 1996). Despite slow advective flow, bottomland wetlands provide important nutrient and sediment sinks (Noe and Hupp, 2005) (See Figure 8). Similar to the Piedmont and Great Valley regions, the Coastal Plain has sustained intensive development and agricultural land use, and pollution from excess nutrients and sediments occurs frequently. Importantly, despite that the Coastal Plain occupies less than 10% of the Bay watershed, this region supports the greatest expanse, nearly 40%, of all wetlands in the region (Tiner, 1994). Tidal wetlands occur almost exclusively within the Coastal Plain and constitute more than half of all wetlands in the region. Remaining tidal wetlands occur predominantly along the shoreline of the Lower Eastern Shore. It is estimated that between 45 and 65% of nontidal wetlands have been drained and converted, mostly for agriculture (Clearwater et al., 2000).

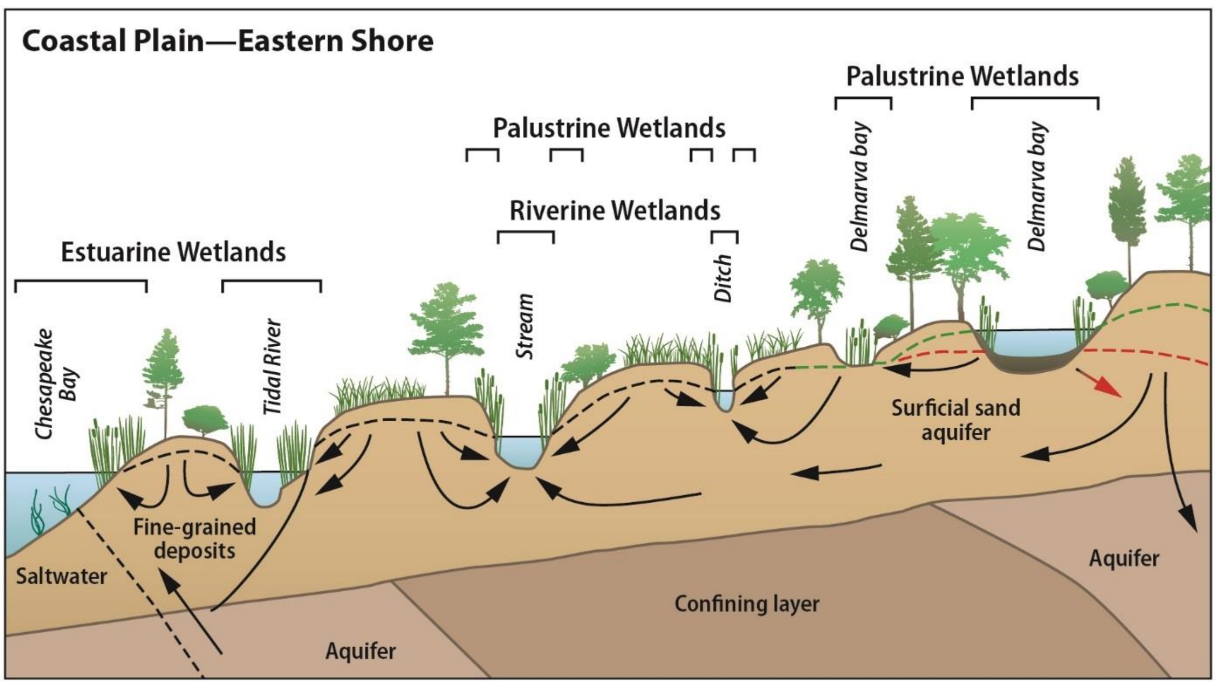


Figure 7. Conceptual model of Coastal Plain shallow groundwater conditions. Alternating and inclined layers of unconsolidated deltaic and estuarine deposits across a flat terrain results in a complex, nested groundwater system.
Modified from Fretwell et al., 1996.

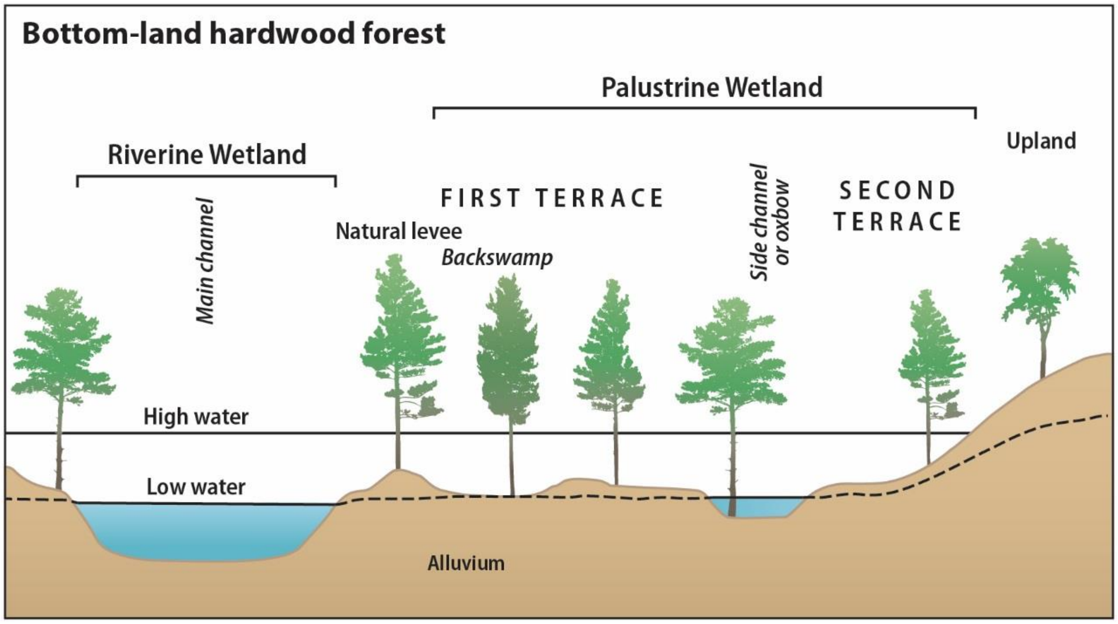


Figure 8. Conceptual model of bottom-land hardwood forest floodplain, which occur frequently in the Coastal Plain lowlands.
Modified from Fretwell et al., 1996.

Box 1 – Acres of wetland land uses in the Phase 6 CBWM beta calibrations

This Box provides a summary of the current acreages of Phase 6 wetland land uses, based on the physiographic regions described here in Chapter 4. Chapter 5 reviews the land uses for nontidal wetlands that were accepted by the CBP partnership in 2015. The acreages in this chapter are from the latest beta version of the CBWM, and are thus subject to change based on CBP partnership decisions and review outside the purview of this panel. It is useful, however, to see the latest land use acres; the latest estimates have been used in this chapter to give the reader an approximation of wetland prevalence in each physiographic region.

An overall goal of considering wetlands as Phase 6 land uses was to evaluate wetland functions across the Bay watershed's landscape. Mapped wetlands were classified as either "Tidal", "Floodplain", or "Other". Tidal wetlands were identified as estuarine and tidal wetlands (using Cowardin et al. 1979, e.g., system, subsystem, class, water regime, etc.) within two meter elevation above sea level, as identified from the 10-meter National Elevation Dataset (USGS). For non-tidal wetlands, floodplain wetlands were classified by creating and overlaying a floodplain mask over National Wetland Inventory (NWI) polygons. Any polygons that intersected the floodplain mask were classified as "Floodplain", while the remaining wetland polygons were classified as "Other" wetlands. The floodplain mask was derived from combining Federal Emergency Management Agency (FEMA) flood hazard layers with a Soil Survey Geographic database (SSURGO) layer created by querying polygons according to attributes linked to floodplain conditions. The "Other" wetland class primarily consisted of isolated depressional wetlands, sloping, riparian wetlands, and flats. Many of the NWI-mapped wetlands are classified as palustrine, providing limited information about hydrologic function and setting. Because sloping and depressional wetlands and flats cannot be distinguished from NWI data, these were grouped as "Other" for the Phase 6 land uses.

The physiographic province of each mapped wetland was determined by intersection with the USGS physiographic map (Brakebill and Kelley 2000; see Figure 2) created by sub-dividing physiographic province according to hydrogeomorphologic conditions and wetland characteristics. The seven major physiographic provinces included the Appalachian Plateau, the Appalachian Ridge and Valley, the Blue Ridge, Piedmont, Coastal Plain, and the Karst Terrain.

With respect to the major provinces, non-tidal wetlands consume 70% of land cover in the Coastal Plain province. Whereas, non-tidal wetlands account for less than or equal to 3% of land cover in each of the remaining physiographic provinces, which are dominated by either riverine wetlands located in topographic slopes or isolated, upland depressions. With respect to acreage, the Coastal Plain floodplain wetlands were dominated by Coastal lowlands that accounted for 60% of the floodplains. On the other hand, the Coastal Plain's "Other" wetlands were more evenly distributed with the Coastal Plain lowlands accounting for 36% (187,977 acres), the Outer Coastal Plain, poorly drained uplands accounting for 35% (182,249 acres) and the Outer Coastal Plain, well drained uplands accounting for 21% (108,302 acres). With respect to the acreage of floodplain and "Other" wetlands in non-Coastal Plain provinces, the Appalachian Plateau (11, 112 acres) and the Piedmont (57,391) provinces had the highest acreage of "Other" wetlands, and the inverse was applied to the Floodplain with the Piedmont accounting for 227,317 acres and Appalachian Plateau accounting for 82,041 acres. When comparing the ratios of floodplain wetlands to other wetlands, the "Floodplain" wetlands accounted for 4 times more spatial area (acreage) than "Other" wetlands in the Piedmont, and the Karst Terrain –Piedmont and Appalachian Ridge and Valley provinces. The "Other" wetlands accounted for almost 6 times more acreage than floodplain wetlands in the Outer Coastal Plains poorly drained uplands followed by well drained wetlands with a 2:1 other: floodplain ratio.

Table 6. Area of non-tidal wetlands and general description of wetland types in major Physiographic Provinces of the Chesapeake Bay watershed.

Physiographic Province	Total Other Wetland acreage[1] (mean size)	Total Floodplain Wetland acreage[1] (mean size)	Combined, nontidal wetland area as % of total province area	Description[2]
Appalachian Plateau	110,112 (2.5)	82,041 (1.8)	2	Diverse wetland types including wet thickets, shrub bogs, seasonally flooded wet meadows and marshes
Appalachian Ridge and Valley	12,408 (1.2)	36,472 (1.3)	1	Wetlands uncommon; located in topographic slopes and depressions
Blue Ridge	2,024 (1.2)	4,870 (1.3)	<1	
Piedmont (inc. Piedmont Crystalline and Mesozoic Lowlands)	57,391 (1.4 to 2.6)	227,317 (2.1 to 2.3)	3	Mostly isolated palustrine and riverine wetlands in floodplains and upland depressional swamps
Coastal Plain				Wetlands located in riparian areas and floodplains, and in upland depressions divides and broad flat areas between along drainage divides
Inner Coastal Plain	45,930 (1.9)	87,569 (2.05)	5	Most wetlands located in riparian areas of stream valleys
Outer Coastal Plain, poorly drained uplands	182,249 (7.7)	32,831 (3.8)	34	Wetlands common in depressions and flats near drainage divides and along low-gradient, poorly incised streams, most of which have been channelized
Outer Coastal Plain, well-drained uplands	108,302 (6.6)	51,396 (3.7)	15	Wetlands generally associated with riparian zones of natural stream channels
Coastal Plain lowlands	187,977 (6.1)	262,190 (3.8)	16	Non-tidal wetlands located in broad swamps and riparian zones
Karst Terrain				
Appalachian Plateau	7,555 (2.6)	4,400 (1.6)	3	
Appalachian Ridge and Valley	5,102 (0.7)	18,844 (1.3)	1	
Piedmont	772 (1.1)	2,859 (1.5)	1	

[1] From Stubbs, written communication, 7/22/2016

[2]From Brooks et al. 2011; Shedlock et al. 1999; (input from Strano MD document)

Advances in understanding how hydrogeologic setting influences wetlands nutrient dynamics

Nitrogen—transport and removal from groundwater and surface water

Our understanding of landscape controls on nitrogen (N) transport and transformations has increased substantially over the past decade. Agricultural fields are a major source of nitrogen in many parts of the watershed (Ator et al., 2011). In the Mid-Atlantic region, approximately 15% of applied fertilizer and manure leaches to the shallow aquifer (Puckett et al., 2011). The most significant shallow aquifer contamination occurs in irrigated, well drained soils (e.g., carbonate-rich, karst terrain or the well-drained Outer Coastal Plain) where as much as 30% of applied nitrogen has been shown to leach into groundwater (Bohlke and Denver, 1995; Puckett et al., 2011). Once delivered to the aquifer, nitrate often remains in that form, with limited biogeochemical transformation, due to high dissolved-oxygen levels and/or lack of carbon substrate, which limits microbial denitrifier populations (Parkin and Meisinger, 1989; Yeomans et al., 1992). Nitrate removal via denitrification does not occur until the contaminated groundwater intersects carbon-rich soils, typically in wetlands (Carlyle and Hill, 2001; Duval and Hill, 2007; Green et al., 2008; Hill and Cardaci, 2004; Koretsky et al., 2007). The conversion of dissolved nitrate to inert nitrogen gas via denitrification is the only long-term and continuous mechanism by which excess biologically available N is converted to inert dinitrogen (N2) gas (Boyer et al., 2006). The distribution of wetlands, therefore likely provides an important control on nitrogen transport and stream water quality (Alexander et al., 2007; Curie et al., 2007; Oehler et al., 2009). Wetlands have the widest range of biogeochemical conditions on the landscape, with both oxidizing and reducing environments in close proximity. Wetlands have immense N transformation capability because the ultimate sink is the atmosphere.

The effectiveness of nitrogen removal via wetlands is dependent on the connectivity between wetlands and nitrogen sources (Goldman and Needleman, 2015; USEPA, 2015). The relative importance of stream baseflow contributed from groundwater versus stormflow generated by overland runoff affects the timing and form of N delivery to regional waterways. Where surface runoff dominates contributions to streams, such as in steep rocky terrains of the Appalachian Ridge and Valley Region, most N is in organic or ammonia forms and concentrations are generally low. As groundwater contributions to total stream flow increase, such as in the flat, unconsolidated Coastal Plain, nitrate typically becomes the dominant source of N. Most nitrate is formed in the soil zone and infiltrates to groundwater through the unsaturated zone.

Nitrate from groundwater is the source of, on average, about half of the nitrogen in surface waters (inclusive of nonpoint and point sources) in the Chesapeake Bay watershed. Contributions of nitrate from groundwater at individual gaging stations ranges between 17 to 80% (Bachman et al., 1998). The variability is due to differences in nitrogen application and hydrogeologic setting that affect the physical transport of water and nutrients and the geochemical conditions that are encountered along surface and subsurface flowpaths. In general, Bay-wide areas with carbonate and crystalline rock aquifers have higher median nitrate concentrations in groundwater and streams than in areas with siliciclastic rocks (Ator and Ferrari, 1997). In the Coastal Plain, areas with thick sandy aquifer sediments have higher nitrate concentrations than in areas with thinner sequences of sandy sediments at the land surface (Ator et al., 2000). Areas with higher concentrations of nitrate in streams are directly correlated to higher inputs, even considering the potential for nitrate reduction by riparian and other wetlands.

Surface- and ground-water nitrogen may potentially be intercepted, especially where nitrate enriched waters intersect reduced, organic-rich substrates and enhance removal via denitrification. Important denitrification zones include headwater depression and sloping wetlands, riparian wetlands, and at the upland-wetland interface of floodplains bordering streams and rivers and poorly drained areas including shorelines of lakes, ponds, and the Chesapeake Bay. These settings commonly occur where near-surface ground- and/or surface-water interactions combined with finer-textured sediments slow water flow, resulting in saturated substrates that reduce decomposition rates and provide organic matter conducive to denitrifying conditions. While denitrification primarily occurs in carbon-rich wetland environments, this redox-sensitive process also occurs in older, less oxygenated groundwater of shallow aquifers in buried organic-rich estuarine deposits, near the boundary layers of overlying geologic stratums, or in contaminant plumes from landfills and other contaminant sources which provide carbon substrate to the denitrifying bacteria (Smedley and Edmunds, 2002). Denitrification in the shallow aquifer may account for as much as 10% of TN loss in groundwater, or 1 to 2% of the total N load (Puckett et al., 1999).

For water that is already in streams, overbank flooding of stormwater into floodplains has been shown to trap particulate N, absorb ammonia, and reduce nitrate in water that infiltrates through the organic-rich sediments (Noe, 2013). Particulate N trapped on floodplains is poorly bioavailable compared to dissolved forms of N. Several studies of flow-through wetlands (including restored wetlands) show significant reductions in N from wetland inlets to outlets (Woltemade and Woodward, 2008; Seldomridge and Prestegaard, 2014; Kalin et al., 2013; Jordan et al., 2003). Nitrogen uptake was found to increase with longer residence time and warmer water temperature. Noe and Hupp (2005) noted retention of nitrogen in the floodplain where it is connected to streams in the Coastal Plain, but the disconnection of the river to the floodplain by channelization at one site resulted in very limited retention. Coastal Plain floodplains typically trap a large proportion of their annual river load of N, similar to the proportion of river load that is particulate N (Hoos and McMahon, 2009; Noe and Hupp, 2009).

Riparian-zone denitrification in slope wetlands is most effective where aquifer sediments are very thin in alluvial valleys and the discharging groundwater mostly passes through near-stream reducing conditions. This denitrification can occur in near-stream wetland sediments and the hyporheic zone (Pucket, 2004; Puckett et al., 2008; Ator and Denver, 2015). These conditions are common in the Coastal Plain on the Western Shore of the Chesapeake Bay and near the fall-line in the northern part of the Eastern Shore (Krantz and Powars, 2000; Ator, et al., 2005). Models developed by Weller et al. (2011) indicated a potential high nitrate removal relative to upland inputs in this area, although groundwater data were not collected to verify upland nitrate concentrations. They can also exist in the Ridge and Valley provinces where water-bearing geologic units emerge at the land surface or where topographic slope changes between the valley walls and alluvial sediments (Winter et al., 1998).

Where the surficial aquifer is thick and groundwater flows along deeper flowpaths, much of the discharging groundwater can bypass reducing conditions in the near-stream riparian zone leading to limited potential for denitrification and elevated concentrations of nitrate in water discharging to a stream (Puckett, 2004; Böhlke and Denver, 1995; Baker et al., 2001). This setting occurs in areas of the Piedmont with thick weathered bedrock sediments at the land surface and in parts of the Coastal Plain with a thick surficial aquifer, as is common on the Eastern Shore (Bachman et al., 1998; Ator and Denver, 2015). It also occurs in carbonate areas where most water in streams originates in springs that are fed by solution channels in the underlying carbonate rocks (Bachman et al., 1998). The widespread distribution of high nitrate concentrations in streams indicates that settings resulting in groundwater bypassing reducing conditions in near-stream areas are common in parts of the Chesapeake Bay region.

The potential for nitrogen removal by wetlands is highly variable and dependent on numerous factors, many of which are difficult to determine without local studies of particular areas. It is important to consider all types of available information and to include local hydrogeology for nitrate transport. Data sources that only look at the land surface are not adequate to determine subsurface processes, but are critical for understanding inputs and potential hydraulic flow paths from upland source areas to discharge areas in streams and rivers.

Phosphorus—fate, transport, and removal from groundwater and surface water

The highly dynamic and complicated pathways that regulate downstream phosphorus (P) delivery continue to challenge our ability to predict P fluxes in relation to landscape setting and management practices. Because dissolved P concentrations originating from arable upland areas generally are low or below detection in groundwater (Denver et al., 2014; Lindsey et al., 2014), storm-based sediment transport and floodplain deposition have been considered the primary mechanisms controlling delivery of excess phosphorus to downstream aquatic habitat (Kröger et al., 2012). Increasing evidence of P-saturated soils and potential for increasing P bioavailablity, however, have raised concerns about the role of wetlands for P management (Sharpley et al., 2014). While organic-rich, wetland soils can provide critically important ecosystem storage compartments for long-term P storage (Bridgham et al., 2001; Dunne et al., 2007; Reddy et al., 1999), anoxic conditions can also contribute to downstream eutrophication (House, 2003; Smolders et al., 1995). The following provides a brief overview of how different wetland types may influence P-availability throughout the Chesapeake Bay watershed, recognizing that these natural filter processes are strongly influenced by local topography and water chemistry along a stream network.

At the watershed-scale, hillslope processes strongly influence P transport and storage: 50 to 90% of P is tied up in recalcitrant forms, and physical processes including erosion, sediment transport and deposition, and burial are considered the primary mechanisms regulating P availability across the landscape. Whereas there are atmospheric mechanisms that deposit N on the landscape, P has no gaseous form of relevance and its availability is driven by terrestrial factors alone. Approximately 80% of annual river loads of P are attached to sediment (Hupp et al., 2009). Vegetated wetlands provide important deposition zones. As flood waters inundate vegetated floodplains, reduced flow velocity allows sedimentation (Zedler, 2003).

Within or across variation in the frequency, magnitude, duration, and timing of flooding, regulate P storage and export. Prolonged flooding reduces decomposition rates and increases accumulation of organic matter (Gambrell and Patrick, 1978; Mitsch and Gosselink, 2000), thus providing a long-term storage pool (Dunne et al., 2007). Conversely, water table drawdown and soil aeration more typical of floodplain wetlands enhances decomposition, organic matter mineralization, and P release (Venterink et al., 2001). Importantly, P dynamics vary across individual sites; for example, soil P mineralization varies laterally across Chesapeake floodplains associated with gradients or water flux, nutrient inputs, soil texture, and soil pH (Noe et al., 2013). Wetlands, and soils more generally, have finite P storage capability; once that storage is reached they can release P back into a dissolved form.

The interaction of natural waters and organic-rich substrates creates a unique biogeochemical environment that strongly influences soil P dynamics depending on pH and redox conditions (Reddy et al., 1999). In acidic, mineral wetland soils, more typical of flats and intermittently inundated floodplains, P sorption is closely related to hydrogen ion activity, organic matter content, and subsequent effects on amorphous (non-crystalline) aluminum and iron dynamics (Axt and Walbridge, 1999; Richardson, 1985). Under circumneutral pH conditions, redox conditions play a more prominent role than pH-controls in regulating P availability (Carlyle and Hill, 2001; Lamers et al., 2002; Lucassen et al., 2005; Smolders et al., 2010). In particular, the redox-sensitive iron-bound P-pools are highly dynamic and affected by short-term hydrologic condition and subsequent effects on water chemistry (House, 2003; Richardson, 1985; Walbridge and Struthers, 1993). Under aerobic drawdown conditions or with oxygenated water supplies, iron-oxides rapidly precipitate with P sorbing to the mineral surfaces (Patrick and Khalid, 1974). For example, in areas of the Outer Coastal Plain, naturally high phosphorus and iron concentrations occur in groundwater associated with reduced, estuarine deposits; in wetlands where the groundwater emerges at the land surface, exposure to the atmosphere enhances iron mineral precipitation and P co-precipitation, thus reducing P availability (Bricker et al., 2003). More typically, however, reduced wetland soils dissolve iron materials and enhance P availability (Reddy et al., 1999) and even can result in eutrophication, especially where nitrate- or sulfate-contaminated waters further enhance iron-P dissolution (Lucassen et al., 2004; Smolders and Roelofs, 1993; Smolders et al., 2006, 2010). In alkaline, reduced environments, likely to occur where calcium-bicarbonate rich water discharge, co-precipitation with calcium minerals can limit phosphorus availability (Moore and Reddy, 1994). Alkaline conditions (pH greater than 9 with calcium concentrations greater than 100 mg/L) limit P solubility by enhancing calcium-P precipitation (Diaz et al., 1994; Plant and House, 2002).

Although soils have a high capacity to sorb phosphorus, the filtration process can be overloaded, resulting in groundwater P contamination (Lory, 1999). For example, sandy soils commonly formed across the Outer Coastal Plain provide limited mineral sorption sites. In addition, rapid infiltration and groundwater recharge in areas with karst geology, shallow, fractured bedrock, or where soils have a high proportion of macropores (e.g., openings formed by organism burrowing or root growth and decay may short-circuit opportunities for P removal by wetland biogeochemical processes (Harvey and Nuttle, 1995). Although these processes can elevate phosphorus concentrations in stream baseflow, impacts to surface water quality are relatively small when compared to the quantity of sediment sorbed P delivered by surface water (Denver et al., 2010). Importantly, although sediment deposition can continue to provide additional sorption capacity, it is important to recognize that soils have a finite P sorption capacity which ultimately limits wetland retention capacity (Dunne et al., 2006). Further, over longer timeframes, sedimentation and concurrent P deposition will shift downstream with floodplain aggradation.

Sediment—fate, transport, and removal from surface water

Sediment transport and deposition processes related to wetlands play an important role in regulating downstream water clarity and water quality. The relatively flat terrain of all wetland types compared to the surrounding watershed results in significant sediment deposition at the upland-wetland edge. For any given wetland, the importance of this function depends largely on the form of the wetland (e.g., size, slope, soil conditions) and also the size of the local contributing area, as well as land management practices within that area (Burkart et al., 2004; Tomer et al., 2015; Wilkinson et al., 2009). Where runoff is distributed via sheet or rill flow (i.e., not channelized), sloping, riparian wetlands along low order streams provide especially important sites for sediment retention, removing 80 to 90% of the gross erosion occurring on adjacent uplands (Brinson, 1993a; Lowrance et al., 1997; Tomer et al., 2003; Whigham et al., 1988). The edge-of-wetland benefit also has been documented as a critical consideration to headwater (e.g., depressional) wetlands management (Cohen et al., 2016), although retention rates are more variable, perhaps due to typically small (<100 km2) contributing areas and potential for more direct impacts from anthropogenic disturbance (Craft and Casey, 2000). Upland-wetland edges of floodplains also provide important sediment deposition zones (McClain et al., 2003).

In addition to edge-of-wetland function, floodplain wetlands are widely recognized for the ability to capture sediment during flood events, specifically where overbank flow rates are slowed and surface water interacts with floodplain vegetation (Whigham et al., 1988). Floodplains along lower reaches of a river system provide key opportunities to capture nutrient-laden fine clay particles (Craft and Casey, 2000). For example, sediment deposition measurements in Coastal Plain floodplains indicated that these wetlands can capture 100% of associated annual river loads (Noe and Hupp, 2009). In contrast to the edge-of-wetland benefit, however, flood deposition occurs infrequently, only during high-magnitude storm events (Alexander et al., 2015).

Although this report focuses on the benefits of nontidal wetlands to water quality, specifically by reducing excess nutrient and sediment loads, the panel also recognizes that watershed-derived sediments strongly influence coastal wetland aggradation. Indeed, the supply of external sediments maybe critical to coastal wetland evolution with sea level rise (Bruland, 2008).

Advanced understanding of human impacts, especially due to changes in timing, rate, and chemistry of sources waters

Human alterations influence wetland water quality and habitat functions largely through effects on hydroperiod and water chemistry (Bedford and Preston, 1988). Resulting changes in the distribution of HGM types within a regional watershed or across physiographic provinces of the

Chesapeake Bay undoubtedly has altered cumulative wetland functions and benefits significantly (Bedford, 1996; Brooks et al., 2014). For example, most streams and rivers in poorly drained areas of the Delmarva Peninsula have been channelized and, in many areas, drainage ditch construction extended entire stream networks by thousands of miles. As a result, many flats and depressional wetlands were drained to form what are referred to as prior-converted croplands. Ditching lowered the water table, allowing former wetlands to be farmed and developed. However, the ditching also short-circuited the natural groundwater and surface flowpaths, resulting in less contact time with, or even complete bypass of, natural wetlands and marshes where processing of nutrients and trapping of sediments occurs (Bricker et al., 2003). In the Piedmont, the long history of intensive agriculture and timber harvest caused extensive watershed erosion, which resulted in burial of many floodplain wetlands and the formation of incised streams with highly erodible streambanks that provide major sources of sediment to downstream locations (Donovan et al., 2015). The steep relief and limited extent of navigable waterways historically limited human impacts to slope wetlands in the Appalachian Ridge and Valley Region and also the Appalachian Plateau. Wetland loss occurred mainly along river main stems, where development often occurs within river floodplains. Across the Bay watershed, expanding impervious surface area, channelization, and general watershed hardening has increased surface water runoff and reduced groundwater recharge, resulting in more significant flooding, altered hydroperiods and shifts in sediment loads throughout entire river corridors (Brooks and Wardrop, 2014; Hupp et al., 2013; Strayer et al., 2003). Compared to physical alterations imposed by human land use, less attention has been focused upon effects of shifting water chemistry. For example, increased nitrate loads ultimately can enhance P availability, especially where pyrite-rich geologic deposits can influence near-surface iron-sulfate-phosphorus chemistry (Smolders et al., 2010). While past human impacts to wetlands provide key opportunities for targeted wetland restoration, related human impacts or needs may also pose limitations in some cases, such as the need to keep certain agricultural lands in production.

Remote sensing capabilities and advances in spatial modeling provide enhanced understanding of near-surface processes in relation to physiographic setting

Remote sensing capabilities and advances in spatial modeling in recent years have provided a better understanding of near-surface processes with respect to the potential for nutrient processing by wetlands. High resolution elevation data made available through LiDAR has been especially important to understanding surface flow and potential areas of interception and infiltration of water containing nutrients in extremely flat areas commonly associated with wetlands. This type of data will be especially useful for understanding phosphorus as most phosphorus transport takes place over the land surface. For nitrogen, there is still a need to include subsurface transport pathways as that is the main pathway for nitrogen transport. Combining LiDAR –derived elevation data with data on aquifer configuration can be used to understand potential subsurface flow pathways.

There has been limited research on the efficiency of wetlands to treat nonpoint source nutrients, such as from agriculture, within the Chesapeake Bay watershed (Goldman and Needleman, 2015). The ratio of wetland to watershed area has been used as a surrogate for hydrologic retention time (Simpson and Weammert, 2009), but this approach does not consider site-specific conditions that affect N removal and only weakly fits the data used to develop the model (Goldman and Needleman, 2015). New regional models that include a broader suite of factors that may influence nutrient transport and transformation are needed. Monitoring targeted to supply data needed for model development will be important to the success of improved models.

Regional differences in surface and subsurface processes affecting nitrogen transport in the environment, including wetland interception, have been generally defined in the Chesapeake Bay watershed in the context of explanation of processes in different hydrogeomorphic or hydrogeologic settings. The Chesapeake Bay watershed was divided into simplified hydrogeomorphic regions by Bachman, et al. (1998). These regions work well for understanding general processes in the hard-rock regions above the Fall-Line. In the Coastal Plain, however, further work has refined understanding, especially with respect to subsurface processing of nitrogen (Ator et al, 2005; Krantz and Powars, 2000). Digital datasets are available to incorporate these interpretations on a regional basis for use with other pertinent data sets such as digital elevation models, soil characteristics, and land use and wetland maps.

Summary

The panel recognizes that the role of wetlands in regulating regional water quality trends depends on hydrologic connectivity between source or contamination areas and downstream regional waterways. Accordingly, the panel recommends evaluating wetland function based on the likelihood of groundwater and/or surface water influence, given watershed position and physiographic setting. Depressional and sloping wetlands and wetland flats in headwater areas likely have the strongest capacity to intercept shallow, contaminated groundwater. Floodplains also provide additional capacity by enhancing sedimentation during storm events. The physiographic setting strongly influences the distribution of wetlands within a region and also the extent to which humans have altered the hydrogeologic setting.

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Chapter 5. Recommendations for Wetlands as land-use and BMPs in Phase 6 Watershed Model

Overview

The Wetlands Expert Panel convened to provide recommendations on how wetlands should be represented and evaluated in the CBP Phase 6 Watershed Model. Based on their cumulative understanding and best professional judgment of the wetland literature and wetland restoration, including past reports and recommendations presented to the CBP, the following overarching conclusions and recommendations are detailed herein:

- Wetlands provide significant and unique water quality benefits to regional water compared to other land use/land cover classes, specifically by reducing excess nutrients and sediment, and therefore should be considered explicitly in the Phase 6 watershed model.
- Similar to unmanaged forests, undisturbed, natural wetlands are unlikely to generate excess nutrient and sediment loads. Few studies, however, report wetlands as sole contributions because these unique landscape features tend to occur as transition zones between upland and aquatic habitats. As such, the panel recommends that the Phase 6 model set wetland loading rates equal to forest loading rates.
- There is strong evidence demonstrating that wetlands naturally filter ground- and surface waters but that effectiveness varies widely based on hydrologic connectivity to up-gradient 'contaminant' sources and to down-gradient regional waterways, and on wetland condition. Quantifying wetland water quality benefits accordingly, however, remains challenging based on available information. To address this need, the panel proposed a simple model to predict the potential for different types of natural, undisturbed or restored wetlands to intercept, transform, and reduce excess nutrient and sediment loads, given physiographic setting and watershed position.

Key findings and considerations in the panel's recommendations include the following:

- The hydrogeologic setting, including geology, topography, land use, and climate conditions, together with position in the watershed influence the hydroperiod (i.e., timing, duration, magnitude, and frequency of saturation, as well as the rate of water table change) and the relative importance of ground- and surface-water sources. Resulting hydrologic fluxes control the potential for wetlands to intercept and treat contaminated waters.
- Connectivity to contaminant sources strongly influences water quality benefits. If up-gradient sources are lacking or contaminated waters by-pass a wetland (e.g., through concentrated flow channels or deep groundwater), limited retention will occur.
- In addition to hydrologic fluxes, natural and anthropogenic influences on water quality affect nutrient fluxes and wetland retention capacities. In particular, effects on pH, redox,

and carbon availability strongly influence N and P transformations in wetlands; human land and water management often artificially influences these environmental controls significantly.

Wetland land uses in the Phase 6 CBWM

The expert panel and wetland workgroup arrived at a set of recommended land uses and relative loading rates for existing wetlands in the Phase 6 CBWM as shown in Table 7. The WQGIT accepted the recommended land uses on September 14, 2015. The accepted land uses will represent natural nontidal wetlands within the Phase 6 CBWM, and do not represent recommended efficiencies or reductions associated with any wetland best management practices (BMPs), such as restoration, creation or enhancement; these BMP reductions are described in the next section of this chapter.

Table 7. Land use classes and relative loading rates for nontidal wetlands in the Phase 6 Watershed Model.

Wetland land uses for Phase 6 Watershed Model	Relative Loading Rate (TN)	Relative Loading Rate (TP)	Relative Loading Rate (Sediment)
Floodplain Wetland	100% Forest	100% Forest	100% Forest
Other Wetland (non-floodplain)	100% Forest	100% Forest	100% Forest

The two recommended land uses and their relative loading rates were supported by the Wetlands Workgroup following their August 28th conference call, with one dissention from Pennsylvania. As noted at that time, Pennsylvania supported establishing wetlands as a land use, which would provide a means to apply the new wetlands enhancement BMP, but they dissented given concerns about the inaccuracy of current NWI data for their state and the inconsistency of the NWI data across the jurisdictions. The panel and workgroup understood that there was opportunity to adjust the data inputs during the 2016 review period, and that allowed for improvements to the mapped wetland land uses in Pennsylvania or other jurisdictions, but they also understood that changes past the October 2016 calibration could not be guaranteed by the Modeling Workgroup. The Wetland Expert Panel and Wetland Workgroup strongly recommended that if updated and/or improved wetland mapping data was available before the final calibration date, the Modeling Workgroup and CBPO Modeling Team would make it a priority to update these data in the modeling tools. At the time this report was developed for in Fall 2016, Pennsylvania was in the process of developing an improved dataset for wetlands to be used in the final Phase 6 CBWM calibration. With the addition of wetlands as an explicit set of land uses, updating wetland data layers will also be a higher priority for partnership resources.

Mapping the recommended land uses

Despite its limitations, the National Wetlands Inventory (NWI) provides an appropriately scaled and comprehensive map of wetland resources throughout the entire Chesapeake Bay Watershed. The database, which includes information on wetland type and setting, can be integrated with other information sources to describe wetland function and can be combined with the proposed land uses for the Phase 6 CBWM almost seamlessly. Targeted NWI wetland classes will include nontidal palustrine, lacustrine, and riverine wetland systems, which will be queried according to the NWI attributes in accordance with the Cowardin et al. (1979) wetland classification system. To summarize wetland water quality functions, wetland class acres will be subdivided into two proposed land use classes: floodplain and other (non-floodplain). Floodplain wetlands will include riverine wetlands and also NWI mapped wetlands that intersect the FEMA Flood Hazard Layer and SSURGO hydric soils layer along National Hydrography Dataset (NHD) mapped waterways. Remaining palustrine wetlands, including flats, depressional wetlands, and sloping wetlands, will be combined into the "other" class. Although the WEP recognized that these wetlands represent very unique systems, the panel agreed that in the absence of additional information, variation in wetland water quality benefits could be captured based on variation of local contributing area (i.e., treatment acres). In limited areas, NWIPlus provides additional information potentially useful to providing a more comprehensive assessment of wetland function, including vegetation type, hydrology, and hydrogeomorphic setting. When completed for the entire Bay watershed, the expanded database structure potentially could provide a more satisfying model to predict water quality benefits.

Justification for wetlands land uses

The recommendation to add wetlands as their own land use classification has been suggested by others in the past (e.g., STAC, 2012), due to the understanding that they perform natural functions that benefit water quality. Recently, however, it has been suggested that wetlands could potentially be captured in the Phase 6 Watershed Model without an explicit set of land uses. If this occurred and wetlands are not included as Phase 6 land uses, they will continue to be lumped with Forest or other land uses similarly to how they are in the Phase 5.3.2 and earlier versions of the Watershed Model. This would limit the recommendations by an expert panel to evaluate how to apply wetlands BMPs, such as wetland enhancement, based on landscape position (a larger driver of BMP efficiency). While wetland BMPs could still potentially be reported on non-wetland land uses, such an approach would ignore an explicit accounting of the water quality functions performed by approximately 900,000 acres[6] of nontidal wetlands in the Chesapeake Bay watershed. CBP partnership efforts to incorporate the habitat benefits of wetlands into planning tools or management actions would also benefit from explicit land uses in the modeling tools. Currently the partnership relies on BMP implementation data for its wetland indicators and these efforts could be enhanced for nontidal wetlands with these new land uses. The panel and workgroup agreed that establishing wetlands as a set of Phase 6 land use classes will provide a better basis for the reporting and crediting of wetlands BMPs and also improve the modeling tools by explicitly simulating the presence and function of natural nontidal wetlands. While the loading rate is unchanged, establishing a unique land use for wetland allows for future refinement and potential for crediting sediment and nutrient reductions from natural wetlands.

The accepted wetland land uses satisfy all of the Land Use Workgroup's criteria for establishing new Phase 6 land uses:

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[6] This is an estimate based on acreage of inland wetlands, excluding freshwater ponds, in Tiner (1987). The actual acres in the beta and final Phase 6 CBWM will differ from this figure and are subject to change until the final calibration.

(1) They can be mapped, albeit imperfectly as conveyed by Pennsylvania. Establishing the land use, however, could incentivize partners and stakeholders to improve available wetland data. Without wetland land uses there is less incentive to improve wetland data in the context of CBP partnership modeling inputs.

(2) They have a unique contribution to the landscape. Wetlands play an important role between the “edge of field” and the “edge of stream” pollutant loads that has not been explicitly captured in previous versions of the modeling tools. While the land-to-water factors in the Phase 6 Watershed Model are understood to implicitly capture the effect of existing wetlands in the landscape through the model calibration, the partnership may wish to apply a distinct factor in the model to account for the retention and treatment effects of existing wetlands. Their inclusion as land uses will be a basis for potentially simulating their contribution in the future. Though the Panel was unable to make a recommendation for a distinct loading rate or retention factor for existing wetlands at this time due to a dearth of science on wetland load contributions, it is recommended that future research using SPARROW or other tools be used to inform the partnership in the future.

(3) They will have unique BMPs applied to them. Though this panel is unable to make recommendations for wetland enhancement and wetland rehabilitation at this time beyond a temporary value, pending investigation by a future panel, these functional gain BMPs are anticipated to only be eligible for reporting on wetland land use acres. The recommended wetland restoration and wetland creation BMPs will also be simulated as a land use change BMP where the previous land use is converted to the wetland land use, with additional treatment of upland acres by the restored/created wetland. Without wetland land uses the crediting and application of these BMPs would become much more complicated for the expert panel, jurisdictions, and the public.

The panel and workgroup support classifying the wetland acres according to their landscape position (i.e. Floodplain and Other) over alternatives (e.g., by type of vegetative cover) because it is more reflective of expected water quality function in terms of nutrient transformation and sediment retention. As detailed in Chapter 4, the proposed framework presented herein attempts to describe how landscape position and hydrogeologic setting influence water quality benefits provided by an existing or a restored wetland.

Justification for wetland nutrient and sediment loading rates the same as forest

It is difficult to assign unique nutrient and sediment loading rates to wetlands because few studies evaluate loading rates separately from surrounding land uses. Indeed, wetlands provide important transition zones between upland and aquatic habitats. The panel agreed, therefore, that assigning loading rates similarly to those of other land uses would not reflect the multitude of studies that support the conceptual model that a wetland’s water quality functions depend on the hydrogeologic setting and the nutrient/sediment load delivered to that wetland. Some limited loading rate data are summarized in this section, but due to the inherent nature of wetlands, the panel did not find it appropriate to establish a unique base loading rate. Instead, efforts were focused on how best to estimate the additional water quality benefits that wetland's provide compared to forests.

To date, it has been challenging to develop a comprehensive description of how wetland water quality functions vary in relation to landscape setting and climate condition. Individual field studies are not coordinated to facilitate integrated meta-analyses that would improve understanding of how function varies across space and time. Published reports often do not provide enough information describing location, and research methods vary widely. To address this challenge and advance future assessments as reported herein, future research could be coordinated to tie more explicitly to modeling tools that are developed to predict wetland water quality benefits (e.g., SPARROW, described below).

A literature review conducted for the panel by Tetra Tech found only two studies that attempted to define loading rates for wetland areas, neither of which were located in the Chesapeake Bay region. Baker et al. (2014) evaluated Barnegat Bay-Little Egg Harbor HUC14 watersheds and determined the export concentration for forest and wetlands combined was 1.17 mg/L for TN and 0.021 mg/L for TP. Similarly, Dodd et al. (1992) created nutrient budgets for the Albemarle-Pamlico Sound area; forest and wetlands were again considered as having the same loading rate, which Dodd et al. determined to be 2.08 lbs/ac/yr for TN and 0.12 lbs/ac/yr for TP. Neither study separated the loading from forest and wetland areas into distinct categories. No other studies were identified that provided a loading rate for wetlands as a uniform land use. However, the panel has concern that the literature review may have omitted pertinent research, e.g., some forest loading rates available in the literature may have been wetlands but were not identified as wetlands in the abstract or other fields.

One study by Harrison et al. (2011) calculated the surface water and groundwater concentrations of TN and TP within wetlands, however, the export rates were not calculated. The wetlands, located near Baltimore, MD, were two restored relic oxbow wetlands in an urban area and two reference forested floodplain wetlands. Across the restored oxbow wetlands, the groundwater concentrations for TN and TP, respectively, were 0.72 mg/l and 11.5 µg/L. The average at the forested floodplain wetlands were 0.37 mg/L and 114.7 µg/L for TN and TP, respectively. Surface water nutrient concentrations measured within the oxbow wetlands averaged 0.6 mg/L for TN and 24 µg/L for TP. A study of natural depressional wetlands in the Choptank watershed found that nitrogen concentrations in groundwater were generally less than 0.1 mg/L N beneath the depressional wetlands as well as their surrounding wooded upland areas (Denver et al., 2014). Natural groundwater on the Delmarva Peninsula is generally found to be 0.4 mg/L as N, which is primarily defined by investigation of forested areas that also contain wetlands (Hamilton et al., 1993).

The panel and workgroup agreed it is most reasonable to keep wetland loading rates equivalent to the Phase 6 Forest land use, which is the most comparable land use with assigned loading rates similar to the few loading rates reported for wetlands. The Phase 6 loading rate for forest land use was set using SPARROW models inclusive of all forested land use area in the Bay watershed. In contrast to forests, however, the panel recognized that wetlands provide important transitional zones and act as nutrients sinks and/or transformers; therefore the panel concluded it is inappropriate to further refine wetland specific loading rates. Instead, the panel focused their efforts on characterizing how wetland nutrient and sediment retention efficiencies vary based on where a wetland occurs in the landscape.

Justification for natural and restored nutrient and sediment retention efficiencies based on hydrogeologic and landscape setting

Given the importance of landscape position to wetland water quality function, the panel explored the potential to develop spatially-explicit retention efficiencies for existing wetlands. The literature review reaffirmed previous meta-analyses that reported wide variation in wetland nutrient and sediment retention efficiencies, but the meta-analysis did not provide enough information to describe variation in efficiencies related to landscape position. The panel therefore developed a conceptual model, based on these studies and current understanding of wetland hydrology, to summarize where different types of wetlands occur throughout the Chesapeake Bay watershed and to evaluate the likelihood of providing targeted water quality benefits accordingly. The resulting framework is intended to provide a basis for integrating future wetland studies and advancing our capacity to characterize wetland water quality benefits.

Wetland BMPs

Review of existing Phase 5.3.2 wetland restoration BMP

The CBP Scientific and Technical Advisory Committee (STAC) and the Mid-Atlantic Water Program have previously attempted to evaluate the effectiveness of wetlands as a BMP. During the April 2007 STAC workshop on quantifying the role of wetlands in achieving nutrient and sediment reductions, a first order kinetic equation was proposed to describe the exponential decline of nutrient and sediment over time related to detention time of runoff in a wetland. The kinetic equation was originally developed by Dr. Tom Jordan from the Smithsonian Environmental Research Center (SERC) and provided in both STAC (2008) and Simpson & Weammert (2009). The Mid-Atlantic Water Program (Simpson and Weammert, 2009) was tasked with defining BMPs and determining effectiveness estimates that are representative of the overall Bay watershed.

Data have shown that longer water residence and retention times improve the nutrient removal efficiency of wetlands (Simpson and Weammert, 2009). The kinetic equation assumes that wetland retention time is proportional to the ratio of the area of wetland to the area of the watershed, see Figure 9. A first order kinetic equation was used to relate the rate of removal to the concentration, thus providing a practical way to express efficiency as a percentage of the inflow pollutant removed by the wetland.

The first order kinetic equation was developed to represent the cumulative removal efficiency of all restored wetlands in a land segment, based on the following assumptions:

- removal is an exponential function of retention time;
- retention time is proportional to the proportion of the watershed that is wetland; and
- there is zero removal when there is no wetland in the watershed.

Nonlinear regression was used to parameterize the model based on the removal data in the literature. This yielded the equation:

Removal = $1 - e^{-k(area)}$

Where:

- Removal: proportion of contaminant removed by the wetland
- Area: proportion of the watershed area that is wetlands
- k: fitted parameter, based on reported retention efficiencies
    - TN, k=7.90, 95% confidence limits [4.56, 11.2]
    - TP, k=16.4, 95% confidence limits [8.74, 24.0].

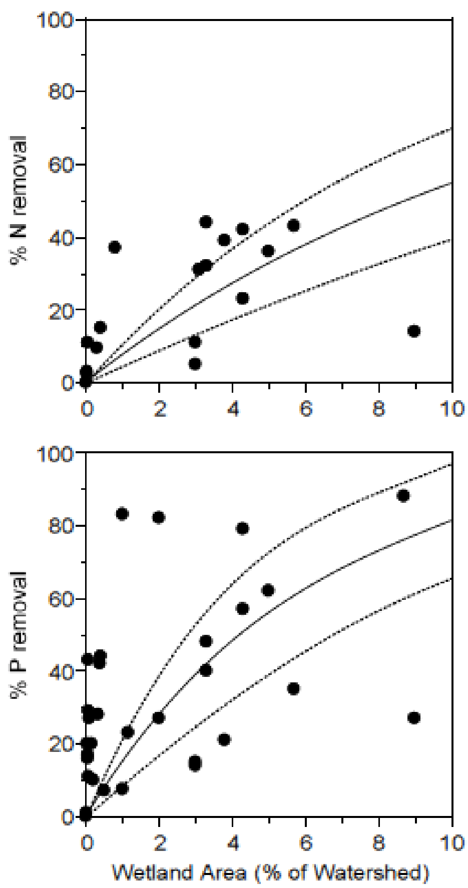

Figure 9. Literature review data points for wetland nutrient removal efficiency based on the wetland area as a proportion of the watershed. Curves indicate non-linear regression fit to data values, with 95% confidence limits. (STAC 2008).

The kinetic equation was developed for wetlands as a BMP (wetlands restoration) in Phase 5.3.2 model scenarios. To use the equation, the ratio of wetland area to watershed area must be defined for each BMP reported by a jurisdiction for a particular land-river segment. If this information was not reported, alternative calculations specific to physiographic regions were developed (Simpson and Weammert, 2009). The alternative calculations assumed wetlands to be 1, 2, and 4% of the watersheds in the Appalachian, Piedmont and Valley, and Coastal Plain geomorphic provinces, respectively. The resulting TN and TP removal efficiencies are described in Table 8.

Table 8. TN and TP removal efficiencies for wetlands by geomorphic province (Simpson and Weammert, 2009).

Geomorphic Province	TN Removal Efficiency	TP Removal Efficiency	TSS Removal Efficiency
Appalachian	7%	12%	4%
Piedmont and Valley	14%	26%	8%
Coastal Plain	25%	50%	15%
Default, if HGM unknown	16.75%	32.18%	9.82%

One of the shortcomings of the kinetic equation is that it cannot account for wetlands that are sources of nutrients. Negative removal values (nutrient export) cannot be derived from this equation. During the literature review for development of the equation, any wetlands where only negative removal values were observed were removed from the calculations. When negative removal occurred in particular years, but not on the average, Simpson and Weammert used the average removal percentage in fitting their simple model. In cases where only negative removal was observed the observation was omitted, i.e. for one negative TP removal for one wetland studied by Kovacic et al. (2000) and negative TN removal by one of the wetlands studied by Koskiaho et al. (2003).

Due to the lack of data, the relationship between total suspended sediment and wetland area was not determined. A uniform 15% removal was approved, based on the average annual removal rates that were available in the literature, plus a margin of safety. This 15% removal was then applied to the region with the highest removal rates (Coastal Plain) and adjusted proportionally to the TP removal for the other two HGM regions.

The kinetic equation is unable to account for variations in wetland age, seasonal variation, spatial and temporal variability of flow, landscape position, or type of wetland. These factors will affect the residence time and loadings to a wetland. For example, Craft and Schubauer-Berigan found that floodplain wetlands removed 3 times the nutrients of depressional wetlands on an areal basis (in Simpson and Weammert, 2009). Nicholas and Higgins found that phosphorus removal declined significantly after about 4 years (in Simpson and Weammert, 2009). Declining phosphorus removal rates over time also are not accounted for in the kinetic equation.

The BMP Assessment recommended future refinements to account for seasonal variability, nutrient discharge, hydraulic loading rate, wetland aging, and potential for dissolved P discharge during anaerobic conditions from wetlands with high phosphorus content (Simpson and Weammert, 2009).

Recommended effectiveness estimates for wetland restoration (re-establishment) in Phase 6

Nontidal wetland re-establishment for Phase 6 Watershed Model

Based on currently available information, the wetlands expert panel recommends assigning wetland retention capacity based on a combination of factors reflecting 1) the efficiency of wetlands to sequester nutrients and sediment given wetland type (floodplain or other); and 2) the likelihood that contaminated waters will intersect wetlands as biogeochemically active transition zones based on physiographic setting and watershed position. The approach is intended to parallel previous modeling studies, including Jordan et al. (as part of Simpson and Weammert 2009), that demonstrate the utility of a simple exponential decay model to tracking contaminant transport:

$$\frac{C}{C_0} = \exp^{-rt}$$

where C is the remaining concentration, C_0 is the initial concentration, *r* is the removal/reaction rate, and *t* is the travel time (e.g., Heinen, 2006). Importantly, previous applications explicitly recognize that both *r* and *t* vary across time and space. Given available information and the scope of the Bay-wide watershed modeling effort, the conceptual underpinning of the decay model was adapted as described below, and acknowledging the following:

- Decomposition or sequestration rates reflect effects of key environmental conditions that drive retention processes and underlie measured retention efficiencies (e.g., soil C and water availability, water chemistry, and temperature).
- The amount of excess nutrient and sediment (i.e., original contaminant concentration) depends on the expanse and intensity of source acres (e.g., croplands or developed lands) in the watershed or local contributing areas and the likelihood that contaminated or enriched waters intersect wetlands of a specific type.
- Time is considered as a unit factor (e.g., one year)

Wetland nutrient and sediment retention efficiencies are proportional to reaction rates

The importance of landscape setting to regulating natural filter functions, and also the importance of wetlands as a BMP to meet Bay watershed goals first led the panel to strongly recommend mapping wetland land cover explicitly in the Watershed model. The panel subsequently endeavored to develop nutrient and sediment retention efficiencies specific to physiographic province and watershed position. The results of a literature review are summarized in Table 9.

Table 9. Summary of wetland TN, TP and Sediment reductions from literature review. The mean retention efficiencies reported for all natural sites (i.e., not constructed sites) are the recommended retention efficiencies for the Phase 6 Watershed Model, to replace the current Phase 5.3.2 values

Wetland Type	Vegetation Type	TN % Reduction Mean Range Median (# of studies)	TP % Reduction	TSS % Reduction
Headwater/ Depressional	ALL	33% -8-97 34% (9)	25% -15-94 10% (13)	28% -30-75% 37% (6)
Floodplain	ALL	44% -8-94 38% (24)	37% -41-100 29% (24)	32% -15-95 14% (7)
All except constructed	Forest, mixed and unknown	47% -8-97 59% (16)	45% -47-100 43% (44)	37% -15-95 32% (8)
All except constructed	Emergent	39% -8-89 36% (20)	31% -15-100 30% (20)	25% -30-75 27% (7)
All	All	40% -8.4-97 36% (48)	40% -54-100 38% (95)	44% -30-98 50% (19)
Chesapeake Bay Only	All	22% -8-89 10% (10)	20% -41-81 17% (10)	24% -15-68 21% (8)
All except constructed	**ALL**	**42% -8-97 39% (36)**	**40% -47-100 41% (64)**	**31% -30-95 27% (15)**

The range of retention efficiencies reported in the literature highlighted the importance of wetlands as natural filters but also revealed the large variability in water quality functions at different locations (Table 9; see also Appendix A). Although the panel recognized the importance of landscape setting, hydrology, soils, and vegetation, published studies often lacked information needed for inter-comparisons, including adequate descriptions of study site settings or field methods. Ultimately, limited information from the updated literature review precluded the panel from assigning wetland retention efficiencies based on wetland type, physiographic setting, or watershed position. Given these limitations, the panel concluded that, currently, the mean reductions for all reported natural wetland studies (i.e. not including constructed wetlands) provide the most reliable estimates of retention efficiency.

The panel determined that the mean value for all wetlands, exclusive of constructed wetlands (see Box 2), offered the most reasonable estimate for nitrogen, phosphorus and sediment reduction efficiencies associated with treatment of upslope acres for re-established wetlands. These are the recommended effectiveness values for wetland re-establishment in the Phase 6 Watershed Model, to replace the current Phase 5.3.2 values described in the previous section. Additional factors described below attempt to capture effects of physiographic setting as described by Simpson and Weammert (2009) and in Chapter 4 of this report, for Phase 5 and Phase 6 of the CBWM, respectively.

Box 2 – Constructed Wetlands

Wetlands constructed specifically, and singularly, for water quality treatment purposes of a defined source. These constructed wetlands are generally of simple hydrology, limited inflow and outflow, and typically vegetated with herbaceous plants only, specifically monocultures of species known for high rates of pollutant uptake, such as cattails (*Typha* spp.) and common reed (*Phragmites*). Thus, constructed wetland studies provide limited information to evaluate or characterize natural wetland water quality functions. Constructed wetlands offer limited habitat value that may be additionally comprised by heavy metals and other toxicants in the effluent waters and may be subject to periodic maintenance, are not generally considered wetlands for regulatory purposes; for example, these systems are not considered as restored or created acres in wetland status and trends assessments. The panel determined that the load reduction values from these wetlands should not be incorporated into the recommended efficiencies for wetland restoration in the Phase 6 model.

Initial excess contaminant loads are a function of hydrologic connectivity and land management

For this report, several conceptual frameworks developed to predict how wetland function varies in relation to landscape position were combined to predict wetland water quality benefits based on hydrologic connectivity and wetland condition. These frameworks included Winter's (1999) treatise on surface- and ground-water as a single resource, Brinson's (1993) river corridor hypothesis, and Brook's et al. (2014) hydrogeomorphic classification of Mid-Atlantic wetlands. Accordingly, the distribution of major wetland types, including depressional and sloping wetlands, wetland flats, and floodplain wetlands were considered in relation to watershed position and physiographic province.

To more fully capture the variability in wetland forms and functions across the Chesapeake Bay Watershed, the number of physiographic provinces was expanded from those used in the Phase 5.3.2 CBWM. The Coastal Plain was divided into three different sub-regions reflecting differences in surface soil permeability and depth to the confining layer of the shallow, unconfined aquifer. In addition, areas dominated by carbonate (karst) bedrock were identified and combined into one class due to their commonly unique hydrologic functions in contrast to the parent physiographic province. Across all provinces, the distribution of different wetland types, according to the HGM classification for the Mid-Atlantic (Brooks et al., 2014), were summarized with respect to watershed position (i.e., headwaters to valley bottom or base level) and water source (see Table 10). Results provided a basis to evaluate how likely natural waters contaminated by nonpoint source pollution are hydrologically connected to wetlands that can provide natural filter functions.

Table 10. Wetland forms and distributions across the Chesapeake Bay Watershed, by physiographic and geomorphic setting. For the Phase 6 Watershed Model, flats, depressional wetlands and sloping wetlands were combined into a single 'other' class because of the limited information available to differentially map these unique wetland types. In this 'other' class, shallow groundwater dynamics primarily drive biogeochemical processes, whereas surface water acts as an important driver in floodplain wetlands.

Physiographic setting	Other Wetlands			Floodplain Wetlands
	Flats	Depressional Wetlands	Sloping Wetlands	
Appalachian Plateau		Moraine depressions	Aquifer outcrops Small tributary Riparia	Valley floors, above bedrock outcrops
Appalachian Ridge & Valley		Aquifer outcrops Fractured rock springs	Small tributary Riparia Slope breaks	Medium to large waterways
Blue Ridge		Ridgetops	Fractured bedrock outcrops Riparia	Tributary confluences Medium to large waterways
Piedmont			Fractured bedrock outcrops Riparia	Eroded stream/river terraces
Inner Coastal Plain			Small streams, floodplain edges	Small to large waterways
Outer Coastal Plain - Poorly drained uplands	Watershed divides	Watershed divides	Small (natural and artificial)tributary Riparia	Small to large waterways
Outer Coastal Plain - Well drained uplands			Small tributary Riparia	Small to large waterways
Coastal Plain Lowlands	Watershed divides		Small (natural and artificial) tributary Riparia	Bottom lands
Karst terrain Appalachian Plateau Appalachian Ridge & Valley Piedmont		Tubular springs	Outcrops, slope breaks, springs	

The summary of wetland types in each of the Bay watershed's physiographic provinces provided a basis to evaluate wetland water quality benefits. For each wetland type, the panel used regional water resources information to evaluate the potential for contaminated source waters to intersect organic-rich, anoxic wetland soils (see Chapter 4). Predominant wetland source waters and their potential for contamination were primary considerations. Results are presented in Table 11. Wetlands supplied by shallow surficial groundwater highly susceptible to contamination from agriculture or development, were ranked high (H). For example, Inner Coastal Plain, sloping, riparian wetlands draining watersheds with extensive agriculture and development were ranked high (H). In contrast, wetlands supplied by groundwater discharge from forested recharge areas (e.g., depressional wetlands across the Appalachian Plateau) or naturally protected, confined aquifers (e.g., sloping, spring-fed wetlands in the Appalachian Ridge and Valley province) were ranked low (L). Wetlands where contaminated waters are likely to by-pass the natural biogeochemical reactors also were ranked low (e.g., sloping, riparian wetlands in the Outer Coastal Plain well-drained uplands). Wetlands with mixed potentials were evaluated as medium potential (M). For example, the Piedmont has a long history of intensive agriculture, and although shallow, surficial groundwater primarily sustains streamflow, deeply incised streams through legacy sediment deposits often limit interactions between contaminated waters and wetland soils.

Table 11. Likelihood of Hydrologic Contact with Non-Point Source Contaminated Waters

Physiographic Setting	Other Wetlands			Floodplain Wetlands
	Flats	Depressional Wetlands	Sloping Wetlands	
Appalachian Plateau		L – variability in hydrologic settings & predominant forest cover	L – confined aquifer discharge not likely contaminated	L - predominant forest cover and greater likelihood of hyporheic exchange rather than wetland discharge
Appalachian Ridge & Valley		L – small contributing area; predominant forest cover	L – confined aquifer discharge not likely contaminated; predominant forest cover	L - predominant forest cover and greater likelihood of hyporheic exchange rather than wetland discharge
Blue Ridge		L – small contributing area; predominant forest cover	H - Surficial aquifer and heavy human impacts	M – Incised, more infrequent events; potential deep aquifer by-pass
Piedmont			M - Surficial aquifer and heavy human impacts	M – Incised, more infrequent events; potential deep aquifer by-pass
Inner Coastal Plain			H - Surficial aquifer and heavy human impacts	H – well connected, more frequently flooded
Outer Coastal Plain - Poorly drained uplands	L – small contributing area; flat hydraulic gradient predominant forest cover	L – small contributing area; flat hydraulic gradient predominant forest cover	M – Small contributing area, but surficial aquifer important and heavily influenced by human impacts	M – well connected, frequently flooded but potentially limited exchange due to flat hydraulic gradients

Physiographic Setting	Other Wetlands			Floodplain Wetlands
	Flats	Depressional Wetlands	Sloping Wetlands	
Outer Coastal Plain - - Well drained uplands			L – Deep aquifers with strong potential to bypass contaminated waters	H – well connected, more frequently flooded
Coastal Plain Lowlands	L – small contributing area; flat hydraulic gradient predominant forest cover		H – well connected, more frequently flooded	M – well connected, frequently flooded but potentially limited exchange due to flat hydraulic gradients
Karst terrain* Appalachian Plateau Appalachian Ridge & Valley Blue Ridge & Valley		H – Strong potential for contaminated discharge.	M – Strong potential for contaminated discharge, but potential for rapid flow-through & short contact time	L/M – see floodplain descriptions above, respectively

H – high potential; M – moderate or variable; and L – low potential for hydrologic connectivity with up-gradient sources of excess nutrients and sediments.

To account for wetland services within the CBWM, the qualitative assessment was translated to a quantitative matrix that can be used to estimate annual retention rates (Table 12). Variation in the potential for delivery of contaminated waters were modeled by adjusting the representative number of upland acres treated by a given wetland type, thus roughly representing variation in initial source loads. Acreages were assigned based on reported local contributing areas for wetland restorations in Maryland (Erin McLaughlin, pers. communication) and on the relative expected water quality benefits compared to other wetland types in different locations. The average local contributing area per acre of restored wetland (2:1 upland-to-wetland ratio) was used as a midpoint for wetlands considered to have moderate potential to reduce excess nutrient and sediment loads. For wetlands with low potential to intercept contaminated or enriched waters, a 1:1 upland-to-wetland acre ratio was assigned. Wetlands with the strongest potential to mitigate water quality impacts from expansive areas of agriculture and development, such as sloping riparian wetlands in the Inner Coastal Plain, were assigned a 4:1 upland-to-wetland acre ratio. Because floodplains provide capacity to reduce nutrients and sediment overbank flooding as well as by treating diffuse groundwater and surface water discharge treated acre ratios were assigned 1.5 times that of ‘other’ wetlands for the same physiographic region. While there is evidence that suggests connected floodplains provide much greater benefits (Noe and Hupp 2009), the Panel assigned this conservatively smaller ratio to reflect that floodplain benefits occur during storm events of varying intensity. In all cases the ratios fall within a reasonable range of 1-to-1 at the low end and 6-to-1 at the high end. All proposed retention efficiencies upland-to-wetland acre ratios were rounded to the nearest whole number.

The Panel recognizes that the recommended effectiveness estimates for nitrogen, phosphorus and sediment in Table 12 – and ratios of upland acres treated in particular – have associated uncertainty. The same can be said for other BMPs' effectiveness estimates used for annual progress reporting, as available scientific studies often leave gaps that the panel must fill using its best professional judgment. It is expected that the information describing treated acres in Table 12 or delivered loads more generally will improve as our understanding of wetland function and landscape modeling advances.

Table 12. Summary of proposed retention efficiencies and upland acres treated by each acre of wetland by wetland type and physiographic subregion.

	Retention Efficiency			Upland Acres Treated	
Physiographic Subregion	**TN**	**TP**	**TSS**	**Other Wetlands**	**Floodplain Wetlands**
Appalachian Plateau	42	40	31	1	2
Appalachian Ridge and Valley	42	40	31	1	2
Blue Ridge	42	40	31	2	3
Piedmont	42	40	31	2	3
Inner Coastal Plain	42	40	31	4	6
Outer Coastal Plain- Poorly Drained	42	40	31	1	2
Outer Coastal Plain- Well Drained	42	40	31	2	3
Coastal Plain Lowland	42	40	31	2	3
Karst Terrain	42	40	31	2	3

Summary of Findings, Recommendations, Key Uncertainties, and Future Research Needs

The expert panel recognizes that wetland nutrient and sediment retention capacity depends on the hydrologic flux (be it ground- or surface-waters or both) through a wetland system (USEPA, 2015). The relative importance of ground- and surface-waters has major implications to retention potential. For example, wetlands sustained by nitrate-enriched groundwater have greater TN removal capacity than unexposed wetlands or wetlands where enriched groundwater can bypass the organic-rich wetland soils needed for denitrification (e.g., Vidon & Hill, 2006; Devito et al., 1999). Surface water dominated systems have greater potential to trap sediment and nutrients, especially during flood events (e.g., Noe and Hupp, 2009). Biogeochemical processes are also related to the dominant vegetative community of the wetland, which reflects the underlying wetland hydroperiod and hydrochemistry. Overall, studies support consideration of a wetland classification scheme that creates the opportunity for attribution of different load reduction values by landscape and hydrogeologic position.

For the Phase 6 CBWM, the Wetland Expert Panel recommends its framework to capture variation in wetland water quality benefits due to differences in hydrogeomorphic settings across the physiographic provinces of the Chesapeake Bay Watershed. Results are intended to parallel Jordan's meta-analysis and resulting kinetic equation relating nutrient and sediment reductions to retention time (see Figure 9), but also to explicitly recognize the importance of location. The updated literature review developed by the panel and Tetra Tech further revealed wide variation in nutrient and sediment retention but limited information to evaluate how performance varies across different landscape gradients (i.e., based on hydrogeomorphic setting and wetland type). Given the wide range of uncertainty in the collective understanding of wetland water quality functions, the Panel recommends using the average reported retention efficiencies for all wetland types (42%, 40% and 31% for TN, TP and TSS, respectively), which fall within the range of values used for the Phase 5.3.2 CBWM. The Panel also recognizes that wetland water quality benefits reflect the nature of wetlands to occur as transitional zones between human dominated uplands and downstream aquatic habitats. Nutrient and sediment retention capacity depends on hydrologic connectivity to upland sources. Accordingly, the Panel also proposed using upland-wetland treatment acreage ratios to reflect expected field conditions in terms of hydrologic connectivity, based on general knowledge of hydrogeomorphic settings and land use history in different physiographic provinces of the Chesapeake Bay watershed. The panel is confident that the recommended framework, which emphasizes the importance of location, represents a positive step towards a more accurate representation of the water quality benefits for wetland restoration in the Phase 6 CBP partnership modeling tools.

Future efforts to describe the role of wetlands and wetland BMPs should focus on refining our understanding of how wetland retention efficiencies vary across space and also in relation to short-term and seasonal weather conditions. Results will help understand impacts to wetland ecosystem functions from shifting climatic conditions. In addition to coordinating field studies to validate our current conceptual understanding, additional modeling efforts may reveal patterns in retention efficiencies. For example, future panels may leverage the SPARROW model to explore and extrapolate wetland water quality benefits throughout a region. In fact, the current panel attempted to apply SPARROW in this manner, but capacity was not available in time for this report. Discussions with USGS staff to develop SPARROW runs in the near future are proceeding. Because these analyses will occur outside the timeframe for this expert panel review, the CBP partnership is encouraged to continue coordinating with USGS and the Wetland Workgroup, perhaps to form a small task force to work with USGS staff in developing the application of SPARROW and interpreting results. Ultimately, the Chesapeake Bay Program should commit to refining a field-scaled accounting framework, based on developing understanding of how wetland ecosystem functions vary by location and condition, to track the benefits and gains attributable to existing and restored wetlands.

Wetland restoration (re-establishment) in tidal areas

In the Phase 6 model, tidal wetlands will be simulated in the estuarine model, not the Watershed Model. This means there are no tidal wetland land use acres to which a tidal wetland restoration BMP can be applied. Given this context and the protocols developed by the Shoreline Management Expert panel already approved, this panel reviewed that effort for relevance to the charge to develop wetland BMPs. Specifically, the panel considered Protocols 2, 3 and 4 as defined by that expert panel.

- Protocol 2: Denitrification
- Protocol 3: Sedimentation
- Protocol 4: Marsh Redfield Ratio

The panel concluded that the Shoreline Management Panel's Protocols 2-4 adequately characterize the relevant nutrient and sediment processes of tidal wetlands and tidal wetland restoration. It was noted that no new literature has been published since 2015 that would affect or change the load reductions recommended by the Shoreline Management panel. It is recommended that these protocols be used as a load reduction effectiveness estimate for tidal wetland restoration BMP in the Phase 6 modeling tools. The overall load reduction is summarized in Table 13 below. While the existing Shoreline Management BMP can be used for reporting wetland restoration in tidal areas in the Phase 6 CBWM, the partnership should consider how it can efficiently track the acres of tidal wetland restoration reported as Shoreline Management for annual progress runs and towards the Watershed Agreement outcome for an 85,000 acre wetland gain.

Table 13. Summary of recommended load reductions.

Shoreline Management Protocol		TN	TP	Sediment
Protocol 2 – Denitrification	Acres of re-vegetation	85	NA	NA
Protocol 3 - Sedimentation	Acres of re-vegetation	NA	5.289	6,959
Protocol 4 – Marsh Redfield Ratio	Acres of re-vegetation	6.83	0.3	NA
Tidal wetland restoration		91.83 lbs/ac	5.589 lbs/ac	6,959 lbs/ac

Recommendations for wetland creation (establishment), wetland enhancement and wetland rehabilitation

This panel was unable to determine a recommended benefit for these BMPs in the time available but strongly encourages the partnership to quickly convene another expert panel to evaluate the effectiveness of these categories of wetland BMPs. The suggested definitions in Chapter 2 and the framework for these BMPs are already provided as a starting point for the future expert panel, which should be convened as a high priority under the WQGIT's BMP Protocol. Unlike wetland restoration and wetland creation, the enhancement and rehabilitation BMPs represent gains in function only, not gains in acres. As such, these BMPs would likely be credited as effectiveness estimates applied to nontidal wetland land use acres in the Phase 6 modeling tools and not represented as a land use change. The Wetland Creation BMP, similar to Wetland Restoration, would be expected to be a land use change plus treatment to upland acres. However, the effectiveness estimate applied to the upland acres for Wetland Creation should not be assumed to be equal to the estimate provided by this panel for Wetland Restoration.

If the future panel is instructed to consider these BMPs for application to tidal areas, the recommended protocols for the tidal BMPs would likely need to reflect the fact that there are no land use acres for tidal wetlands as they are simulated through the Estuarine Model, not the Watershed Model.

Following approval of this report and the wetland restoration BMPs, the Wetland Workgroup and Habitat GIT should work with the Water Quality GIT to promptly form an ad hoc group to craft the charge and scope for a new expert panel to evaluate the effectiveness wetland enhancement and wetland rehabilitation BMPs to reduce nitrogen, phosphorus and sediment loads. The future panel should build and clarify on the recommended definitions of this panel, but is asked to maintain the broader category definitions described in Table 2 of Chapter 2.

The future panel may consider using the same distinction for the BMPs according to physiographic region (Coastal Plain, Piedmont, etc.) and land use (Floodplain and Other), or it may decide that an alternate approach is appropriate for the functional gain BMPs or Wetland Creation.

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Chapter 6. Accountability Mechanisms

Wetland restoration practices must be accounted for and verified for credit toward Chesapeake Bay water quality goals. The Panel recommends the following reporting and verification protocols for wetland restoration projects consistent with existing CBP wetland BMP verification guidance:

1. Initial verification – The installing agency must confirm that the proposed practice was installed to design specifications, is hydrologically stable and vegetatively stable, and all erosion and sediment control measures have been removed.

   All jurisdictions have or will have verification protocols for reporting wetlands BMPs. Protocols were based on Chesapeake Bay Program (CBP) guidance. The addition of wetland enhancement/rehabilitation as BMPs will require additional guidance from CBP on the practices that would be included under the new wetland enhancement/rehabilitation BMP. Outreach to practitioners will be necessary to ensure that additional qualifying practices are reported. In addition, CBP will have to ensure that reporting databases contain appropriate fields to receive data on the new BMP, distinct from other wetland BMPs.

2. Recordkeeping – The installing agency must keep records of all wetland restoration projects.

3. Reporting and duration of credit – Once a year, the NEIEN coordinator for each state will compile this information and submit it to Chesapeake Bay Program.

4. Tracking
   a. The following 8 fields are requested from the state contacts every year:
      i. Field 1: County
      ii. Field 2: HUC-10
      iii. Field 3: Is the project on Federal Land?
      iv. Field 4: Prior landuse
      v. Field 5: Wetland drainage area (acres)
      vi. Field 6: Project Partners
      vii. Field 7: Completion date
      viii. Field 8: Gains in acres (by wetland type: nontidal emergent, nontidal shrub, nontidal forested, nontidal other, tidal)
         1. Gains – Reestablishment (i.e. Wetland Restoration – See Table 2)
         2. Gains – Establishment (i.e. Wetland Creation – See Table 2)
         3. Functional gains – Enhancement (i.e. Wetland Enhancement – See Table 2)
         4. Functional gains – Rehabilitation (i.e. Wetland Rehabilitation – See Table 2)

5. Protection – Long-term (i.e. applied toward Watershed Agreement protection outcome – See Table 3)
6. Protection – Short-term (i.e. applied toward Watershed Agreement protection outcome – See Table 3)

b. NEIEN has been updated for Phase 6 to reflect the four categories of wetland BMPs that are now available as defined by this panel and future panel(s). It will accept and distinguish Wetland Restoration and Wetland Creation as acreage gains and; Wetland Enhancement and Wetland Rehabilitation as functional gains. State databases must also be updated to accommodate the enhancement and rehabilitation entries.

5. Ongoing verification – Verification is required to ensure that the wetland restoration projects are performing as designed. The installing agency should confirm that the project was built according to plans (as-built survey was completed). Monitoring of vegetation, hydrology, and soil should be completed for the first three - five years of the project. Native vegetation species cover, invasive species, and wetland indicator status should be recorded. Invasive species should be managed early to prevent further invasion. Hydrology or indicators of hydrology should be recorded, as well as indicators of hydric soils (per the Army Corps of Engineers Wetland Delineation Manual and Regional Supplements). After 5 years, annual observations are recommended to document the continued success of the project. However, if on-site observations are not possible, other methods can be used as a proxy. The Chesapeake Bay Program BMP Verification guidance states the following:

> Onsite monitoring within the three years following construction is recommended. For any long-term monitoring, use of aerial imagery for remote observations is highly recommended for verification of wetland BMPs; remote observations can indicate encroachment of agricultural activities, clearing, and tree removal. Any issues or concerns with projects implemented on private lands are typically reported by the landowner to the installing agency and addressed as needed.

Wetland restoration and construction projects are reported to CBP either as stormwater BMP's or Ag BMP's/Voluntary restoration. The flow chart shown in Figure 10 was developed to help practitioners and agency personnel determine how to correctly report wetland acres. Wetland restoration practices that would receive the recommended Phase 6 BMP efficiency values described in this report would fall under the Tidal and Nontidal portions of Figure 10; though as noted in the diagram there are other practices (e.g., shoreline management) that are covered through other BMPs as defined by the CBP.

Existing BMP verification guidance for wetlands is available online as part of the CBP’s adopted BMP Verification Framework at:
http://www.chesapeakebay.net/about/programs/bmp/verification_guidance

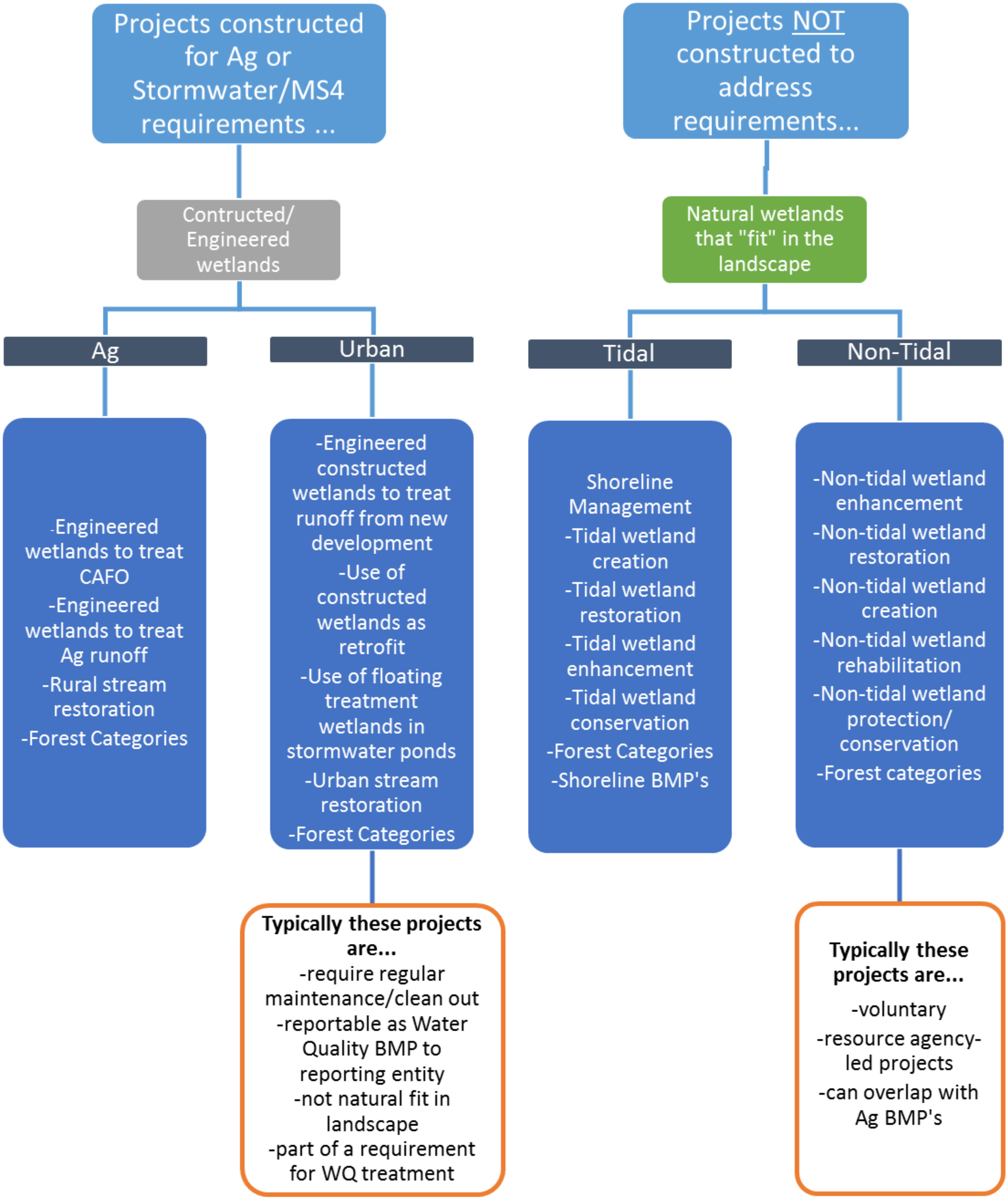

Figure 10. Wetland BMP Reporting Matrix

Chapter 7. Unintended consequences and qualifying conditions of wetland BMPs

There are numerous benefits associated with tidal and nontidal wetlands aside from their potential to reduce nutrient and sediment pollution, including vital habitats for waterfowl, fish, other animals, and plants; flood control, water storage, storm abatement, and aquifer recharge; carbon sequestration; and reduction of toxic pollutants (see Appendix B for more information). For these and other reasons, implementing wetland enhancement, restoration, and creation as a BMP in the Chesapeake watershed will provide many benefits, especially in urban and agricultural areas, among others. The panel believes that these practices are critical to meeting the Chesapeake Bay's water quality 2025 goals under both the Chesapeake Bay TMDL and the 2014 Watershed Agreement. However, it is the intention of the panel that wetland BMP projects only earn nutrient and sediment reductions if they are implemented at appropriate sites which do not damage existing ecological conditions. For instance, the panel believes BMPs should not compromise existing high quality habitat resources. The panel does not recommend the conversion or alteration of high quality wetlands for the purposes of nitrogen, phosphorus or sediment load reductions. The panel recognizes that improvements to water quality or other functions may not be zero-sum and can mutually benefit one another, but this requires careful planning and implementation by multiple stakeholders at the local, state and federal levels.

Changing the functions and/or values of existing high quality wetland systems and high quality non-wetland ecosystems that already provide denitrification and phosphorous or sediment trapping should not be pursued. Also, important ecosystems such as rare and endangered species habitat, older growth forests, unique ecotones (i.e. Delmarva Bays, Magnolia bogs, critical fish spawning areas, among others) should not be priorities for wetland practices solely for the nutrient and sediment reductions recommended by this panel for use in the Phase 6 suite of modeling tools. This list is not all inclusive of every important ecosystem of the Chesapeake Bay; however, project prioritization, selection and implementation should include the assessment of the project area to make sure these types of systems are not negatively impacted. It is understood that each project should be assessed based on federal, state, and local regulatory requirements, according to best professional judgments in the field, and supported by benchmarks presented in state and federal guidance documents. While this minimizes the risk of implementing extraneous wetland BMPs that could potentially harm habitat or other functions at the expense of nutrients and sediment, the panel wants to emphasize that practitioners, permit reviewers, and other stakeholders should not take these safeguards for granted. Jessop et al. (2015) found that designing wetlands to focus on nutrient reduction may come at the expense of biodiversity, which reinforces the panel's consensus that practitioners should prioritize wetland functions based on local site and watershed context. For instance, practitioners should be aware of wetland types that are classified as key wildlife habitats in State Wildlife Action Plans, and follow recommendations for preserving or enhancing these areas for wildlife purposes.

Implementation of the practices described in this report for the purposes of nutrient and sediment load reductions should be performed in or adjacent to areas that have relatively high potential to export these pollutants. If the site is a relatively healthy wetland or forested area, or if it already provides valuable habitat to native flora and fauna then alternate sites should be prioritized to reduce the potential for unintended negative consequences. Furthermore, it is recommended that each project that may require a permit to work in “waters of the US” or “waters of a state” may want to pursue a pre-application meeting to discuss project specific information with the Federal and state regulatory agencies. This will allow for a more efficient regulatory review of the proposed project.

Appendix B summarizes some studies related to ancillary benefits and potential negative impacts of wetlands, though it is not a comprehensive or exhaustive literature review since that would take much more time and effort than available to this expert panel. With that in mind, the literature review reinforces the notion that on average the benefits of wetlands far outweigh the potentially negative impacts and that the negative impacts can be avoided through proper site selection as encouraged by the panel in this section.

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Chapter 8. Future research and management needs

The work of the panel was focused on three differing services of wetlands: 1) what, if any, are the nutrient and sediment loads contributed by wetlands to receiving waters (landuse/landcover), 2) what, if any, reductions in loads are achieved by wetlands adjacent to parcels of land with known pollutant loads (efficiencies), and 3) what, if any, load reductions can be achieved by implementation of wetland Best Management Practices (BMPs).

The literature is largely silent on the contribution of wetlands as sources for nutrients and sediment, though numerous studies exist showing differences between nutrient and sediment inputs compared to outputs. Since the scientific literature and existing Bay models have not focused on wetlands as a unique landcover with regard to nutrient loading, this information is sparse. The historic paradigm still largely held in scientific circles is that wetlands are sinks for N and temporary storage for P – at least most wetlands, most of the time, for most pollutants.

The literature on wetland efficiencies is more robust and there is a large body of work on wetlands as BMPs. However, much of the research has focused on constructed wetlands for water treatment. These wetlands are generally of simple hydrology, limited inflow and outflow, and typically vegetated with herbaceous plants only, specifically monocultures of species known for high rates of pollutant uptake, such as cattails (*Typha* spp.) and common reed (*Phragmites*). These constructed wetlands are not accounted for in wetland status and trends as new wetland acreage. The panel determined that the load reduction values from these wetlands should not be incorporated into the recommended efficiencies for use in the Phase 6 model. While there are fewer studies on the role of natural wetlands and even fewer on restored, enhanced, or created habitat wetlands in the reduction of nutrients and sediments, the values from these studies were used for the panel recommendations. A more expansive literature search than conducted for this report may identify additional useful studies on nutrient dynamics in natural wetlands, which could refine efficiencies in future models.

The panel also notes the lack of, or inefficient, crediting process to capture the integration of wetland BMP practices with other natural features and engineering practices and the synergistic benefits of systems-level actions. Assignment of load reduction efficiencies to wetland restoration does not adequately reflect the total of the ecosystem benefits (water quality and quantity, habitat, erosion control and other socio-economic services) appreciated by these practices.

Given the state of the science, the panel seeks to advance research efforts on the role of existing and created/restored wetlands on nutrient and sediment loads to the Bay.

First: Studies that investigate the question of wetlands as sources or sinks, or both, would improve the accuracy of the landuse loading values in the Chesapeake Bay Watershed model and potentially provide a different loading rate from forest in future model versions. It is likely that we will learn much from the inclusion of wetlands as a landuse/landcover class in the watershed model. The lessons learned should be used to help direct future research on this aspect of wetlands and water quality.

Second: Investigations are needed to determine the efficiencies of various types of wetlands in different Chesapeake Bay physiographic regions to intercept and reduce the nutrient and sediment inputs from other land uses via surface or subsurface flow.

The SPARROW model offers the possibility to assess the overall role and magnitude of impact that existing wetlands have at the watershed scale. Such an analysis would help address these first two research needs and serve as an informative next step towards understanding the effect of wetlands as sources, sinks, or both across the Chesapeake Bay region, as well as providing a comparison with forest land. The Wetland Workgroup is encouraged to take lead on such an effort in coordination with USGS staff that work with the SPARROW tool.

Third: The load reductions of various BMP practices are dependent not only on the practice (restoration, creation, enhancement, rehabilitation) but other attributes such as landscape position, hydrology, vegetative community, etc. To accurately attribute load reductions to the various practices for purposes of giving credit to specific project(s), we need additional research to determine load reductions for the various practices and attributes. Specific recommendations to address these needs include the following:

1. Define specific restoration/conservation objectives related to wetland function to provide a basis for prioritization;
2. Map "shuffle zones," where near surface- and groundwater interactions, and soil conditions create organic-rich biogeochemical hotspots;
3. Overlay knowledge of soil depth, carbon content, mineralogy and/or groundwater quality to predict nutrient storage, transport, and transformations;
4. Identify surface features indicating likely groundwater flow pathways and groundwatershed;
5. Combine information to map restoration efforts, including estimates of water quality and habitat benefits. There also is opportunity, as well as a need, for development and improvement of tools and data to better understand prior-converted areas that may offer the best opportunities for targeted (and likely more effective) wetland restoration activities overall;
6. Investigate via improved reporting on wetland practices and landscape models, the areal relationship between wetland area and catchment to improve the values assigned to acres treated.

Fourth: Develop an accounting system to capture the multiple co-benefits from wetland BMP practices.

Fifth: Given need for practitioners to assess and select BMP practices to address their interests and needs, and the potential confusion caused of the plethora of possible practices, the panel recommends development of materials to further clarify selection and use of the CBP approved practices for reporting purposes. These materials would include specific examples in formats (e.g., fact sheet, webinar, etc.) requested by the Wetland Workgroup, using available partnership resources. The materials could follow examples of what is provided by the Chesapeake Stormwater Network to its community of stormwater professionals and stakeholders.

As has been discussed in the report, and this chapter, the scientific understanding of particular wetland BMP practices and project elements is sometimes limited, as is our understanding of wetland nutrient and sediment contributions (and demands in the face of climate change). Management of water quality improvement efforts that incorporate wetlands will need to be adaptive. That is, as the understanding of wetlands as source, sink or both - based on landscape position, hydrology, soils and vegetation - improves, appropriate changes to water quality models and habitat priorities and practice should be modified accordingly.

Appendix A – Literature Review for Nutrients and Sediment

Literature Review – Technical Appendix

Prepared by Tetra Tech, Inc. for the Wetlands Expert Panel

Final Version, January 2016

Contents

How Wetlands are Currently Represented in the Model

Spatial representation of wetlands

In the Phase 5.3.2 Chesapeake Bay watershed model, forested and emergent non-tidal wetlands are aggregated with into the forest, woodlots and wooded land use (Forest). (EPA 2010). This land use is calculated as the remaining land use after all agricultural, developed, extractive and open water land uses are subtracted from the total acres in each land-river segment. Wetlands are not explicitly mapped or included as a separate land use from forest. Wetlands in the forest land use category only included forested and nontidal emergent wetlands. Tidal wetlands are represented as part of the Chesapeake Bay Water Quality and Sediment Transport Model (WQSTM) (EPA 2010). Additional information on representation of wetlands in the model can be found in Chapter 4 of Chesapeake Bay Phase 5.3 Community Watershed Model documentation.

Forest loading rates

The loading rate for the forest land use is based on the input from atmospheric deposition. Other sources are not considered to contribute to the load (EPA 2010). Numerous existing literature reviews were aggregated to develop a value representative of the exporting loading found in the literature. The export targets for the entire Bay watershed were set at the median loading rates (3.1 lb/ac-yr TN and 0.13 lb/ac-yr TP). Total nitrogen loading rates were adjusted for the proportional change in atmospheric deposition between the land-river segment and the watershed average atmospheric deposition. Total phosphorus was determined not to be highly variable, and the target load is a constant 0.13 lb/ac-yr across the watershed (EPA 2010). Additional information on nutrient loading rates in the model can be found in Chapter 10 of Chesapeake Bay Phase 5.3 Community Watershed Model documentation.

Sediment loading was based on the expected annual average edge of field loading rates data in the National Resources Inventory database. These data are based on average erosion rates from the universal soil loss equation (USLE). The average edge of field loading rate is 0.26 tons/ac-yr (EPA 2010).

Wetlands loading rates

Wetlands are assigned the same loading rates as the forest acres in each land-river segment.

Approach proposed by STAC and the Mid-Atlantic Water Program

The CBP Scientific and Technical Advisory Committee (STAC) and the Mid-Atlantic Water Program have previously attempted to evaluate the effectiveness of wetlands as a BMP. Loading rate reduction methodologies were designed to calculate the load reductions from upland contributing land uses, rather than a load from the wetland itself.

During the April 2007 STAC workshop on quantifying the role of wetlands in achieving nutrient and sediment reductions, a first order kinetic equation was proposed to describe the exponential decline of nutrient and sediment over time related to detention time of runoff in a wetland. The kinetic equation was originally developed by Dr. Tom Jordan from the Smithsonian Environmental Research Center (SERC) and provided in both the STAC Report *Quantifying Role of Wetlands in Achieving Nutrient and Sediment Reductions in Chesapeake Bay* and the 2009 *Developing Nitrogen, Phosphorus and Sediment Reduction Efficiencies for Tributary Strategy Practices BMP Assessment: Final Report* by the Mid-Atlantic Water Program at the University of Maryland. The Mid-Atlantic Water Program was tasked with defining BMPs and determining effectiveness estimates that are representative of the overall Bay watershed.

Data have shown that longer detention times improve the nutrient removal efficiency of wetlands. The kinetic equation assumes that wetland detention time is proportional to the ratio of the area of wetland to the area of the watershed. First order kinetics also describe, generally, the finding that the rate of removal is proportional to the concentration, making first order kinetics a practical way to express efficiency as a percentage of the inflow pollutant removed by the wetland.

A first order kinetic equation was developed to represent the removal efficiency of restored wetlands, based on the assumptions that:

- removal is an exponential function of detention time;
- detention time is proportional to the proportion of the watershed that is wetland; and
- there is zero removal when there is no wetland in the watershed

Nonlinear regression was used to fit the model to the removal data in the literature. This yielded the equation:

$$\text{Removal} = 1 - e^{-k(\text{area})}$$

Where:

- Removal: proportion of the input removed by the wetland
- Area: proportion of the watershed area the is wetlands
- k: fitted parameter
    - TN, k=7.90, 95% confidence limits [4.56, 11.2]
    - TP, k=16.4, 95% confidence limits [8.74, 24.0].

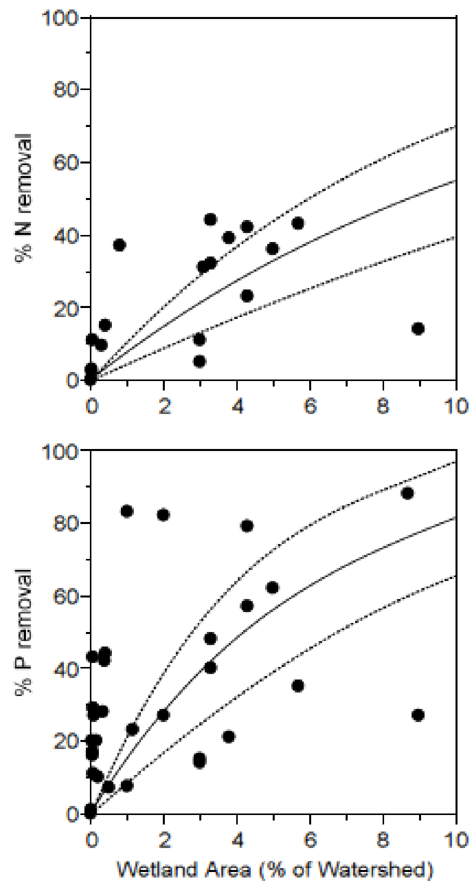

Figure 11. Literature review data points for wetland nutrient removal efficiency based on the wetland area as a proportion of the watershed. Curves indicate non-linear regression fit to data values, with 95% confidence limits. (STAC 2008).

The kinetic equation was developed for wetlands as a BMP (wetlands restoration), rather than wetlands as a land use, since wetlands were not represented as a distinct land use in the Phase 5.3.2 Watershed Model. To use the equation for BMP reporting, the jurisdictions would have been required to submit the ratio of wetland area to watershed area. As a contingency if this information was not reported by a jurisdiction, alternative calculations for the geomorphic regions were developed, based on an assumed proportion of wetlands in the watershed. Wetlands were assumed to be 1, 2, and 4 percent of the watersheds in the Appalachian, Piedmont and Valley, and Coastal Plain geomorphic provinces, respectively. The resulting TN and TP removal efficiencies are described in Table 14. If a jurisdiction does not report the geomorphic region of a wetland restoration, a uniform 16.75 percent and 32.18 percent, for TN and TP, respectively are applied.

Table 14. TN and TP removal efficiencies for wetlands by geomorphic province (Simpson and Weammert 2009).

Geomorphic Province	TN Removal Efficiency	TP Removal Efficiency
Appalachian	7%	12%
Piedmont and Valley	14%	26%
Coastal Plain	25%	50%

One of the shortcomings of the kinetic equation is that it cannot account for wetlands that are sources of nutrients. Negative removal values (nutrient export) cannot be derived from this equation. During the literature review for development of the equation, any wetlands where only negative removal values were observed were removed from the calculations. In addition, the equation only applies to nitrogen and phosphorus. Due to the lack of data, the relationship between total suspended sediment and wetland area was not determined. A uniform 15 percent removal was approved, based on the average annual removal rates that were available in the literature, plus a margin of safety.

The kinetic equation is unable to account for variations in wetland age, seasonal variation, spatial and temporal variability of flow, landscape position, or type of wetland. These factors will affect the residence time and loadings to a wetland. Craft and Schubauer-Berigan found that floodplain wetlands removed 3 times the nutrients of depressional wetlands on an areal basis (in Simpson and Weamert 2009). The declining phosphorus removal rate over time is also not accounted for in the equation. Nicholas and Higgins found that phosphorus removal declines significantly after about 4 years (in Simpson and Weamert 2009).

The BMP Assessment recommended future refinements to account for seasonal variability, nutrient discharge, hydraulic loading rate, wetland aging, and potential for dissolved P discharge during anaerobic conditions from wetlands with high phosphorus content (Simpson and Weamert 2009).

Literature Review Process

The goal of the Wetland Expert Panel was to develop a preliminary loading rate for a wetland land use(s). In 2014, a literature review was conducted to identify literature that provided loading rates or related information for nitrogen, phosphorus and sediment. Literature cited in the STAC report was used as a starting point, followed by a search of published articles, primarily peer-reviewed, using EBSCO, Agricola, and Google Scholar. Members of the Wetlands Expert Panel were also queried to identify potentially relevant articles.

The literature search using the available databases was focused on providing the broadest range of articles about the topic. Search terms were kept general, and included “wetlands” “marsh” “nutrients” “sediment”, “flux” and “loading rate” in various combinations to identify potential relevant materials. The term “constructed wetland” was specifically excluded from the search because constructed wetlands are explicitly a water quality treatment BMP and the Panel is interested in establishing a loading rate for natural or restored wetlands as a land use, not a treatment. Resources were initially parsed into three categories, data from Bay states, data from the United States but outside the Bay watershed, and international studies.

Over 100 articles and reports were originally identified. Following a review of these articles and reports, the Expert Panel indicated an interest in including additional studies in the literature review. A second set of articles was provided by the Expert Panel Coordinator in November 2015.

Results of literature review

The goal of the literature review was to determine loading rates. In the absence of actual, explicit loading rates for wetlands, the panel also identified monitoring studies that included event mean concentrations (EMCs) in and out of wetlands, loading in and out of wetlands and annual retention rates that could potentially be used to back-calculate a loading rate. Data that could differentiate major wetland types and hydrologic flow paths were sought. In keeping with the previously identified first-order kinetic equation, the ratio of wetland area to watershed area was also collected, when available.

Data Source Characterization

The weight placed on the literature review findings follows the Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Model (WQGIT, 2014). The data source characterization matrix (Table 1 in the Protocol) was used to assess data appropriateness and influence.

	High Confidence	**Medium Confidence**	**Low Confidence**
Applicability	Definition matches technical specifications	Generally representative	Somewhat representative
Study Location	Very representative of soils and hydrology	Generally representative	Somewhat representative
Variability	Relatively low	Medium	Relatively high
Number of studies	Many	Moderate	Few
Scientific Support	Operational scale research (peer reviewed)	Research scale (peer reviewed)	Not peer reviewed (gray literature)

Applicability

Many of the studies identified for this literature review did not contain relevant data and were removed from the evaluation. There are no technical specifications for natural wetlands, but the Expert Panel did attempt to exclude constructed or wastewater treatment wetlands from the evaluation on the grounds that they do not necessarily represent the normal functioning of a natural wetland. Despite this restriction, a few studies using constructed wetlands were identified and used in the analysis. The data on natural wetlands were very limited, and could not support watershed-wide loading rates or reduction efficiencies on their own. A few studies also provided data based on mesocosms, rather than in-field wetlands. These isolate nutrient processing in a very controlled manner, but do not necessarily represent the full complement of wetland functions. Data applicability can be considered to have a medium level of confidence.

Study Location

The available data was not limited to the Chesapeake Bay watershed, and most of the useful data was derived from studies outside the watershed. Similar soils and hydrology can be generally representative even in locations across the country; however some other factors that change with location may be less representative, such as temperature, which can have a large impact on denitrification rates, one of the key mechanisms for nitrogen removal. Overall, the data can be considered to have medium confidence level.

Variability

The reported results from the scientific literature are highly variable. In many instances this is because each study is evaluating something different, either different types of wetlands or different processes in the wetlands. The inherent variability of local conditions makes it unlikely that there would be low variability in wetland loading or removal rates among wetlands. There is a low to medium confidence level in the variability of the data. Attempts are made below to aggregate data by wetland type and processes, to group similar wetlands and lower variability. This was completed with mixed success.

Number of Studies

The number of studies included in each reference varies from a single study to multiple studies included as part of another literature review. While it is ideal to be able to use data from the original source, rather than an average value already calculated by another literature review, these sources provide relevant data and a cross-section of reasonable or expected values. The current literature review identified a relatively high number of overall data sources from which to derive aggregated literature values, or single study values; however, when the data are broken down into more specific wetland categories, the data for individual categories is sparse in some instances. Despite the large number of studies, there was little consistency in which parameters were studied and great differences in the types of wetlands and hydrologic regimes studied. When taken as a whole, the data provide a medium confidence level, but for individual wetland categories the confidence varies from low to medium.

Scientific Support

All of the relevant resources that are used in this literature review are peer reviewed, but there is a mix of operational and research scale studies, providing medium to high confidence in the scientific support for the data.

Characterization of Findings

Typically, the Chesapeake Bay Program has defined land use loading based on a relatively uniform land use within a catchment; however, results of the literature review indicated that this is not a common approach to how wetlands are represented or evaluated. Wetlands are not generally a uniform land use at the watershed scale and more often are representative of a small area in the watershed, making isolation of a loading rate for wetlands difficult. Most often, the loading from a wetland is in the context of the surrounding land uses.

Of the 42 articles addressing wetlands in the Chesapeake Bay watershed, 13 were identified as having potentially relevant data. The remainder did not specifically address nutrient or sediment loading rates or reduction efficiencies. A number of these studies looked at the nutrient concentrations in wetland soils, watershed-wide loading rates, and floodplain sediment accumulation rates, but these data could not be extrapolated to wetland nutrient and sediment loading rates or removal efficiencies.

Given the low success rate in identifying Chesapeake Bay-specific data, calculations of loading rates and reduction efficiencies include numerous studies from outside the watershed. When findings specifically from Chesapeake Bay watershed studies are especially relevant, they are called out below. Thirty seven relevant articles were identified that addressed wetlands outside the Chesapeake Bay watershed.

Although during the beginning stages of the literature review articles addressing evaluations of constructed/treatment wetlands were excluded from the literature search, a few of these articles have now been included, either because the initial literature search did not identify them as constructed wetlands or because an expert panel member identified the article as relevant. In many cases, there is a more significant body of research on constructed wetlands because they are specifically designed to remove nutrients and sediment. However, the degree to which their function can be compared to natural wetlands is unclear. When findings from constructed wetlands are highlighted in the following discussion, they are identified as such.

Wetland Loading Rates

Only two studies were identified that attempted to define the loading rate for a wetland area independent of the surrounding land uses. Baker et al. (2014) evaluated Barnegat Bay-Little Egg Harbor HUC14 watersheds and determined the export concentration for forest and wetlands combined was 1.17 mg/L for total nitrogen and 0.021 mg/L for total phosphorus. Similarly, Dodd et al. (1992) created nutrient budgets for the Albemarle-Pamlico Sound area, forest and wetlands were again considered as having the same loading rate, which Dodd et al. determined to be 2.07 lb/ac/yr for total nitrogen and 0.12 lb/ac/yr for total phosphorus. Neither study separated the loading from forest and wetland areas into distinct categories. No other studies were identified that provided a loading rate for wetlands as a uniform land use.

One study by Harrison et al. (2011) calculated the surface water and groundwater concentrations of TN and TP within the wetlands, however, the export rates were not calculated. The wetlands, located near Baltimore, MD were two restored relic oxbow wetlands in an urban area and two reference forested floodplain wetlands. Across the restored oxbow wetlands, the groundwater concentrations for TN and TP, respectively, were 0.72 mg/l and 11.5 µg/L. The average at the forested floodplain wetlands were 0.37 mg/L and 114.7 µg/L for TN and TP, respectively. Surface water nutrient concentrations measured within the oxbow wetlands averaged 0.6 mg/L for TN and 24 µg/L for TP.

Denver et al. (2014) provided groundwater nitrate as nitrogen values for depressional wetlands in an agricultural setting. The two natural wetlands in the study had a mean value of 0.055 mg/L NO3-N. The prior-converted cropland had a mean concentration of 7.4 mg/L, and the restored wetlands had a mean value of 1.9 mg/L.

Restored and Natural Wetland Reduction Efficiencies

The majority of studies identified represented wetlands as a BMP, calculating the load reduction from the concentration entering the wetland from upstream land uses. The following discussion summarizes the results. Articles containing data on constructed wetlands were analyzed separately. Twenty five studies with TN, TP or TSS wetland load reduction efficiencies were identified. Of these, five had study sites within the Chesapeake Bay watershed, in Prince George's County, MD and Queen Anne's County, MD. A few studies also provided data from Austria, Australia, Canada, Hungary, and Spain. The remaining studies focused on wetlands throughout the United States, including in Florida, Georgia, Louisiana, North Carolina, and Ohio.

Several studies included aggregated literature review data values and provided a range of reduction efficiencies. When a range of values was provided, these data were not used in the calculation of a mean efficiency value, but are taken into account in providing the range of values.

Eighteen studies contained TN load reduction efficiencies for studies of natural or restored wetlands (excluding constructed wetlands). The mean from the studies that provided values instead of ranges of values is a reduction of 42%. The reduction efficiencies ranged from -8% to 97%. Studies that included value ranges had reductions from -8-450 %. When only the studies with data in the Chesapeake Bay watershed are used, the mean TN efficiency is 22%, with a range of -8-89%.

A few studies also evaluated ammonia and nitrite reductions. One study in Maryland with field data found that the wetlands were a source of ammonium with an increase of 7%, and a range of -21 – 8%. The mean NH4-N reduction was 33% with a range of -49-96%. Noe and Hupp (2007) evaluated a bottomland hardwood forest in Maryland, and found nitrite reductions were only 3%, with a range of 29-33% from event-based monitoring.

Eighteen studies provided NO3 or NO3-N reduction efficiencies that covered a wide variety of wetland field measurements and laboratory analysis. The mean nitrate (NO3) reduction was 38%, with a range of -16-97%, and the mean nitrate-nitrogen (NO3-N) was 56%, with a range of -30-99%. Four studies measured TKN, with a mean reduction of 39%, with a range of -2-79%. Two studies also evaluated total organic nitrogen, with a mean reduction of 34% and a range of -15-71%. While Kovacic et al. (2000) reported that organic nitrogen was exported from constructed wetlands, two other studies provided organic nitrogen reduction efficiencies for natural or restored wetlands (Jordan et al. 2003, and García-García et el. 2009). Jordan et al. (2003) found that in a wet year organic nitrogen was exported from the restored wetland in Queen Anne's County, Maryland, but was removed in a dry year. Jordan et al. (2003) also cited a literature synthesis from Kadlec and Knight 1996 that found the overall organic nitrogen removal efficiency to be 56%. The mean organic nitrogen removal rate from the two studies was 28.7% with a range of -15-71%, substantially lower than the findings from Kadlec and Knight 1996.

Twenty studies contained TP load reduction efficiencies for natural or restored wetlands. TP load reduction efficiencies across studies ranged from -46% to 133%. The mean from the studies that provided values instead of ranges of values is a reduction of 41%. Studies that included value ranges had reductions from -14-133%. When only the studies with data in the Chesapeake Bay watershed are used, the mean TP efficiency is 20%, with a range of -41-81%.

Three studies evaluated phosphate (PO4-P) reductions from natural or restored wetlands. The majority of the data were from one event-based study of a golf course in South Carolina where only reduction ranges were provided. Reductions ranged from 0 to 100%. One study looked at total organic phosphorus (Jordan et al. 2003) and found that the mean removal was 26.4% over two years. In the dry year the wetland removed 61% of TOP, and in the wet year served as a source, with a negative efficiency of -8.3%.

Nine studies contained data on TSS reductions; the average reduction was 31% with a range of -30 to 95%. When only the studies with data in the Chesapeake Bay watershed are used, the mean TSS efficiency is 24%, with a range of -15-68%.

Table 15. Nutrient and sediment reduction efficiencies by wetland and vegetation type.

Wetland Type	Vegetation Type	TN % Reduction Mean Range (number of data points)	TP % Reduction	TSS % Reduction	Sources
Headwaters/ Depressional	Forest (and unknown)	78% 59-97 (2)	80% 66-94% (2)	--	Ardón et al. 2010; Vellidis et al. 2003
Headwaters/ Depressional	Emergent	20% -8.4-40 (7)	15% -11-59% (11)	28% -30-75% (6)	Kalin et al. (2013); Jordan et al. 2003; Knox et al. 2008; Huang et al. (2011)
Headwater/ Depressional	ALL	33% -8.4-97 (9)	19% -11-94 (13)	28.3% -30-75% (3)	
Floodplain	Forest (incl. mixed and unknown)	38% -8-94 (11)	26% -41-100 (16)	32% -15-95 (7)	Ardón et al. 2010; Jun Xu 2013; Lizotte et al. 2012; Lowrance, et al., 1997; McJannet et al. 2012; Mitsch, 1992; Noe and Hupp, 2007; Olde Venterink et al., 2006; Reddy et al. 1999; Richardson, et al. 2011; Rogers et al. 2009; Shields and Pearce 2010; Tockner et al., 1999
Floodplain	Emergent	49% 26-89% (13)	58% 10-100% (8)		Ardón et al. 2010; García-García et al. 2009; Mitsch et al. 2012; Olde Venterink et al., 2006

Wetland Type	Vegetation Type	**TN % Reduction** Mean Range (number of data points)	**TP % Reduction**	**TSS % Reduction**	**Sources**
Floodplain	ALL	44% -8-94 (24)	37% -41-100 (24)	32% -15-95 (7)	
Tidal Fresh	Forest	62% 59-65% (2)	32% -47-89% (4)	--	Ardón et al. 2010; Brantley et al. 2008; Day et al. 2006
Tidal Fresh	Emergent	--	--	--	
Tidal Saline	Forest	--	--	--	
Tidal Saline	Emergent	--	0% No range (1)	2% No range (1)	Etheridge et al. 2015
Constructed	Emergent (plus mixed, other and unknown)	32% 11-52% (12)	38% -54-97% (31)	92% 88-98 (4)	Ardón et al. 2010; Dierberg et al. 2002; Kovacic et al. 2000; Mitsch, 1992; Moustafa et al. 2012, Raisin, Mitsch and Croome 1997; Reddy et al., 1999; Reinhardt et al. 2005
All except constructed	Forest, mixed and unknown	47% -8-97 (16)	43% -47-100 (44)	37% -15-95 (8)	
All except constructed	Emergent	39% -8-89 (20)	31% -15-100 (20)	25% -30-75 (7)	

Wetland Type	Vegetation Type	TN % Reduction Mean Range (number of data points)	TP % Reduction	TSS % Reduction	Sources
All	All	40% -8.4-97 (48)	39% -54-100 (95)	44% -30-98 (19)	
Chesapeake Bay Only	All	22% -8-89 (10)	20% -41-81 (10)	24% -15-68 (8)	Kalin et al. (2013); Jordan et al. 2003; Lowrance, et al., 1997; Noe and Hupp, 2007

Constructed Wetlands Reduction Efficiencies

Nine studies contained information on constructed wetlands removal efficiencies. Constructed wetlands were specifically excluded from the literature search process but a few articles were included unintentionally, or constructed wetland information was included as part of a literature review within an article. The data from studies providing individual data points are presented in Table 15 for comparison; note that two of the studies calculated removal efficiencies from mesocosm sampling, rather than in-field data. Two studies provided a range of removal efficiencies for TN and TP. Across these two studies, constructed wetlands were evaluated in Florida, Illinois, Norway and Appalachian Pennsylvania. The TN reduction range was 3-88%, and the TP reduction range was 21-79%, which are consistent with the ranges derived from the individual data points in other studies, shown in Table 15.

In addition to TN and TP, the studies also provided data on other constituents. Kovacic et al. (2000) evaluated NO3-N, NH4-N, PO4-P, organic N and organic P removal percentages at three adjacent constructed wetlands. The mean NO3 removal efficiency was 35.8% with a range of 14-55%. NH4-N removal was 7.6% with a range of -150% to 75%. One site had an outlier rate of -567%, making it a source; however, in absolute terms, the additional loading was only 3.9 lb/yr. This value was excluded from the mean NH4-N removal efficiency calculation. All three wetlands were sources of organic-N, with no organic-N detected at the inlet and resulting concentrations at the outlets ranging between 0.2 and 0.3 mg/L. Similarly, organic-P was exported from the wetlands at concentrations between 0.03 and 0.04 mg/L. Ortho-P was also exported at higher concentrations than entered the wetlands. Concentrations increases ranged from -24 to -9%, with a mean export increase of 16.7%. During most years all three wetlands removed PO4-P. The mean efficiency was 34.9% with a range of -27 to 90%.

Wetlands as Sources of Nutrients and Sediment

Jordan et al. (2003) found that wetlands in Queen Anne's County, Maryland averaged negative removal for TOP-P, TPO4-P, TP, TON-N, TN, based on weekly composite samples over two years. In the two years that the sites were monitored, there was similar total rainfall in both years, but year 2 rainfall was about twice as much during the summer, allowing for flow over the weir. Jordan et al. notes that "because large net fluxes occur sporadically in different weeks, it is difficult to judge whether the wetland is a long-term source or sink of nutrients or TSS. The chance occurrence of one week with high flux can have a strong influence on the annual net flux. This underscores the importance of using continuous automated sampling to observe the effects of rare but critically important events." This finding highlights that certain events, such as changes in rainfall pattern or flow, can occur and will influence the overall removal efficiency, despite being relatively infrequent.

Ardón et al. (2010) collected two years of data with weekly samples and 10 storm samples at a restored riverine wetland in Tyrell County, North Carolina. Ardón et al. (2010) indicated confidence that "our sampling covered the range of flows that occurred during the 2 years. We included the storm data in our estimates of nutrient export even though the cumulative storm export did not account for more than 10% of the annual exports for any of the nutrients." The wetland was a sink of NH4-N in year 1 and a source in year 2. TP changed from a source to a sink between years 1 and 2. It was an overall source of TP over two years, but altered the form of exports from inorganic P to particulate P. Seasonal nutrient flux patterns indicated that NH4-N was mostly released during the fall and winter of both years. TP exports were in the spring, coinciding with high temperatures and the largest inundation area. Overall restoration of the wetland seemed to reduce the NO3-N export to the estuary. DON export was higher after restoration, as was TP mass export. Nitrification was inhibited in the flooded, acidic soils of the restored wetland, as compared to its prior actively drained agricultural state. Reflooding increased export of NH4-N and DON. However, the wetland was very good at eliminating the high NO3-N pulses from upland agricultural field fertilization.

Garcia-Garcia et al. (2009) found that export of NH4-N may be sensitive to slight changes in sediment redox potential, and organic matter content. In a temperate Mediterranean climate (Spain) export was hypothesized to be a result of litter decomposition and mineralization creating NH4-N sources in the wetland-stream complex.

Aldous et al. (2007) measured release of phosphorus on newly flooded restoration wetland in Oregon. The study used mesocosms, rather than in-field data. Soils were flooded on a weekly basis. During the four month experiment, the soils in the mesocosms released 1-9 g P/m2. Net flux continued to be from the soils to the water column throughout the experiment, but after day 62 phosphorus flux was not significantly different from 0. The authors extrapolated the results to the Upper Klamath Lake emergent marsh area, finding that restoration would release 64 tons of phosphorus; however, this one-time release was noted to be preferable to the 21-25 tons of phosphorus released annually under agricultural use.

Rogers et al. (2009) attributed large amounts of sediment export in a degraded wetland in Wisconsin to the erosion of sediment that had accumulated in the low-gradient channel of the wetland and was then eroded during two large storms. Drainage ditches also contributed to the net export of sediment.

Kovacic et al. (2000) analyzed removal rates from three wetlands receiving subsurface tile drainage. The nutrient budgets indicated that the wetlands, created by berming part of the floodplain and rerouting tile drainage lies in Illinois, were consistently sources of organic nitrogen and organic phosphorus, ortho-phosphate, and sources of NH4-N and total phosphorus on a less regular basis. The study found that overall these wetlands were neither a source nor a sink for phosphorus, and remained effective at removing NO3-N.

Key processes affecting nutrient/sediment retention

In addition to investigating load reduction efficiencies from wetlands, the literature review also included an evaluation of whether specific processes affecting nutrient and sediment retention in wetlands were identified in the studies. Many studies focused on wetland restoration projects and constructed wetlands, rather than natural wetlands.

Fisher and Acreman (2004) conducted a meta-analysis using studies that collectively evaluated 57 wetlands around the world to identify the important factors affecting nutrient reduction in wetlands. Figure 12 summarizes their findings on the most commonly identified factors affecting nutrient retention or reduction. For both swamps/marshes and riparian zones, sediment oxygen availability and redox potential were cited most commonly. These are strongly linked to the flooding/drying regimes and hydroperiod. Hydraulic loading and retention time were also frequently mentioned in studies of both types of wetlands.

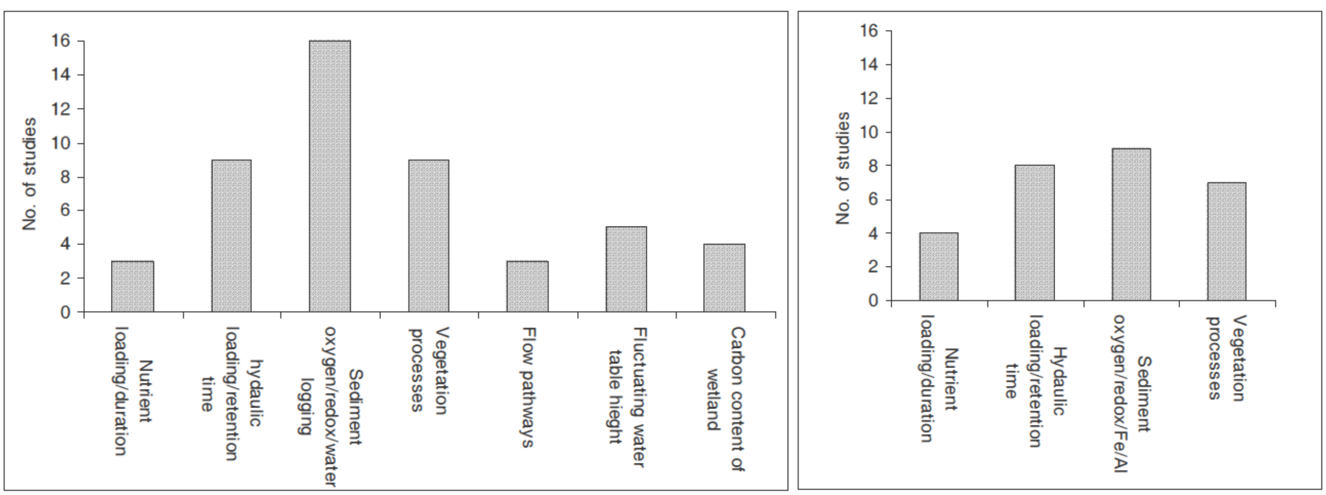

Figure 12. The factors most commonly quoted as being of importance to the nutrient retention or reduction abilities of swamps and marshes (left) and riparian zones (right). From Fisher and Acreman 2004.

Hydroperiod/Hydraulic Loading/Retention Time

Acreman et al. (2007) evaluated the connection between hydrology and wetland restoration across Europe, key issues that were identified included the effect of water level management and the effects of reconnecting rivers to their floodplains and oxbow lakes.

Jordan et al. (2003) linked hydroperiod/retention time to whether a wetland was a source or sink of TN and TP, monitoring a coastal restored wetland in Queen Anne's County, Maryland over a period of two years. In years with a drying period, wetlands acted as a sink, but in wet years, where a drying period did not occur, the wetland became a source of both TN and TP. The findings for TSS were the opposite, in wet years, the wetland acted as a sink, and in dry years it acted as a source. Wet years tended to have more high flow events. During high flow events the detention time in the wetland was reduced, preventing some of the water from remaining in the wetlands for more than a few hours, reducing the potential for the wetland to remove nutrients and sediment. Kovacic et al. (2003, in Jordan et al. 2003) found that nitrate removal capacity was exceeded in constructed wetlands with unregulated flow during high flow events. Jordan et al. (2003) concluded that removal at the Queen Anne's County site would have been higher with a constant inflow rate rather than variable flows that reduced detention time. Jordan et al. cited the Carleton et al. (2001) conclusion that wetland receiving unregulated inputs from urban or agricultural runoff had overall similar performance as wetland with regulated flows; however, performance was highly variable and possibly related to the variability of inflows. Overall, Jordan et al. found that TN and TP removal rates increased with decreasing hydraulic loading rate and increasing detention time. Similarly, several studies cited in Fisher and Acreman (2004) found that residence time strongly affects denitrification and sediment phosphorus retention.

Mitsch et al. (2012) addressed pulsed flooding of wetlands during a 15-year monitoring study of floodplain diversion wetlands (Olentangy River Wetland Research Park) in Ohio. Although the wetlands did not become a nutrient source on an average basis, in years when the wetlands experienced a spring flood pulse, TN reductions were about half what they were in years when the flood pulse was suppressed or normal river pulse conditions were allowed to occur (25-35% vs 55-60%). Marton, Fennessy and Craft attributed the comparable denitrification rates at natural and restored riparian buffers in a separate Ohio study to the pulsed hydrology in the area, "suggesting that the hydrologic regime was successful in reestablishing N removal via denitrification within 5 years following restoration" (2013).

Seasonality and Temperature

Seasonality (and more generally, temperature) may play a role in nutrient removal. Hernandez and Mitch (2007) found that soil temperature was a significant factor in the denitrification rates in created wetlands at the Olentangy River Wetland Research Park (ORW). Warmer soil temperatures were correlated with higher denitrification rates, although they acknowledge that results have been mixed in other riparian soil studies. Other studies support the observation that denitrification is temperature dependent and can vary accordingly by season (Hunt et al. 1999, Spieles and Mitsch 2000, in Jordan et al. 2003). Mitsch et al. (2005) found that nitrate-nitrogen retention at the Caernarvon, Louisiana wetland was 55 percent by both mass and concentration, while at a comparable wetland at the ORW, the retention was only 35 percent. Mitsch et al. (2005) note that the subtropical climate in southern Louisiana is more conducive to higher denitrification rates and nutrient uptake than the temperate climate of central Ohio, where the ORW is located. The subtropical climate contributes in both higher water temperatures and a longer growing season.

Kovacic et al. (2000) found that in a series of constructed wetlands in an agricultural setting in Illinois, 95 percent of the TN load entering the wetlands was transported in the winter and spring. Although the removal rates for these seasons (26% and 35%, respectively) were much lower than in the summer (95%) and fall (86%), the majority of the loading occurred in the winter and spring, causing these seasons to account for the vast majority of the TN removal (87%). Kovacic et al. noted that other similar wetlands in the Midwest with higher TN removal rates had longer residence times, and were only operational during the warmer growing season, creating higher apparent reduction efficiencies.

Kovacic et al. (2000) also found that TP predominantly entered the wetlands in the winter and spring, when removal rates were the lowest. Export of organic P was offset by dissolved P removal, resulting a net effect of the wetlands neither being a source or sink of TP. Winter and early spring pulse flows transported dissolved P out of the wetlands prior to the annual growth of plants in the wetland.

Vegetation

Vegetation can play a role in nutrient removal. Moustafa et al. (2012) conducted an experimental design using mesococosoms with varying hydroperiod, loading rate and vegetation. They found that emergent vegetation was the dominant factor influencing phosphorus flux in a low phosphorus loading rate system in south Florida/Everglades. They conclude that the presence of emergent vegetation "is the most critical for managing large wetland treatment systems receiving low P loadings, while hydrology should be the focus in managing treatment systems receiving high P loadings."

Loading Rates and Concentrations

Brantley et al. (2008) notes that several studies have found that "nutrient removal is inversely related to the loading rate." When loading rates are low, the efficiency of removal is high and when loading rates are high, the overall removal efficiency is lower. In a meta-analysis by Fisher and Acreman (2004), they found that 35 percent of the variation in nitrogen reduction across wetlands was explained by the nitrogen loading; however, there was no significant relationship between inflow nitrogen concentrations and the nutrient reduction. There was insufficient data to conduct a similar analysis on phosphorus (Fisher and Acreman 2004).

Different processes affecting N and P

Fisher and Acreman's meta-analysis found that nitrogen removal is more efficient in conditions conducive to denitrification (anerobic conditions), while phosphorus removal is more efficient under aerobic conditions. Soluble phosphorus transport out of wetlands was noted to increase when wet/water logged conditions were predominant. Nitrogen export increased under conditions of fluctuating water tables, or aerobic and anaerobic sediment zones within close proximity (Fisher and Acreman 2004).

Different Wetland Types

Marton, Fennessy and Craft (2013) found that depressional wetlands in Ohio had twice the phosphorus soil sorption of riparian wetlands, but riparian wetland had significantly higher denitrification rates. Fisher and Acreman (2004) evaluated the efficacy of riparian wetlands versus marshes and swamps for nutrient removal. Overall, riparian wetlands reduced TN and TP more frequently than the swamps and marshes. However, riparian wetlands were also found to be more likely to increase ammonium-N and soluble P loading than marshes and swamps. Fisher and Acreman suggest that soluble nutrients in marshes and swamps are less easily exported into adjacent waters because of slower water movement when compared to riparian wetlands, which are adjacent to flowing water (2004).

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Appendix B – Literature review for habitat and other impacts of wetland BMPs

Wetland Habitat Benefits and Unintended Consequences Literature Review

Prepared by Tetra Tech, Inc. for the Wetlands Expert Panel

Final version, March 2016

Contents

Wetland Functions and Values

Each Chesapeake Bay Best Management Practice (BMP) Expert Panel is responsible for developing loading or effectiveness estimates for the specific nutrient and sediment reducing technologies and practices they are tasked to address (WQGIT 2015). A previous literature review was conducted to evaluate the effectiveness of wetlands as a BMP (Tetra Tech 2016). The previous literature review for wetlands was conducted to quantify total nitrogen, total phosphorus and sediment removal efficiencies that are representative of the overall Bay watershed.

BMP Expert Panels must also identify any significant ancillary benefits or unintended consequences beyond impacts on nitrogen, phosphorus and sediment loads. This follow-up wetland literature review summarizes literature regarding the habitat functions and values of wetlands in different landscape contexts, including potential unintended consequences to habitat functions and values as a result of various management actions. The value of wetlands to and for habitat is considered, in addition to the pollutant load reductions. This review researches and summarizes existing information to support the Expert Panel's scientific recommendations to protect and promote habitat in the Expert Panel report recommendations. It is important to note that this literature review is not intended to be a fully comprehensive study, but rather to provide an overview of the benefits and/or unintended consequences of wetlands. It does not represent all possible wetland benefits and consequences.

Any identified ancillary benefits or unintended consequences do not change the definitions and loading or effectiveness estimates for nutrient and sediment reducing technologies and practices in the final Expert Panel report. State and local governments may consider both the definitions and effectiveness estimates from the main Panel report, as well as any ancillary benefits or unintended consequences included in this appendix, when deciding which technologies and practices they intend to select, fund and implement within their respective jurisdictions.

Literature Review Process

The initial goal of the Wetland Expert Panel was to develop preliminary loading rates for wetland land uses as well as nutrient and sediment removal efficiencies for various wetland types. In 2014 and 2015, literature reviews were conducted to identify literature that provided loading rates and removal efficiencies for nitrogen, phosphorus and sediment. This follow-up wetland literature review summarizes literature regarding the habitat functions and values of wetlands, including ancillary benefits and potential unintended consequences (both positive and negative) to those habitat functions and values. Literature identified during the wetlands BMP efficiency literature review was used as a starting point, followed by a search of published articles, primarily peer-reviewed, using EBSCO, and Google Scholar. Members of the Wetlands Expert Panel were also queried to identify potentially relevant articles; however, the Panel did not provide any new articles.

The literature search using the available databases was focused on providing the broadest range of articles about the topic. Search terms were kept general, and included *wetlands*, *restoration*, *habitat*, *value*, *benefits*, *floodplain*, *tidal*, *vegetation*, *animal*, *storage*, *erosion*, *downstream*, *toxics, hydrology, carbon sequestration, denitrification,* and *living shorelines* in various combinations to identify potential relevant materials. The term *constructed wetland* was specifically excluded from the search because constructed wetlands are a stormwater treatment BMP and the Panel is interested in identifying benefits and functions of natural or restored wetlands as a land use, not a treatment. This literature review focuses on the benefits of wetlands, but more specifically the benefits of wetlands restoration. Over 130 articles and reports were identified and 73 were determined to be relevant to the habitat benefits of wetlands restoration.

All Bay states have fish and wildlife agencies with additional information on wildlife use of wetland habitats. All States have or are in the process of updating State Wildlife Action Plans which would have recent relevant information on wetland benefits to wildlife.

In addition, the Chesapeake Bay Program released a document *Habitat Requirements for Chesapeake Bay Living Resources* which contains habitat information, including wetlands, for selected species

Results of Literature Review

The goal of the literature review was to identify the habitat functions and values of wetlands in different landscape contexts such as fresh and salt water tidal wetlands, floodplains, upland/headwater/depressional wetlands, and restored wetlands. The review includes potential unintended consequences to habitat functions and values as a result of various management actions.

Data Source Characterization

The weight placed on the literature review findings follows the Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model (WQGIT 2015). The data source characterization matrix (Table I in the Protocol) was used to assess data appropriateness and influence. Note that this literature review for wetland habitat benefits is more qualitative in nature than the previous literature review for wetland nutrient removal efficiency rates (Tetra Tech 2016). Therefore, there was not a strong focus on the data source characterization topics of *Extent of Replication* and *Data Collection & Analysis Methods* included in the matrix below.

	High Confidence	**Medium Confidence**	**Low Confidence**
Extent of Replication	Clearly documented and well-controlled past work that has since been replicated or strongly supported by the preponderance of other work; recent (< 5-year old) work that was clearly	Clearly documented older (>5-yr old) work that has not yet been replicated or strongly supported by other studies, but which has also not been contraindicated or disputed	Work that was not clearly documented and cannot be reproduced, or older (>5-yr old) work for which results have been contraindicated or disputed by more recent results in peer-reviewed publication or by other

	High Confidence	Medium Confidence	Low Confidence
	documented and conducted under well-controlled conditions and thus conducive to possible future replication		studies that are at least equally well documented and reproducible
Applicability	Purpose/scope of research/publication matches information/data need	Limited application	Does not apply
Study Location	Within Chesapeake Bay	Characteristic of CB, but outside of watershed	Outside of CB watershed and characteristics of study location not representative
Data Collection & Analysis Methods	Approved state or federal methods used; statistically relevant	Other approved protocol and methods; analysis done but lacks significance testing	Methods not documented; insufficient data collected
Conclusions	Scientific method evident; conclusions supported by statistical analysis	Conclusions reasonable but not supported by data; inferences based on data	Inconclusive; insufficient evidence
References	Majority peer-review	Some peer-review	Minimal to none peer-review

Extent of Replication

As aforementioned, this literature review for wetland habitat benefits is more qualitative in nature than the previous literature review for wetland nutrient removal efficiency rates (Tetra Tech 2016). This results in a medium confidence level since there are not necessarily studies that can be replicated. The literature reviewed includes a mixture of peer-reviewed articles as well as informational documents such as literature reviews, fact sheets, and training modules. Most of the articles reviewed are recent. The oldest was published in 1978, while the most recent articles were published in 2015.

Applicability

Many of the studies identified for this literature review did not contain relevant data and were removed from the evaluation. Seventy three of the 131 articles reviewed were determined to be relevant and are included in this summary. There are no technical specifications for natural wetlands, but the Expert Panel did attempt to exclude constructed or wastewater treatment wetlands from the evaluation on the grounds that they do not necessarily represent the normal functioning of a natural wetland. Despite this restriction, three studies using constructed wetlands were identified and used in the analysis. Data applicability can be considered to have a medium level of confidence.

Study Location

The available data were not limited to the Chesapeake Bay watershed, and most of the useful data were derived from studies outside the watershed. Only nine of the 73 relevant articles were within the Chesapeake Bay watershed. Similar soils and hydrology can be generally representative of wetlands even in locations across the country; however some other factors that change with location may be less representative. An example is climate, which can have an impact on the types of benefits a particular wetland offers. Overall, the data are considered to have a medium level of confidence.

Data Collection & Analysis Methods

As mentioned above, this literature review for wetland habitat benefits is more qualitative in nature than the previous literature review for wetland nutrient removal efficiency rates (Tetra Tech 2016). Therefore, specific approved state or federal methods were not typically employed and are not relevant to this literature review.

Conclusions

The conclusions of the reviewed articles have a medium confidence, meaning the presented conclusions are reasonable but not always supported by data. There are often inferences based on data. Some studies did present results based on scientific method; however, other papers were often literature reviews that summarized existing information regarding wetland functions and values.

References

The majority of the relevant resources that are used in this literature review are peer reviewed, but there is a mix of peer reviewed journal articles, papers written by state and federal agencies, papers written by non-profit organizations and papers written by other individuals or organizations. This provides medium confidence (mostly peer review) in the scientific support for the data.

Characterization of Findings

Wetlands are among the most biologically productive ecosystems in the world (NRCS 2014). While wetlands only occupy about five percent of the continental U.S. land surface, up to one-half of all North American bird species feed or nest in wetlands, more than one-third of endangered and threatened species rely on them, and wetlands are home to nearly one-third of our country's plant species (NRCS 2014). Results of the literature review indicated that both saline and freshwater wetlands provide multiple habitat benefits to mammals, birds, fish, amphibians, and reptiles as well as provide human benefits such as flood reduction, water quality improvement, carbon sequestration, and recreational and educational opportunities.

Of the 14 articles addressing wetlands in the Chesapeake Bay watershed, nine were identified as having potentially relevant data. The remainder did not specifically address ancillary wetland benefits and focused on land uses different than wetlands or nutrient removal rates rather than wetland habitat benefits.

Given the low success rate in identifying Chesapeake Bay-specific information, several studies from outside the watershed were included. When findings specifically from Chesapeake Bay watershed studies are especially relevant, they are called out below. Sixty four relevant articles were identified that addressed wetlands outside the Chesapeake Bay watershed.

Although during the beginning stages of the literature review articles addressing evaluations of constructed/treatment wetlands were excluded from the literature search, a few of these articles have now been included because the initial literature search did not identify them as constructed wetlands. When findings from constructed wetlands are highlighted in the following discussion, they are identified as such. The following sections summarize the findings regarding the various ancillary benefits and unintended consequences of wetlands (in addition to nutrient and sediment reduction).

Creation of Animal, Waterfowl, and Fish, and Vegetation Habitat

The literature review resulted in 23 articles on the benefits of wetlands to the habitats of animals, waterfowl, fish, and endangered and threatened species. Most of the articles focused on general animal habitat (17), while five of the articles discussed waterfowl habitat specifically, nine articles discussed fish habitat, and four articles discussed the benefits to endangered and threatened species.

Animal Habitat

Wildlife habitat is an important functional value of all types of wetlands (Amman and Stone 1991; Woodward and Wui 2001). Wildlife use wetlands to varying degrees depending upon the species involved (USEPA undated). Reptiles, amphibians, muskrat, beaver, mink, rabbits, and other small mammals depend on wetlands (Interagency Workgroup on Wetland Restoration, undated). Wetlands serve as the primary habitat for some species that live in wetlands for their entire lives, such as beaver and muskrat, while other species require wetland habitat for only part of their life cycle or during particular seasons when wetlands provide food, water, and cover. Still other species, such as otter, black bear and raccoon use wetlands even less frequently, mostly for feeding.

A literature review completed in 2015 on the connectivity of wetlands to downstream waters indicates that riparian wetlands and non-floodplain wetlands can provide refuge for aquatic insects and other lotic organisms from predators or other environmental stressors (USEPA 2015). This refuge facilitates individual or population survival. Wetlands provide refuge during certain life stages such as breeding, nesting, or nursery sites for frogs, other amphibians, and some reptiles that reside in streams as adults.

In addition to mammals, amphibians, and reptiles, “80% of [the] American breeding bird population and over 50% of protected migratory bird species rely on wetlands” (Mitsch and Gosselink 2007; Interagency Workgroup on Wetland Restoration, undated; NRCS 2014). Diverse wetland types are necessary to support the diversity of bird species. New Zealand’s Greater Wellington Regional Council (2009) indicates that wetlands cover less than 2 percent of New Zealand’s land area, but are home to 22 percent of the native land bird species.

Golladay et al. (1997) tested the hypothesis that regular inundation and drying are important influences on community structure in some seasonal wetlands. Three forested limesink wetlands in southwest Georgia were included in the study and were found to support an abundant invertebrate fauna. Tidal marshes have been found to be some of the most productive ecosystems on earth (Kelly et al. 2011 and Greater Wellington Regional Council 2009) and provide a range of valuable ecosystem services including habitat.

There is a large amount of research on the restoration of agricultural wetlands. Fennessy and Craft (2011) found that agricultural conservation practices increase wetland ecosystem services in the Glaciated Interior Plains in the Upper Mississippi River basin. Eight wetland types were graded low, medium, or high for their relative contribution to animal habitat. No wetland types were graded “low”. Riparian and floodplain forests were considered to provide “high” productivity and connectivity for habitat and depression and vernal pool wetlands provided “high” breeding grounds. Wet meadows and seeps provided “medium” plant diversity in terms of animal habitat.

NRCS (2014) provides a summary of the Natural Resources Conservation Service’s (NRCS’s) Wetlands Reserve Program (WRP) over the last 20 years. The WRP restores wetlands on frequently flooded agricultural land where restoration maximizes habitat for migratory birds and other wildlife and improves water quality. The WRP provides habitat for a wide variety of animals that depend on wetlands.

NRCS established the Migratory Bird Habitat Initiative (MBHI) to increase habitat for migratory birds impacted by the Deepwater Horizon/BP oil spill (NRCS 2014). NRCS worked to increase open water and available food for migrating birds. WRP projects made up a significant portion of the nearly 500,000 acres NRCS enrolled in MBHI, providing more habitat for the over 50 million birds that migrate the Mississippi, Central, and Atlantic flyways each year (NRCS 2014). These WRP restorations can create groups of smaller wetlands that can provide necessary habitat in an agricultural area (Mitsch 1992).

Wetland creation for the purposes of simultaneous nutrient retention and increased species diversity also benefits the biodiversity of agricultural landscapes. Thiere et al. (2009) found that the density of aquatic habitats was increased by at least 30 percent. These results disagree with a study by Jessop et al. (2014) that found that designing wetlands to focus on nutrient reduction may come at the expense of biodiversity (See Negative Impacts section below).

A living shoreline is another type of wetland restoration/creation that is seeing some success. A living shoreline is a sloped, erosion control technique built to protect an embankment that mimics natural habitat and allows for natural coastal processes to remain through the strategic placement of plants, stone, sand fill, and other structural and organic materials (GDNR 2013; Shumway et al. 2012). Living shorelines generally use hard materials, such as oyster shells, to absorb the energy of incoming water to reduce erosion. Living shorelines are included in this literature review because traditional bulkheads may be effective at reducing erosion and upland loss, but they often cause a loss of habitat connectivity to tidal habitat that is essential to shorebirds, fish, and shellfish (GDNR 2013; Shumway et al. 2012). “Through the promotion of native species and habitats, living shorelines can preserve and enhance the ecological integrity of the coastal environment. In general, these environments provide essential water filtration, habitat, and recreational and commercial opportunities…. Oyster reefs, such as those created by living shorelines…, provide up to $100,000/hectare (ha) ($40,500/acre) through water filtration, habitat, bank stabilization, and harvesting potential" (GDNR 2013). Living shoreline implementation occurring along the Delaware River estuary are expected to protect 10 acres of intertidal habitat for every mile of living shoreline (Stutz 2014).

Habitat provided by wetland restoration benefits not only wildlife, but humans as well. Teal and Peterson (2005) feel that the societal benefits of wetland restoration should be measured rather than implied or assumed. Habitat restoration was considered to be a societal benefit in a study of four watersheds [Mississippi River, Delaware Bay, Lower Fox River (Wisconsin), and South Cape Beach Marsh (Massachusetts)].

Waterfowl Habitat

Many birds, including shorebirds and wading birds, feed, nest, and/or raise their young in wetlands (USEPA undated). Migratory waterfowl, including cranes, ducks, geese, swans, and shorebirds move between and use estuarine, riverine, riparian, and non-floodplain wetlands for resting, feeding, breeding, or nesting grounds for at least part of the year (USEPA undated, 2015).

In the Chesapeake Bay Region (a major wintering area for waterfowl), coastal wetlands supported an annual average of nearly 79,000 wintering black ducks from 1950 to 1994 (USEPA undated). Most of these ducks also rely on the depressional wetlands in the upper mid-west and adjacent Canada and interior wetlands in northeastern North America for nesting. Wood ducks are found throughout freshwater deciduous forests of North America. Preferred breeding sites include floodplains, remote ponds, and woodland pools (USEPA 2015). Wetland restoration through the WRP has restored over 530,000 acres in the Mississippi Alluvial Valley, the nation's largest floodplain, which is a critical region for numerous species of waterfowl, including wintering mallards and wood ducks (NRCS 2014).

The U.S. Fish and Wildlife Service (USFWS) also estimates that WRP wetlands in the Prairie Pothole Region of the Dakotas have a potential waterfowl carrying capacity of over 48,000 pairs of ducks per year (NRCS 2014). In addition to the NRCS's WRP, their Conservation Reserve Program (CRP) provides large blocks of restored grasslands and wetlands. The CRP addresses the vital reproductive rates of waterfowl populations in their most important breeding grounds in North America, the prairie pothole wetlands in the upper Midwest. "Wetlands that occur in grasslands tend to attract higher densities of ducks and are considered superior in biological function to those that occur in cropland" (Allen and Vandever 2005).

Nebraska's neighboring Rainwater Basin (RWB) is also an important stop along the Central Flyway. Only 17 percent of the historically greater than 200,000 acres of wetlands in Nebraska's RWB still exist; however, millions of migrating waterfowl continue to stop there each year (NRCS 2014). Wetlands provide wetland-derived food for migrating waterfowl while they are in the RWB.

Webb et al. (2010) conducted a study to determine local (within wetland and immediate watershed) and landscape-scale factors influencing wetland bird abundance and species richness during spring migration at RWB playas. Wetlands were observed to quantify wetland bird use and determine the relative importance of habitat characteristics. Wetland area, vegetation, and water depth were consistently important habitat characteristics to various waterfowl species (Webb et al. 2010). The relationship between duck abundance and wetland area was most evident during times of lower wetland availability, resulting in lower food availability. In general, species richness increased with wetland area. Dense stands of emergent vegetation can limit feeding activity as well as predator detection. Birds tended to look for wetlands with a 50:50 ratio of open water to vegetation. Water depth was negatively correlated with bird abundance. Deep water reduces invertebrate food resource availability for many species of migratory shorebirds.

Fish and Shellfish Habitat

In addition to animals and birds, fish greatly benefit from wetlands. Coastal wetlands serve as important spawning and nursery areas for the young of many recreational and commercial fish and shellfish because they are the most productive of all wetlands and produce so much plant biomass and invertebrate life (Long Island Sound Study 2003; Hamill undated; USEPA undated). "95% of commercially harvested fish/shellfish in the U.S. are wetland dependent" (Mitsch and Gosselink 2007; Interagency Workgroup on Wetland Restoration, undated).

Riparian wetlands can also provide feeding habitat for fish during periods of overbank flow (USEPA 2015). Teal and Peterson (2005) link increased fish habitat in restored wetlands to improved fishing as a societal benefit of wetland restoration. Some examples of wetland restoration projects with benefits to fish habitat are described below.

Abt Associates (2014) assessed the potential economic value of long-lasting environmental benefits provided by recent coastal restoration projects: tidal marsh restoration in the San Francisco Bay; eelgrass meadows and oyster reefs restoration in the Seaside Bays of Virginia; and living shorelines in Mobile Bay, Alabama. The projects showed that restoration investment, in terms of initial construction cost, provided a variable return on investment. For every $1 invested in construction costs, the projects each produced between $0.06 and $36 in total long-term ecosystem service benefits. Some, but not all, projects can be expected to demonstrate favorable cost-benefit ratios. Fish populations and diversity showed a positive response to the increased habitat availability and increased range of environmental conditions (primarily salinity). These increased numbers could provide additional forage base for larger game fish of recreational interest (Abt Associates 2014).

Gooseneck Cove in Rhode Island was restored and brought back the natural tidal flow in the marsh, along with native vegetation and improved habitat for striped bass and bluefish (NRCS 2014). Stream restoration projects on floodplain wetlands along Sligo Creek (in the Anacostia watershed within the Chesapeake Bay watershed) have improved habitat conditions so that supported fish populations increased from 2 to 11 native species (Montgomery County and MD DEP 2003).

Endangered and Threatened Species Habitat

NRCS (2014) states that more than one third of all federally listed species depend on wetlands during part of their lifecycle, while the USFWS estimates that up to 43 percent of both federally threatened and endangered species rely directly or indirectly on wetlands for their survival (USEPA undated). “There are more than 40 plant and animal species [in the Long Island Sound] of special concern, threatened, or endangered status that depend on the presence of tidal marshes for one, or many, of their life stages” (Long Island Sound Study 2003). “Conservation and restoration programs provide the habitat these [endangered] creatures need to ensure our wildlife survives into the future” (Hamill undated). Restored wetland habitat can help prevent the listing, and accelerate the recovery, of at-risk species (NRCS 2014). Examples of endangered or threatened species that depend on wetlands for their survival are described below.

Sixty two landowners in Oregon’s Willamette River watershed worked together to enroll 7,600 acres into WRP, resulting in improved habitat and Oregon chub survival (NRCS 2014). The Oregon chub was down-listed from Endangered to Threatened. Other species also benefitted, such as the Upper Willamette Spring Chinook salmon, Fender’s blue butterfly and Nelson’s checkermallow (NRCS 2014).

Wood storks nest in colonies in cypress swamps and are currently listed as a federally endangered species. In 2010, a colony of over 125 wood stork nests, 580 cattle egrets and various other waterfowl were discovered on a WRP project in southwest Georgia (NRCS 2014). Since these restored wetlands are so valuable to these birds, WRP is considered essential to the federal Wood Stork Recovery Action Plan.

WRP helped reverse the federally threatened Louisiana black bear’s decline by restoring lost habitat (NRCS 2014). WRP also provides habitat for the bog turtle in eastern states with specific focus in Pennsylvania. This small, semi-aquatic turtle has been listed as a federally threatened species since 1997 (NRCS 2014).

In addition, the federally endangered whooping crane is dependent upon wetland habitat in the Midwest. Conservation efforts, including wetland restoration, have played a critical role in the survival of the whooping crane (NRCS 2014).

Vegetation Habitat

Wetlands are also an important habitat for vegetation. Riparian wetlands provide habitat for aquatic vegetation, emergent vegetation, and phytoplankton (Ducey et al. 2015; USEPA 2015). Vegetation species diversity and habitat quality increase rapidly with re-vegetation of a wetland (Abt Associates 2014). Long Island Sound Study (2003) indicates that the primary productivity of wetlands rivals that of rainforests and high yield agricultural fields. Above-ground production of salt marsh angiosperms along the Connecticut coast ranges from 0.13 pounds (lbs)/square feet (ft^2)/year to 0.41 lbs/ft^2/year (Long Island Sound Study 2003).

Tidal salt marshes in the San Francisco Estuary have heterogeneous landscape patterns that support primary productivity and carbon sequestration as well as increased vegetation diversity and habitat for wildlife (Kelly et al. 2011). This indicates that vegetation pattern, in addition to quantity, should be considered when restoring wetlands.

Organic soil amendments in restored wetlands can improve soil properties critical for wetland functioning but the benefits of the treatment and the development of the plant community are highly influenced by initial site conditions (Ballantine et al. 2011). A case study on the restored tidal freshwater Kingman Marsh along the Anacostia River in the Chesapeake Bay watershed indicates that the environmental conditions of urban settings impose constraints in restored wetlands that result in plant communities more like those of urban natural wetlands than those of wetlands in less urbanized watersheds (Baldwin 2004).

Gleason et al. (2008) found that restoration practices improved upland floristic quality and native species richness relative to cropped catchments, but upland floristic quality and native species richness of restored catchments did not approach the full site potential as defined by native prairie catchments. Audet et al. (2015) indicates that high groundwater levels and low nutrient availability are important factors in improving species richness in restored wetlands.

Ho and Richardson (2013) examined floral succession under natural processes following wetland restoration of floodplain and marsh habitats in an urban setting in North Carolina. The most natural wetland succession trajectories occurred in the wettest sites (Low Marsh). Species richness increased by 58 percent in the Low Marsh, while it decreased by 58 percent in the High Marsh. It appears that the frequent inundation of the Low Marshes prevented the establishment of invasive species, while the drier High Marsh was overwhelmed by invasive species. "After the wetland restoration, however, pockets of depressions formed mosaics of micro-environments that gave rise to new habitats and helped diversify plant communities" (Ho and Richardson 2013).

Effect of Wetlands on Flood Control and Water Storage

Peak Flow Reduction

Flood control potential is another important wetland functional value (Amman and Stone 1991). "Small wetlands high in a watershed can reduce and delay flood peaks by temporarily storing water" (Zedler 2003). Non-floodplain wetlands can increase the time for stream discharge to rise and fall in response to a precipitation event due to wetland storage capacity (USEPA 2015). Restored wetlands can help reduce downstream flooding and lessen damaging impacts from floods by providing an area not occupied by homes or farms to spread, slow and store floodwaters (NRCS 2014; Landstudies, Inc 2010; Hunt 1997; Interagency Workgroup on Wetland Restoration undated), and regulate "water movement" (Ducey et al. 2015). Trees and other wetland vegetation also slow flood waters (NRCS 2014).

Streamflow records from 30 gauging stations in watersheds with variable wetland areas were analyzed to assess the influence of wetlands on streamflow (Demissie and Khan 1993). "The floodflow volume to total precipitation ratio decreases by 1.4 percent for an increase of one percent wetland area in the watershed. The decrease in the floodflow volume parameter is significantly lower than for the peakflow parameters" (Demissie and Khan 1993).

A wetland restoration along Grays River in the state of Washington did not show the benefit of peak flow reduction due to wetland restoration (Breithaupt and Khangaonkar 2011). There was little difference found in maximum peak water surface elevations between the pre-restoration and post-restoration analyses.

Bullock and Acreman (2003) presents a database of 439 published statements on the water quantity functions of wetlands from 169 studies worldwide. Emphasis is placed on hydrological functions relating to gross water balance, groundwater recharge, base flow and low flows, flood response and river flow variability. Table 5 in the document lists the number of functional statements for each of the wetland types that were analyzed (floodplains, surface water depressions and slopes, groundwater depressions and slopes, and general wetlands) for these hydrologic functions. Because of the massive amount of wetlands used in this paper, it was not feasible to list the attributes of each individual one. However, a summary of the studies that evaluated flood response shows that the majority of functional statements about wetlands indicated a decrease in the flood peak and flood event volume and an increase in the flood time to peak. The results also indicate that the majority of studies showed that wetlands are an important factor in reducing or delaying floods and increasing flood recession.

Water Storage

"[Riparian wetlands] provide valuable ecosystem services such as floodwater storage…" (Audet et al. 2015). Riparian wetlands and non-floodplain wetlands can be sinks for water by intercepting overland or subsurface flow, if available water storage capacity of the wetlands is not exceeded, which can reduce or attenuate flow to downstream waters and flooding (USEPA 2015). Riparian wetlands can temporarily store water following overbank flow, which then can move back to the stream over time as baseflow. "Both the drained and undrained wetland have the capacity to store water; but because the undrained wetland drains so much more slowly, it stores more water in a given storm event" (Potter 2011).

Because of their low topographic position relative to uplands, wetlands store and slowly release surface water, rain, snowmelt, groundwater and flood waters (USEPA undated). A one-acre wetland typically stores about one million gallons of water (NRCS 2014). Trees and other wetland vegetation also impede the movement of flood waters and distribute them more slowly over floodplains. This combined water storage and slowing action lowers flood heights and helps reduce floods. Hunt (1997) supports the use of a natural storage approach to reduce flood damages by restoring the Upper Mississippi River basin's natural hydrology. WRP projects in Minnesota's Red River Valley, which is part of the Upper Mississippi River basin, are helping slow and store floodwaters (NRCS 2014). WRP wetlands in the prairie pothole wetlands of the region have a water storage capacity of over 23,000 acre-feet, which covers 46,000 acres, or an area the size of Washington, D.C., in six inches of water (NRCS 2014).

Gleason et al. (2007) conducted a study to develop and apply approaches to quantify changes in ecosystem services resulting from wetland restoration activities in the Prairie Pothole area of the upper Mustinka watershed in Minnesota. In a 110,145 acre watershed area, the watershed-wide water storage was found to be 458,151 acre-feet. Gleason et al. (2007) found that in a 130,368 acre watershed, a 25 percent restoration of the previously farmed and drained prairie pothole wetlands resulted in a watershed-wide water storage increase of 27-32 percent and a 50 percent restoration of the wetlands resulted in an increased water storage of 53-63 percent.

Another study of a 3.2 acre restored wetland receiving unregulated inflows from a 34.6 acre agricultural watershed in Kent Island, Maryland in the Chesapeake Bay watershed, had a water storage net gain of 127 m^3 (Jordan et al. 2003).

Storm Abatement

"Wetlands act as a giant sponge, helping to control water flow and water quality. Their plants slow the flow of water off the land so that, in times of flood, more can be absorbed into the soil" (Greater Wellington Regional Council 2009). The services provided by wetlands include protection against floods (Woodward and Wui 2001; Teal and Peterson 2005) and in general, restoration of a wetland increases local evapotranspiration losses, leading to an effect on downstream flood levels, particularly in dry regions (Potter 2011; Bullock and Acreman 2003).

Floodplain wetlands reduce flooding by absorbing and slowing floodwaters. Headwater wetlands are more unpredictable; although wetland vegetation impedes flow, the saturated subsurface has no available pore space to absorb water and therefore quickens surface flow. Downstream flood risk is likely to be reduced by maintenance of intact forests and upland wetlands (Brauman et al. 2007).

Costanza et al. (2013) used a regression model for 34 major U.S. hurricanes (including storms impacting the Chesapeake Bay watershed) since 1980. A loss of wetlands in the model resulted in an increase in storm damage. The ability of wetlands to control erosion is so valuable that some states, such as Florida, are restoring wetlands in coastal areas to buffer the storm surges from hurricanes and tropical storms by dissipating wave energy before it impacts roads, houses, and other man-made structures (USEPA undated).

Hunt (1997) and Hey and Philippi (1995) discuss the use of a natural storage approach to reduce flood damages by restoring the Upper Mississippi River basin's natural hydrology and wetlands. The watershed area in the Upper Mississippi River basin is 733,591 square miles (mi^2) (Mitsch and Gosselink 2000) and would need seven percent of the watershed area as wetlands for successful flood control.

Aquifer Recharge

While many wetlands help to reduce floods and water flow during storm events, they are also useful during times of dry weather and low flow. Some wetlands maintain stream flow during dry periods; others replenish groundwater (USEPA undated). Wetlands allow water to be absorbed into the soil providing groundwater recharge (NRCS 2014). Non-floodplain wetlands can contribute to groundwater recharge under low water table conditions, which ultimately contributes to baseflow (USEPA 2015).

Pollutant Reduction and Water Quality Improvement

As aforementioned, Tetra Tech (2016) already completed a previous literature review to evaluate the effectiveness of wetlands as a BMP. That literature review focused on the effectiveness of wetlands at removing nitrogen, phosphorus, and sediment. This current literature review briefly discusses nutrient and sediment removal, but focuses on the reduction of toxic pollutants, denitrification, and carbon sequestration with regard to water quality improvement and pollutant reduction.

Services provided by constructed and restored wetlands, in conjunction with ecologically sound watershed practices, can remove contaminants from water (Zedler 2003; Woodward and Wui 2001; Hunt 1997). Wetlands improve water quality by intercepting surface runoff and removing or retaining nutrients, pesticides, and metals, processing organic wastes, and reducing suspended sediments before they reach open water (USEPA 2015, NRCS 2014, USEPA undated). Without wetlands, these pollutants can clog waterways and affect fish and amphibian egg development. Wetlands also reduce environmental problems, such as algal blooms, dead zones, and fish kills, that are generally associated with excess nutrient loadings. The capacity of wetlands to function as a water purifier is limited. Too much surface runoff carrying pollutants can degrade wetlands and the societal services they provide.

Ecological restoration is becoming regarded as a major strategy for increasing the provision of ecosystem services as well as reversing biodiversity losses (Bullock et al. 2011). Bullock et al. (2011) show that restoration projects can be effective in enhancing both, but that conflicts can arise, especially if single services are targeted in isolation. “Soil properties related to water quality in restored wetlands were <50% of reference values after 55 years” (Bullock et al. 2011).

Marton et al. (2015) consider controls on biogeochemical functions that influence water quality, and estimate changes in ecosystem service delivery that would occur if these wetlands were lost. They specifically estimated that the loss of over 9 million acres of prairie pothole wetlands in the Midwest has resulted in an increase of between 5 million and 140 million tons of sediment entering surface waters per year.

Mitsch and Gosselink (2000) estimate that for general water quality improvement in Illinois, a 146 mi^2 watershed would need 1 to 5 percent of the area to be wetlands. “Based on research done at the Des Plaines River Wetlands Demonstration Project, a conservative hydraulic loading rate, yet one sufficient to accomplish substantial improvement in water quality, would be 0.083 cubic feet per second per acre” (Hey and Philippi 1995). Using this hydraulic loading rate, the area necessary to provide essential flood control and water quality improvement at the same time in the Mississippi River at Thebes, Illinois can be calculated. If the mean annual flood flow were to be treated, assuming the same loading rate, about 6 million acres of wetlands (1.3% of the watershed) would be needed. Approximately 13 million acres of wetlands (2.9% of the watershed) would be needed to treat a 100-year flood.

Downstream Effects on Sedimentation

An important function of wetlands is the stabilization of sediment, which reduces erosion (Woodward and Wui 2001). Wetlands also improve downstream water quality by exporting water after sediment has been retained (Marton et al. 2015). Wetland soils and plants help to break down pollutants and trap sediments (Greater Wellington Regional Council 2009).

Mitsch (1992) presents case studies of riparian wetland systems that were evaluated for their role in controlling nonpoint source pollution. The natural riparian cypress swamp had a retention of 0.092 lbs/ft^2 (3 percent removal efficiency) during a flood event. Constructed riparian wetlands (with a pump) in the Des Plaines River had annual retentions of 0.159 to 0.163 lbs/ft^2 (90 and 88 percent removal efficiency, respectively) with a high flow influx rate. Annual sediment retention rates with a low flow influx rate ranged from 0.041 lbs/ft^2 (93 percent removal efficiency) to 0.044 lbs/ft^2 (98 percent removal efficiency).

Another study showed that constructed wetlands in the agricultural Glaciated Interior Plains in the Midwest provided 2,387,606 lbs/year sediment retention (Fennessy and Craft 2011).

Downstream Effects on Streambank Erosion

Wetlands also act as buffers that help protect shorelines and streambanks against erosion. Wetland plants stabilize soil with their roots, absorb the energy of waves, and break up the flow of stream or river currents (Interagency Workgroup on Wetland Restoration undated; USEPA undated). Teal and Peterson (2005) include erosion control as a societal benefit of wetland restoration.

Mitsch (1992) indicates that "…steeper terrain is often most susceptible to high erosion and hence high contributions of suspended sediments…One approach is to attempt to integrate terraced wetlands into the landscape". Another approach is the installation of a living shoreline, which is currently being used to forestall further erosion of existing wetlands to protect and restore Delaware Bay's tidal wetlands (Stutz 2014).

Denitrification

Wetlands also support denitrification. Several wetland denitrification studies are presented below. Four of the studies provide denitrification rates and four provide removal efficiencies. The denitrification rates and removal efficiencies are presented in Table 1 and discussed in more detail in the following paragraphs. In general, denitrification rates appear to be higher at wetland sites with slower flow and a high water table (Hernandez and Mitsch 2007; McPhillips et al. 2015; McJannet et al. 2011; Mitsch et al. 2012; Knox et al. 2008; Gumiero et al. 2011; and Ator et al. 2013).

Table 1. Denitrification rates in wetlands

Wetland Type	Denitrification Rate	Nitrate Removal Efficiency	Source
Low riparian wetland	7.13±0.91 lbs N/acre	NA	Hernandez and Mitsch 2007
High riparian wetland	4.09±0.78 lbs N/acre	NA	Hernandez and Mitsch 2007
Riparian wetland (fast flow rate)	410 to 772 µg N/kg soil/day	NA	McPhillips et al. 2015
Riparian wetland (slow flow rate)	727 to 5,261 µg N/kg soil/day	NA	McPhillips et al. 2015
Floodplain	208 lbs/2 year period in groundwater	NA	McJannet et al. 2011
Floodplain	13,239 lbs/2 year period in soil	NA	McJannet et al. 2011
Forested riparian wetland	61 lbs N/acre/year	NA	Vellidis et al. 2003
Restored agricultural wetland	NA	52%	Jordan et al. 2003
Planted riparian wetlands (flood pulses)	NA	6.6%	Mitsch et al. 2012
Planted riparian wetlands (suppressed flood pulses)	NA	3.1%	Mitsch et al. 2012
Unplanted riparian wetlands (flood pulses)	NA	9.6%	Mitsch et al. 2012
Unplanted riparian wetlands (suppressed flood pulses)	NA	4.2%	Mitsch et al. 2012
Planted and unplanted riparian wetlands (normal river conditions)	NA	2.2%	Mitsch et al. 2012
Reference wetland (low flow)	NA	27%	Knox et al. 2008
Channelized wetland (high flow)	NA	3%	Knox et al. 2008
Forested wetlands	NA	39% - 88%	Gumiero et al. 2011

NA = not applicable

Hernandez and Mitsch (2007) measured denitrification in two created riparian wetlands in the Olentangy River Wetland Research Park, Ohio. The highest mean denitrification rates were observed in the permanently flooded low marsh zone (7.13±0.91 lbs N/acre), which were significantly higher than the high marsh area (permanently saturated with standing water only during flood pulses) (4.09±0.78 lbs N/acre).

Denitrification at a pair of agricultural riparian sites in central New York was characterized by different hydrologic regimes (fast and slow) (McPhillips et al. 2015). "Denitrification ranged from 727 to 5,261 μg N/kg soil/day at the slow site…[and]...410 to 772 μg N/kg soil/day at the fast site" (McPhillips et al. 2015). The denitrification rate decreased with groundwater flux at both sites and accounted for only 5 to 12 percent of total nitrate removal at both sites.

Analysis of residence times in a naturally occurring floodplain in Australia showed that the wetland is well mixed; however, the time that water spends in the wetland is short (90 percent of the flow passed through the wetland in less than 6 hours), leaving little time for denitrification to take place (McJannet et al. 2011). The hydraulic loading of the wetland was also shown to be much higher than that recommended for denitrification. Annual retention was 208 lbs/2 year period in groundwater and 13,239 lbs/2 year period in soil (McJannet et al. 2011).

Another example of a restored wetland (forested riparian wetland buffer) receiving water from an agricultural watershed resulted in an average annual denitrification rate of 61 lbs N/acre/year (Vellidis et al. 2003).

Denitrification removal efficiencies were provided in four studies. These removal efficiencies support the idea that denitrification occurs at a higher rate in wetlands with slow flow and more water. A restored wetland receiving unregulated highly variable inflows from an agricultural watershed in the Chesapeake Bay watershed (Kent Island, MD) was effective at removing nitrate via denitrification with a removal efficiency of 52 percent (Jordan et al. 2003).

Mitsch et al. (2012) studied a pair of flow-through created riverine wetlands in the Olentangy River Wetland Research Park, Ohio. The percentage of nitrogen removed due to denitrification in a planted wetland was 6.6 percent during artificial spring pulses and 3.1 percent during suppressed flood pulses. The percentage of nitrogen removed due to denitrification in an unplanted wetland was 9.6 percent during artificial spring pulses and 4.2 percent during suppressed flood pulses. Denitrification was 2.2 percent during normal river pulse conditions for both planted and unplanted wetlands.

Knox et al. (2008) examined benefits to water quality provided by a natural, flow-through wetland and a degraded, channelized wetland located in the flood-irrigation agricultural landscape of the Sierra Nevada foothills of Northern California. Removal efficiency was 27 percent due to denitrification and other processes in a reference wetland (low flow) and 3 percent in a channelized wetland (high flow).

Gumiero et al. (2011) studied the potential capacity of an afforested riparian zone in removing nitrogen from river water in Italy. Denitrification potential indicated that carbon availability was the most limiting factor. The denitrification process is more effective in a riparian zone where topographic and soil conditions are conducive to a high water table for as long as possible. Removal efficiencies in forested wetlands ranged from 39 to 88 percent (Gumiero et al. 2011).

A geographic model describing the spatial variability in the likely effectiveness of depressional wetlands in watershed uplands at mitigating nitrogen transport from nonpoint sources to surface waters was constructed for the Northern Atlantic Coastal Plain, including portions of the Chesapeake Bay watershed (Ator et al. 2013). It was found that natural or restored depressional wetlands in the very flat poorly drained upland and the flat poorly drained lowland would likely have a high potential to mitigate nitrogen transport from nonpoint sources to local streams. The area is extremely flat and is underlain by organic soils with relatively high available water capacity and likely reducing geochemical conditions; "water would move slowly through the low-gradient landscape providing ample opportunity for denitrification" (Ator et al. 2013).

While the above studies found that slow flow and a high water table benefits denitrification, Denver et al. (2014) found that there does not seem to be a direct correlation between wetland water table elevation and wetland nitrate removal rates in current and former depressional wetlands in an agricultural landscape in the Choptank River watershed, Maryland in the Chesapeake Bay watershed. The forested natural wetlands studied had a high potential for denitrification.

Three of the denitrification studies also found that natural wetlands are better for the purposes of denitrification than restored or constructed wetlands (Bruland et al. 2006; Ducey et al. 2015; and Hunter and Faulkner 2001). Four constructed or restored wetland/natural wetland pairs in North Carolina were sampled to determine denitrification potential (Bruland et al. 2006). The constructed and restored wetland soils only experienced a limited range of soil chemical conditions and associated biogeochemical transformations; however, the highly variable distribution of nitrate in the natural wetlands indicated that natural wetland soils experienced wider ranges in nitrate concentrations.

Natural wetlands typically have higher denitrification enzyme activity rates as compared with restored wetlands and prior converted croplands (Ducey et al. 2015). Denitrification potential was not found to be significantly different among restored and natural bottomland hardwood wetlands in summer or spring, but in fall and winter denitrification was highest in the natural mature wetlands and lowest in the wetlands restored without hydrology reestablished (Hunter and Faulkner 2001).

While several studies show flow rate, water table, and natural wetlands to play an important role in denitrification, Wolf et al. (2011) also found microtopography in a wetland to be an important factor. Wolf et al. (2011) investigated three constructed wetlands in the Chesapeake Bay watershed in Loudoun County and Prince William County, Virginia that incorporated microtopography during construction. The study found that microtopography enhances denitrification in these constructed wetlands.

Gilbert et al. (2013) determined that nitrate was removed between the Lower Columbia River and estuary in Oregon and Washington. This was likely due to denitrification, dissimilatory nitrate reduction to ammonium (DNRA), or assimilation by phytoplankton in the freshwater tidal flats or water column.

Toxics Reduction

In addition to nutrient and sediment removal, wetlands can be used to reduce toxic pollutants. The roots in riparian areas can be important in removing pesticides from shallow subsurface flow because the labile organic matter and organic residues that accumulate near roots can increase microbial biomass and activity (USEPA 2015). Pesticides and their metabolites can be mineralized and adsorbed where surface area contact is high and contact time with roots is sufficient. Research shows that "the atrazine load carried by storm water into a tributary of the Mississippi River was almost entirely removed when detained in wetlands. Atrazine settled out of the water and was adsorbed by cattail debris, soil, and sediments after 6 to 30 days" (Kadlec and Alvord 1993, unpublished data cited in Hunt [1997]).

Seelig and DeKeyser (2006) agree that many pesticides and other man-made organic chemicals are degraded in wetland environments; however, they warn that if "the rates of addition exceed the capacity of the wetland to perform chemical transformation, toxic concentrations may result". Toxic concentrations in wetlands could result in deterioration of the wetland biotic system, causing a reduction in function, and elevated chemical concentrations in adjacent aquatic systems due to reduced wetland function (Seelig and DeKeyser 2006).

Carbon Sequestration

The following section discusses the role of wetlands in carbon sequestration, but focuses mainly on "blue carbon", which is the ability of tidal wetlands and seagrass habitats to sequester and store carbon dioxide and other greenhouse gases from the atmosphere, helping to mitigate the effects of climate change (https://www.estuaries.org/bluecarbon, accessed 2/18/2016).

Coastal marine habitats such as tidal salt marshes, mangroves, and seagrass meadows each account for areas 1 percent or less of the dominant terrestrial habitats of forests, grasslands and deserts; however, the carbon stocks in these marine systems are similar to those observed in many of these terrestrial systems (Pidgeon 2009). Tidal wetlands store globally significant amounts of soil carbon and can remove carbon dioxide from the atmosphere at rates three to ten times greater than forests (CEC 2014).

The difference between the coastal marine and terrestrial habitats is the extensive belowground biomass of the dominant wetland vegetation and the capacity of marine habitats for long term carbon sequestration in sediments (Pendleton et al. 2013; Mcleod et al. 2011; Philip Williams & Associates 2009; Pidgeon 2009; Crooks et al. 2011). Inland forests typically store most of their carbon in aboveground biomass such as tree trunks (Pendleton et al. 2013). Vegetated coastal habitats transfer large amounts of carbon to the sediments, contributing about half of the total carbon sequestration in ocean sediments even though they account for less than 2 percent of the ocean surface (Pidgeon 2009; Crooks et al. 2011). This carbon can remain stored in buried sediments for thousands of years.

Wetlands in saline environments have the added advantage of emitting negligible quantities of methane, which is a more potent greenhouse gas than CO_2, whereas methane production in freshwater wetlands partially or wholly negates short-term carbon sequestration benefits (Crooks et al. 2011; Needelman and Hawkes 2012; Chumra 2009).

According to Chumra (2009), tidal marsh soils sequester 1,874 lbs C/acre/year, which is a "substantial rate". "Each molecule of CO_2 sequestered in soils of tidal salt marshes…probably has greater value than that stored in any other natural ecosystem due to the lack of production of other greenhouse gases" (Chumra 2009). Tidal marshes are the coastal wetland habitat most appealing for greenhouse gas reduction goals due to their high rates of carbon sequestration (averaging 2,000 lbs C/acre/year) (Needelman and Hawkes 2012). This carbon sequestration rate is more than three times greater than the sequestration rates of agricultural lands, grasslands, peatlands, mineral wetlands, and forests, which all have carbon sequestration rates below 450 lbs C/acre/year (Needelman and Hawkes 2012).

Callaway et al. (2012) evaluated the potential for wetland carbon sequestration in the San Francisco Bay. There was little difference in the sequestration rates among natural and restored sites, indicating that a single carbon sequestration rate could be used for crediting tidal wetland restoration projects. The average carbon sequestration rate was 705 lbs C/acre/year (Callaway et al. 2012). A study by Neely (2008) found that carbon sequestration rates did vary between natural and restored wetland soils. Southeastern soils (in North Carolina) have far lower carbon levels than Midwestern soils. Natural wetland carbon levels averaged 124,361 lbs C/acre, while restored wetlands averaged 22,813 lbs C/acre. Average carbon accumulation in restored wetlands was 2,378 lbs C/acre/year (Neely 2008). Ducey et al. (2015) found that wetland restoration, as opposed to no wetlands, resulted in significantly increased levels of carbon sequestration in the North Carolina Coastal Plain.

The Snohomish Estuary in Washington provides a case study for restoration of tidal wetlands and estimates of carbon storage along the northwest coast of the U.S. and southwest coast of Canada (Crooks et al. 2014). This study found that restoring wetland sites shows good potential for high rates of carbon storage. Historic land use change resulted in estimated emissions of 9.9 billion lbs of carbon, of which 6.2 billion lbs of carbon was a result of clearing forested wetland and 3.7 billion lbs from draining soils. Of the 11,846 acres of converted and drained wetlands, 3,343 acres are currently in planning or construction for restoration. These projects are anticipated to rebuild soil carbon stocks of 700 million lbs as wetlands recover to former tidal elevations, and an additional 800 million lbs with sea level rise of 3 feet. Full estuary restoration would rebuild soil carbon stocks of 2.6 billion lbs as marshes build to emergent wetland tidal elevations, and a further 2.6 billion lbs as they accrete with sea level rise of 3 feet (Crooks et al. 2014).

The Blackwater National Wildlife Refuge in the Chesapeake Bay watershed provides another case study on carbon sequestration (Needelman and Hawkes 2012). The USFWS and the U.S. Army Corps of Engineers has considered a long-term project to use clean dredged material from the Chesapeake Bay shipping channel to restore up to 20,000 acres of tidal marsh at the Blackwater National Wildlife Refuge and surrounding state and private lands. Barges would carry the dredged material to a coastal storage location where it would be slurried and pumped to the refuge. Estimates for restoration sequestration rates range from 8,000 to 19,000 pounds of CO_2/acre/year. The total project could sequester from 165 million to 375 million pounds of CO_2/year (Needelman and Hawkes 2012). Target salinities of the restored marshes have not been established, but methane emissions have been documented from brackish marshes in this region, so a portion of this sequestration would be offset by methane. Methane emissions in brackish wetlands range from 0.5-1.8 ppt (part per trillion) (Needelman and Hawkes 2012).

In the Prairie Pothole Region of the upper Midwest, estimates show that over 90 million pounds of carbon are sequestered or stored in plants on WRP lands (NRCS 2014). On average, it is estimated that every acre of replanted floodplain forest will sequester 5,500 lbs of carbon each year. Conservative estimates show that, WRP easements could account for over 1.2 billion pounds of sequestered carbon annually (NRCS 2014).

Additional Wetland Benefits

Wetland benefits, in addition to the benefits discussed above, include recreation and education such as bird-watching and hunting; community involvement such as counting species of birds, amphibians, reptiles, mammals, insects and plants; outdoor education possibilities such as outdoor classrooms for local schoolchildren; and restoring tribal lands back to historic marsh conditions (NRCS 2014; USEPA undated). Outdoor classrooms provide a place to study vegetative structure, ecological functions, natural ecological processes, biodiversity, and plant-animal interactions.

Additional benefits of wetlands include high biological productivity. Nutrients are transferred to adjacent aquatic systems, which enhances their productivity. Other benefits include aesthetics; hunting and fishing; hiking; natural observation; photography; and canoeing (USEPA undated; Interagency Workgroup on Wetland Restoration undated). Protecting and restoring wetlands can contribute to the economic health, public safety, and quality of life (Wisconsin Wetlands Association undated).

Wetland resources can provide a significant economic benefit as well. Humans use many natural products from wetlands, including mammals and birds, fish and shellfish, and timber (USEPA undated). Various plants such as blueberries, cranberries, mints, and wild rice, are produced in wetlands. Some medicines are also derived from wetland soils and plants. Many of the U.S. fish and shellfish industries harvest wetland-dependent species (e.g., striped bass and brown shrimp). The fish and shellfish that depend on wetlands for food or habitat constitute more than 75 percent of the commercial and 90 percent of the recreational harvest (USEPA undated). Wetlands are also habitats for commercial fur-bearers like muskrat, beaver, otter, and mink, as well as reptiles such as alligators.

“Wetlands are the most productive places on Earth, providing an enormous food source for fish, birds and other animals” (Greater Wellington Regional Council 2009). NRC (1992) discusses wetland value for the food chain. Many mammals, birds, and fish use wetlands as feeding areas.

Understanding of food web alterations as wetlands are reduced is not well studied; however, “the native food web is no doubt essential to the maintenance of community structure” (NRC 1992).

Negative Impacts

The positive impacts of wetlands on habitat identified in this literature review far outweigh the potentially negative impacts, but some negative impacts are discussed below.

Increased Toxics Concentrations

The fact that many pesticides and other man-made organic chemicals (e.g., PCBs, dioxins, PAHs and antibiotics) are degraded in wetland environments is well-documented; however, if the rates of addition exceed the capacity of the wetland to perform chemical transformation, toxic concentrations may result (Seelig and DeKeyser 2006). “The consequences may be twofold: 1) deterioration of the wetland biotic system, causing a reduction in function; and 2) elevated chemical concentrations in adjacent aquatic systems due to reduced wetland function...Losses of surface water impoundment and lowered water tables will result in reduced capacity of wetlands to attenuate and transform man-made organic chemicals” (Seelig and DeKeyser 2006). The role of wetlands as an environmental filter for contaminants is closely connected to the maintenance of natural hydrologic conditions. Therefore, it is important to maintain natural surface water impoundment and water tables to support a wetland’s capability to attenuate and transform man-made organic chemicals (Seelig and DeKeyser 2006).

Microbial communities in riparian wetlands and non-floodplain wetlands can also transform elemental mercury to methylmercury before it enters a stream (USEPA 2015). Methylmercury is a particularly toxic and mobile form that bioaccumulates in aquatic food webs. Mercury methylation occurs in the presence of anoxic, saturated soils high in organic matter, mercury-methylating microbes, and mercury from either atmospheric deposition or soils.

Nuisance Species

A second potential negative impact of wetlands is nuisance or invasive species. Four restored depressional freshwater wetlands in western New York were investigated to observe the impact of organic amendments of differing lability on the soil and vegetative development (Ballantine et al. 2011). After 2 years, plant biomass had recovered and reached levels comparable to natural wetlands; however, both native wetlands species and invasive species colonized the sites indicating that the plant community is highly influenced by initial site conditions. Results indicate that site selection for wetland restoration and creation is crucial. It is best to choose sites that are not close to seed sources of invasive species because they are likely to become colonized by those plants.

In addition, biological connections are likely to occur between most non-floodplain wetlands and downstream waters through either direct or stepping stone movement of amphibians, invertebrates, reptiles, mammals, and seeds of aquatic plants, including colonization by invasive species (USEPA 2015). There are benefits of wetland connectivity to downstream systems, but isolation can also have important positive effects on the condition and function of downstream waters. Isolation acts to reduce material fluxes between systems. Increased isolation can decrease the spread of invasive species and increase the rate of local adaptation. Therefore, both connectivity and isolation should be considered when examining material fluxes from streams and wetlands. The natural balance between connectivity and isolation should be considered when determining potential biological interactions.

Other Negative Impacts

Jessop et al. (2014) found that designing wetlands to focus on nutrient reduction may come at the expense of biodiversity. "Vectors for biodiversity indicators pointed opposite of those related to nutrient-cycling related services…, suggesting that wetlands with greater habitat value provide lesser nutrient-cycling ecosystem services" (Jessop et al. 2014). Given this tradeoff, it is unrealistic to expect all wetland functions to be maximized. Restoration practitioners should prioritize wetland functions based on local site and watershed context. In addition, where a wetland is needed to reduce pollutants such as nutrients, domination by fewer plant species (i.e., less diversity) may be more efficient at removing the pollutants than a wetland with more diversity.

Callaway et al. (2012) evaluated the ability of salt and brackish tidal wetlands to keep pace with sea-level rise through sediment accretion and to estimate the potential for wetland carbon sequestration. Citing others, the study notes that while tidal freshwater wetlands can sequester carbon effectively, methane emissions from these same wetlands can outweigh the benefits of carbon storage and careful management is required.

Mitsch and Gosselink (2007) warned of the potential to increase flows, depending on the location of the wetland, indicating "the location of wetlands in the river basin can complicate the response downstream. For example, detained water in a downstream wetland of one tributary can combine with flows from another tributary to increase the flow peak rather than desynchronize flows." The usefulness of wetlands in reducing downstream flooding increases with an increase in wetland area; the distance that the wetland is downstream; the size of the flood; the closeness to an upstream wetland; and the lack of other upstream storage such as reservoirs.

Conclusions

Most of the articles and studies that were reviewed focused on restored wetlands; however, constructed and natural wetlands were included as well. Results of the literature review indicate that all wetlands are beneficial to mammals, birds, fish, amphibians, and reptiles for providing temporary feeding, breeding, nesting, and rearing areas as well as permanent habitat. Tidal marshes appear to provide more benefits than other wetland types because they are the most productive wetlands and provide much greater carbon sequestration opportunity than freshwater wetlands without the emission of methane gas associated with freshwater wetlands. Natural wetlands with a high water table and slow flow appear to be more successful at denitrification than restored wetlands with those same characteristics; however, restored wetlands still result in greater amounts of denitrification than degraded or no wetlands. The positive habitat benefits of wetlands, including animal habitat, flood reduction, storm abatement, improved water quality, reduced erosion, and groundwater recharge, seem to outweigh the few negative impacts such as increased toxic concentrations and invasive plant and animal species. Many of these negative impacts can be avoided through proper site selection for restored wetlands and attentive management.

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Appendix C: Technical Requirements to Enter Wetland Restoration BMP into Scenario Builder

Presented to the WTWG for Review and Approval:

Background: In accordance with the *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model* (WQGIT, 2015) each BMP expert panel must work with CBPO staff and the Watershed Technical Workgroup (WTWG) to develop a technical appendix for each expert panel report. The purpose of this technical appendix is to describe how the Wetlands Expert Panel's recommendations will be integrated into the Chesapeake Bay Program's modeling tools including NEIEN, Scenario Builder and the Watershed Model.

Technical Requirements for Reporting and Crediting Wetland BMPs

Q1. How are Wetland Restoration BMPs defined in the Phase 6.0 Chesapeake Bay Watershed Model?

A1. The Wetlands Expert Panel defined four categories of wetland BMPs recommended for incorporation into the Chesapeake Bay Program (CBP) partnership's Phase 6 Chesapeake Bay Watershed Model (CBWM).

Table C1. Proposed categories for wetland BMPs in the Chesapeake Bay Program's Phase 6 Chesapeake Bay Watershed Model.

BMP Category	Proposed CBP Definition (for Phase 6 CBWM)
Restoration	Re-establish The manipulation of the physical, chemical, or biological characteristics of a site with the goal of returning natural/historic functions to a former wetland.
Creation	Establish (or Create) The manipulation of the physical, chemical, or biological characteristics present to develop a wetland that did not previously exist at a site.
Enhancement	Enhance The manipulation of the physical, chemical, or biological characteristics of a wetland to heighten, intensify, or improve a specific function(s).
Rehabilitation	Rehabilitate The manipulation of the physical, chemical, or biological characteristics of a site with the goal of repairing natural/historic functions to a degraded wetland.

Q2. How will Wetland BMPs be simulated in the Phase 6.0 Watershed Model?

A2. The expert panel recommended that simulation of wetland BMPs vary by the type of practice. Functional gain practices treat upland acres only since they enhance or rehabilitate existing wetlands. Acreage gain practices treat upland acres and are also a land use conversion BMP in Phase 6 since they either re-establish or establish a wetland that was not there at time of implementation. The nutrient and sediment reduction credit for a land use conversion BMP equals the relative, or percent change in nitrogen, phosphorus and sediment load achieved by converting the existing land use to the appropriate wetlands land use.

Table C2. Summary of Wetland BMP simulation in the Phase 6 CBWM.

BMP Category	Land Use Conversion	Treatment of Upland Acres
Restoration*	YES	YES – based on physiographic region (Table C3)
Creation**	YES	YES – 1 upland acre per acre of created wetland
Enhancement**	NO	YES – 1 upland acre treated per acre of created wetland
Rehabilitation**	NO	YES – 1 upland acre treated per acre of created wetland

*The efficiency values and the upland acres for Phase 6 Wetland Restoration are based on the Wetland Expert Panel's recommendations for the Restoration practice, summarized in Table C3.
**The efficiency value for these practices is based on the current Phase 5 approach for Wetland Restoration and are summarized in Table C4. A future panel can recommend different ratios and efficiency values based on their evaluation of the science and the expected performance of these practices.

Q3. What are the upland treatment efficiencies for Wetland BMPs in the Phase 6.0 Watershed Model?

A3. Upland treatment efficiencies for each Wetland BMP are summarized in Tables C3 and C4.

Table C3. Summary of upland acres treated by each acre of wetland, by wetland type and physiographic subregion.

		Upland Acres Treated		Watershed Model HGMR
Wetland BMP Category	**Physiographic Subregion**	**Other Wetlands**	**Floodplain Wetlands**	
Restoration	Appalachian Plateau	1	2	Appalachian Plateau Siliciclastic
	Appalachian Ridge and Valley	1	2	Valley and Ridge Siliciclastic
	Blue Ridge	2	3	Blue Ridge
	Piedmont	2	3	Piedmont Crystalline Mesozoic Lowlands
	Inner Coastal Plain	4	6	Western Shore: Coastal Plain Uplands Coastal Plain Dissected Uplands
	Outer Coastal Plain-Poorly Drained	1	2	Eastern Shore: Coastal Plain Uplands
	Outer Coastal Plain-Well Drained	2	3	Eastern Shore: Coastal Plain Dissected Uplands
	Coastal Plain Lowland	2	3	Coastal Plain Lowlands
	Karst Terrain	2	3	Piedmont Carbonate Valley and Ridge Carbonate Appalachian Plateau Carbonate
Creation	N/A	1	1	N/A
Enhancement	N/A	1	1	N/A
Rehabilitation	N/A	1	1	N/A

Table C4. Summary of proposed upland treatment efficiencies for wetland BMPs in the Phase 6 calibration.

Wetland BMP Category	Reduction Efficiency		
	TN	TP	TSS
Restoration*	42	40	31
Creation**	16.75	32.18	9.82
Enhancement**	16.75	32.18	9.82
Rehabilitation**	16.75	32.18	9.82
Note: The efficiency values of 16.75% TN, 32.28% TP and 9.82% TSS are the average of the Phase 5 Wetland Restoration efficiencies for the Coastal Plain, Piedmont and Appalachian Plateau HGMs. *The efficiency values and the upland acres for Phase 6 Wetland Restoration are based on the Wetland Expert Panel's recommendations for the Restoration practice. This is a change from the Phase 5 approach which assumed 1 upland acre treated per acre of implementation, and applied the efficiency rates summarized in the other rows. **The efficiency value for these practices will treat one upland acre for each acre of created, enhanced or rehabilitated wetlands. This is based on the current Phase 5 approach for Wetland Restoration. A future panel can recommend different ratios. Furthermore, the efficiency values are equal to the average Phase 5 TN, TP and TSS values applied to upland acres for these practices. A future panel can also recommend different efficiency values based on their evaluation of the science and the expected performance of these practices.			

Q4. What should jurisdictions submit to NEIEN to receive credit for Wetland BMPs in the Phase 6 Model?

A4. For wetland BMPs, jurisdictions should report the following information to NEIEN:

- *BMP Name:* Practice Name (i.e. Wetland Restoration)
- *Measurement Name:* Acres of Wetlands Restored/Enhance/Rehabilitated/Created (Acres)
- *Geographic Unit:* Qualifying NEIEN geographies including: Latitude/Longitude; *or* County; *or* Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); *or* State
- *Date of Implementation:* Year the wetland was restored/enhanced/rehabilitated/created
- *Land Uses:* All agricultural land uses and land use groups for Wetland Restoration and Wetland Creation. Wetland Enhancement and Wetland Rehabilitation are applied to the two nontidal wetland land uses: Floodplain and Other.

Q5. Is Wetland Restoration an annual or cumulative BMP?

A5. The credit of this BMP is cumulative, which means that the acres reported in a previous year carry over into the next year.

Q6. What is the credit duration for the Wetland Restoration BMP in the Model?

A6. The suggested BMP credit duration is 15 years.

Q.7 How will Phase 5 wetland restoration BMPs map to the new, Phase 6 BMPs?

A7. A crosswalk between the BMPs in the Phase 5 NEIEN appendix and the Phase 6 BMPs are summarized in Table C5.

Table C5. Summary of how BMPs currently mapped to Phase 5 Wetland Restoration BMP will translate to Phase 6 wetland BMPs

BMP in current Phase 5 NEIEN appendix	Associated FSA or NRCS practice code, if applicable	Suggested wetland BMP using Phase 6 BMP definitions
CREP Wetland Restoration	CP23, 327, 657	Wetland Restoration
Wetland and Buffer Restoration, Wetland Restoration		N/A
Wetland Buffer		N/A
Wetland Creation	658	Wetland Creation
Wetland Functional Gains - Enhanced	659	Wetland Enhancement
Wetland [Acreage] Gains - Established	658	Wetland Creation
Wetland [Acreage] Gains - Reestablished	657	Wetland Restoration
Wetland Restoration	657	Wetland Restoration
N/A		Wetland Rehabilitation

Q8. How should jurisdictions report Wetland BMPs on tidal wetlands?

A8. For Wetland Restoration or other wetland BMPs in tidal areas, the implementation can be reported under the existing protocols (protocols 2-4, NOT protocol 1) for the Shoreline Management BMP. The Shoreline Management BMP is simulated as a load reduction per acre, as summarized in Table C6 below.

Table C6. Summary of load reductions from Shoreline Management Expert Panel Protocols 2, 3 and 4

Shoreline Management Protocol		TN	TP	Sediment
Protocol 2 – Denitrification	Acres of re-vegetation	85	NA	NA
Protocol 3 - Sedimentation	Acres of re-vegetation	NA	5.289	6,959
Protocol 4 – Marsh Redfield Ratio	Acres of re-vegetation	6.83	0.3	NA
Tidal wetland restoration		91.83 lbs/ac	5.589 lbs/ac	6,959 lbs/ac

Appendix D – Compilation of panel meeting minutes

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Wednesday October 1st, 2014, 10:00 AM-12:00PM
Meeting #1

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	N
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	N
Ken Staver	UMD	N
Steve Strano	NRCS	N
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	N
Support staff and guests		
Neely Law (Coord.)	Center for Watershed Protection	Y
Brian Benham	Virginia Tech (Project Director)	N
Hannah Martin	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	Y
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	Y
Emma Giese	CRC	Y
Denise Clearwater	MDE	Y
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	Y
Brian Needleman	UMD	Y
Bob Krotochvil	UMD	Y
Brenda Winn		Y

Summary of ACTION Items & DECISIONs:

- Law will send instructions to access the SharePoint site.
- Law will revise scope for expert panel to include wetlands in urban and other land uses beyond agricultural lands.

Minutes:

Action: Law will send instructions to access SharePoint site. SharePoint will be used to share resources and post meeting minutes and literature.

Water Quality GIT BMP Review Protocol and Panel Charge and Timeline (Neely Law)
The process for convening expert panels was recently updated with more explicit than last guidance. Copies provided to panel membership. Law provided an overview of the process, highlights below.

- Recommendations from the WEP will go to the Wetland Workgroup for comments/approval. Once workgroup approval is given, the recommendations move to the Watershed Technical Work Group, Habitat GIT and Water Quality GIT. Invited review by other workgroups such as Agriculture and Urban Workgroups may also occur.

The WEP Scope of work was crafted in March 2014. The Wetland Workgroup approved the scope of work for the Ag wetlands expert panel at their meeting on September 11, 2014. Previous workshops have explored urban wetlands, however they are largely engineered practices for storm water management. The purpose of WEP is to look at wetlands on agricultural land that are more naturally functioning practices.
<u>Discussion:</u>

- It was discussed at the Sept 11 Wetland workgroup meeting that there are in fact more natural wetlands in urban areas that provide habitat functions. The workgroup recommended that WEP shouldn’t exclude this type of restoration opportunity so the group could potentially revise scope and purpose to include crediting/tracking “natural” wetlands in urban areas similar to those credited/tracked on ag lands.
    - McLaughlin: At the workgroup meeting, several individuals supported that natural wetlands are being restored in urban settings. These practices do treat storm water but that is not the main intent (habitat purpose with water quality benefits).
    - Greiner: The wetlands outcome in the Watershed Agreement is to create/reestablish 85,000 acres and enhance 150,000 acres in both ag and urban. Focus of the habitat team is on ag side but wetland workgroup talked about the other type of project that deserves some credit in the model.
    - Muir: there are opportunities to restore wetlands in urban landscapes and similar impairments across land use types (urban and ag).
    - Boomer: agree with idea of considering urban wetlands
    - McLaughlin: The reason this came up in the workgroup meeting is because urban wetlands are credited for drainage area treated by the practice while ag wetlands are credited by the actual footprint acreage of the practice.
    - Law: Also, there is different verification guidance depending on BMP on ag vs urban so credit might be similar but reporting and verification might be different.
- Action: Revise scope for expert panel to include wetlands in urban and other land uses beyond ag

Chesapeake Bay Watershed Model (Jeff Sweeney, CBPO)
Presentation on the Chesapeake Bay Watershed Model and how wetlands are currently defined, their loading rate and pollutant load reductions calculated.

The current Watershed model is in Phase 5.3.2. The model will be updated with Phase 6 by 2017 and will give a clean slate to add new BMPs and land uses. Currently, Wetland Enhancement is not credited but it is part of the wetland outcome in the Watershed Agreement.

Credit for wetland restoration is based off Tom Jordan's previous work/group (incl STAC workshop) that investigated water quality benefits of these practices. The credit is based on the area of the wetland itself and the watershed that drains to it, however since 2007, little if any reported of the watershed is reported which is needed. Therefore, a default was created and now when a drainage area is not provided, a landuse conversion from crop to forest and reduction efficiencies are assigned by hydrogeomorphic area based on regional conditions (see presentation for values).

- Sources of this data are reserve program, CREP, CEP, FWS. Wetland data are inputted by state data contacts into the National Environmental Information Exchange Network (NEIEN) and the Chesapeake Bay Program's Watershed Model receives the data from NEIEN in order to track progress and issue credits.
- The task of the WEP is it develop recommendations pre and post BMP of wetlands. Consider the available data in order to credit the mechanism. The Bay Program has EPA funding for states and can put in requirements about what needs to be collected/reported in order to receive the credits the WEP recommends.
- Things to consider
    - Reporting mechanism is NEIEN.
    - There aren't many required fields currently but it has capability to add more information for the projects being done. More we know about these projects the more likely it is meeting design standards. Good way to track projects that are more likely to be maintained.
    - Best professional judgment in comparison to other BMPs
    - Wetland enhancement: need to account for degraded condition before benefits can be applied to enhancement.
- Model Support for the WEP: Call Jeff Sweeney with specific questions about the model. Quentin Stubbs is working with Peter Claggett and the land use workgroup and will also provide technical support.
- <u>Discussion:</u>
    - Greiner: The real issue is how to get states to include certain information like enhancement data. Previously not reported. Lack of incentive to report enhancement for credit
        - Give states notice in the implementation plans and make it clear that if that field isn't filled in then they won't get credit. The need for verification is a justification for keeping that language in the WIPs.
    - McLaughlin: if groups are designing the projects, they have to know the drainage area so that's an opportunity with Chesapeake Bay Trust Fund that apply for grant funding to tell them what they need to provide. That will work in MD but needs to spread to other states.

Action: A copy of the presentation is uploaded to the Sharepoint site

Proposal to Define Wetlands as a Land Use for the Phase 6 Chesapeake Bay Watershed Model (Erin McLaughlin)

Currently, wetlands are lumped together with forests as a land use in the Watershed Model. Loading rate for wetlands are similar to forests so in the model they are represented as forest. Want to represent wetland area in the model and determine loads for P, N, and Sediment. Wetland restoration field practitioners would like to pull out wetlands and wetland types as their own separate land use. In order to add wetlands as a new land use, the WEP would be tasked to define loads from land use types.

- Why do practitioners want to have wetlands as a new land use? Wetlands process differently than forest and habitat values are different than forest and being able to track wetlands separately would be important to meeting targets of Watershed agreement. They may not have significantly different loading rates than forests but there is concern that this has not been fully explored and agreed upon.
- Olivia Deveraux (Chesapeake Bay Program) will present at Nov meeting on the land use targets that are being developed for Phase 6 of the model and tell us what they are looking for in order to have wetlands as a new land use.
- NWI is the primary data across watershed because it is standardized. There are discrepancies in states that have LiDAR maps however not all counties have LiDAR maps.

Discussion:

- Sweeney: you want to differentiate between the landuses. 1. Diff loading rates 2. Own goals you need to measure though images like NWI 3. Climate change
- Jeff, DEP: clarify streams as a landuse?
    - Currently streams represented in model are 100 cfs or greater. In the next model hoping to get more specific and detailed than that. Not modeling every creek but that is acres of streams that are greater than 100 cfs.
- Ideally would need working numbers by December and then finalized by February ideally.
    - 1. Smaller working groups to propose definitions and loading rates to the larger groups in order to vet
    - 2. Move together and focus on landuse for 4 months and then look at efficiencies.
- What wetland classifications are missing?
    - Freshwater tidal
    - Coastal
    - Tidal forested
    - Cowardin Wetland System: http://www.fws.gov/wetlands/Documents/Wetlands-and-Deepwater-Habitats-Classification-chart.pdf
    - NOAA CCAP: http://coast.noaa.gov/digitalcoast/_/pdf/ccap_class_scheme.pdf?redirect=301ocm
    - Boomer is interested in participating in smaller landuse group discussion.
    - New version of Sparrow coming out and has a delivery factor that accounts for factors that understand ground water recharge and runoff. Vegetative index. Two

factors for groundwater (recharge potential in an area, AWC average water contact) carbonate areas in piedmont (factor for delivery N).

Next meetings: moving forward.

- First Wednesday of the month at 10
- Reconvene with Boomer and develop strategy to set starting point to start literature review.
- December: research workshop where we lay out articles and people are assigned and can provide summaries.
- RAE Summit first week of November, so move to second week. Look for doodle poll.

MEETING ADJOURNED: 12:10pm

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Wednesday November 12th, 2014, 10:00 AM-12:00PM
Meeting #2

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	N
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	Y
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	N
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	N
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	N
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	N
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Neely Law (Coord.)	Center for Watershed Protection	Y
Brian Benham	Virginia Tech (Project Director)	N
Hannah Martin	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	N
Peter Claggett	USGS, CBPO	N
David Wood	CRC	Y
Emma Giese	CRC	N
Denise Clearwater	MDE	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N
Brian Needleman	UMD	N
Bob Krotochvil	UMD	N
Olivia Devereux	Devereux Consulting	Y
Kristen Saacke Blunke	Headwaters, LLC	Y

Summary of ACTION Items & DECISIONs:

- Send Neely 2 articles that you will review and provide a summary at the Dec 1st meeting
- Kathy Boomer to explore use of Mendely as a repository for publications and commenting on publicationvs vs

Minutes

The main objective of the WEP Meeting #2 is to prepare for the in-person research workshop scheduled for December

Panel Announcements

- Wetland Expert Panel Stakeholder Forum is scheduled for November 21st, 9:00AM-12:00PM at the Chesapeake Bay Program Office. This will serve as an opportunity for stakeholders to present data or experiences to help inform the panel. For more information, visit the calendar website.
- The next WEP meeting is scheduled for December 1, 2014 and will be an in-person research workshop.
- Panel modifications based on comments on the WEP scope of work
  - New! Members: Dr. Jarrod Miller (UMD Extension Educator), Jeff Thompson (MDE), Ralph Spagnolo (EPA R3), Kristen Saacke Blunk (Headwaters LLC, Ag Workgroup Co-Chair)
  - New! Panel Name: "Wetlands Land Use Definition and Wetlands Restoration BMP Expert Panel"

Land use Loading Rates Phase 6 Chesapeake Bay Watershed Model

- Presentation provided by Olivia H. Devereux. Copy available on Sharepoint site. Highlights from the presentation provided below.
- The Chesapeake Bay Watershed model is currently in Phase 5 but is currently undergoing a review to update to Phase 6 with latest science for loading rates/targets and to include additional land uses.
- 3 reasons to have land uses
  - Distinct land use loading rates from literature, models, other data sources
  - BMPs are exclusive to one type of land use (e.g.: stream corridor buffers or fencing)
  - Helps jurisdictions for planning and reporting purposes. In this case, there would not be a different loading rate.
- Literature based targets are specified loading rates of pounds of Nitrogen, Phosphorus and Sediment that come off different land uses and these targets are used to calibrate the Phase 6 Watershed model.
- These targets show the relative difference among land use loading rates and actual rates are adjusted based on monitoring data and the calibration process balances loads spatially (targets may vary geographically based on nutrient balance and watershed characteristics).
- Phase 5 of the model had 24 land uses and Phase 6 has 46 proposed land uses (this includes wetlands).
- Currently, wetlands are not an individual land use in Phase 5, they are grouped together in the forest land use.
- The goal is to have targets at the smallest scale (i.e., edge-of-field) that also is best informed by data.

Timeline:

- December 31, 2014 - Sparrow and literature review results for draft land uses
- February 28, 2015 - draft targets for draft land uses
- April 30, 2015 - final targets approved by Modeling Workgroup for draft land uses

- Oct 1, 2015 - Once the final land uses are approved, we will finalize targets using a Sparrow update, final sensitivities, and other information.

Discussion:

- Wetlands are not currently mapped in the Phase 5 of the Watershed model because wetlands are grouped under the forest land use. Therefore, the model only accounts for wetlands processes and functions as a BMP (not a specific land use). Given the functions that wetlands provide throughout the landscape, the scope of work for the WEP is to decide if it is meaningful to have wetlands more directly accounted for in the model.
- The target load rates for wetlands will be identified from the literature review; Sparrow groups wetlands under the forest land use and does not have a specific loading rate for wetlands alone.
- These loading rate targets are the pounds of N, P, and S that is exported/runs off from wetlands. The most important information is what runs off the wetlands but it is ideal to know the depth of the concentrations/loads as well as the edge of the wetlands to help improve the calibration.
- Since wetlands are not currently mapped within the model, what information is available to map wetlands throughout the watershed and what is that timeline for data vs the loading rates? The mapping information is needed ASAP because the team is working over the next month to two months on merging the different land covers together to see what the best scale is for the map. Current efforts are focused on NWI, but it's necessary to transform NWI (from GIS format shapefil). Need to be aware aggregation issues and the 'dilution' of information at data is scaled to lower spatial resolutions

Summary & Discussion of Preliminary Research Findings on Wetlands Land Use Loading Rates

- Presentation by Kathy Boomer and Aileen Molloy. A copy of the presentation is available on Sharepoint
- Boomer and Molloy initiated a very broad and general literature review to identify studies that report wetland loading rates. This review included general search terms but did not include constructed wetlands

  Literature Review Results

- 26 Bay-specific articles (all reviewed, 13 not relevant)
- 70+ U.S. articles (16 reviewed, 10 not relevant)
- 6 international articles (2 reviewed)
- Not Relevant = no loading rates or no load reduction information

  Concerns about current representation of wetlands as BMPs and their definitions by the CBP
- Does not address role of natural wetlands and mitigation wetlands (treated the same as forest)
- No credit for enhancement of degraded wetlands

- Inadequate definition of conditions needed to qualify for nutrient and/or sediment reductions
- Focuses only on water quality benefits; does not address wildlife/habitat benefits.

<u>Presentation of Options to Better Represent Natural Wetlands in Model</u>

- **Option 1**: Define wetland loading rates
- **Option 2**: Assign retention efficiencies as part of CBWM input
    - Develop wetland overlay
    - Assign forest or open/shrub community loading rates
    - Apply retention benefits
- **Option 3**: Recognize natural wetlands as bmp's
    - Develop wetland overlay and assign efficiencies
    - Incorporate as filter/bmp application model component
        - Incorporate effects of up-slope contributions
        - Compare predicted benefits with bmp's more directly.
        - Provides easier framework for updating information and integrating with County WIP plans

<u>Discussion</u>

- The explicit assignment of land use loading rates similar to other land use loading rates may not be supported in the current literature. The best option moving forward may be to get input on where the three options fit with WEP members' knowledge as practitioners/regulators.
- S. Strano states wetlands are a unique land use; need to consider how wetlands land use updated in future years
- Wetlands are unique in that they could be a land use but also function as a BMP. Ability to assign loading rates to different types of wetlands limited (J. Thompson).
- A commonality across the studies is that vegetation is a short term sink for uptake of the nutrients which had lead researchers to think of wetlands as permanent sinks.
- Option 2 and 3 may be the best options for WEP to address.
- Q. Stubbs request for wetland mapping data from States. Important to consider scale of data, define a baseline year and how acreage will change in future years

R. Spagnolo stated EPA Watershed Resources Registry as a potential source of data for mapping wetlands

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Monday December 1st, 2014, 10:00 AM-2:00PM
Meeting #3

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	Y
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	N
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	N
Ken Staver	UMD	Y
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	N
Support staff and guests		
Neely Law (Coord.)	Center for Watershed Protection	Y
Brian Benham	Virginia Tech (Project Director)	N
Hannah Martin	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Emma Giese	CRC	N
Denise Clearwater	MDE	N
Anne Wakeford	WV DNR	Y
Ken Murin	PA DEP	N
Tom Jordan	SERC	Y
Bob Krotochvil	UMD	N
Olivia Devereux	Devereux Consulting	N
Kristen Saacke Blunke	Headwaters, LLC	Y

Summary of ACTION Items & DECISIONs:

- Law will distribute the updated Scope of work
- Brooks provide publications on routing related to HGM classifications
- Staver volunteers to review two more papers
- Send doodle to schedule next meetings
- WEP Meeting#2 Minutes approved

Minutes

Updates
The WEP scope of work has been updated based on comments received from the wetland workgroup. Action: Law will distribute the updated SOW
The WEP membership has been updated. Denise Clearwater is the new MDE alternate for Jeff Thompson and Anne Wakeford is the new WV representative (both are wetland workgroup members).

Presentation: Modeling Wetlands in the Watershed (Tom Jordan, SERC)
Tom Jordan presented on modeling wetlands in the watershed, comparing N and P removal among wetlands receiving unregulated inflows, and predicting removal efficiency from the proportion of wetlands in watersheds. Noted importance of wetland flowpaths on wetland function and effect on water quality benefits. Jordan concludes that efficiency cannot be assigned a single value because it is a function of wetland size relative to inflow and it is important to quantify uncertainties when dealing with BMP selection. Determining the uncertainty is important because just using the best-guess efficiency biases selection toward inexpensive, poorly-understood (risky) BMPs.
- Baker et al. 2006 propose functional riparian metrics to account for spatial distribution of forest areas based on flow pathways. NLCD (30m) not sufficient resolution to measure buffer widths; subsequent publication by Weller and Baker applied analysis to CB Watershed
Discussion:

- Law: This presentation supports the importance of landscape positon and representation of wetlands in the model
- Saacke Blunk: Is there anyone on the WEP that can explore the question of uncertainties with the efficiency?
    - Jordan: Expert Panelss should report their estimated efficiency along with the uncertainty of the estimate so that both can be taken into consideration when designing/driving BMP selection. Report uncertainty along with metric on pollutant removal
    - Strano: Every BMP has so many uncertainties/variability associated, if you get too precise on that aspect you will never be able to get that certainty of the efficiencies related to other BMPs in the real world.
    - Staver: Bottom line is to capture the average value and you do the best you can but you have to be careful about chasing the uncertainty values. The local governments are thinking about the TMDL because they are required to meet those targets.
    - Strano: It’s hard to compare urban BMPs vs ag style BMPs. Ag BMPs tend to have other benefits (wildlife, habitat benefits) and it’s important to include in the presentations and document habitat benefits and how to incorporate into this report.

Presentation: Mapping Wetlands (Quentin Stubbs, USGS/CBP)

Wetlands are not currently explicitly represented in the Chesapeake Bay Watershed Model. Quentin overviewed the data requirements and land use classes. Wetlands are proposed to be a land use under the natural land uses with tidal emergent, fresh emergent, and non-tidal woody as the subclasses of wetlands. Quentin laid out specific key questions that the expert panel members must consider while discussing mapping wetlands.

1. *What is the best spatial scale to use?*
2. *How will we decipher between "perceived" versus "known" wetlands?*
3. *What will serve as the base year of wetland coverage*
4. *Is it feasible to differentiate the HGM conditions and subsequent loading rates for each land use class at each level?*
5. *How will we justify having wetland types with different loading rates?*
6. *What type of credit will we give BMPs?*
    a. *How would we translate the credit into loading rates for wetlands?*

Discussion:

- Law: Recommendations on wetland land use part of panel scope; may consider this initial mapping as a starting point.
- Brooks: Must think about landscape position and definitely need to go to 10m level and combine National Land Cover Dataset (NLCD) with high resolution. Is it possible to incorporate HDM into NWI and possibly create a hybrid classification? I like the idea of using other sources such as National Hydrography Dataset (NHD) and digital elevation models (DEMs) and soil/crop data to get closer to what areas are most likely wetlands but groundtruthing exercises will be needed to determine accuracy. Base Year; 2009 (BMPs, TMDL began), 2012 (last ag census for crop data) but PA wetlands data are from the 80's and they don't plan on updating.
- Sweeney: Base year is key and inventory, but more important is being able to do the same inventory 5-10 years in the future.
- Stubbs: USGS requested data from local jurisdictions. Quality and type of data provided highly variable
- Brooks: Nutrient removal efficiencies are different for different vegetative types for wetlands
- Law: Is there in interest for tidal/non-tidal emergent/non-emergent as 4 key groupings as a starting point?
    - McLaughlin: There is also tidal woody wetalnds
- Sweeney: what are the proposed breaks? 10 m as minimum with hybrid between level 2 and 3 to account with emergent and forested but data are needed to justify.
- Brooks: Is it possible to build in HGM with modifiers because isolated wetlands versus those associated with streams/rivers will have a different function?
- Denver: Hydrogeology based on geographic region
- Action: Brooks will send publications on flow routing/ HGM report

Literature Reviews (All)

Boomer and Molloy laid out three options at the last meeting for the WEP members to consider.

Option 1*: Define wetland loading rates*
Option 2*: Assign retention efficiencies as part of CBWM input (apply efficiencies as part of the input data set that drives the model)*

- *Develop wetland overlay*
- *Assign forest or open/shrub community loading rates*
- *Apply retention benefits*

Option 3*: Recognize wetlands as natural bmp's in the landscape (efficiencies are applied in the application step to use as part of the scenario assessment process)*

- *Develop wetland overlay to existing land uses and assign efficiencies*
- *Incorporate as filter/bmp application model component*
    - *Incorporate effects of up-slope contributions*
    - *Compare predicted benefits with bmp's more directly.*
    - *Provides easier framework for updating information and integrating with County WIP plans*

Overview Discussion:

- Law: Need to define natural wetland for the wetlands land use and then you can apply wetland BMPs to it to enhance.
- Boomer: We could propose to expand to capture benefits of wetland enhancement for existing wetlands. Count explicitly/include benefits of natural wetlands which could be incentive for protection.

Literature Review Report Outs

1. **Rob Brooks**
    a. Kroger, R, RE Lizotte, Jr., FD Shields, Jr., E Usborne. 2012. Inundation influences on bioavailability of phosphorus in managed wetland sediments in agricultural landscapes. Journal of Environmental Quality 41:604-614.
        i. This would be a good paper for other EP members to review and refer to it. The tables are dense but have a lot of information and the reporting range are quite wide but overall it is a good review. The tables do not give you an idea of the specific wetland type, rather it's more flux type (amount moving through the system through various pathways). The illustrations are useful too.
        ii. Law: Might be noteworthy to see if the data reported in Fisher and Acerman is similar.
    b. Parn, J, G Pinay, U Mander. 2012. Indicators of nutrients transport from agricultural catchments under temperate climate: a review. Ecological Indicators 22:4-15.
2. **Anne Wakeford**
    a. Noe, Gregory B., et. al (2013) Hydrogeomorphology Influences Soil Nitrogen and Phosphorus Mineralization in Floodplain Wetlands Ecosystems 16:75-94
        i. Boomer: Important to map wetlands but need to determine if they have distinct loading rate that is different from forest land use.

3. **Judy Denver**
    a. Seldomridge and Prestegaard, 2014. Geochemical, Temperature, and Hydrologic Transport Limitations on Nitrate Retention in Tidal Freshwater Wetlands, Patuxent River, Maryland. Wetlands (2014) 34:641-651
    b. Kellogg, et al. 2008. Riparian Ground-Water Flow Patterns using Flownet Analysis: Evapotranspiration-Induced Upwelling and Implications for N Removal. JAWRA Vol. 44, No. 4:1024-1034.
4. **Kristen Saacke Blunk**
    a. Duriancik, L. F. et al. 2008 The First Five Years of the Conservation Effects Assessment Project – CEAP Wetlands Component (NOT RELEVANT)
    b. Richardson, C.J. et al. 2011 Integrated stream and wetland restoration: A watershed approach to improved water quality on the landscape
5. **Steve Strano**
    a. Mitsch, WJ, JW Day, L Zhang, and RR Lane. Nitrate-nitrogen retention in wetlands in the Mississippi River Basin. Ecological Engineering 24-267-278, 2005
    b. Huang, J, WJ Mitsch and DL Johnson. Estimating biogeochemical and biotic interactions between a stream channel and created riparian wetland: A medium-scale physical model. Ecological Engineering 37-1035-1049, 2011
    c. Discussion:
        i. Both papers are more about BMP efficiencies but would apply to passive diversion
6. **Ken Staver**
    a. Wilson and Morris. 2012. Biogeochemistry. The influence of tidal forcing on groundwater flow and nutrient exchange in a salt marsh-dominated estuary.
    b. Rogers et al. 2009. JAWRA. Hydrologic and water quality functions of a disturbed wetland in an agricultural setting.
    c. Action: Staver volunteers to review two more papers
7. **Erin McLaughlin**
    a. Dianna M. Hogan and Mark R. Walbridge. Urbanization and Nutrient Retention in Freshwater Riparian Wetlands. 2007. Ecological Applications 17(4): 1142–1155.
    b. Allison R. Aldous, Christopher B. Craft, Carla J. Stevens, Matthew J. Berry, and Leslie B. Bach. Soil Phosphorus Release from a Restoration Wetland, Upper Klamath Lake, Oregon. 2007. Wetlands 27(4): 1025-1035.
    c. John M. Marton, M. Siobhan Fennessy, and Christopher B. Craft. USDA Conservation Practices Increase Carbon Storage and Water Quality Improvement Functions: An Example from Ohio. 2013. Restoration Ecology.
        i. USDA BMPs-Ohio; depends on vegetation and location of practices but it is useful to support options 2 and 3.

These literature reviews/papers will be posted on sharepoint.

There will be continued literature review to build familiarity with data out there and see if we can begin to see if one of these three options would be best supported. This discussion will continue over email exchanges before the next WEP meeting.

Continued Discussion:
1. Representing wetlands (mapping) in CBW.
   - Minimum would be 10 M dataset and fine tune with other finer scale data analysis to capture tidal/nontidal, emergent/woody
   - Need to make sure that the data used will be there in the future in order to continue to calibrate the model
2. Check-in with expert panel on Options 1, 2, 3
   - Stubbs: Pass
   - Staver: 2&3
   - Wakeford: Pass
   - Strano: 2&3 based on availability of data
   - Denver: 3
   - Boomer: 3
   - McLaughlin: 3

Action: Send doodle to schedule next meetings.

ADJOURN

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Tuesday January 13th, 2015, 10:00 AM-12:00PM
Meeting #4

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	Y
Dave Davis	VA DEQ	N
Judy Denver	USGS	N
Jeff Hartranft	PA DEP	Y
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	Y
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	N
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Neely Law (Coord.)	Center for Watershed Protection	Y
Brian Benham	Virginia Tech (Project Director)	N
Hannah Martin	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	Y
David Wood	CRC	N
Emma Giese	CRC	N
Denise Clearwater	MDE	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N
Jill Whitcomb	PA DEP	Y
Whitney Smith	EPA Region 3	Y

Summary of ACTION Items & DECISIONs:

- All: review Meeting 3 minutes to approve at Meeting 5.
- Case study mapping exercise to implement recommended wetland land uses. Quentin to present findings at next meeting
- Nominate panel chair

Minutes:

Wetland Expert Panel Meeting 4 Purpose—Presentation on a recommended approach and data to generate a map of wetland land uses across the Chesapeake Bay Watershed. The Land use workgroup and modeling team will be working together in 2015 to implement information to map wetlands and other land uses.

Presentation: Phase 6 Wetland Land Use Classification, Quentin Stubbs

a. Recommendations to use NWI coupled with other supplemental data at state and local level . A comparison of wetland mapping data options suggests NWI provides the 'best available' data as a starting point for bay-wide mapping purposes. The 3 proposed wetland land uses based on the water quality benefit functions provided by wetlands to include: estuarine, floodplain, depressional
b. Discussion:
    i. Claggett provided further clarification on input requested from expert panel. Proposing to use NWI and state wetland maps to determine where wetlands are located. Then look at how those wetlands function with respect to their water quality function for nutrient and sediment reduction. Review attributes in NWI database to assist with land use type, in addition to landscape context to determine how these wetlands (ancillary data will come in to inform the breaks between estuarine, floodplain, and depressional wetlands).
    ii. Timeline: Mid March-draft land use data set and methods needed to be given to Water Quality GIT. Refine mapping between March and October
    iii. Spagnolo: Are we going to use the NWI classifications?
    iv. Law: This will be placeholder and starting point to determine if it is or is it not a wetland and is this data sufficient to capture wetlands bay-wide
    v. Spagnolo: Why do we need the categories?
    vi. Claggett: Need to know classes/categories we are going to be mapped and define a unique loading rate with each of them. Proposing simplistic, minimum of three classes by March. March-October. This is for land use, not BMP.
    vii. Brooks: States will have different quality data, is it necessary to have consistent data across the whole watershed or can you use better data where it's available. Unlikely you will get seamless one layer of wetlands for the whole basin. Important to document decisions in metadata.
    viii. Boomer: Agree with Brooks, especially because quality of NWI varies state by state. Could someone come forward and restore a wetland that occurs but isn't mapped? Specify how you use data for practitioners and county for meeting the WIPs. Note to Panel: we need to address this as part of reporting and tracking
    ix. Mason: Need to resolve mapping of regulatory wetlands; NWI may not include these wetlands. Need to clarify
    x. Mason: Recommends creation of a tidal wetland class to include both freshwater and saline. From a modeling perspective, tidal wetlands modeled in the Estuarine model and not the Chesapeake Bay Watershed
    xi. Thompson: How did Quentin come up with the three classifications?

xii. Claggett: Landscape position and how these wetlands would perform.

xiii. Discussion to include and/or differentiate between isolated, headwater and depressional wetlands. Panelists decided to include headwater and depressional. The use of the term isolated wetlands has a specific regulatory meaning. To avoid confusion it was decided that isolated would be captured under the depressional wetland land use.

xiv. Strano: Isolated wouldn't have runoff and they don't have a load to them. Headwater wetlands are those that affecting runoff from landscape before it goes into waterway. You need a stream and drainage ditch data set for that.

xv. Mason: Headwater wetlands receive a load and have a discharge especially in storm events. Depressional wetlands expect to have little, if any discharge.

xvi. Thompson: Flowpaths are important to wetland function; look at hydrogeomorphic issues and classifications. Correlate back to NWI based on HGM (i.e., Flats: mineral flats, coastal. Not tidal).

xvii. Law: proposal accepted by panel members to define 4 wetland land use classifications, tidal (freshwater, saline), depressional, floodplain and headwater. Assign a basic loading rates for each of those classifications and then modify based on retention efficiencies. The retention efficiency would be defined based on an empirical approach and/or landscape features that can be readily extracted and (hopefully) automated bay-wide

xviii. Boomer: Further explained that at a given location the water quality benefits of a wetland would represent factors affecting wetland function such as groundwater vs surface water controlling flux of N P and S at a particular site. Think about what attributes would be good indication of relative importance of those vectors. Local watershed area ratio could be related to those two sources. 1:1 would be headwater and have groundwater importance, smaller ratio would be lower in the watershed and have surface water importance.

xix. Question to panel members if there is sufficient data or research to rank water quality performance/retention rates for the 4 proposed wetland classes. Panel agreed.

xx. Stubbs/Claggett conduct preliminary mapping exercise to implement recommended method using 4 case study counties (Lancaster, Fairfax, Charles and Wicomico). Law and Boomer to meet with Stubbs and Claggett to refine approach.

xxi. Law, Mason and Sweeney to meet and discuss how proposed wetland mapping would be tracked and reported, historically and in the future

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Wednesday February 11th, 2015, 10:00 AM-12:00PM
Meeting #5

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	Y
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	Y
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	N
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	N
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Neely Law (Coord.)	Center for Watershed Protection	Y
Brian Benham	Virginia Tech (Project Director)	N
Hannah Martin	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Emma Giese	CRC	N
Denise Clearwater	MDE	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N
Tom Jordan	SERC	N
Bob Krotochvil	UMD	N
Olivia Devereux	Devereux Consulting	N
Kristen Saacke Blunke	Headwaters, LLC	N

Summary of ACTION Items & DECISIONs:

- Set –up meeting to review mapped wetland land uses and potential use of wetland monitoring and assessment program information to verify acreage in case study counties (Neely/Rob/Pam/Aileen/Quentin/Jeff/ Tom/Ralph)
- Request Tetra Tech to assist USGS on mapping and retention efficiency analysis
- Set-up meeting to discuss retention efficiency analysis (Quentin, Peter Claggett, Aileen, Kathy, Neely)
- Ralph Spagnolo forward EPA study on wetland nutrient and sediments

  - Tom U offered to contact states for updates on wetland mapping – check with Peter and Quentin re information received from states on land use land cover as part of Phase 6
  - Meeting minutes #3 and #4 approved.

<u>Mapping Wetland Land use & Discussion</u> (Quentin Stubbs, USGS)

- Quentin presented methods and results of preliminary mapping of wetlands land uses using 4 County case studies and multiple data sources.
- The Panel asked to provide feedback on the wetland mapping and recommendations to accept and, or modify the methods.
  1) Does the preliminary distribution of wetlands appear reasonable?

  2) What additional information may be used to further identify and map depressional wetlands?

- 4 wetland classes extracted from NWI database and supplement data to define wetland type to include: tidal (fresh and saline, floodplain, headwater and depressional
- 4 Counties used to implement proposed method to identify and map wetland land uses: Charles County, MD, Wicomico County, MD, Lancaster County PA and Fairfax County, VA
- Methods and results are summarized in the presentation (attachment provided).
- A hierarchical method used to label wetland land use classes
  (tidal >floodplain>headwater>depressional)

- Findings
  - Experimented with data sources to differentiate amongst wetland classes (spatial resolution of data sources such as geology vs SSURGO, 10 m DEM vs NHD)
  - Tidal and floodplain wetlands generally readily identified
  - Results of mapping identified challenge to identify depressional wetlands, data to identify floodplain wetlands may under-represent this class; spatial resolution of data and connectivity of stream channels affects identification of headwater vs depressional (NHD, 10m). Other mapping efforts by Bay Program support use of 10m DEM; NHD layer won't pick up a lot of the streams, specifically the Eastern Shore
  - Coastal area missing mineral flats
  - Found wetland distribution in Lancaster County "spotty". This may not be a result of the data sources, rather a result of geology and limestone sinkholes resulting in a lack of surficial hydrologic connectivity
  - J. Hartranft noted that in PA the impact of legacy sediment disconnects wetlands from streams
  - K. Boomer notes geomorphology identifiers in SSURGO dataset along with NWI floodplain provide a reasonable approximation for wetlands in these areas (K. Boomer)
  - Model representation. What time period does this wetland land use represent?

<u>CBWM Land Use Data</u>

  - Land use change in time 1985 – 2025 for other land uses
  - Some NWI data represents a 2nd point of wetland coverage but NWI layer completed in mid 1980s so would be represented as a baseline condition

- Additional data source from MDE can provide an inventory of restored wetlands
    - Need to think about accuracy with level of effort given what is lost and gained given relative percentage of land use. E.g. wetland resotraiton small percentage of total land area in County
    - Voluntary restoration no location data
    - Look into Status and Trends reports
- **Tom U contact states for updates**
- **State wetland mapping efforts, PA DEP e-fact mine for permitting actions, state data not updated recently e.g .MD 1990s**

<u>Wetland Verification</u>

- What is the ability to ground truth wetlands mapped vs existing (Jeff) Quentin replied there is limited capacity to do so – could ask localities
- Pam suggested verification of wetland acreage mapped by model could be cross-referenced with monitoring and assessment programs, PA DEP Jeff focus on streams, very small number of wetlands
- Rob Brooks: 50% of wetlands not detected (clarify was assessment was updated)
- **Rob/Pam/Aileen/Quentin/Jeff – Tom/Raph: follow-up call for verifying wetlands (review verification guidance)**
- Rob classification MidAtlantic HGM classification: headwater complex. Kathy and Steve agree
- Steve wetlands not truly isolated act or function as headwater
- *Quentin thesis: Delmarva peninsula on net gain 1%, correlation with permitting agencies

<u>Retention Efficiencies</u>

- Jeff S. reminded expert panel that efficiencies would be relative rates to forest land use loading
- Kathy B stated that we are more concerned with variation in retention
- Judy and Pam stated this would make best use of available data reported on welands
- ***EPA study N, P and Sediment, Ralph will forward**

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Tuesday June 2nd, 2015, 10:00AM-12:00PM
Meeting #6

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Denise Clearwater	MDE (for Jeff Thompson)	Y
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	Y
Michelle Henicheck	VA DEQ	Y
Robert Kratochvil	UMD	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	Y
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Hannah Martin	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	Y
Peter Claggett	USGS, CBPO	Y
Katherine	EPA Region 3	Y
Kristen Saacke-Blunk	Headwaters LLC, AgWG Co-Chair	Y
Anne Wakeford	WV DNR	Y

Summary of Action Items:
ACTION: Hanson will coordinate with Habitat GIT and Water Quality GIT about approving the expert panel recommendations for wetlands to be included as a land use in Phase 6 model
DECISION: one watershed from four different counties will serve as case studies for discussion on a future call-Fairfax County (completed), Lancaster, Wicomico, and Charles
ACTION: Claggett will get back to Hanson about ETA of other case studies
ACTION: Contact Hanson if you are interested in volunteering as Chair/Co-Chair of the panel

Minutes:
<u>Introductions</u>

- Jeremy Hanson (Virginia Tech) is the new panel coordinator. VT has a cooperative agreement with the Chesapeake Bay Program to coordinate expert panels. Brian Benham is principal investigator on the cooperative agreement.

Recap Panel Status

The previous coordinator, Neely Law with the Center for Watershed Protection (CWP), needed to step down after the CWP grant was renegotiated with the Chesapeake Bay Program. Before CWP ended their contract, this expert panel met five times with the most recent time in February 2014. The expert panel was focused on the discussion of wetlands being included as a land use in the Phase 6 model.

Timeframe: Phase 6 Land use recommendations needed to be confirmed back in April 2015 but there is another opportunity to add recommendations later this year. Recommendations from the Wetlands Expert Panel need to be approved by the Wetlands Workgroup, Habitat GIT and Water Quality GIT. Ideally the relevant GITs and workgroups can endorse the panel's recommended land use classes, loading targets and methods by the end of August.

ACTION: Hanson will coordinate with GIT coordinators on dates in August for the approval process.

> **Post-meeting note:** The Wetland Workgroup has a call on July 16th. The Modeling Workgroup has its quarterly meeting scheduled for July 21-22. The WQGIT has a scheduled conference call on August 10. The Habitat GIT has no scheduled calls or meetings in that timeframe, but they can be invited to join the WQGIT on August 10 to consider the panel's recommendations at that time.

Update on mapping wetlands a land use in the watershed (Quentin Stubbs and Peter Claggett)

Stubbs provided overview on the progress so far on the expert panel's first task to make recommendations for wetlands to be included as a new land use in the Phase 6 model. In order to do this, wetlands need to be mapped and the best data set was determined to be NWI (most of the other datasets are rooted in NWI). Through the process it was discovered that it is difficult to distinguish between the four suggested wetland classifications so it's recommended to move to three categories (Tidal, Floodplain, headwater) or two categories (Tidal vs non-tidal).

DECISION: one watershed from four different counties will serve as case studies for discussion on a future call-Fairfax County (completed), Lancaster, Wicomico, and Charles. These would be mapped and Tom Jordan's first order efficiency equation would be applied. Initial findings suggest that regardless of resolution, non-tidal areas located in floodplain and intercept a lot of flow and impact would be 20%. That raised questions about applying in other areas and refine technique but wetlands floodplain have riparian buffers and receive credit and hard to discern if reductions are real (collective reduction or exclusive to wetland). Buffer effect vs wetland effect. Load adjustments needed, will it nullify wetlands? Early stages and only looked at one watershed.

Deliverables: continuous raster maps: creating what percentage of each pixel is each landuse (general wetland cover, tidal wetlands, non tidal wetlands). Still analyzing state/local data and had to combine wetland cover with forest cover in order to get better idea of continuity of tree cover vs urban tree canopy

<u>Discussion:</u>

- Staver: reconsider role of things and because watershed model is calibrated based on delivered loads, understand why source loads are higher than delivered loads. Justification to protect existing wetlands. We know that in a lot of watershed you lose

50% of nitrogen between edge of field and delivered load—wetlands are a big part of that. Understanding that would be good scientific exercise and mgmt.
    - Claggett: one option is to take ratio of wetland area to drainage area in every catchment (sparrow model) and include percent of stream miles buffered by forest in the sparrow model and see if the ratio comes out as significant variable compared to riparian buffer variable.
- Strano: does it affect other land use activities to make up for the other practices?
    - Claggett: that's what we have to tease out conceptually.
    - Strano: if loading rates for the wetland areas are a lot less, calibrating to what comes out, then loading rates for ag areas and urban areas would go up. Would that result in more needing to be done?
    - Claggett: potentially yes, haven't talked about loading rate for wetlands. Wetlands load like forests until this panel decides otherwise. Wetlands are really going to have their impact on their treatment of runoff, that's not loading rate that's the reduction from other land uses. Presumably some loads from other land uses would go up because they aren't treated by wetlands.
- Denver: there are different areas where denitrification is occurring so it can't determine fully that it's retained in wetlands.
- Strano: confused on loading rate of ag lands that drains through a wetland and those don't. We aren't doing that yet except that when we put a bmp place. I thought loading rate was purely land use
    - Claggett: loading rate is purely land use, but new version of the model for sediment and nutrient, explicitly in space trying to account for streams and wetlands in estimating how land use loads get from edge of field to point of the watershed and what happens to them. Given what we know, what level of generalization is needed to more accurately portray wetlands and loads coming from landscape.
    - Land use loading rates: talking about rates delivered to the water from the particular land use. Wetlands; assume they are different than forests but need to address this still.
- Hartranft: There was a recommendation heard earlier that recognizing landscape position is critical when assigning loading rates, how has that been addressed? Do we have confidence in Jordan's equation?
    - Claggett: Need to get recommendation from the panel to use Jordan's equation, if not, how else how should we do this?
    - Strano: use the equation for existing wetlands that function as BMPs, how different is that from the current reductions given to wetlands?
- Sweeney: wetlands occupy area in watershed so they are a land use but at the moment they are assigned as forests because they are thought to have similar loading rates. If they occupy space, whatever the loading rate it's the inverse of retention efficiency. Figure out retention efficiency on various types of wetlands, take inverse to get the loading rate and compare to other landuse like forests. Is it more or less for N and P and sediment between the land uses and how does it vary among the categories?
    - Boomer: found in the literature review, depends on landscape position, what is delivered to the wetland.

- Staver: possible to get how much attenuation between sources and edge of stream throughout the watershed?
    - Sweeney: yes but difficult once you get to the headwaters, that's what we are trying to get different in this model to better understand attenuation between edge of stream. Calibrated to land use and then the gauging stations and attributing to sources
- Claggett: NWI + is something we are looking into. They have landscape position water flow path classification that can be tagged onto NWI but hasn't been done in too many places. Some degree talking about tom Jordan's equation is to use landscape position as one factor when looking at wetland efficiencies.
- Quentin: Option 1: have to do this if you can't come up with different efficiencies between the different types Option 2: preferred if there is a distinct difference between the categories
    - Denver: need range of potential efficiencies related to what you are trying to retain and where it is in the landscape. Can't give a blanket retention efficiency. Wouldn't feel comfortable. Need a matrix otherwise it's not meaningful
    - Mason: helpful to have and look over the case studies accomplished to review (maps and efficiency information).
    - Denver: identify areas where wetlands are more effective than other areas. Better understanding where adding wetlands is more valuable.
    - Sweeney: TMDL purposes all about implementation of restoring/constructing wetlands and that's what will be tracked and assessing where we are towards the goals. Focused on the benefits of wetlands that are already there, need to do something with the information. Maybe publish a study like forestry workgroup that did the consequences of forest loss and use the model to support. Benefits of restoring/enhancing a wetland for TMDL purposes.
- **ACTION**: Claggett will get back to Hanson about ETA of other case studies. Prototype in Fairfax County completed but has not done the three other counties. It would be informative to do the other three case studies. Need to answer question with modelers what type of impact will that have on TMDL if we go more complex route. What other non TMDL benefits might we gain from proceeding on more complex route? Certain thing we know about the landscape if we didn't account for would be ignoring information.

<u>Moving forward</u>

- Schedule end of June and July conference calls
- Next meeting: discuss what Claggett/Stubbs have in order to get idea of how we want to distinguish all the wetlands.
- Panel Chair and co-chair need to be identified by the end of this month to help present recommendations from the group to the partnership in august and beyond for BMP panel report. If you are interested contact Jeremy.

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Tuesday June 30th, 2015, 10:00AM-12:00PM
Meeting #7

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	Y
Dave Davis	VA DEQ	N
Judy Denver	USGS	N
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	Y
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	Y
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	N
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Hannah Martin	CRC	N
Jennifer Greiner	USFWS, Habitat GIT Coordinator	Y
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	Y
Katherine	EPA Region 3	N
Denise Clearwater	MDE	N
Kristen Saacke-Blunk	Headwaters LLC, AgWG Co-Chair	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	Y

Summary of Action Items:

- Small group (Jeremy, Ralph, Pam, Peter, Quentin) will talk offline about presentation/update to the Modeling Workgroup on July 21-22.
- Hanson will distribute a poll to schedule next call for last week of July or first week of August
- Panel will receive updated lit review from Molloy next week (~July 7th or shortly thereafter).
- Hanson will share the WetCAT links/materials from Henicheck with the full panel.
- The panel will revisit the wetland types and opportunity decisions after considering the updated literature review and WetCAT information.

Minutes:

Welcome and Introduction

- Jeremy asked for any final corrections or edits to the June 2nd minutes. None were raised; the minutes were approved.
- **DECISION**: The June 2nd call minutes were accepted as written.

Review and discussion of retention case study results

Stubbs reviewed the objectives, methods and results of the pilot study. Charles, Wicomico, Lancaster, plus they included two additional areas Steuben (NY) and Cumberland (PA). He asked the group to consider if there are any variables missing, if the reductions are too high, or any other comments. Brooks asked for clarification about the relationship between the summary table and the graphs. Proportionally, the coastal plain areas have higher percentage of wetlands, so that appears to be main reason for the higher reductions compared to the Piedmont or Appalachian areas. Later this summer the GIS and modeling team has plans to use work from Weller and others to more explicitly incorporate forest buffers into the modeling tools. A lot of the wetlands are floodplain wetlands, and those NWI polygons include the open water of the stream. We essentially nulled those out. It was noted that Wicomico may also be tidal and would likely need to include the open water treatment for tidal-fresh and tidal-saline. Peter pointed out that Jordan's equation doesn't include direct interaction with the water column. Judy was unable to join the call, but Quentin explained some of her concerns with the methods regarding relationships to groundwater and surrounding land covers. For the land uses we want to know if the removal efficiencies are dramatically different across the types. Then determine how to adjust the rates based on the known differences using NWI, etc.

- Brooks pointed out that the range of removal efficiencies for wetlands is extremely large in the literature, ranging from significant sinks to sources. Looking at the literature most wetlands do act as sinks but we can see cases where they act as sources. We can probably learn more about what factors make a wetland a source vs. a sink.
- Sweeney noted there are options for how the panel can address large flow events, but all panels should account for it somehow. The easiest way to account for it, is to assume that at least one or two large events will occur over a certain number of years (e.g., 10) and adjust the reduction accordingly.
- Mason mentioned that the group may need to crosswalk with some of the tidal wetland considerations from the shoreline management panel's recommendations. She recapped that the first question to resolve is whether the group wants to revisit changing the number of types? We had four, were down to three, and now five were under discussion. She noted Stubbs and Claggett need that answered first before they can update their analysis. Then there is the issue of opportunity for the wetlands to treat the surrounding areas or land uses. Looking at percentage of total acres treated, how much weight do we apply to factors like that? Will need to answer that eventually.
- Claggett: we have land cover data for the entire watershed. Based on the ratios, Jordan's equation and the land covers we can make the necessary adjustments. The type question is more difficult.
    - It was suggested to wait until after the literature review is updated to define or distinguish the types.

- Henicheck mentioned WetCAT, which scores wetlands based on habitat or other stressor factors. WetCAT is GIS analytical tool from VIMS and VA DEQ that was developed for permit programs, but also for monitoring and assessment. Fairly comprehensive tool that incorporates water quality, habitat, land use and other variables. So it is another tool that could potentially be used to help guide our approach to classifying wetlands or extrapolating their retention or effectiveness. Henicheck will send link and documents to Hanson.
- Claggett: Eastern Shore will likely be most challenging area, so perhaps they could test out applying the kinetic equation to the entire Shore and get a better sense of how to adjust or apply the equation/methods.
- There was general agreement from the group that over the next few weeks everyone can look at WetCAT and the literature review to help modify how, and justify why, we distinguish the 3-4 classes/types.

Literature review update and status

Molloy cautioned that while the spreadsheet has quite a few entries, there is a smaller subset of studies that have relevant loading data broken down by wetland type or other factors of interest. The group agreed that she continue to not exclude data or information if it is only nitrate. The model and panel can still use nitrate as a part of TN. The same goes for other species of N (or P, where available), such as dissolved, ammonia, etc. Molloy noted she has added a few sources and need to rerun some of the numbers. Will try to more fully explain and include a discussion of factors that affect nutrient removal, such as retention time, etc. in the narrative. May not be able to do quantitative analysis due to limited results, but can at least describe them qualitatively. She mentioned that she will continue to come across studies looking at constructed wetlands for stormwater and she asked how the group felt she should handle those studies. It was agreed that while they are not an explicit part of this group's charge, they can still be included overall, but separated from the natural wetland studies. They may provide some insight when compared to the natural wetland studies, though the group will need to be wary of the methods and how to properly compare and contrast their results.

Confirmation of Panel Co-Chairs

DECISION: Pam Mason and Ralph Spagnolo were confirmed as Co-Chairs for the panel.

Moving forward

Hanson outlined some next steps for the group. See summary of action items above.

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Wednesday July 29th, 2015, 10:00AM-1:00PM
Meeting #8

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	Y
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	Y
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Hannah Martin	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	Y
David Wood	CRC	Y
Denise Clearwater	MDE (attending for Jeff Thompson)	Y
Kristen Saacke-Blunk	Headwaters LLC, AgWG Co-Chair	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N

Summary of Action Items:

- Hanson will share conflict of interest disclosure form for WEP Members to fill out
- Hanson will follow up with modeling team on specifics on modeling tidal wetlands in the estuarine vs watershed models (potential presentation at next meeting)
- Claggett will contact SPARROW modelers to see if it's appropriate to add wetlands as a primary landuse and run analysis similar to that of forested to come up with values.
- Initial drafting team (Hanson, Mason, Spagnolo, Clearwater) will draft narrative to support the wetland classification recommendations
  - August 5th- Share narrative draft with WEP membership
  - August 12th- WEP membership submit comments on narrative draft
  - August 13th- Hanson to make revisions to narrative
  - August 14th- Submit wetland classification recommendations and narrative to Water Quality GIT for review

    - August 24th-Water Quality GIT meeting to discuss/approve panel recommendations.
- Hanson will send doodle for a next WEP call in late August

Minutes:

Welcome and Introduction

- Hanson asked for any final corrections or edits to the June 30th minutes. None were raised; the minutes were approved.
    - **DECISION**: The June 30th call minutes were accepted as written.
- Updates made to the BMP Expert Panel Protocol—changes affect the process for writing the final report and comment review period.
- Panel members must now fill out the conflict of interest disclosure form. **ACTION**: Hanson will share the form with panel members
- Mason presented to the modeling workgroup; slides were provided to WEP members

Discussion of wetland loading rate(s)

NONTIDAL-Use SPARROW to confirm Jordan equation. The WEP decided to take all nontidal wetlands in watershed and apply the Jordan 1st order kinetic equation to the entire watershed and then take efficiencies and average within NHD+ catchments. USGS SPARROW model—takes multiple variables (like forest riparian buffers) and overlays wetland efficiencies and SPARROW will determine at regional scale if the efficiencies calculated with Jordan equation explain N, P and sediment efficiencies are comparable. If coefficient is 1 then it works, if it's 2 then the efficiencies should be twice as much as the equation. If 0 then wetlands don't have an effect that can be explained with the Jordan equation. Ideal would be coefficient of 1 which gives us confirmation/confidence that Jordan's equation is ideal method.

- Denver: important to understand; I like running kinetic equation but would prefer it to be done for the entire area that will give us information about where that equation represents. Riparian wetlands are the last place water goes before it enters stream. Need to determine where the equation comes close to 1 and then look at those areas and how it's related to hydrogeology to determine if wetlands are a contributing factor to that area. Also, get results of that analysis and compare directly to places that we know what's going on in order to learn a lot about what's important for attenuation. Don't screen so we can look at areas that don't work and determine why. Explain importance of attenuation and factors in certain areas.

TIDAL—both fresh and saline then it would be taken out of watershed model and no longer be a landuse because accounting for their loads and functions would be moved to the water quality model (Estuarine Model). Issue is that the estuarine model does not handle crediting BMPs—unclear how tidal wetland restoration/enhancement would be credited.

ACTION: Hanson will follow up with modeling team to get more information on the best approach to modeling tidal wetlands. Is it possible to build a module similar to the SAV in estuarine model with load reductions? How can we best realistically account for tidal wetlands as a natural resource as well as tidal wetlands that are a restored/created resource—do these belong in the same model?

Initial call with Modeling team will include Hanson, Claggett, Spagnolo, Mason, and Boomer. Potential presentation for August WEP meeting.

Since Tidal wetlands are unclear and may be moved to the Estuarine model, this WEP meeting will focus on deciding the recommendations for the non-tidal wetland classification categories and loading rates.

The panel members provided professional opinions that the loading rates are probably different than those of forests, however the current literature review and science cannot support these opinions. For example, nontidal wetlands should have higher rate for sediment than forest due to typical vegetated patterns. Some members expressed dissatisfaction with the results of the literature review, and that there are relevant studies which were not included. Some members offered to re-examine the literature for more studies, which could be used to produce a defensible loading rate in the future.

Mason: The isolated depressional wetlands are chronically going to trap sediment, unless there's a discharge event like a major storm. How that varies from forest, that's probably still a net trap of sediment. From landscape position, they don't have a load into the waterway which makes them a perfect sink. Statistically knowing how much it represents on landscape, they aren't the majority of the wetlands. Least information about those systems (least amount of literature) because they are assumed to be sinks. More groundwater relationship
Denver: tend to be sources of groundwater, add to groundwater. Not intercepting much. Sending clean water to the streams, don't add sediment or P.
Clearwater: The scrutiny given to wetlands as landuse should be no different than other land use. For example, if one study was used to set loadings or efficiencies for forests, one study should also be sufficient for wetlands. . Also curious if any of the forested studies were done on hydric soils and could be pulled out for this purpose.

- The next SPARROW run will add all Phase 6 landuses with unique loading rates and therefore SPARROW sets the primary loading rates. Can wetlands be added as a primary rate to get a difference between wetlands and forests?
- **ACTION**: Claggett will contact SPARROW modelers to see if it's appropriate to add wetlands as a primary landuse and run analysis similar to that of forested to come up with values.

DECISION: Based on the available science and NWI classifications, WEP members agreed on the table of recommendations for three wetland categories (PFO, PSS, PEM) as the initial building block for Non-tidal Wetlands. If an area is identified as a wetland complex, it will be classified as the first category shown in NWI.

NONTIDAL (Palustrine) Classification	Loading Rate-Nitrogen	Loading Rate-Phosphorus	Loading Rate-Sediment
PFO (Forested)	100% TRUE forested	100% TRUE forested	100% TRUE forested
PSS (Shrubs)	100% TRUE forested	100% TRUE forested	100% TRUE forested
PEM (Emergent)	100% TRUE forested	100% TRUE forested	100% TRUE forested

A narrative is needed to document how the WEP membership came to consensus on this table.
ACTION: Initial drafting team (Hanson, Mason, Spagnolo, Clearwater) will draft narrative to support the wetland classification recommendations.

- August 5th- Share narrative draft with WEP membership
- August 12th- WEP membership submit comments on narrative draft
- August 13th- Hanson to make revisions to narrative
- August 14th- Submit wetland classification recommendations and narrative to Water Quality GIT for review
- August 24th-Water Quality GIT meeting to discuss/approve panel recommendations.

Wrap-up and next steps
ACTION: Hanson will send doodle poll for Aug meeting.

Next Meeting: Someone from modeling team to clarify tidal wetlands in the next model.
Start moving into BMP questions.

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Wednesday September 2nd, 2015, 1:00PM-3:00PM
Meeting #9

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	Y
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	N
Quentin Stubbs	USGS, UMD	N
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	Y
David Wood	CRC	N
Denise Clearwater	MDE	Y
Kristen Saacke-Blunk	Headwaters LLC, AgWG Co-Chair	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N
Lew Linker	EPA CBPO	Y

Summary of Action Items & Decisions:

- Decision: The July 29th call minutes were accepted as amended.
- Action: Lew Linker will share the agenda for the upcoming October 5th Modeling Workgroup quarterly meeting, which will include a more detailed discussion of tidal wetlands in the next version of the Water Quality and Sediment Transport Model. Hanson and Runion will distribute the agenda to the panel and wetlands workgroup, respectively.
- Decision: The existing NWI data layer will be used as the basis for the initial October 2015 calibration. Note: Newer data from the jurisdictions can be incorporated during the 2016 review period.
- Action: Claggett can be on the WQ GIT meeting to reassure group that changes can be made within the model to include new data as it becomes available.

- Decision: NWI data for riverine, palustrine, and lacustrine wetlands will be used as the basis for the wetland land uses in the initial Phase 6 model calibration (upon Water Quality GIT approval). Riverine (vegetated) and lacustrine (vegetated) will be changed from open water to wetland when there is overlap with acres of the existing open water land use. Acres of all three (palustrine, riverine and lacustrine) will then be split into the Floodplain and Other classifications using a combination of FEMA and SSURGO maps, as Peter and Quentin have already been doing. Note: If adjustments need to be made to the rules to change how the acres are split between the two "buckets," they can be made following the October 2015 calibration.
- Action: WEP members should reach out to WQ representatives colleagues and inform them of these land use changes to gain support for the 9/14 WQ GIT vote.
- Action: Edits or comments on the recommendations memo should be provided (in track changes format) to Jeremy (jchanson@vt.edu) by **COB Thursday 9/3 (tomorrow)**.
- Action: Hanson will send doodle poll for next meeting in October.

Minutes:

Welcome and Introduction

- Hanson asked for any final corrections or edits to the July 29th minutes. None were raised; the minutes were approved.
    - Decision: The July 29th call minutes were accepted as amended.
- Review/summary of Wetland WG call from 8/28
    - Non-tidal wetland land-use categories for Phase 6 model moves from three vegetation-based classes to two landscape classes: floodplain and other.
    - Process has been collapsed in a short timeframe that has caused frustration and confusion. The preferred deadline to determine number of categories was months ago and the timeline of the group conflicts with this. Now we are limited to three or fewer classes with the first calibration on October 1st. The two proposed classes have support from the workgroup, though, and two land uses for nontidal wetlands would be a major achievement.
    - Hanson: Overall, we will have wetlands added to the Phase 6 (with WQ GIT approval 9/14). Today we will review the recommendation memo and land use labels.

Discussion of tidal wetlands loading rate(s)

Lew Linker:

- Motivation behind including a tidal wetland:
    1. Assessment of effect of climate change/sea level rise on the TMDL and other standards on the Bay with a loss of tidal wetlands.
    2. There has now been documentation of attenuation of N and P in tidal wetlands – TN/TP attenuated 46/74% from tidal wetlands (Anderson, Iris et. al.)
    3. Model needs update in attenuation.
    4. Alignment with other expert panels.
- Calibration of tidal wetland attenuation will be initiated this month.
- Will be able to credit tidal wetland creation.
- Attempting to provide an assessment to guide management.
- Timeline – Both should be fully operation by the end of 2015 and review by CBP by 2016.

- Action: Lew Linker will share the agenda for the upcoming October 5th Modeling Workgroup quarterly meeting, which will include a more detailed discussion of tidal wetlands in the next version of the Water Quality and Sediment Transport Model. Hanson and Runion will distribute the agenda to the panel and wetlands workgroup, respectively.

Discussion of updated Phase 6 land use recommendations

- Review of most recent recommendations document – altered to reflect the Wetland Expert Panel's recommendation as supported by Wetland WG. PA dissent from WG recommendation has been documented as against adding wetlands as a land use due to the age and inaccuracy of NWI in their state, although they expressed support of the land uses to allow for reporting BMPs such as wetland enhancement.
- *Hanson*: The current need for the model is to include wetlands in this first calibration in order to add new, more accurate data next year wherever better data may exist.
- *Staver*: Critical part of differentiating wetlands and forests in the model is attenuation, not loading rate.
- *Claggett*: We're in agreement that attenuation of wetlands comes from surrounding lands. WQ GIT is resistant to adding wetlands as a land use because loading rates are different from efficiencies. Including efficiencies adds transparency to the model.
- *Staver*: Need to include wetlands to have a "mechanistic narrative" in order for the model to be understandable.
- *Hanson*: Second criteria for new land use described as "contribution" in the memo rather than loading rate or efficiency in order to be more comprehensive.
- *Mason*: Incorporating this data gives additional opportunities within the model such as habitat uses.
- Updating the wetland mapping model
    - Decision: The existing NWI data layer will be used as the basis for the initial October 2015 calibration. Note: Newer data from the jurisdictions can be incorporated during the 2016 review period.
    - Starting 1/1/16 there is a full review period of the calibrated model. There would be opportunity to change or make improvements (NWI+) whenever available. This adds incentive to develop NWI+ and put resources towards new data
    - Action: Peter Claggett can be on the WQ GIT meeting to reassure group of this.
- Decision: NWI data for riverine, palustrine, and lacustrine wetlands will be used as the basis for the wetland land uses in the initial Phase 6 model calibration (upon Water Quality GIT approval). Riverine (vegetated) and lacustrine (vegetated) will be changed from open water to wetland when there is overlap with acres of the existing open water land use. Acres of all three (palustrine, riverine and lacustrine) will then be split into the Floodplain and Other classifications using a combination of FEMA and SSURGO maps, as Peter and Quentin have already been doing. Note: If adjustments need to be made to the rules to change how the acres are split between the two "buckets," they can be made following the October 2015 calibration.
- *Sweeney*: Creating a land use in the model is difficult and the modelers are prepared to enter zero for these land uses; the WEP must be able to answer various questions from different groups. Ex. Why do we have multiple wetland classes if the loading rate/efficiencies are the same?

- Action: WEP members should reach out to WQ representatives colleagues and inform them of these land use changes to gain support for the 9/14 WQ GIT vote.
- Action: Edits or comments on the recommendations memo should be provided (in track changes format) to Jeremy (jchanson@vt.edu) by **COB Thursday 9/3 (tomorrow)**.

Wrap-up and next steps

Action: Hanson will send doodle poll for next call in October.

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Thursday November 5th, 10:00 AM-12:00PM
Meeting #10

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	N
Rob Brooks	Riparia, Penn State	Y
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	Y
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	Y
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	N
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	N
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	N
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	N
Kristen Saacke-Blunk	Headwaters LLC, AgWG Co-Chair	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	Y
Lew Linker	EPA CBPO	N

Summary of ACTION Items & DECISIONs:

- **DECISION**: The September 2nd call minutes were accepted.
- **ACTION:** Members will send any additional literature to be reviewed by Tetra Tech to Hanson. Any that emerge after 11/6 will need to be reviewed and summarized by a panel member.
- **ACTION**: Rob/Erin will provide list of common wetland practices that the panel will then work to categorize under reestablishment, rehabilitation, or enhancement.
- **ACTION**: Ralph, Pam and Erin will discuss the tidal wetland conversion issue offline.
- **ACTION**: Erin will share the wetland workgroup's NEIEN wetland BMP data flowcharts with the panel. She will work with Virginia (Pam & Michelle) to get their flowchart similar to the other jurisdictions.

- **ACTION**: Conflict of interest forms for the panel should be in to Hanson by Tuesday, 11/10/15.

Minutes:

Welcome and Introduction

- Hanson asked for any final corrections or edits to the September 2nd minutes. None were raised; the minutes were approved.
    - **DECISION**: The September 2nd call minutes were accepted.

Updates and Timeline

- Our tasks at a glance…
    - Recommendations for the Phase 6 wetlands land uses were made as two classes: "floodplain" and "other."
    - Recommendation of loading rates for Phase 6 Land Uses is ongoing
    - Evaluation and recommendations of wetland BMPs is ongoing
- Timeline outlook
    - November 2015: finalize additional literature for inclusion by Tetra Tech.
        - **ACTION:** Members will send any additional literature to be reviewed by Tetra Tech to Hanson. Any that emerge after 11/6 will need to be reviewed and summarized by a panel member.
        - Literature to be separated between constructed/restored and natural wetlands.
    - December (week of the 7th): Panel call to refine BMP definitions Peter and Quentin to begin SPARROW analysis. Build report outline.
    - January 2016: Updated nutrient/sediment literature review from Tetra Tech & SPARROW analysis to be discussed. Continue report outline.
    - March: Work to complete first full draft of report. Face-to-face meeting.
        - Murin: Should try to deliver the draft report to the panel as soon as possible to ensure all can review and comment in time.
    - April: Begin comment/review/approval process. Present recommendations to Wetlands WG, Habitat GIT, Watershed Technical WG, WQ GIT.
        - Spagnolo: Ideally will have comments from these groups in time for them to come back to the Panel for review before final approval.
            - Hanson: Any substantive changes will come to the Panel, but minor changes in language etc. will be dealt with by the Chairs/Coordinator.
    - September: All model inputs must be final.
    - October 2, 2016: Final Phase 6 CMWM is calibrated.
    - Members should give Hanson, Spagnolo, and Mason notice if they are taking time off or have issues with any content.

BMP Definitions

- For Phase 6, we want to
    - Have more clarity in the BMP definitions used by CBP for annual progress reporting

        - Mason: Definitions that exist were created to be used for agricultural settings. Moving forward, we want to consider all BMPs.
        - McLaughlin: We're also building new categories of restoration to include practices where there is an ecological uplift, but no gain in acres.
    - Distinguish restoration, creation, and enhancement
    - Recommend distinct effectiveness values for each of the BMPs
- Will be helpful to create a list to identify specific implementation practices that could be classified under these BMPs for CBP reporting (as well as a list of practices that should not be classified).
    - Example: Legacy sediment removal is currently a CBP approved Stream Restoration BMP but should be changed to a Wetland BMP.
    - Spagnolo: Cannot have people start converting land just for the sake of BMP credits. Even if there is a rise in water quality with a change, it may not be justified when weighed down by the tradeoffs.
        - Will set qualifying conditions for these practices to ensure tradeoffs aren't net negative
    - **ACTION**: Rob/Erin will provide list of common wetland practices that the panel will then work to categorize under reestablishment, rehabilitation, or enhancement.
- Murin: There is an existing regulatory definition from the EPA and USACE based on their mitigation role from 2008. We could utilize this consistent definition for the various wetland types. The NRCS Conservation Practice Standards definition could be used as an example for the type of activity that qualifies for the wetland BMP.
    - Brooks: Should not have to be exclusive in which we use. NRCS definitions are more consistent with practitioners as opposed to the regulatory definition.
- Reestablishment, Rehabilitation, and Enhancement as categories under Restoration
    - McLaughlin: Enhancement involves tweaking/improving one function while Rehabilitation consists of multiple functions.
    - Mason: We should keep these categories separate for now, but if we cannot determine loading figures later on they can be consolidated into fewer categories.
        - Staver: List the practices and have them define the categories.
    - McLaughlin: There won't be a land-use change for rehabilitation, but there will be an acreage of improved function. Value change, not an area change.
    - Mitigation is not counted/credited by the Bay Program.
        - Constructed wetlands that are created for a purpose such as waste/pollution treatment. Similar to mitigation but often done voluntarily
            - Hanson: There are other BMPs and panels that deal with engineered stormwater wetlands. Will list and refer to the appropriate panel in the BMP list.
- Creation
    - Creation is straightforward once the qualifying conditions are set.
- Tidal Wetlands
    - Mason: What do we call vegetated wetland creation on near-shore shallow waters? NWI already classifies this area as wetlands, so how can this be called creation? Ex. Living shorelines that give an ecological lift and are given BMP credits but replace existing aquatic resources.

        - McLaughlin: Conversion/enhancement of one wetland habitat to another with improved function.
    - Could be included in other panels, such as living shorelines, and we should defer to that panels' recommendations.
    - **ACTION**: Ralph, Pam and Erin will discuss the tidal wetland conversion issue offline.
- Restoration to be split into four categories: Reestablishment, Rehabilitation, Enhancement, and Creation.
    - Spagnolo: Creation vs. other restoration can be separated by the presence of hydric soils.

<u>Wrap-up and next steps</u>

- The Wetland Workgroup will meet on 11/19, 1-3 pm. All panel members are welcome to join.
    - The Upper Susquehanna Coalition will be giving a presentation on a potential method to update NWI data for PA.
- Wetland WG has put together a flow chart for each state of who is reporting to the NEIEN contact. Mainly NRCS practices but expanding, so these contacts are helpful.
    - **ACTION**: Erin will share the wetland workgroup's NEIEN wetland BMP data flowcharts with the panel. She will work with Virginia (Pam & Michelle) to get their flowchart similar to the other jurisdictions.
- Specific questions/topics for subgroups
    - What practices should be on the lists of approved and non-approved wetland BMPs? (also to be reviewed by Wetland Workgroup)
    - Review of issues where other panels also exist (ex. Tidal wetland creation → living shorelines)
    - Identify format of BMP loading coefficients (ex. fixed percentage or sliding scale) and order of effectiveness of restoration activities.
- **ACTION**: Conflict of interest forms for the panel should be in to Hanson by Tuesday, 11/10/15.

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Friday December 11, 2015th, 9:00 AM-12:00PM
Meeting #11

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	N
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	N
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	N
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	Y
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	N
Kristen Saacke-Blunk	Headwaters LLC, AgWG Co-Chair	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	Y

Summary of ACTION Items & DECISIONs:
DECISION: The November 5th call minutes were accepted.
ACTION: If you find any additional literature, please provide a summary of the key elements (e.g., site description, methods and relevant findings) that the panel can readily add into the lit review or the panel's full report.
ACTION: Panelists should review the BMP table at the end of the "Proposed BMP categorization" document and send additional comments to Hanson. (comments made during this meeting are listed below)
ACTION: Hanson will follow-up with Bill Stack and CBPO modelers to answer some questions raised by the panel in relation to the CBP-approved stream restoration BMP protocols. Specifically, is it possible for the acres reported under the stream restoration BMP (Protocol 3 for floodplain reconnection) to be used for tracking purposes under the Watershed Agreement's outcome for wetland restoration?

ACTION: Hanson will update the table based on the discussion during the call or offline and share it with the panel.

Minutes:

Welcome and Introduction

- Hanson asked for any final corrections or edits to the November 5nd minutes. None were raised; the minutes were approved.
  - **DECISION**: The November 5th call minutes were accepted.

Updates and Timeline

- About 50 pieces of literature were sent to Aileen Molloy at Tetra Tech for review. So far 15 have been reviewed, with 7 having relevant data (1 from Chesapeake watershed). Most had a removal efficiency or a way to determine it. Findings from the literature review should be delivered to the Wetland Expert Panel in mid-January. **ACTION**: If you find any additional literature for Tetra Tech from now on, please provide a summary as Aileen's hours are limited.

SPARROW Analysis

- Mason: Questions arose last summer when the group became aware of the SPARROW model process which was used to set the forest values for the Chesapeake Bay Watershed model. This validated model could also be used to determine a loading rate for wetlands within the model.
- Stubbs: Timeline update (best case timeline for modelers, not WEP):
  - Mid-December: In contact with USGS liaison to determine a timeline for the SPARROW model to run. We are creating a spreadsheet vector dataset of the area of the wetlands by NHD catchment to evaluate the wetlands in SPARROW. We will forward the spreadsheet next week to run the SPARROW model.
  - Late December/early January: Results of the SPARROW model in so we have time to run through the results and ensure there are no glaring errors.
  - Mid-January: Go back to the algorithm from Tom Jordan to calculate the wetland efficiency rate.
  - Late-January: The results will be forwarded to the WEP for review.
  - Early February: Sent to Wetland Workgroup for review.
    - Hanson: Reminder of calibration timelines: January 1st, 2016, first calibration/beta version. April, second beta version. June/July, third beta version. All inputs final in September. When can we deliver the efficiencies? In time for a beta?
- Pros and cons of this group having more time vs modelers having more time…
  - Hanson: The later the modelers receive a WQGIT-approved recommendation, the less likely it is to be included. A simple loading rate is easy/quick, while a more complex approach (curve, etc.) would be more difficult and require more time to build into the modeling tools.
    - Murin: WEP is supposed to deliver best science decision. Need to be aware of timelines with modeling, but that can't be the driver of our decision. Can't rush and deliver a poor product.

- Mason: The current timeline seems to allow for the recommendations to possibly be incorporated into that third beta version. The timeline would give both the panel and modelers time to prepare and adjust.
    - Greiner: Would involve delivering to the Wetland WG and Habitat GIT in May/June
- Hanson: The recommendation requires a comprehensive memo, so it would not be efficient to split the loading rate into N/P/… in order to deliver some product sooner.
    - Hanson: call mid-late January to examine Tetra Tech review and SPARROW analysis review. Early March – face to face meeting, Baltimore, Annapolis. Comments in first 30 days after…
        - Stubbs: Potential for new wetland area numbers as we find methods to update maps. New numbers could require another SPARROW analysis. Hopefully that can be automated, so not time consuming.
            - Hanson: Ideally would have SPARROW and literature give us a uniform loading rate for each of the two wetland land uses. Then it might not be necessary to redo the SPARROW runs.
            - Murin: We hope to have PA wetland mapping (USC & UVM proposal) set to work by January 1 and completed by the end of July.

BMP

Provided to the group was a BMP categorization as well as an old "WetlandTrackingDefs" slide that provided a base for our categorization of wetland BMP practices. Jeremy explained that he used that old 2005 table as a template for a way to categorize the panel's recommendations for Phase 6 wetland BMPs. The panel discussed how various practices may be included or excluded under the Phase 6 wetland BMPs.

- Wetland vs. stream restoration, credits for BMPs
    - Legacy sediment removal, often done as floodplain reconnection outside of the stream channel, could be counted towards wetland BMP and acre gain rather than stream in many cases.
        - McLaughlin: Huge potential for wetland acreage towards the Watershed Agreement; do not mean to take away from streams but need to credit wetlands as they are reconnected.
            - Spagnolo: Clear way to do it (not how it is being done right now) is that in channel areas go towards stream restoration and floodplain areas go to wetland credits.

                - Spagnolo: This sediment itself can become a source of pollution if not transported/used properly. We need to be careful when categorizing this as legacy sediment is done in different ways by different people/states.
                    - Questions for Jeff Sweeney and Bill Stack: Are states reporting floodplain reconnection as wetland or stream credits? Varies state to state. Should coordinate with Stream Health Workgroup (CWP contractual support ends 12/31/15, so any questions for them should be asked quickly).
                        - Mason: What do we do with non-georeferenced projects along waterways with regards to area of wetland creation and nutrient reduction?
                        - Do the nutrient reduction efficiencies for these stream restoration projects include floodplain sediment trapping?
                    - Modelers can avoid double count IF they receive the geo-reference from the state every time (not always the case).
                        - Staver: Are stream restoration benefits counted with wetlands benefits? Don't need to capture the nutrient reduction, but want to use the acres for wetlands towards the goal
- "Other Wetland Restoration project types" credited under stream but have potential for wetland
    - Regenerative stormwater conveyance
        - McLaughlin noted that when done outside of a stream channel, RSC is called Coastal Plain Outfall. (same technique)
    - Hanson: some not ambiguous, creditable elsewhere (living shoreline, constructed wetlands, and riparian tree plantings)
        - Living shorelines - gap in crediting
        - Invasive species - not credited elsewhere,
        - Wetland meadow planting – restoration.
            - Strano: planting herbaceous vegetation on cropland with hydric soils. Restoration in that they are installing vegetation where it used to be, but whether or not they work with hydrology is another question. Land is not under protection – can be converted back to cropland.
                - Mason: This results in a wetland acreage gain.
                    - Strano: This practice is done under NRCS code 327 (conservation cover). Associated with wetland restoration. Should assign 657 over the whole area and 327 over just the meadow planting. Should avoid double counting: can't count 327 as enhancement and entire 657 area as restoration.
- **ACTION:** Panelists should review the BMP table at the end of the "Proposed BMP categorization" document and send comments to Hanson.
    - Greiner: Background on initial table: this table is about a decade old, based on how practitioners were reporting in 2005. Definitions taken from White House wetland working group in the 90s. Seeking to make this table more reflective of current work and terminology.

- McLaughlin: Create new category for rehabilitation (functional gain) rather than having it within enhancement. Invasive species removal should be moved to enhancement. Floodplain reconnection would fall under rehabilitation. Legacy sediment removal would fall under restoration.
- Mason: Similar thoughts… comes down to explaining our decisions to who it effects
- Spagnolo: Note that "Practice and Project Examples" is not comprehensive
  - Should clarify "regulate flow…" under enhancement
    - Greiner: Group was trying to distinguish between habitat and water quality within enhancement.
    - Murin: NRCS, PA berms, with control structure to expand wetland area into wetlands
      - Strano: Restoration/creation if it is upland
  - Need to be clear that rehabilitate is repairing to natural/historic functions, while enhancement is functional gain of some kind.
- Staver: Agree
- Strano: Include "reestablishing native vegetation on cropland with wetland hydrology" in restoration.
  - Many pastures require the hydrology be restored to be considered wetlands again.
    - Will need to clarify if pasture will be included in land uses.
- Thompson: Enhancement, waterfowl – this does not consider moist soil management
  - Ditch plugging would be rehabilitation if done in the woods, restoration if done in agricultural lands
- Will need qualifying conditions and disclaimers to ensure the BMP credits aren't being taken advantage of with regards to actual benefit to wetlands.
  - McLaughlin: Counties putting in BMP practices in order to gain credits… implementing practices that gain more credit rather than the practice that is best for the site. Mostly in developed areas, suburban, not ag

Follow up

The WEP will have another call in mid to late January to examine the literature review from Tetra Tech. We plan to have a face to face meeting in late February or early March in the Baltimore/Annapolis area. Depending on progress and workload, we may have another short call in early February (Delaware wetland conference in early February is a scheduling conflict). Be on the lookout for Doodle polls soon for these 2-3 dates.

We hope to have our report released in April to go through groups at the CBP and have loading rates approved for the summer beta version of the Phase 6 Watershed model.

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Wednesday January 27th, 2016, 9:00 AM-12:00PM
Meeting #12

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	Y
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	Y
Kristen Saacke-Blunk	Headwaters LLC, AgWG Co-Chair	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N

Summary of ACTION Items & DECISIONs:
DECISION: The December 11th call minutes were accepted.
ACTION: If you find any additional literature for Tetra Tech from now on, please provide a summary as Aileen's hours are limited. We are now focused on the literature review for unintended consequences and ancillary benefits of wetland BMPs.
ACTION: Hanson and Runion will send a table listing chapter assignments. Please email Hanson if you'd like to help with any other section.
ACTION: Draft sections due March 9th. March 16th as back-up deadline. Must be done before March 23rd meeting for members to review.
ACTION: The Chapter 5 outline will be updated to reflect the categorization proposed today and shared with the group by Hanson

Minutes:

Welcome and Introduction

- Hanson asked for any final corrections or edits to the December 11th minutes. None were raised; the minutes were approved.
    - **DECISION**: The December 11th call minutes were accepted.

Updates

- The revised BMP categorization table was distributed; we will continue to revisit and revise the document as needed.
- Hanson spoke to Bill Stack and modelers at CBP about stream restoration BMPs. No news to report, but will be an evolving conversation.
- We hope to see SPARROW results in mid-February; hopefully in time to discuss during out 2/18 call.

Literature Review, Aileen Molloy

- About 50 pieces of literature were sent to Aileen Molloy at Tetra Tech for review. Of articles addressing wetlands in the Chesapeake Bay watershed, 13 were identified as having potentially useful data.
    - 18 studies had TN load reduction efficiencies
    - 20 studies had TP load reduction efficiencies
    - 9 studies had TSS reduction efficiencies
    - Studies varied geographically
        - 8-10 data points within the Bay watershed
    - Wetland types were very different
    - Results are broken down by nutrient and sediment reduction efficiencies by wetland and vegetation type in table 2 of the literature review (distributed)
        - Mean % reduction given in this table was calculated using only data points given in studies, not data ranges. The ranges are also described above the table.
- The spreadsheet distributed along with the literature review document gives all studies provided and provides a reason for rejection for those studies that were not used (columns J and K).
- Boomer: Would like to thank Aileen. The literature review is a great head start into the report. The processes affecting the fate and transport of nutrients could be addressed better in the final report.
- The literature review of unintended consequences and ancillary benefits of wetland BMPs has not yet been started. Some current literature could be used, but additional relevant literature would be appreciated.
    - Hanson: The focus is on restoration/BMPs of wetland habitats, not just wetlands in general. Will be more of a qualitative rather than quantitative review. Any benefits/consequences besides nutrients/sediment (habitat, toxic contaminant, etc.)
        - Staver: Benefits could even include downstream effects on hydrology related to stream channel erosion. There is a large scale thinking of benefits.

        - Strano: These studies look at a single type of wetland. In large storm events, headwater wetlands become overrun and floodplain wetlands become even more important.
        - Boomer: Wetland importance can also be shown with water storage and hydrograph effects.
- **ACTION**: If you find any additional literature for Tetra Tech from now on, please provide a summary as Aileen's hours are limited.

SPARROW Analysis, Quentin Stubbs

- We are in the process of reformatting two datasets for SPARROW. We have to create an updated wetland layer to include MD wetlands, and a layer that accounts for land cover that is between agriculture and stream bank. Want to see if they can actually detect if there is forest or wetlands between the agriculture and stream. Trying to identify how many nutrients these wetlands are absorbing. After we have those two layers, we will resubmit to the modelers to run. A long line of other groups wanting to run SPARROW things.
    - Hanson: Output from analysis?
        - The basic efficiency rate from the analysis will be entered into the Jordon equation, which is what is of interest to us.
    - Hanson: Hope to have this before 2/18 call.

Report Outline

- We have to release our report in April in order to have it approved by September. Priorities are land use loading rates and wetland restoration BMPs in the calibration history.
- Will need input and effort from everyone in writing the report. Look at the outline
- Chapter 1: Charge and membership of the expert panel
- Chapter 2: Definitions of terms used in the report
- Chapter 3: Background on wetlands and wetland BMPs in the Chesapeake Bay Watershed
    - Chapters 1-3 are background and can be done by staff here at CBP
- Chapter 4: Review of available science
    - Literature review is a good start here, but some sections can be expanded on (processes affecting the fate and transport of nutrients)
    - Boomer, Denver
- Chapter 5: Recommendations for Wetlands as land-use and BMPs in Phase 6 Watershed Model
    - A, Wetlands as a landuse
        - Staver, Strano
    - B, Wetlands as landscape efficiencies and BMPs
        - Break out by restoration/creation/enhancement/rehabilitation or tidal, non-tidal floodplain/non-tidal other?
            - Looking through BMP categorization and determining what projects can take place in floodplain/other can help clarify this.
        - Floodplains: Strano, Boomer, Greg Noe, Denver
        - Non tidal/headwater depressional: Staver, Denver

            - Tidal: ?
    - Hanson: Note the distinct difference in wetland loading rate and wetland as a landscape efficiency.
        - Staver: 5b and the recommended loading rates may be the most important section; everything is built to defend the numbers in 5b.
            - Sweeny: 5a is just as important, as when wetlands are reported, the land is moved from whatever it is classified as into wetlands, creating a benefit as it will no longer be moving to forests. TMDL will receive credit just for that move.
                - Staver: Loads from wetlands as a landuse are going to be uniformly smaller than loads coming from upland, aka the landscape efficiency
        - Staver: Experimental issues such as waterfowl, cover crops, etc. External sources of nutrients that may overall remove/replace nutrients beneficially but can credit/blame these nutrients on wetlands.
- Chapter 6: Accounting mechanisms
    - McLaughlin and Clearwater
- Chapter 7: Unintended consequences and ancillary benefits of wetland BMPs
    - Forthcoming literature review from Tetra Tech, Molloy will provide a base here
    - Spagnolo, Uybarreta, Mason
- Chapter 8: Future research and management needs
    - Likely to populate as a group
    - Mason, Spagnolo, Uybarreta
    -
- Chapter 9: References
- **ACTION**: Hanson and Runion will send a table listing chapter assignments. Please email Hanson if you'd like to help with any other section.
- These reports can be updated as needed but only by a new panel, so it may take 3-5 years.
- **ACTION**: Draft sections due March 9th. March 16th as back-up deadline. Must be done before March 23rd meeting for members to review.

<u>Next Steps</u>

- Habitat/other consequences (other than nutrient/sediment effects) literature should be sent to Aileen. Focus should be on BMPs.
- Next call: February 18th. We don't expect to have first draft of report yet, but hope for it to be started. Chapter 4 is a priority and having a draft of that for 2/18 or shortly after would be ideal.
- **ACTION**: The Chapter 5 outline will be updated to reflect the categorization proposed today and shared with the group by Hanson
- March face to face meeting: Wednesday March, 23rd 10am-4pm. Location is TBD.

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Thursday February 18th, 2016, 10:00 AM-12:00PM
Meeting #13

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	Y
Michelle Henicheck	VA DEQ	Y
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	Y
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	N
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	N
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	Y
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	Y
Kristen Saacke-Blunk	Headwaters LLC, AgWG Co-Chair	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N
Bill Stack	CWP	Y

Summary of ACTION Items & DECISIONs:

- March meeting: Wednesday, March 23rd. 10am – 4pm.
    - NRCS office, 339 Buschs Frontage Rd #205, Annapolis, MD 21409
    - There is a WaWa nearby for lunch. We will also look into delivery options.
- **ACTION**: Draft report deadline: March 9th. March 16th as backup deadline.

Minutes:

Welcome and Introduction

- Hanson asked for any final corrections or edits to the January 27th minutes. Some panelists have not reviewed minutes; approval pending further review.

Literature Review, Aileen Molloy

- Tetra Tech has moved on to their second literature review based on unintended consequences.
- Molloy: We have gotten through all the articles that were sent in (over 100). Roughly half were found to be relevant (others continued to focus on nutrient and sediment reductions, which were addressed in the initial literature review).
    - Many articles addressed benefit to habitat. Other positive impacts included flow reduction, water storage, storm abatement, aquifer recharge, and water quality improvements.
    - Negative impacts found included nuisance vegetation, toxics concentration, unintended flooding, and methane emissions.
    - Other topics mentioned by panelists: carbon storage and sequestration, denitrification and how it changes with varying water tables and soils.
- Hanson: Some studies came out in this search that involved nutrients. These should be double checked to ensure they were included or are added in the previous literature review.

SPARROW Analysis, Jeremy Hanson

- SPARROW analysis is not going to be completed within our necessary timeframe. This analysis still could be useful to various GITs and workgroups, but it will not be complete until after our report is out for review/completed.
    - Mason: Large portion of time required for SPARROW is USGS's round of QA/QC, which was not accounted for in our timeline.
    - Clearwater: Our report should note that the recommended efficiency could change based on the results of this model.
        - Greiner: Could place an addendum based on newly available information in these reports.
    - Hanson: There will be CBP modelers trained in SPARROW in early March, who would be able to conduct this analysis with an expected completion date of this summer.
    - Hartranft: Does the literature support moving forward with these efficiency recommendations? The original charge stated that if it did not, we would make recommendations on what new science is required.
        - Hanson: No recommendation yet but there does seem to be sufficient information to determine rates. We just need to review and agree on numbers.
            - Hartranft: Could also consider scaling up and lumping categories together to determine a loading rate rather than splitting down to each specific practice.
                - Mason: Splitting further is unlikely. We would need to have many studies for each categorization. Terms are not explicitly defined (as we have done) in literature.
                - Greiner: CBP adopted the federal tracking definitions in 2005. Recommending anything other than those to change those would require significant effort for approval.

    - Denver: SPARROW is particularly important as it can take geographical conditions into consideration.
    - **Post-meeting note:** On Feb. 24th, Hanson was informed that USGS is no longer able to provide SPARROW training for CBP modelers until June or July at the earliest, if at all. This new information makes it extremely unlikely that the desired SPARROW work and subsequent analysis could be done in time to inform the final Phase 6 model calibration. Hanson will keep the panel informed if any new ideas surface or anything changes.

CBP BMPs, Bill Stack

- Hanson: There are two panels (stream restoration and shoreline management) that have released reports that relate to our floodplain and tidal wetlands sections. There is some content here we could possibly use and build on. Those panels' recommendations have already been reviewed and approved by the partnership, so we should utilize information that we can and make sure the protocols are consistent or do not lead to double-counting.
- Two panels have dealt with this nutrient and sediment removal efficiency related to wetland processes.
- Sujay Kaushal, UMD, and Paul Mayer, EPA, did research on nitrogen reduction with reconnection of a stream to its floodplain. They developed recommendations for quantifying denitrification in the hyporheic zone (applies to baseflow, stormflow has other protocol).
    - Hartranft: In Kaushal's study, are the floodplain access areas actually wetlands? Actual wetlands rather than floodplain areas could have even higher nutrient removal.
        - Stack: They installed monitoring wells in the stream up to the floodplain wetlands. Connectivity of the water table was the key in these areas meeting our qualifying conditions of this study. Qualifying conditions to determine wetland status were not developed by the expert panel.
            - Clearwater: "Reconnection" is misleading in this process as it assumes the floodplain is being used with any stormwater while the cutoff in natural channel design for disconnection is flooding at over the 2 year storm event. To treat it like it is disconnected can be misleading.
                - Stack: This protocol pertains to baseflow, the stormflow protocol addresses that issue.
- Credit for floodplain reconnection volumes during storm flow
    - Floodplain connection volume of stormflow increases when floodplain is more easily accessible.
    - We then took efficiencies from the Tom Jordan curves and multiplied by the volume of annual runoff.
    - A certain ratio of wetland area to watershed area proved to be optimal for nutrient removal.
    - Floodplain reconnection has to reconnect to a wetland as defined… same assumptions as Tom Jordan.
        - Spagnolo: Were these wetlands categorized? Was hydrology measured?

- Strano: The wetlands used in this study were restored wetlands, not floodplain wetlands used in the study.
    - Hartranft: The criteria for categorization of restoration sites in the Jordan study was different than what we are working under. The ratio of wetland size to watershed size was not statistically significant, but rather a general trend that he established. This relationship may work well at large scales (watershed) in theory but it may not at floodplain wetland scales and even up to several order tributary scales.
        - Stack: Two parts of this protocol. First part estimates the volume of annual flow that enters the wetland area. This affects the efficiency more that the Jordan curve. Second, the expert panel used that ratio of watershed area to wetland area to try to address the uncertainty associated with the method; this tries to be conservative. The 1% ratio chosen helped account for sufficient hydrologic retention time.
            - Wetland vs floodplain size drives denitrification, though there are other factors such as landuse and inputs.
                - Hanson: The phase 5 rates are largely based on Jordan equations. Nitrogen: 16.75%, Phosphorus: 32.18%, Sediment: 9.82%.
                    - Hartranft: Is the panel considering a removal rate attributed to floodplain wetlands in addition to or in lieu of an acre efficiency?
                        - Hanson: Load reduction – pound figure, efficiency – calculated based on upland loads or the loads of that landuse.
                        - Clearwater: The floodplain reconnection protocol is considered part of the stream restoration BMP whether or not there are existing wetlands there or ones are created or restored.
                            - Stack: This credit applies to the volume of upland runoff treated by the wetland.
                            - Hartranft: Recommendations for stream restoration apply to all types of floodplain reconnection, whether it be wetland restoration or stream work. For example, legacy sediment removal was named in the urban stream restoration expert report, but lumped with other types of BMPs (no specific removal rate).
                            - Spagnolo: Stream restoration getting credit for wetlands created after restoration.
                                - Clearwater: What's measured is the difference between pre- and post-construction volume.
                        - Stack: There are three different protocols for stream restoration projects based on different processes. Though they don't directly define an efficiency based

on legacy sediment, we allowed flexibility on the efficiency based on monitoring data.

- Do not want to double count, but do want to accurately track and report between streams and wetlands.
  - Spagnolo: Credit is on an area basis. Will have to discuss minimum project size at March meeting.
  - Mason: The modeling workgroup (or whoever may be appropriate) will have to deal with double counting. We can say in our report that there might be complications in tracking the data.

- Tidal shoreline management protocol
  - Protocols 2, 3 and 4 apply to living shorelines/fringe wetlands. A literature review led to median values applied to area of wetland. Credits applied as annual reductions. Verification recommendations ensure that wetlands are still functioning. Credits are adjusted accordingly.
    - Denitrification rate (TN)
    - Accretion that occurs due to fluctuation tides (TP, TSS)
    - Marsh Redfield Ratio: biomass stored in wetland. One-time annualized credit over 20 year period based on standing crop (TN, TP)
  - Mason: Protocol 1: sediment prevention/retention remains largely unknown, so TSS rates are project specific.
  - Hanson: Could these same protocols apply to tidal wetlands? We could save ourselves a lot of work, but do not want to do so just for convenience sake, the panel would need to agree that the shoreline management protocols are valid estimates of reductions for tidal wetland BMPs.
    - Mason: The panel would need to consider if there have there been any significant studies on this science since these recommendations were made. VIMS researchers are looking at N & P uptake of living shorelines, but otherwise doesn't seem to be much more new information to modify the protocols.
  - Clearwater: Unfortunately, habitat is not yet being counted. Until a habitat multiplier is developed, it may as well be counted as a shoreline BMP.
    - Hanson: Even if living shorelines and tidal wetlands are credited the same, having them reported separately can be useful towards our tracking efforts.
    - Mason: Differentiating between tidal wetlands and living shorelines categories in the crediting can help show other ecosystem services such as habitat.
      - Greiner: In terms of the direction of this partnership, there is a value added by differentiating and keeping habitat in mind. Should include enough in report to begin to develop this distinction.

Next Steps

- Tidal discussion to continue at our March meeting.
- March meeting: Wednesday, March 23rd. 10am – 4pm.
  - NRCS office, 339 Buschs Frontage Rd #205, Annapolis, MD 21409

    - There is a WaWa nearby for lunch. We will also look into delivery options.
- Draft report deadline: March 9th. March 16th as backup deadline.

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Wednesday March 23rd, 2016, 10:00 AM-4:00PM
Meeting #14

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	Y
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	N
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	N
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	N
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	N
Kristen Saacke-Blunk	Headwaters LLC, AgWG Co-Chair	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N
Bill Stack	CWP	Y

Summary of ACTION Items & DECISIONs:
DECISION: The minutes from our February 18th call are approved.
ACTION: Boomer and Denver request help in describing the distribution of physiographic provinces. They will contact Brooks.
DECISION: Panel agreed to cite and use reductions for TN, TP and TSS from the Shoreline Management Panel (sum of protocols 2, 3 and 4) as reductions for tidal wetland restoration BMP.
ACTION: All updated draft report chapters are due to Hanson and Runion by 4/15/16.
DECISION: The panel agreed that reduction efficiencies for TN should be the same between the Floodplain and Other land uses.
DECISION: The panel agreed that reduction efficiencies for existing wetlands will be the same between Floodplain and Other.

ACTION: Molloy will attempt to tease out physiographic regions and wetland:watershed ratios from the literature review to see if we are able to tease out regarding those attributes.
DECISION: There was consideration for using reduction efficiencies from the Riparian Forest Buffer report (2014), but the panel agrees that our own literature review is likely more accurate and will continue to discuss this. Hanson will distribute the RFB Report.
ACTION: Staver will chase down the CBWM 5.3.2 reduction efficiencies for current land uses.
ACTION: Stubbs will separate out wetlands using the beta watershed model calibration for Maryland and one other state (DE or PA) by 4/1/16.
Next Steps: We will schedule a two hour call during the week of 4/11/16 and another face to face meeting will be scheduled during the following weeks. Please complete the NeedToMeet polls by Thursday 3/31: April two hour conference call; April face to face meeting

Minutes:

Welcome and Introduction

- Hanson asked for any final corrections or edits to the February 18th minutes. None were raised. **DECISION**: The minutes from our February 18th call are approved.
- The focus of today is to make decisions about how to structure BMPs of the land uses; whether or not we want to have different rates for floodplain/other, physiographic regions, and restoration/creation/rehabilitation. The next step is to decide values or at least ranges of reduction efficiencies for these BMPs.
- Our overall deadline is the Phase 6 calibration in September. We hope to have the report released by the end of April/early May in order to be able to get through the review process in a timely fashion.

Review of Draft Chapters

Please send any comments to the chapter authors and Hanson

Chapter 1. Charge and membership of the expert panel, Hanson

- Mason: Some of the description should be more definitive in how some of these things evolved. “In addition to review….” Be clear that the group is in support of rather than determine if there is sufficient evidence for including wetlands in the Chesapeake Bay Watershed Model (CBWM)

Chapter 2. Definitions, Hanson

- Will be added for next version

Chapter 3. Background on wetlands and wetland BMPs in the Chesapeake Bay Watershed, Hanson

- Mason: It is important for our partners to check the nontidal/tidal wetlands percentages as they may be dated. If anyone has a specific reference, please share with Hanson & Runion.
    - Boomer: Would also be worthwhile to ensure our geospatial datasets are matching up with these numbers. We’d also ultimately want our NWI tables to be separated by county and physiographic region.

        - Hanson: This will be worked out with the modelers. Our maps and numbers will likely change once we receive the updated Pennsylvania mapping from the Chesapeake Conservancy/University of Vermont/Upper Susquehanna Coalition project. Stubbs will also have literature on how the GIS layer was created to include in an appendix.
        - Denver: Suggest we split the Eastern and Western shore with in the Coastal Plain for our physiographic provinces. Wetland functions are very different between the two.
- Denver: It would be nice to have some graphics to show tidal/nontidal and floodplain/other on maps or pie charts to give an understanding of where and how we are targeting these wetland BMPs.
- Mason: Flow diagram from the wetland verification guidance may need updating. We also need to clearly state that this data does not include wetlands created primarily to capture stormwater runoff.
    - McLaughlin: The Wetland Workgroup is looking into tackling this issue of urban wetland restoration projects.

Chapter 4. Review of available science, Boomer and Denver

- Boomer: Chapter 4 has three basic sections
    - Conceptual model overview based on combination of hydrogeomorphic, hydrogologic, and stream classification framework
        - There is still some literature to review. The framework is well built, but we need to pull additional references and discuss what we know in hydrogeomorhpic and watershed position.
        - Mason: Considering the baseflow contributions from groundwater and the capacity of wetlands, is the relative contribution of wetlands something to think about?
            - Boomer: Thinking of wetlands as a source of nutrients, and that the amount retained will really depend on the amount in the contributing area.
                - Staver: Will the model show that delivered loads much lower than source loads where there are wetlands?
                    - Denver: The SPARROW model does this now. Higher water content is associated with wetlands, and we'd likely see a correlation between source and load with wetlands.
    - Boomer reviewed the N and P Dynamics they'll cover in the chapter: available in the slides distributed along with these minutes.
    - Predicting importance of biogeochemical processes based on location in relation to landscape model
        - We'll need to marry what we know about these processes with the distribution of wetlands across the landscape in different physiographic provinces.

        - Denver: A map or pie chart with the distribution of wetlands within physiographic provinces would be helpful here as well. Recognize that Eastern and Western shores are separated within the outer coastal plain.
  - Boomer reviewed their remaining to-do list for Chapter 4:
    - Incorporate key landscape model papers
    - Description of general hydrogeology by physiographic province, including overview of HGM type distributions
    - Outline dominant N and P transport processes based on landscape framework
    - Discuss human impacts on wetland nutrient & sediment processes
    - **Action**: Boomer and Denver request help in describing the distribution of physiographic provinces. They will contact Brooks.
    - Mason: The text of the chapter could be integrating instead of bullets to make it flow like a report.

Chapter 6. Accountability mechanisms, McLaughlin

- Initial verification that the proposed practice was installed correctly, and is hydrologically, vegetatively, and physically stable should be done by the installing agency. That agency should deal with record keeping and report to state NEIEN. Note that the database must be modified as we start to collect enhancement and rehabilitation.
  - Clearwater had put what is currently stated in the BMP verification guidance: as long as you can verify you have the three parameters and are keeping an eye on invasives you should be good; remote observations can serve as a proxy.
  - Spagnolo: Accountability is visual/on site. Is there a procedure CBP uses a site will be registered as a wetland after 5 years monitoring? As land use changes, how do we update it? Having a form that practitioners can register to put the landuse change on a map would be helpful (if we could register is as a polygon & tabular data)
    - Hanson: The model updates land uses year to year but changes are typically to agriculture and urban areas as that’s where the data is. Presumably the wetland land uses would be held constant and only change based on BMP implementation or when changes to other land uses force changes to the wetland acres. Other groups in the partnership beside this panel will work out those specific details as needed.
      - Stubbs: Also depends on the resolution of the imagery. If the size of the project is less than minimum mapping unit then it doesn’t get counted through the imagery.
      - Mason: Is there no GIS post processing that goes along with data submissions to convert landuse data layer from agricultural to wetland when wetlands are created?
        - Stubbs: No, but in Phase 6 there could be the landuse change BMP

        - McLaughlin: This may be helpful in capturing restoration area. We have current landuse vs restored landuse but we do not have landscape position.

Chapter 7. Unintended consequences and qualifying conditions of wetland BMPs, Spagnolo

- We do not want to have projects where ecosystems of high quality are altered or degraded, functionally, just to receive wetland BMPs. "Wetter isn't necessarily better."
    - Could be worth defining "high quality wetlands," or it could be left up to the jurisdiction.
        - Hartranft: Suggests using "natural" rather than "high quality" as in PA there are instances where it would be beneficial to restore a degraded "high quality" ecosystem (think degraded forested wetland). "Highly functional"?
- Mason: Would be worth cross-walking BMP description in this chapter with our BMP categorization table (which largely follow the existing NRCS definitions). Would also be worth including that BMP table and examples in Chapter 2 rather than laying out the BMPs here.
- Ralph thought it may help to define "pre-application meeting." Input from other states as to if this is necessary would be appreciated.

Chapter 8. Future research and management needs, Mason

- Though literature is scarce on wetlands as a source, there is plenty of literature on removal efficiencies largely focused on wetlands explicitly served for nutrients.
- Helpful future research would investigate wetlands as both sources and sinks, efficiencies of inputs from other landuses, and determine load reductions for various practices and attributes (landscape position, hydrology, vegetation, etc.).
    - SPARROW would have been helpful to get numbers (we still may, in order to compare, but not in time to add to the report).

ACTION: All updated draft report chapters are due to Hanson by 4/15/16.

<u>Discussion of how to frame, determine, and finalize wetlands reductions for TN, TP, and TSS</u>

<u>Tidal</u>

- As discussed in a past call with Bill Stack, the Shoreline panel has already developed reductions using literature on the nutrient and sediment processes of tidal marsh areas. Note: we are only concerned with Protocols 2, 3, and 4. Protocol 1 is not applicable for our purposes.
- **Decision**: Panel agreed to cite and use reductions for TN, TP and TSS from the Shoreline Management Panel (sum of protocols 2, 3 and 4) as reductions for tidal wetland restoration BMP.

<u>Nontidal</u>

- Floodplain and Other
    - Stubbs: These categories were originally floodplain vs headwater/depression, but are now lumped into Floodplain and Other following the partnership's decision in

the Fall. Floodplain is mapped with FEMA plus SSURGO and overlaid by water layer. A wetland can make the first cut with NWI but is disregarded if it is overlaid by open water.

- Denver: If only third order or high count in Floodplain, does Other include floodplains that are 1st or 2nd order?
    - Stubbs: FEMA and SSURGO are primary sources. Third order mainly used to check what could be open water; trying to preserve third order floodplains.
    - Denver noted the distinction between floodplain and other may be more important for TP and TSS than it is for TN.
        - Spagnolo agreed, as denitrification is generally lower in floodplains associated with flashy hydrology.
            - Mason: The reduction efficiency should be the same for TN between Floodplain and Other. Objections? None raised.
            - **Decision**: The panel agreed that reduction efficiencies for TN should be the same between the Floodplain and Other land uses.

- Creation vs Restoration
    - How to credit existing wetlands
        - Hanson: With Phase 6 being a new model, the effect of existing could change in the model.
            - Staver: Realistically, loads to the Bay will not change with our efficiencies. Existing should be the same between Floodplain and Other as there will be no change in function and therefore no change in effect/benefit to the Bay.
        - **Decision**: The panel agreed that reduction efficiencies for existing wetlands will be the same between Floodplain and Other.
    - Discussion of using percent reduction or removal rate by area
        - Mason: We can’t give a percentage reduction without knowing the drainage area. If we give a lbs/acre measurement, the model would then calculate that percent.
        - Hanson explained that it doesn’t exactly work that way in the modeling tools. A percent reduction (i.e. efficiency) is much easier to use in the model for a number of reasons and will not require translation from the results of our literature review. Absolute reductions (in pounds) can get much more complicated from a modeling perspective. The panel is strongly encouraged to consider what the relative impact of a wetland or wetland BMP is compared to a no-wetland or no-BMP baseline. We should be able to do that with the literature available.
        - Staver: Have to consider the wetland:watershed ratio in securing accuracy of this method.

        - Staver suggested the panel could consider using the same efficiencies from the Riparian Forest Buffer report from 2014.
        - Denver: Agree. Converting the RFB numbers into a range would be more comfortable. These numbers also include physiographic regions (though not exactly the ones we laid out), which is helpful.
        - Hartranft felt the RFB panel's numbers should be our minimum as wetlands assuredly have higher removal efficiencies than RFBs.
        - Mason noted there is some suspicion that the RFB numbers are too high in their own right. We shouldn't copy any potential mistakes. The mean removal rates from our literature review is the best option we have and they are notably lower than any of the RFB values. In the report we can acknowledge that further investigation is needed and give opportunities to modify.
        - Hanson pointed out that the panel would want to very carefully consider the RFB panel's underlying assumptions before deciding to adopt their numbers wholesale or not. Especially if they are still largely based on the original RFB work from the 1990s, which was not updated in the Simpson and Weammert (2009) review, and again not updated by the latest (2012) RFB panel. Would need to fully understand what assumptions they are making regarding the performance and longevity of buffers in the real world vs. optimal or perfect conditions, among other things.
        - **Action**: Molloy will attempt to tease out physiographic regions and wetland:watershed ratios from the literature review to see if we are able to tease out regarding those attributes.
        - **Decision**: There was consideration for using reduction efficiencies from the Riparian Forest Buffer report (2014), but the panel agrees that our own literature review is likely more accurate and will continue to discuss this. Hanson will distribute the RFB Report.
- Rehabilitation vs. Enhancement
    - Staver: These cannot be as high as existing, as we are interested in the change/increase of function. It cannot receive full credit for function if it already has a fraction of that function.
        - Boomer: if we've got some suboptimal efficiency, there can be a burden placed on counties in determining which are high quality and thus cannot be restored.
    - Discussion on this topic will continue at the next call & meeting.
- **Action**: Staver will chase down the CBWM 5.3.2 reduction efficiencies for current land uses.
- Stubbs: Within the model, there is an option of looking at state, county, or portion of province in a county or state.
    - **Action**: Stubbs will separate out wetlands using the beta watershed model calibration for Maryland and one other state (DE or PA) by 4/1/16.

Next Steps: We will schedule a two hour call during the week of 4/11/16 and another face to face meeting will be scheduled during the following weeks. Please complete the NeedToMeet polls by Thursday 3/31: April two hour conference call; April face to face meeting

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Monday April 18th, 2016, 9:00 AM-11:00AM
Meeting #15

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	Y
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	Y
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	Y
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N
Jana Davis	CBT	Y
Matt Johnston	UMD, CBPO	Y

Summary of ACTION Items & DECISIONs:

Action: Any member that has wetland:watershed ratio values from a study or project, please send them to Hanson this week for consideration. We can review these in full at our next meeting. McLaughlin, Strano, and Clearwater mentioned they each have values.
Decision: The panel will tentatively move forward with option 3A as the upslope efficiency for wetland restoration (TN: 42%, TP: 40%, TSS: 31% based on all wetland types, excluding constructed). Any other feedback should be sent to Hanson.
Action: Updated report chapters are due; please send to Hanson and Runion.

Welcome and Introduction

- Mason: We are so close to finishing up and while it has taken a lot of time, we have accomplished a lot and are close to delivering a finished product.

- Davis: Big appreciation to the WEP, as expert panels can be strenuous work. It seems the panel is very close, and we are at a very opportune moment within the Watershed Model's timeline where we can benefit by adding wetlands as a land use. We will have opportunities to refine the BMP numbers in the future, so we just need our best possible recommendations now to incorporate into the model before the upcoming calibration.
- Greiner: Would also like to thank the panel members for their hard work. Many expert panels are behind and the WEP even had an extra bump in the road with the land use classification process, but the finish line is in sight and we hope to finish strong.

How Wetlands Differ Spatially Across the Watershed, Matt Johnston, UMD

- Johnston reviewed and clarified some common land use & BMP terms. Refer to powerpoint, distributed to the panel.
- Landscape effects: Factors come from SPARROW analysis.
    - Land-to-Water. Ex. Nitrogen is more likely to move from edge of field to small order streams in the Susquehanna system, while phosphorus transport is very efficient in the coastal plain.
    - USGS is working on improving SPARROW and trying to determine how much drainage area there is per wetland. This may be done in time for the next calibration, but would be addressed outside of this panel by the Modeling Workgroup, which would coordinate with the Wetlands Workgroup or other workgroups as needed.
- Mason: The efficiency aspect is largely accounted for. Our focus should be on the BMP side of things.
    - Staver: Important to characterize existing wetlands as a sink of nutrients to show their value. This idea should be captured in the report and identified as a task for the next panel.
- Johnston: There is currently no difference between wetlands and forest in the model but by separating wetlands, you are giving USGS ability to differentiate within these factors.
    - Mason: The panel feels that this is a high priority.
        - Johnston: Recommends that the panel includes this in a list of requests.

Discussion of wetland restoration BMP effectiveness estimates

- Hanson: Focusing exclusively on BMPs and removal efficiency values.
    - Numbers used currently in the Phase 5.3.2 model are shown in Figure 1, with a description of how they were developed below.
        - Denver: Just as this section states that the kinetic equation does not account for wetlands as a source, we should recognize the shortcomings in our report as well. The kinetic equation also does not account for groundwater inputs, only surface flows.
    - Six different options are proposed based on the summarized results of values in the literature. Options are fully described and listed in the "Wetland reduction option" document. Both mean and median are listed as options. Some options differentiate values for Floodplain and Other, while some do not.

- Constructed refers to wetland stormwater facility.
- Staver: What/where are these number applied? We need to further discuss the potential to develop a watershed:wetland ratio for these efficiencies. A 1:1 ratio will lead to the efficiencies being very conservative. A qualifier should be included that this only applies to newly created and restored wetlands.
    - Mason: We do not have the capacity to do this right now, but part of this effect is captured in the landscape effects for existing wetlands. By acknowledging there is an issue with the ratio applied to the BMP, we can incorporate the appropriate efficiency values and allow this issue to be resolved in a later model run.
        - **Action:** Any member that has ratio values from a study or project, please send them to Hanson this week for consideration. We can review these in full at our next meeting. McLaughlin, Strano, and Clearwater mentioned they each have values.
    - Clearwater: We have always been trying to get the size of the watershed when a project is reported, but many did not report and 1:1 was used as a default. Leaning towards option 3.
    - Strano: Agrees that the effect will likely be severely underestimated on a 1:1 watershed scale.
    - Staver: Riparian Forest Buffers (RFBs) have a 4:1 and 2:1 ratio for N and P, respectively. Reasonable that wetlands should have at least this area treated, but the modeling folks don't agree. The scrutiny level will increase as our proposed ratio gets higher.
        - Strano, Clearwater, and McLaughlin agree that the RFB ratios can serve as a minimum value for our ratios.
        - Hanson: Wary of comparing efficiencies with the RFBs as we are unsure of their accuracy as applied to wetlands in the next version of the model. Their ratios are conservative as well, but we would need a basis to accept them. We will revisit this discussion at our next meeting. Then we can look at some of the available information about wetland:watershed ratios. Important to consider that we don't select a ratio that would be too high as there will be projects that are closer to a 1:1 ratio.
        - Sweeney: Right now there's no basis for using the RFB upslope ratios of 4:1 and 2:1 for wetlands. The panel could justify using those ratios but they need to explain why those ratios are useable for wetlands.
- Vote on option 3A (values from the literature review for all wetlands, excluding constructed wetlands. Floodplain and Other are combined).

        - In favor: Mason, Spagnolo, Thompson, McLaughlin, Clearwater, Denver, Staver, Miller, Strano.
        - Boomer asked for some time to review and send her thoughts via email vote, but tentatively agreed.
        - **Decision**: The panel will tentatively move forward with option 3A (TN: 42%, TP: 40%, TSS: 31% for all wetland types, excluding constructed). Any other feedback should be sent to Hanson.
- Mason: The efficiencies from Table 1 that are separated out into geomorphic provinces are based on any landscape ratios of 1, 2 and 4% - having a background on these values would be helpful.
    - Sweeney: Will find out and share with the panel.

<u>Wrap-Up</u>

Action: Updated report chapters are due; please send to Hanson and Runion.

Our next meeting is Thursday, April 28th from 10am-4pm at the NRCS office in Annapolis. If you cannot attend, please provide any input or comments to Hanson before the meeting.

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Thursday April 28th, 2016, 10:00 AM-4:00PM
Meeting #16

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	Y
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	Y
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	N
Ken Staver	UMD	Y
Steve Strano	NRCS	N
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N
Matt Johnston	UMD, CBPO	N

Summary of ACTION Items & DECISIONs:

ACTION: Please send any report comments to Jeremy and the appropriate chapter author by the end of next week (5/6/16).

ACTION: Panel members should review Chapter 2 (Definitions), and send any recommended additions to Hanson.

ACTION: Panel members should review the updated Chapter 4 and provide comments to Boomer and Denver by early next week (5/2-5/6).

ACTION: Panel members should review the "Justification for wetlands land uses" section in Chapter 5 as it is from an older memo (September 2015) and may require updates or clarification based on our progress.

ACTION: Panel members will need to help explain the reasoning for why the reduction efficiencies we are proposing are an improvement to the current Phase 5.3.2 method.

ACTION: If anyone has photos appropriate for the report, please provide them to Hanson.
DECISION: Minutes from the 4/18/16 conference call were approved.
ACTION: Wetland verification guidance figure (contact Clearwater if any edits are necessary) moved from Chapter 3 to Chapter 6 (Accountability Mechanisms). Table 3.X updated with 2015 annual progress run.
ACTION: Changed "Freshwater" to "Non-Tidal" in title of Chapter 4.
ACTION: Stubbs will cut the wetland area in Chapter 4, Table 1 to only the watershed.
ACTION: Reformatted Table X of reductions to move the "All except constructed" Wetland type to the bottom of the table and include those numbers in the below text.
DECISION: Based on geologic features, the panel tentatively agreed on the following Physiographic Subregions: Coastal Plain Western Shore incised, Coastal Plain Eastern Shore well-drained, Coastal Plain Eastern poorly-drained, Coastal Plain lowland, Piedmont, and Plateau/Ridge & Valley.
ACTION: Boomer will consult with Greg Noe for review and help with classifying categories for retention efficiencies.
ACTION: Please complete the NeedToMeet poll for mid-May call.

Welcome and Introduction
DECISION: Minutes from the 4/18/16 conference call were approved.

Overview of current points of agreement and remaining decisions

- During our last call (4/18/16), we tentatively agreed on using wetland reduction values from our Tetra Tech literature review, excluding constructed wetlands, with no difference between floodplain and other wetlands. The mean values were chosen: TN 42%, TP 40%, TSS 31%.
    - One of the remaining decisions is what area to apply this reduction efficiency to (watershed:wetland ratio). The current, default value is 1:1, but the panel agreed that this was generally too low. We have some data from panel members which allowed for example ratios, which we can review for our Phase 6 recommendations.
- Mason: The work by this panel to create land uses for wetlands for the Phase 6 model and start to attribute load reduction values will open opportunities for future panels.
    - McLaughlin: The high resolution imagery completed for parts of VA and DE is using forested and emergent classifications for wetlands, which is a cause for concern. They likely used NWI as a basis, but Stubbs was worried as they were not separating tidal and non-tidal. He will be asking for comment from the panel, and we should be working with the workgroups in this modeling work.

Discussion of panel report, remaining tasks, and writing assignments

- Chapter 1: No changes
- Chapter 2: Terms chosen to define are those that may be left to interpretation, or those which have a specific definition for the panel. Our audience must include the public, so

scientific and technical terms (especially those in Chapter 4) may be later defined in a glossary.

- **ACTION**: Panel members should review Chapter 2 (Definitions), and send any recommended additions to Hanson.
- Glossary definitions should be consistent – USGS may have existing glossaries to use as starting point.
- The table of wetland creation/restoration/enhancement/rehabilitation definitions will also be included in Chapter 2.

- Chapter 3: **ACTION:** Wetland verification guidance figure (contact Clearwater if any edits are necessary) to be moved to Chapter 6 (Accountability Mechanisms). Table 3.X will be updated with 2015 annual progress run.
- Chapter 4: Recently updated by Boomer and Denver. The basis of the chapter has not changed, but some edits and additions were made.
  - **ACTION:** Change "Freshwater" to "Non-Tidal" in title of Chapter 4.
  - A summary of the types of wetlands that occur in different physiographic provinces was added (5th paragraph).
    - The classifications made in this paragraph could be merged with table 1 below.
      - The wetland acres in this table includes some out of the watershed areas. Adding a wetland percentage of total area in each physiographic province would be helpful. **ACTION**: Stubbs will cut the wetland area in Chapter 4, Table 1 to only the watershed.
    - Brooks: Slope can be a major factor differentiating these provinces. The unidirectional flow which is mainly a groundwater contribution breaks down in the coastal plain without geologic contact zones.
      - Boomer: A shallower gradient in the coastal plain will lead to slower flow
  - Boomer: In this paragraph we started to lay out biogeochemical processes, but haven't quite connected them back to wetland types. This could be expanded on.
  - **ACTION**: Panel members should review the updated Chapter 4 and provide comments to Boomer and Denver by early next week (5/2-5/6).
- Chapter 5: Still incomplete and awaiting some of the panel's decisions.
  - We are unsure of the current status of the Pennsylvania wetland mapping project. The final report is due in August, anticipated in time for the new calibration. This can be represented in Chapter 5.
  - **ACTION**: Panel members should review the "Justification for wetlands land uses" section in Chapter 5 as it is from an older memo (September 2015) and may require updates or clarification based on our progress.
  - Hartranft had comments on the "Wetland BMPs" section, which were incorporated into the most recent draft summarizing the basis for the Phase 5.3.2 BMP.
  - Important to note that wetlands used for Simpson and Weammert study (Phase 5.3.2 model) were mainly constructed.

- **ACTION:** Panel members will need to help explain the reasoning for why the reduction efficiencies we are proposing are more accurate than the current method.
- Boomer: Breaking down our table by wetland type and physiographic province will show the importance of landscape setting. How we can populate this table will provide evidence of our research limitations.
- **ACTION**: Reformat Table X of reductions to move the "All except constructed" Wetland type to the bottom of the table and include those numbers in the below text.
- Boomer: Supports Denver's idea of developing a table with an array of wetland type by region and assigning high/medium/low retention capacity with specified retention percentage ranges. A basis for assigning that range will be provided from the literature.
  - Staver: Another idea is to provide a default credit and then offer higher levels of credit with data provided to increase efficiency. This will help steer management toward collecting that data.

- Hanson will review entire document to make formatting and layout more consistent; he will hand off to Aileen for Tetra Tech to do more thorough editing for consistency through the whole report.

Discussion of default upslope acres for Phase 6 wetland restoration BMP

- **ACTION**: If anyone has photos appropriate for the report, please provide them to Hanson.
- The goal of the afternoon portion of the meeting is to work towards defining a recommended wetland:watershed ratio for which projects receive credit if they do not report the drainage area.
  - Panelists sent in a total of 69 usable sites for Hanson to review watershed:wetland ratios.
    - Data was analyzed both including and excluding the ratio while including the wetland area in the watershed (drainage) area. There was a minor change, and including this conflicts with past calculations (Jordan).
    - The implied upslope acres per acre of wetland restored (watershed:wetland ratio) came out to for the be 2 for the Coastal Plain, 4 for the Piedmont, and 8 for the Appalachian Plateau and Ridge & Valley.
  - The physiographic regions should be divided into subregions in order to accurately define retention efficiencies and acres treated.
    - Denver: The Coastal Plain is extremely non-uniform, so this is especially important to separate.
    - Sweeney: This is mappable by county reported. We can classify down to coordinates, so any additional information given, such as HUC-10 is helpful, but the minimum data we receive is the county in which the project took place.
      - Boomer: Could be classified by land-river segments.

        - **DECISION:** Based on geologic features, the panel tentatively agreed on the following Physiographic Subregions: Coastal Plain Western Shore incised, Coastal Plain Eastern Shore well-drained, Coastal Plain Eastern poorly-drained, Coastal Plain lowland, Piedmont, and Plateau/Ridge & Valley.
            - Denver: Depressional wetlands should only receive the wetland acreage for nitrogen as most of the nitrogen is focused in groundwater, and the water table is not sufficiently interacting with the wetland to remove nitrates. The only substantial nitrogen effect is where the reduction of fertilizer application takes place.
                - Nitrogen moves by groundwater (subsurface process) and, overall in the Piedmont and Coastal Plain, the removal will be variable. This is where a Low/Medium/High rate of removal will help. Phosphorus and sediment are simpler as they are surface processes.
                - McLaughlin: A 1:1 ratio for nitrogen fits here. Phosphorus should have a 2:1 ratio based on surface features.
            - Denver: Lowland needs to be separated as they tend to be finer textured, with very little groundwater interaction. Poorly drained uplands are on the drainage divide for the Chesapeake with a sandy subsurface. Well drained also occur on the eastern shore in stream valleys.
            - Denver/Boomer: Nitrogen efficiencies for the Coastal Plain western shore will be high as stream incisions cut through the aquifers. Nitrogen efficiencies for Coastal Plain eastern shore well drained will be lower for nitrogen removal as there is a better opportunity for transport due to slope (low retention time). Nitrogen efficiencies for Coastal Plain eastern shore poorly drained will be medium because much of the organic matter that traps nitrogen is removed in this region. Nitrogen efficiencies for Piedmont is medium because of often erosion/incision in the stream in this region. Nitrogen efficiencies for the Coastal Plain lowland will be medium/high because of the low flow volume and high efficiency of nutrient reduction.
            - Floodplain TN is set at medium and TP/TSS at high as a default.
                - Piedmont: a combination of high stream incision (lower interaction) and the angle of flow interaction led to the nitrogen efficiency being medium.
            - Phosphorus and sediment can generally be tracked together, unless otherwise stated. General topography led to TP and TSS removal being medium in other wetlands and high in floodplain wetlands.
    - Acres treated are taken from Hanson's project review.

- Coastal Plain eastern shore poorly drained and lowland should have a watershed:wetland ratio (acres treated) of 1 because of the low slope.
- Coastal Plain western shore incised and eastern shore well drained (besides west TN) will follow the ratios found in Hanson's review.
    - TN for Coastal Plain western shore incised is treated similar to the Piedmont because of a higher slope.
- Floodplain acres tested are double of other as a placeholder.
    - These wetlands are receiving the baseflow delivery as well as a storm pulse – justification for doubling these numbers.
        - Staver: Could back this up using per acre trapping rates for floodplain wetlands (discussed in a previous call).
    - Panel should remember that "Floodplain" wetlands also include those wetlands within a certain distance of the stream, not just those directly adjacent.
    - McLaughlin: This will provide more justification for projects to be sited in floodplain locations, which would be a negative consequence of having ratios this high. These projects convert nice existing slope wetlands into reconnected floodplains.
        - Could place a cap on maximum acres treated, as a ratio too high will lead to projects not reporting drainage area.
- Hanson summarized that based on the discussion confidence seemed higher for "other" than "floodplain" at this time. Boomer offered to get feedback from Greg Noe about the panel's approach for floodplain. Panel can revisit and finalize at its next call.

- **ACTION:** The panel will consult with Greg Noe for review and help with classifying categories for retention efficiencies.

		Retention Efficiency			Acres Treated			
Physiographic Subregion	**Other**	**TN**	**TP**	**TSS**	**TN**	**TP**	**TSS**	
CP West incised	Y (Headwaters)	H	M	M	4	2	2	
CP East well drained	Y (Headwaters)	L	M	M	2	2	2	
CP East poorly drained	Y (Delmarva Bays)	M	M	M	1	1	1	
CP lowland	Y (Flats)	M/H	M	M	1	1	1	
Piedmont	? (Headwaters)	M	M	M	4	4	4	
Plateau, R&V	? (Headwaters)	H	M	M	8	8	8	
Physiographic Subregion	**Floodplain**	**TN**	**TP**	**TSS**	**TN**	**TP**	**TSS**	
CP West incised	Y (Overbank)	M	H	H	8	4	4	*best guess with two hydrologic sources
CP East well drained	Y (Overbank)	M	H	H	4	4	4	
CP East poorly drained	Y (Overbank)	M	H	H	2	2	2	
CP lowland	Y (Backwater)	M	H	H	2	2	2	
Piedmont	Y (Overbank)	M	H	H	8	8	8	
Plateau, R&V	Y (Overbank)	M	H	H	16	16	16	

Next Steps

- We will be scheduling another call for mid-May. **ACTION:** Please complete the NeedToMeet poll for mid-May call.
- The Wetland Workgroup will be meeting on 5/26/16 from 1-3pm at MD DNR in Annapolis. WEP members are encouraged to attend or call in, as we hope to give the workgroup a review of our report.
- **ACTION**: Please send any report comments to Jeremy and the appropriate chapter author by the end of next week (5/6/16).

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Monday May 16th, 2016, 10:00 AM-4:00PM
Meeting #17

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	N
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	N
Jeff Hartranft	PA DEP	Y
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	Y
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	N
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	Y
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N

<u>Summary of ACTION Items & DECISIONs</u>:

- **ACTION**: Boomer and Denver will clearly define the physiographic subregions and provide logic for the proposed efficiencies in Chapters 2 and 5, respectively.
- **ACTION:** Hanson will touch base with Denver and Stubbs regarding a map of the subregions.
- **ACTION**: Hanson will check with Boomer and Denver regarding feedback from Greg Noe on retention efficiency and acres treated in the developed table.
- **ACTION**: Panelists should provide comments and edits to the report by 5/20. Please use the SharePoint link, distributed by Hanson, if possible. Otherwise, use the version distributed by Hanson on 5/13 to make edits using track changes.
- **ACTION**: Panelists should make every effort to attend or call in to the Wetland Workgroup's meeting on 5/26 as the workgroup will be reviewing and asking questions about the report. Hanson will give key highlights and major points of the report, but other

panelists must be available to answer questions. Another meeting may be held in June for approval of the report.

  - **ACTION**: McLaughlin will follow up with Greiner regarding the role of those who are on both the expert panel and the workgroup.

Welcome and Introduction

- Minutes from the 4/28 meeting were distributed on 4/29. Any comments or edits should be sent to Runion and Hanson by 5/20.

Minutes

- The main product of our last meeting was the “Wetland Retention and Acres by Physiographic Subregion” where six physiographic subregions were developed, retention efficiencies were assigned as high, medium, or low, and an acres treated ratio was developed for each.
  - Some titles are unclear in a wetland sense, such as incised and well-drained.
    - **ACTION**: Boomer and Denver will clearly define the physiographic subregions and provide logic for the proposed efficiencies in Chapters 2 and 5, respectively.
    - **ACTION:** Hanson will touch base with Denver and Stubbs regarding a map of the subregions.
  - **ACTION**: Hanson will check with Boomer and Denver regarding feedback from Greg Noe on retention efficiency and acres treated in the developed table.
    - Currently the Floodplain category is doubled in the acres treated section to account for both hydrologic sources: groundwater and surface flow.
- Clearwater: Explanation for why certain studies were considered but excluded from the literature review should be provided.
- In “Option for combining mean nutrient and TSS removals with panel BMP framework” document, Hanson laid out a summary of means from the Tetra Tech literature review to provide preliminary options for the high, medium, and low retention efficiencies. This Table 1 needs to be refined into Table 2, ideally with input from another expert such as Noe.
- Staver: Substantiating our findings with past work may help during the review process.
  - Mason: The 1:1 ratio used with the Jordan equations were a placeholder based on the best available science. The data we have mined of watershed ratios gives us better available science and has more merit in being included in the Watershed Model. This fits the adaptive management approach that the Chesapeake Bay Program is following.
- Hanson: For most BMPs that are entered in the scenario builder, there is one element to calculate reduction. For example, in the Phase 5 BMP, the reported wetland area determines the area of land use change and treated acreage using the 1:1 default ratio. The issue is if we ask them to report drainage and wetland area, there are then two elements necessary to calculate the reduction in Scenario Builder, meaning that the drainage area determines the upland area treated by the BMP efficiency while the

wetland area determines the area for the land use change. This can be done, but modelers will need notice in order to code this into the tools; only other BMP that uses more than one element is stormwater performance standards. Our options are to either just have it as a land use change, or have a default ratio for upland acres regardless of whether or not the drainage area is reported.

  - Sweeney: No reporting agency has ever asked us to accommodate the need to report the area of the wetland and the treated area (in 5-7 years). The model can accommodate this, but having never had to do so, it may be unlikely that we will in the future.
    - McLaughlin: The information is available, as they have the numbers when designing projects but it is never reported.
      - Mason: The Bay Program has an opportunity to include this information going forward so we can continue to improve how wetland BMPs are managed with regards to water quality.
- **ACTION**: Panelists should provide comments and edits to the report by 5/20. Please use the SharePoint link, distributed by Hanson, if possible. Otherwise, use the version distributed by Hanson on 5/13 to make edits using track changes.
  - Hanson would like the draft report finished and distributed to the partnership by COB 6/14. The report will be changing throughout the review period, but it must be at a near-final stage by this date. The following appendices are still needed for addition to the report: glossary, minutes, Tetra Tech literature reviews (2), scenario builder technical appendix, and a BMP protocol checklist.
  - The verification guidance flowchart could be updated. Clearwater or Greiner may have the original (currently an image in report).
- **ACTION**: Panelists should make every effort to attend or call in to the Wetland Workgroup's meeting on 5/26 as the workgroup will be reviewing and asking questions about the report. Hanson will give key highlights and major points of the report, but other panelists must be available to answer questions. Another meeting may be held in June for approval of the report.
  - **ACTION**: McLaughlin will follow up with Greiner regarding the role of those who are on both the expert panel and the workgroup.
- Hanson: As this panel is running short on time, wetland creation can be a land use change and credit will be assigned at a 1:1 area treatment.
  - McLaughlin: With the long time to establish function, creation should not be given the same efficiencies.

Adjourned

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Monday July 18th, 2016, 1:00 PM-3:30PM
Meeting #18

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	N
Quentin Stubbs	USGS, UMD	N
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	N
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Paige Hobaugh	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	N
Anne Wakeford	WV DNR	Y
Ken Murin	PA DEP	N

Summary of ACTION Items & DECISIONs:

- **ACTION**: Solicitation for volunteers from the Wetland Workgroup to assist USGS with SPARROW analysis will take place on the next WWG meeting on Thursday, July 28th.
- **DECISION:** The panel will include in the report recommend efficiency rates of 42% TN, 40% TP and 31% TSS for Wetland Restoration in Phase 6.
- **ACTION**: Panelists should carefully review Chapter 5 for to ensure our comments/caveats regarding our recommendation are included as well as other chapters where content may fall under your expertise.
- **ACTION**: Boomer and Denver will provide strawman of table 2 adjusted for 7/22, 9-10:30 am call for discussion and vote. The updated Chapter 4 and the slides from this meeting will be distributed.

Welcome and Introduction

- Since our last call, we have updated Chapters 4 and 5. Kathy, Judy, and Pam have worked to complete the recommendations, which we will vote on today. Chapters 1-3 and 6-8 remain largely the same. Remaining appendices are to be completed by Jeremy with help from other CBPO staff as needed.

Minutes

- The USGS SPARROW timeframe will be too late for this panel. The Wetland Workgroup may be able to work with USGS on setting up the SPARROW analysis and coming back to the partnership with an analysis, which may or may not have implications for the Phase 6 Watershed model. **ACTION**: Solicitation for volunteers from the WWG will take place on the next WWG meeting on Thursday, July 28th.
- Kathy explained the framework that she and Judy had worked on since the last call. Wetland water quality effect is largely based on the strength of the source, size of contributing area, and likelihood of bypass could be linked to acres treated. Wetland types were characterized by geological occurrence within each physiographic province (Blue Ridge and Karst terrain added).
    - Ratings (high/medium/low) were given for each wetland type that occurred in each physiographic province for likelihood of both elevated contaminant supply rate and hydrologic contact. Analysis attempts to include watershed position within physiographic provinces for each type of wetland. These ratings are available in the "Efficiency recommendations" powerpoint (distributed, email runion.kyle@epa.gov for access).
- Staver: Worry that reported acres may include the buffer area, inflating the number of acres.
    - McLaughlin: MD DNR is careful about separating the buffer since that acreage could be reported as a separate BMP, but not sure this is the case everywhere. The projects used for our upland acre assessment were reported appropriately regarding buffers.
- Boomer: In support of breaking out removal rates into categories of floodplain and other with physiographic regions. The acres treated data is lacking. Examining the distribution of wetlands within a physiographic province and key drivers behind that distribution can give a relative size of contributing area that you can expect those wetlands to treat. This may give a more accurate and appropriate measure than the limited dataset we have used.
    - Mason: There is also a lack of data here to tease this out. We previously asked the Bay Program for modeling to get some numbers here but it didn't happen.
        - Boomer: Recommend that Table 2 be made consistent with Chapter 4 and to have two columns for floodplain and other wetlands. Floodplain numbers would be different as those wetlands receive water from both groundwater and surface flow water. We had "floodplain" acres at double the "other" acres at a previous meeting, but the panel is not confident in this arbitrary measure. Based on the high/medium/low assignments, we

could assign the current acres treated number to medium and then give a percent increase/decrease for high/low.

- Mason: Sites with an acre reported can be modified and put into the BMP tracking database. The panel developed table 2 at the face to face meeting – without additional information, our options are to use it as a recommendation, acknowledging that it is not ideal but the best we have, or to remove table 2 and have the model continue the overall 1:1 acres treated.
    - Hanson: These numbers may not be perfect but are certainly a step forward from the current acres treated numbers (1:1 across the board). They are within a safe margin based on the context of existing BMPs (with a possible exception of the 8:1 ratio).
        - McLaughlin: These numbers also make sense based on the Jordan curves.
        - Staver: Suggests to lower the Plateau R&V acres treated ratio from 8:1 to 4:1.

- Hanson: Final timeline for the report release is early August if decision is reached on the outstanding issues soon.

Question #1: Do you agree with the following statement: "I support using the suggested efficiency rates of 42% TN, 40% TP and 31% TSS for Wetland Restoration in Phase 6."

Table 1 – Proposed removal efficiencies for wetland restoration BMP in Phase 6 Watershed Model, applied to upland acres treated

TN removal (%)	TP removal (%)	TSS removal (%)
42	40	31

- Votes
    - Yes: Mason, Spagnolo, McLaughlin, Boomer, Denver, Staver.
        - **DECISION:** The panel will include in the report recommend efficiency rates of 42% TN, 40% TP and 31% TSS for Wetland Restoration in Phase 6.
    - For those not on the call, any objections must be communicated to Hanson, Mason, and Spagnolo by COB on 3 August 2016 with an explanation and alternative solution. Please understand that the panel will proceed with the majority decision but that any dissent will be included as a part of the report.
- Comments regarding decision
    - Staver: The data comes from diverse sources and these numbers are reasonable and appropriate.
    - Boomer: The variability in function will be captured in the second table/question.
    - McLaughlin: Report should state that these percentages can be adjusted as new data is made available in the future with upcoming panels.

- **ACTION**: Panelists should carefully review Chapter 5 for to ensure our comments/caveats regarding our recommendation are included as well as other chapters where content may fall under your expertise.

Question #2: Do you agree with the following statement: "I support using the acres treated shown in Table 2 for Wetland Restoration in Phase 6."

Table 2 – Proposed ratio of upland acres treated, by physiographic subregion, for use in Phase 6 Watershed Model

	Number of upland acres treated per acre of restored wetland
CP West dissected	4
CP East well drained	2
CP East poorly drained	1
CP lowland	1
Piedmont	4
Plateau, R&V	8

- Votes
  - Yes: Mason, Spagnolo, McLaughlin
  - No: Boomer, Denver, Staver
- Comments regarding decision
  - McLaughlin: In support of it as this was the consensus we made at one of the last meeting. We do not have the perfect amount of information but these are the best we have and it can be changed.
  - Boomer: Since the last meeting we have had time to assemble info to substantiate numbers (presented earlier in this call). From that work, there is a strong basis to structure table 2 in a way that is more parallel to new science framework. The group should work to modify numbers accordingly based on this new info. Also recommends that Plateau be separated from Ridge & Valley and Karst be added as a physiographic province. The numbers may be the same, but there is a need to recognize the functional difference between provinces.
    - **ACTION:** Boomer and Denver will provide a strawman of an updated table for the panel to review for a call on 7/22 from 9-10:30am.
  - Denver: Feels the Plateau, R&V ratio is high. Supports reducing it to 4.
  - Staver: Agrees with Denver; having a certain practice 8x more effective than another is a red flag. Efficiency generally decreases as contributing area increases, which isn't addressed in our work.

- Denver: Would like to follow up offline with Hanson and Stubbs regarding acreage mapping.
  - Boomer: Plan was to have Quentin intersect data from SSURGO and NWI to assign wetlands with floodplain or other and then intersect that with physiographic province based on data layers that Judy has provided. Review acres based in the intersections. Would like to move forward with this if possible.

<u>Wrap-Up</u>

- ACTION: Boomer and Denver will provide strawman of table 2 adjusted for 7/22, 9-10:30 am call for discussion and vote. The updated Chapter 4 and the slides from this meeting will be distributed.

Adjourned

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Friday July 22nd, 2016, 9:00 AM-10:30AM
Meeting #19

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	N
Ken Staver	UMD	Y
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	Y
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N

Summary of ACTION Items & DECISIONs:

- **ACTION**: The following edits will be made to the “Likelihood...” table: Outer Coastal Plain poorly drained uplands sloping and floodplain wetlands are given medium and high rankings, respectively, and Karst depressional and sloping wetlands are changed from high to medium.
- **ACTION:** In the “Acres Contributing...” table, Karst will be reduced from 4 and 6 for other and floodplain wetlands to 2 and 3 acres, respectively. The Inner Coastal Plain will be revisited.
- **ACTION:** Strano will work with Boomer and others to edit the “Acres Contributing” table based on Strano’s comments.

Welcome and Introduction

- On Monday, we voted on questions 1 and 2 (removal efficiencies and upland acres treated ratios). Question 1 was approved at 42% TN, 40% TP, and 31% TSS. Question 2 was not approved. Boomer and Denver have worked to provide a revised question 2, which will be presented today.

Minutes

- Boomer and Denver worked together to develop a new table of upland acres treated ratios including columns for both floodplain and other wetlands. The framework for this involved describing wetland distributions by physiographic province and wetland type and then assigning a quantitative value for likelihood of hydrologic contact with non-point source contaminated waters. These quantitative values were then translated into an acreage ratio. All descriptions are available in the "Efficiency recommendations 22June16" file, distributed by Kathy on the morning of Friday, 7/22.
    - "Karst" was added as a physiographic province. Karst areas have a medium/high potential for contamination and nutrient removal where it occurs within other provinces.
    - "Likelihood of Hydrologic Contact..." table takes into consideration not only size of contributing area but information of likelihood of impact due to human land management and potential of through-flow vs bypass. This table provides the reasoning for the acres treated numbers. A low likelihood will correspond to a lower acres treated ratio.
        - Denver: Outer Coastal Plain – Poorly drained uplands, sloping wetlands should be given a medium ranking due to the often low contact due to ditches yet high organic matter. Floodplain in the same province should be listed as high with large potential for contact. Karst also may have lower contact and should have a medium ranking in both depressional and sloping wetlands.
        - Strano: Suggest to include category of converted wetlands, specifically within the outer coastal plain poorly drained to address the issue of site selected restoration projects vs natural placement (which is the basis of this table). Ex. many restoration projects are placed directly where uptake will occur, so the low ranking doesn't accurately describe this.
        - **ACTION**: The following edits will be made to the "Likelihood..." table: Outer Coastal Plain poorly drained uplands sloping and floodplain wetlands are given medium and high rankings, respectively, and Karst depressional and sloping wetlands are changed from high to medium.
    - The "Acres Contributing..." table was developed using the previous "Likelihood" table. Other wetlands with low rankings were assigned 1 acre, high rankings were assigned 4 acres, and medium rankings were assigned 2 acres. Floodplain wetlands were assigned 150% of the other wetland figure within the same physiographic province.

        - **ACTION:** In the “Acres Contributing...” table, Karst will be reduced from 4 and 6 for other and floodplain wetlands to 2 and 3 acres, respectively. The Inner Coastal Plain will be revisited.
    - Staver: Suggest including a paragraph stating this is a foundation for how wetlands work in our landscape, this generalizes their position relative to land use to transition into the discussion of restored hydrology.
- Hanson confirmed with participants that they agreed with the overall framework and approach described and presented by Boomer. He asked if anyone else had significant concerns or comments outside of the specific rows or issues raised so far, e.g. by Staver and Strano. Hanson noted the time and that some of the specifics in the tables still need some additional work in light of the discussion before a decision can be made, but there is agreement on the general approach as well as most of the categories. So the panel is making progress and is one step closer to a decision.
- **ACTION:** Strano will work with Boomer and others to edit the “Acres Contributing” table based on Strano’s comments.

Wrap-Up

- After panelists have some time to talk offline and make edits to tables, either a call will be planned to discuss and vote on approval, or a poll will be distributed to seek approval.

Adjourned

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Wednesday October 19th, 2016, 1:00 PM-3:00PM
Meeting #20

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	N
Jeff Hartranft	PA DEP	N
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	Y
Jarrod Miller	UMD	N
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	N
Steve Strano	NRCS	N
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	N
Tom Uybarreta	EPA Region 3	N
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	Y
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	Y
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N

Summary of ACTION Items & DECISIONs:

- Panel members should review the draft report to check if their comments have been addressed **by COB Tuesday 10/25.** Please indicate if the comment was addressed; if your comment has not yet been addressed to your satisfaction, please provide a suggested resolution or additional language to include in the report as a response to your comment.
    - Jeremy distributed the complete draft report on October 19th (4:19pm).
    - If you didn't have comments carried over in that distributed version you are still encouraged to glance through for a sense of what feedback you want to provide by Friday 11/4.
    - Contact Jeremy (preferably by phone) if you have questions on a specific comment between now and Tuesday the 25th.

- Next Wednesday, Jeremy will remove comments that have been addressed and distribute a cleaner version of the report on SharePoint and by email for final feedback/comments/edits **by COB Friday November 4th.**
    - If you're able to access and make edits via Sharepoint, please do so as that will be more efficient for the group; if not you can email your feedback on the report using track changes to me and Kyle.
    - Ralph asks that members (particularly regulatory folks) read over the unintended consequences chapter once more for any final feedback by the November 4 deadline.
    - Kathy requests members review Chapter 4 to see if there's anything to add.
    - Panel members are encouraged to contact each other directly between now and November 4th regarding technical questions or items as they work on providing feedback; contact Jeremy with overall or process-related questions.
- Please follow this link to indicate your availability for a call on Wednesday November 9th to discuss final comments and edits before report becomes final. Please provide your availability **by COB Tuesday, 10/25.**
- Following the call on November 9, Jeremy will coordinate with others as needed to resolve any final revisions before the report undergoes final formatting/editing prior to release to the partnership. **The report will be ready for release no later than Tuesday, November 22.**
- At this stage any disagreements from panel members on panel recommendations described in the report must be provided in writing and then may be included in the report as a dissenting opinion.

Welcome and Introduction

- The goal for the panel is to have the final report released by Thanksgiving. Specific edits and language is required from panel members. We have developed a timeline today to complete this task.

Minutes

- The Water Quality GIT is meeting October 24-25 and will make a decision regarding deadlines for full approval of BMP panels, including ours.
- On September 15th, the Wetland Workgroup approved our preliminary results, allowing for the framework to be included in the most recent beta version of the Watershed Model. Minutes and other materials from that meeting are available online.
- Denise: MDE's caveat was to not include the enhancement and rehabilitation BMPs until we are certain that the data system has distinct categories for them and they won't be included with acreage gains.
    - Jeff Sweeney: In the Phase 6 model, you will be able to designate practices with land use change (restoration and creation) with those that do not (other categories)

- Panel members should review the draft report to check if their comments have been addressed **by COB Tuesday 10/25.** Please indicate if the comment was addressed; if your comment has not yet been addressed to your satisfaction, please provide a suggested resolution or additional language to include in the report as a response to your comment.
    - Jeremy distributed the complete draft report on October 19th (4:19pm).
    - If you didn't have comments carried over in that distributed version you are still encouraged to glance through for a sense of what feedback you want to provide by Friday 11/4.
    - Contact Jeremy (preferably by phone) if you have questions on a specific comment between now and Tuesday the 25th.
- Thanks to Quentin we now have a map of the physiographic regions and acreage numbers. Updated numbers may come in a few weeks as the GIS team is currently running datasets for each county with the new high resolution land cover data.
- Kathy: It may be helpful to include the spreadsheet of Tetra Tech's literature reviews in the appendix for those who want to see the data behind our recommendations.
    - Jeremy: The summary tables will certainly be included in the report and the actual spreadsheets could either be included or be posted somewhere online and referred to in the report.
- The USGS SPARROW report is yet to come but we are hoping for it in early 2017.
    - MD still has a desire to have the report completed.
- Next Wednesday, Jeremy will remove comments that have been addressed and distribute a cleaner version of the report on SharePoint and by email for final feedback/comments/edits **by COB Friday November 4th.**
    - If you're able to access and make edits via Sharepoint, please do so as that will be more efficient for the group; if not you can email your feedback on the report using track changes to Jeremy and Kyle.
        - Ralph asks that members (particularly regulatory folks) read over the unintended consequences chapter once more for any final feedback by the November 4 deadline.
        - Kathy requests members review Chapter 4 to see if there's anything to add.
        - The Chapter 5 BMP section following the discussion of the Phase 5 Model version requires a review from panel members to ensure it is accurate and conveys the thoughts of the panel.
    - Panel members are encouraged to contact each other directly between now and November 4th regarding technical questions or items as they work on providing feedback; contact Jeremy with overall or process-related questions.
- Table 11 will be removed by Jeremy.
- It had been said in a previous call that the Chapter 6 graphic based on wetland BMP reporting matrix could be updated; if anyone has a more recent graphic, please provide it.
- Table 2 will see some edits based on comments from September Wetland WG meeting.

- The two literature reviews provided by Tetra Tech are Appendices A & B. Appendix C is the technical appendix for the scenario builder. Appendix D is the meeting minutes. Appendix E is a glossary which may need some updates. Appendix F is a BMP checklist which Jeremy will complete.
- If there are maps that we need to include in the report, the map must be already existing to fit into our timeline. If it already exists, we may source and cite the map in the report.
- Documents such as the land use memo to the WQ GIT and the preliminary report to the Wetland WG will not be included – all of this information is already included within the report.
- Please follow this link to indicate your availability for a call on Wednesday November 9th to discuss final comments and edits before report becomes final. Please provide your availability **by COB Tuesday, 10/25.**
- Following the call on November 9, Jeremy will coordinate with others as needed to resolve any final revisions before the report undergoes final formatting/editing prior to release to the partnership. **The report will be ready for release no later than Tuesday, November 22.**
- At this stage any disagreements from panel members on panel recommendations described in the report must be provided in writing and then may be included in the report as a dissenting opinion.

Wrap-Up

- Check and provide resolutions to your comments by October 25th
- Complete this NeedToMeet poll by October 25th.
- Jeremy will provide a clean version of the report by November 4th
- November 9th: placeholder for 90 minute call if necessary.
- The report will be released no later than November 22nd.

Adjourned

SUMMARY OF ACTIONS AND DECISIONS
Wetlands Expert Panel
Wednesday November 9th, 2016, 1:00 PM-3:00PM
Meeting #21

Name	Affiliation	Present? Y/N
Kathy Boomer	TNC	Y
Rob Brooks	Riparia, Penn State	N
Dave Davis	VA DEQ	N
Judy Denver	USGS	Y
Jeff Hartranft	PA DEP	Y
Michelle Henicheck	VA DEQ	N
Pam Mason	VIMS	Y
Erin McLaughlin	MD DNR	N
Jarrod Miller	UMD	Y
Ralph Spagnolo	EPA Region 3	Y
Ken Staver	UMD	Y
Steve Strano	NRCS	Y
Quentin Stubbs	USGS, UMD	Y
Jeff Sweeney	EPA CBPO (CBP modeling team rep)	Y
Jeff Thompson	MDE	Y
Tom Uybarreta	EPA Region 3	N
Support staff and guests		
Jeremy Hanson (Coord.)	Virginia Tech (Project/Panel Coordinator)	Y
Brian Benham	Virginia Tech (Project Director)	N
Kyle Runion	CRC	Y
Jennifer Greiner	USFWS, Habitat GIT Coordinator	N
Aileen Molloy	Tetra Tech	Y
Peter Claggett	USGS, CBPO	N
David Wood	CRC	N
Denise Clearwater	MDE	N
Anne Wakeford	WV DNR	N
Ken Murin	PA DEP	N

Summary of ACTION Items & DECISIONs:

- **ACTION:** Hanson will make edits to address the ditching issue and confirm changes with Strano and Staver.
- **ACTION:** Table 11 asterisks will be removed as they were notes back from when acres treated were described as high/medium/low rather than acreage number. All of this information is captured in the text.

Welcome and Introduction

- The report will be distributed to the partnership on November 23rd. Today's call will ensure everyone is up to date on changes and all final comments are addressed. The majority of comments and edits requiring discussion are in Chapters 4 & 5.

Minutes

- Chapter 4:
    - Boomer: Chapter 4 edits did not contain any major changes to the direction of the text. Figures were more directly tied to the content of the text.
    - Box 1 had edits from multiple authors to bridge the gap between Chapter 4's physiographic province descriptions and Chapter 5's land uses/mapping.
        - National Elevation Dataset requires citation (Stubbs).
    - Staver: Is there a restored wetland inventory to date anywhere? This can help show the future potential of restored wetlands.
        - Boomer: This would be helpful: a table showing current wetlands and which of those are restored.
        - Hanson: We have summarized what was reported in the Phase 5 Watershed Model under that definition of the "wetland restoration" BMP, and we have the baseline data from NWI for existing wetlands. The report does include some language along those lines, which is tied to Strano's earlier comments about prior converted wetlands.
            - Boomer: This is a good response to make regarding PA DEP's concern on how we're tracking wetland restoration.
        - Boomer: Next on our to-do list: capture PA DEP's concerns and involve this restored wetland inventory in the section on uncertainties/future direction. There is some related discussion in Chapter 4. This could either be pulled to the end of Chapter 4 or put into Chapter 7.
    - Strano: In the "Advanced understanding of human impacts..." section, the sentence starting with "where ditching has lowered the watertable..." should be edited to convey the conversion of groundwater flow to surface flow paths being the cause of bypass.
        - Revision offered: "Ditching lowered the water table, allowing former wetlands to be farmed and developed. However, the ditching also short-circuited the natural groundwater and surface flowpaths, resulting in less contact time with, or even complete bypass of natural wetlands and marshes where processing of nutrients and trapping of sediments occurs."
    - Staver: The big issue with ditching was that it allows for a bypass of nutrient processing and creates a potential for a nutrient source in farming. Mentioning this double whammy issue would strengthen the "Advanced understanding..." section.
        - Boomer: The "Across the Bay watershed" sentence could be expanded to include ditches with channelization and mention that ditching reduces the interaction between contaminated waters with wetlands.
        - Staver: Could also add that are source loads for nutrient inputs" to the "As a result, many flats..." sentence earlier in this section.

    - **ACTION:** Hanson will make edits to address the ditching issue and confirm changes with Strano and Staver.
  - Hanson asked if there were any other issues to discuss on Chapter 4; none were raised.
- Chapter 5:
  - Boomer: Most of the changes made to Chapter 5 are structural and help make the chapter parallel the presentation given to the Wetland Workgroup in September, outlining how we came to the ultimate set of recommendations to estimate wetland retention function. The chapter begins with an overview of the recommendations and a summary of key factors considered and follows with land uses, loading rates, and logic behind our recommendation for wetland restoration loading rates and acres treated ratios.
    - Staver: The mean values used for retention efficiencies are appropriate and match what expert panels generally report. Fine scale estimation isn't possible without fine scale reporting, which hasn't been provided by the states.
    - Mason: The framework created here will be extremely helpful for future panels.
- Staver: During the review period, a major argument may be that the reduction efficiency for all of the regions is the same. While this is articulated in the report, we should be prepared to answer questions such as this. The acres treated is biggest difference between Phase 5 and our recommendations, so this may also be under scrutiny.
- **ACTION:** Table 11 asterisks will be removed as they were notes back from when acres treated were described as high/medium/low rather than acreage number. All of this information is captured in the text.
- Hartranft: The Chapter 6 tracking component, field 8 lists acreage gains for establishment and reestablishment while these terms have been abandoned by the panel and replaced with restoration and creation.
  - Hanson: Table 2 earlier in the report clarifies these are essentially interchangeable terms for CBP purposes (i.e. restoration and re-establishment; creation and establishment). We can add a citation back towards this table to avoid confusion. [viii. (refer to table 2 for term definitions)]
- Hanson asked if there were any other issues to discuss for Chapter 5 or other parts of the report; none were raised. He noted that panel members can contact him directly if anything else comes up following the call. Given the extensive discussions in meetings and offline it seems the panel has consensus on the major points and logic of the recommendations, with standard caveats that there is room for improvement in the future.

Wrap-Up

- Hanson noted this is the panel's final conference call. He thanked everyone for all their time and effort over the past 2+ years and commended them for the excellent work.
- The Water Quality GIT is holding BMP panels to the end of 2016 deadline for completion. The review period will be condensed, described below.

Review Period

- November 23rd: Final Panel Report released for Partnership review
- December 1st-2nd: Webinar to discuss Final Report with the Partnership.
    - Wil require assistance from certain panel members to lead the technical aspects of the report. If you are interested in presenting, please let Hanson know.
- December 7th: All comments due to Hanson, Mason, and Spagnolo
- December 13th: Wetland Workgroup meeting to seek approval of the report (1-3pm)
- December 19th: Water Quality GIT conference call with Habitat GIT to seek final approval of the report.

Adjourned

Appendix E. Glossary of common technical terms

The Association of State Wetland Managers (2002; last accessed November 2016) developed the initial glossary of these following terms, available online here: http://www.aswm.org/watersheds/69-toolkit/887-wetlands-and-watershed-protection-toolkit?showall=&start=15

There are terms in this glossary that are not necessarily used in the panel's report.

Some terms and definitions were added for the panel's purposes. The definitions for these added terms are the top result from a Google search of the given term.

The terms and definitions in this glossary are NOT recommended for any official CBP partnership purposes such as model documentation. Terms with definitions for specific contexts such Phase 6 BMP definitions for CBP purposes are defined elsewhere. This glossary is provided strictly for informational purposes for the benefit of a general reader who is likely unfamiliar with one or more technical terms used in the panel's report, appendices, or cited references.

A

Acre – a measure of land, 43,560 square feet

Areal Cover - a measure of dominance that defines the degree to which aboveground portions of plants (not limited to those rooted in a sample plot) cover the ground surface; it is possible for the total areal cover in a community to exceed 100 percent because (a) most plant communities consist of two or more vegetative strata; (b) areal cover is estimated by vegetative layer; and (c) foliage within a single layer may overlap

Aerobic – (of an organism or tissue) requiring air for life; pertaining to or caused by the presence of oxygen

Alluvium, Alluvial Soil – soil composed primarily of eroded material such as sand, silt, or clay, that has been deposited on land or on the bottom of water bodies by rivers and streams overflowing their banks

Alpine Snow Glade – a marshy clearing between slopes above the timberline in mountains

Anaerobic – living in the absence of air or free oxygen; pertaining to or caused by the absence of oxygen

Anoxic – without oxygen

Aquifer – a geological formation, such as fractured bedrock, glacial sands or gravels, which contains water and yields significant quantities of water to springs and wells; also known as ground water

B

Bank – the rising ground that borders a stream, pond or other body of water

Bank storage – the change in the amount of water stored in an aquifer resulting from a change in stage of an adjacent surface–water body

Base Flow – the sustained low flow of a stream, usually resulting from groundwater inflow to the stream channel

Bed – the ground under a river, pond or other body of water

Bed Material – sediment composing the streambed

Bedrock – a general term used for solid rock that underlies soils or other unconsolidated material

Benthic Organism – a form of aquatic life that lives on the bottom or near the bottom of streams, lakes, or oceans

Biodiversity – the sum of all species of plants and animals. An ecosystem is considered healthy when it supports the most diverse numbers and types of species it is capable of supporting
Biological Assessment (Bioassessment) – using biomonitoring data of samples of living organisms to evaluate the condition or health of a place (e.g., a stream, wetland, or woodlot)

Biological Monitoring (Biomonitoring) – sampling the biota of a place (e.g., a stream, a woodlot, or a wetland) repetitively to monitor change over time
Biomass – the amount of living matter, in the form of organisms, present in a particular habitat, usually expressed as weight-per-unit area

Biota – the plants and animals living in a habitat

Bog –wetlands characterized by a waterlogged, spongy mat of sphagnum moss, ultimately producing a thickness of acid peat; bogs are highly acid and tend to be nutrient poor; they are typically dominated by sedges, evergreen trees and shrubs

Buffer Zone – the area of land next to a body of water or wetland, where activities such as construction are restricted in order to protect water or water quality

C

Channelization – the straightening and deepening of a stream channel to permit the water to move faster or to drain a wet area for farming

Clay - a sedimentary material with grains smaller than 0.002 millimeters in diameter

Confining Layer – a body of impermeable or distinctly less permeable material stratigraphically adjacent to one or more aquifers that restricts the movement of water into and out of the aquifers
Conservation – careful preservation and protection of natural resources from loss, harm, or waste, planned management of a natural resource to prevent exploitation, destruction or neglect

D

Degraded – condition of the quality of water that has been made unfit for some specified purpose

Delineation – identification and documentation of the boundary between wetlands and uplands
Delta – the low, nearly flat tract of land at or near the mouth of a river, resulting from the accumulation of sediment supplied by the river in such quantities that it is not removed by tides, waves, or currents

Depressional Wetland – a wetland that lay within a depression in the landscape, generally draining a small surface area

Direct Runoff – the runoff entering stream channels promptly after rainfall or snowmelt

Discharge – the volume of fluid passing a point per unit of time, commonly expressed in cubic feet per second, million gallons per day, gallons per minute, or seconds per minute per day

Discharge Area (ground water) – area where subsurface water is discharged to the land surface, to surface water, or to the atmosphere

Dissolved Oxygen - oxygen dissolved in water and available to aquatic organisms; one of the most important indicators of the condition of a water body; concentrations below 5 mg/l are stressful and may be lethal to many fish and other species

Drainage Basin – the land area drained by a river or stream; also known as "watershed"; the area is determined by topography that divides drainages between watersheds

Drained – a condition in which ground or surface water has been reduced or eliminated from an area by artificial means

E

Ecoregion – a region defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, and other ecologically relevant variables
Ecosystem – an organic community of plants and animals viewed within its physical environment (habitat); the ecosystem results from the interaction between soil, climate, vegetation and animal life

Emergent Plants – water plants with roots and part of the stem submerged below water level, but the rest of the plant is above water; cattails and bulrushes

Erosion – the process whereby materials of the Earth's crust are loosened, dissolved, or worn away and simultaneously moved from one place to another

Eutrophication – a natural process, that can be accelerated by human activities, whereby the concentration of nutrients in rivers, estuaries, and other bodies of water increases; over time this can result in anaerobic (lack of oxygen) conditions in the water column; the increase of nutrients stimulates algae "blooms" as the algae decays and dies, the availability of dissolved oxygen is reduced; as a result, creatures living in the water accustomed to aerobic conditions perish

F

Fen – peat-accumulating wetland that generally receives water from surface runoff and (or) seepage from mineral soils in addition to direct precipitation; generally alkaline; or slightly acid

Fill – the process where low-lying, wet land is filled with materials in an attempt to make it arable or suitable for construction, any material that raises the ground elevation of a wetland or waterbody

Flooded - a condition in which the soil surface is temporarily covered with flowing water from any source, such as streams overflowing their banks, runoff from adjacent or surrounding slopes, inflow from high tides, or any combination of sources

Flood Attenuation – a weakening or reduction in the force or intensity of a flood

Flood Plain – a strip of relatively flat land bordering a stream channel that may be overflowed at times of high water; the amount of land inundated during a flood is relative to the severity of a flood event

Floodplain Wetlands – wetlands that are influenced by and associated with floodplains, where the overflowing water of rivers and streams is the dominant hydrologic input

Fluvial – pertaining to a river or stream

Frequently Flooded - a flooding class in which flooding is likely to occur often under normal weather conditions (more than 50-percent chance of flooding in any year or more than 50 times in 100 years)

Forested Wetland – a wetland class where the soil is saturated and often inundated, and woody plants taller than 20 feet form the dominant cover, e.g. red maple, American elm, and tamarack; water tolerant shrubs often form a second layer beneath the forest canopy, with a layer of herbaceous plants growing beneath the shrubs (abbreviated FO)

Fringe Wetland – wetland near a large body of water that receives significant and regular two-way flow

Function – refers to how wetlands and riparian areas work – the physical, chemical, and biological processes that occur in these settings, which are a result of their physical and biological structure

Functions – the roles that wetlands serve, which are of value to society or environment

G

Geomorphic – pertaining to the form of the Earth or of its surface features

Geomorphology – the science that treats the general configuration of the Earth's surface; the description of landforms

Ground Water – in the broadest sense, all subsurface water; more commonly that part of the subsurface water in the saturated zone; a layer of underground water that forms when precipitation soaks into the soil and becomes trapped between the soil above and a rock or clay layer below

Ground Water Discharge – ground water that emerges at the land surface, in the form of springs or seepage areas; ground water can also discharge into rivers (via bank seepage) and sustain flow during the drier months

Groundwater Flow System – the underground pathway by which groundwater moves from areas of recharge to areas of discharge

Groundwater Recharge – the process whereby infiltrating rain, snowmelt or surface water enters and replenishes the groundwater stores

H

Habitat – the sum total of all the living and non-living factors that surround and potentially influence an organism; a particular organism's environment

Hardpan – a relatively hard, impervious, and usually clayey layer of soil lying at or just below land surface-produced as a result of cementation by precipitation of insoluble minerals

Hydraulic Head – the height of the free surface of a body of water above a given point beneath the surface

Hydraulic Gradient – the change of hydraulic head per unit of distance in a given direction

Hydric – relating to, marked by, or requiring considerable moisture

Hydric Soil – a soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation; field indicators of hydric soils can include: a thick layer of decomposing plant material on the surface; the odor of rotten eggs; and colors of bluish–gray, gray, black, or sometimes gray with contrasting brighter spots of color

Hydrogeomorphic – of or pertaining to a synthesis of the geomorphic setting, the water source and its transport, and hydrodynamics

Hydrogeomorphic (HGM) Classification – a wetland classification system based on the position of a wetland in the landscape (geomorphic setting), dominant sources of water, and the flow and fluctuation of water once in the wetland; hydrogeomorphic classes include riverine, depressional, slope, mineral soil flats, organic soil flats, estuarine fringe, and lacustrine fringe

Hydrogeomorphic (HGM) Approach – a method that compares a wetland's functions (e.g., water retention, nutrient cycling) to similar wetlands of the same type (as defined by HGM classification) that are relatively unaltered; HGM functions normally fall into one of three major categories: (1) hydrologic (e.g., storage of surface water), (2) biogeochemical (e.g., removal of elements and compounds), and (3) habitat (e.g., maintenance of plant and animal communities)

Hydrologic Cycle – the circulation of water from the sea, through the atmosphere, to the land, and thence back to the sea by overland and subterranean routes

Hydrology – the study of the cycle of water movement on, over and through the earth's surface; the science dealing with the properties, distribution, and circulation of water
Hydroperiod – depth, duration, seasonality, and frequency of flooding

I

Impaired – condition of the quality of water that has been adversely affected for a specific use by contamination or pollution.

Impairment – a detrimental effect on the biological integrity of a waterbody caused by an impact that prevents attainment of the designated use

Infiltration – the downward movement of water from the atmosphere into soil or porous rock

Intermittent Stream – streams that flow primarily during the wet seasons when the water table is high, and remain dry for a portion of the year; most intermittent streams flow for a good portion of the year

Intertidal – alternately flooded and exposed by tides

Intertidal Habitat – the tidal area between the mean lower low water and mean higher high water which is alternately exposed and covered by water twice daily

Inundation – a condition in which water from any source temporarily or permanently covers a land surface.

Invasive Species - plant, fungus, or animal species that is not native to a specific location (an introduced species), and which has a tendency to spread to a degree believed to cause damage to the environment, human economy or human health.

Irrigation – controlled application of water to arable land to supply requirements of crops not satisfied by rainfall

Isolated Wetland – wetland not regulated by the COE because it does not have an interstate commerce connection; typically does not have surface water connection to other waters or wetlands

J

Jurisdictional Wetlands – wetlands which are under the jurisdiction of the COE and the EPA pursuant to Section 404 of the federal Clean Water Act because they meet the COE and EPA definition of wetlands; those areas which "...are inundated or saturated by surface or ground water at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions"; identified in the field based on the 1987 Corps of Engineers Wetland Delineation Manual which requires indicators of the following three parameters:

A) a dominance of wetland plants;

B) hydric soils; and

C) wetlands hydrology

K

Karst – a type of topography that results from dissolution and collapse of carbonate rocks such as limestone, dolomite, and gypsum, and that is characterized by closed depressions or sinkholes, caves, and underground drainage

L

Lacustrine – pertaining to, produced by, or formed in a lake

Lacustrine Wetlands – wetlands within a lake or reservoir greater than 20 acres or within a lake or reservoir less than 20 acres if the water is greater than 2 meters deep in the deepest part of the basin; ocean-derived salinity must be less than 0.5 part per thousand

Load – material that is moved or carried by streams, reported as weight of material transported during a specified time period, such as tons per year

M

m – meter; there are approximately 39 inches in a meter

Marsh – an area of soft, wet, low–lying land, characterized by grassy vegetation and often forming a transition zone between water and land; marshes are dominated by non-woody vegetation and they tend to develop in zones progressing from terrestrial habitat to open water
Maturity – a stage in the evolutionary erosion of land areas where the flat uplands have been widely dissected by deep river valleys

mg/l – milligrams per liter; a unit of concentration

Migratory – a creature that moves from one region to another when the seasons change

Mineral soil – soil composed predominantly of mineral rather than organic materials; less than 20 percent organic material

Mitigation – a process of minimizing or compensating for damages to natural habitats, caused by human developments; these activities are designed to decrease the degree of damage to an ecosystem and may include restoration, enhancement, or creation; according to the Clean Water Act, mitigation is a sequential process that includes avoiding impacts, then minimizing impacts, and lastly, compensating for impacts
Monitoring – the regular measurement of an area or quantity/quality over time (generally of things that can change)

N

Native – an animal or plant that lives or grows naturally in a certain region

Navigable Water – a water that has in the past, currently is or can be used for interstate commerce (i.e., movement of logs downstate); term is defined differently by the COE under the different regulatory programs

Nonpoint Source – a source (of any water–carried material) from a broad area, rather than from discrete points

Nutrient – any inorganic or organic compound that provides the nourishment needed for the survival of an organism

O

Open Water – a wetland class consisting of areas of open water less than 6.6 feet deep; there are often submerged or floating–leaved plants in the shallower portions along the edges of the waterbody (abbreviated OW)

Organic – containing carbon, but possibly also containing hydrogen, oxygen, chlorine, nitrogen, and other elements

Organic Material – anything that is living or was living; in soil it is usually made up of nuts, leaves, twigs, bark, etc.

Organic Soil – soil that contains more than 20 percent organic matter in the upper 16 inches

Organic Waste – the decaying or decayed matter from once living organisms

Overland Flow – the flow of rainwater or snowmelt over the land surface toward stream channels

Oxbow – a bow–shaped lake formed in an abandoned meander of a river

P

Palustrine Wetlands – freshwater wetlands including open water bodies of less than 20 acres in which water is less than 2 meters deep; includes marshes, wet meadows, fens, playas, potholes, pocosins, bogs, swamps, and shallow ponds; most wetlands are classified as Palustrine

Peat – organic material (leaves, bark, nuts) that has decayed partially; it is dark brown with identifiable plant parts, and can be found in peatlands and bogs

Perched Groundwater – unconfined ground water separated from an underlying main body of ground water by an unsaturated zone, typically by an impermeable clay layer

Percolation – the movement, under hydrostatic pressure, of water through interstices of a rock or soil (except the movement through large openings such as caves)

Permeability – the capacity of a rock for transmitting a fluid; a measure of the relative ease with which a porous medium can transmit a liquid

Physiographic Province – a region in which the landforms differ significantly from those of adjacent regions

Physiography – a description of the surface features of the Earth, with an emphasis on the mode or origin

Point Source – originating at any discrete source (i.e., a discharge pipe)

Pollution – The Clean Water Act (Section 502.19) defines pollution as "the [hu]man-made or [hu]man-induced alteration of chemical, physical, biological, and radiological integrity of water."

Pond – a relatively small body of standing, fresh water; usually shallow enough for sunlight to reach the bed

Ponded – a condition in which water stands in a closed depression; water may be removed only by percolation, evaporation, and/or transpiration

Poorly Drained – water is removed from the soil so slowly that the soil is saturated periodically during the growing season or remains wet for long periods

Porosity – the ratio of the volume of voids in a rock or soil to the total volume

Precipitation – the process by which condensed water builds up in clouds and falls to the ground as rain, sleet, snow, or hail

Prior Converted Wetland – wetland converted to farmable land before December 23, 1985

Pristine – the earliest condition of the quality of a water body; unaffected by human activities

Q

Quantitative – a precise measurement or determination expressed numerically

R

Reach – a continuous part of a stream between two specified points

Reaeration – the replenishment of oxygen in water from which oxygen has been removed

Recharge (groundwater) – the process whereby infiltrating rain, snowmelt or surface water enters and replenishes the ground water stores

Recharge Area (groundwater) – an area in which water infiltrates the ground and reaches the zone of saturation

Reference Condition – set of selected measurements or conditions of minimally impaired waterbodies characteristic of a waterbody type in a region

Reference Site – a minimally impaired site that is representative of the expected ecological conditions and integrity of other sites of the same type and region

Regolith - the layer of unconsolidated rocky material covering bedrock

Riparian – pertaining to or situated on the bank of a natural body of flowing water

Riparian Area – an area of streamside vegetation including the stream bank and adjoining floodplain, which is distinguishable from upland areas in terms of vegetation, soils, and topography
Riparian Forest – a swamp that is narrow in width and runs along the shore of and affects a river or stream

Riverine Wetlands – wetlands within river and stream channels; ocean–derived salinity is less than 0.5 part per thousand

Runoff – rainwater that flows over the land and into streams and lakes; it often picks up soil particles along the way and transports it into streams and lakes

S

Salt Flat – the level, salt-encrusted bottom of a dried up lake or pond

Salt Marsh – flat land dominated by non-woody vegetation that is flooded by salt water brought in by tides; it is found along saltwater rivers, bays, and oceans

Salt Meadow – a meadow subject to overflow by salt water

Saltwater – water with a high concentration of salt; sometimes used synonymously with seawater or saline water

Sand – a sedimentary material, finer than a granule and coarser than silt, with grains between 0.06 and 2.0 millimeters in diameter

Saprolite – Soft, thoroughly decomposed and porous rock, often rich in clay, formed by the in-place chemical weathering of igneous, metamorphic, or sedimentary rocks

Saturated Zone – generally the zone within sediment and rock formations where all voids are filled with water under pressure greater than atmospheric

Saturation – a condition in which all easily drained voids (pores) between soil particles are temporarily or permanently filled with water; soil has as much water in it as it can hold

Scrub – a straggly, stunted tree or shrub; a growth or tract of stunted vegetation

Scrub–Shrub Wetland – a wetland class dominated by shrubs and woody plants that are less than 20 feet tall, e.g. dogwoods, alders, red maple saplings, etc.; water levels in shrub swamps can range from permanent to intermittent flooding (abbr. SS)

Sea Level – the long–term average position of the sea surface; in this volume, it refers to the National Geodetic Vertical Datum of 1929

Sediment – fine–grained mineral and organic material in suspension, in transit, or deposited by air, water, or ice on the earth's surface

Sedimentation – the act or process of forming or accumulating sediment in layers; the process of deposition of sediment

Shrub – a woody plant generally less than 7 meters in height, having several stems arising from the base and lacking a single trunk; a bush

Shrubland – land covered predominantly with shrubs

Silt – one of three main parts of soil (sand, silt, and clay); silt is small rock particles that are between .05 mm and .002 mm in diameter

Siltation – the deposition or accumulation of silt (or small–grained material) in a body of water

Site – the portion of land chosen as the basis for an activity or ecological assessment

Soil– unconsolidated mineral and organic material that supports, or is capable of supporting, plants, and which has recognizable properties due to the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over time

Soil Moisture – water occurring in the pore spaces between the soil particles in the unsaturated zone from which water is discharged by the transpiration of plants or by evaporation from the soil

Somewhat Poorly Drained– soils that are wet near enough to the surface or long enough that planting or harvesting operations or crop growth is markedly restricted unless artificial drainage is provided; commonly have a layer with low hydraulic conductivity, wet conditions high in the profile, additions of water through seepage, or a combination of these conditions

Streamflow – the discharge of water in a natural channel

Substrate – the base or material on which an organism lives; subsoil

Surface Runoff – water that flows over the surface of the land as a result of rainfall or snowmelt; surface runoff enters streams and rivers to become channelized stream flow

Surface Water – water present above the substrate or soil surface; an open body of water such as a lake, river, or stream

Suspended Sediment – sediment that is transported in suspension by a stream

Swamp – a wetland where the soil is saturated and often inundated and dominated by shrubs (e.g., alder) or trees (e.g., red maple); contrasting with a marsh that has non–woody plants

T

Terrestrial – pertaining to, consisting of, or representing the Earth; refers to anything that is land based

Terrain – physical features of a tract of land

Tidal Flat – an extensive, nearly horizontal, tract of land that is alternately covered and uncovered by the tide and consists of unconsolidated sediment

Tidal Prism – the total volume of water passing in and out of a particular area, such as a lagoon or salt marsh, during a tidal cycle

Tidal Wetland – a wetland that is subject to the periodic rising and falling of sea level generated by the gravitational forces of the moon and the sun.

Tide – the rhythmic, alternate rise and fall of the surface (or water level) of the ocean, and connected bodies of water, occurring twice a day over most of the Earth, resulting from the gravitational attraction of the Moon, and to a lesser degree, the Sun

Topography – the general configuration of a land surface or any part of the Earth's surface, including its relief and the position of its natural and man–made features

U

Undercutting – a process of riverbank erosion whereby the base or 'toe' of the riverbank is 'eaten away' as a result of river flow or wave action. It results in the section of bank above becoming unstable and prone to collapse

Unsaturated Zone – a subsurface zone above the water table where the pore spaces may contain a combination of air and water

Upland – a general term for nonwetland; elevated land above low areas along streams or between hills; any elevated region from which rivers gather drainage

V

Very Poorly Drained – water is removed from the soil so slowly that water remains at or on the surface during most of the growing season

W

Water Column – an imaginary column extending through a water body from its floor to its surface

Water Table – the upper level of the portion of the ground (rock) in which all spaces are wholly saturated with water; the water table may be located at or near the land surface or at a depth below the land surface and usually fluctuates from season to season; springs, seepages, marshes or lakes may occur where the water table intersects the land surface

Watershed – all the water from precipitation (snow, rain, etc.) that drains into a particular body of water (stream, pond, river, bay, etc.); surface drainage area that contributes water to a lake, river, or other body of water; the area drained by a watercourse; different watersheds are separated by divides or water partings

Wet Meadow – emergent wetlands that are generally seasonally flooded and have saturated soil for much of the growing season. Wet meadows are dominated by grasses, sedges and rushes and are very often cultivated or pastured
Wet Prairie – herbaceous wetland dominated by grasses rather than sedges and with waterlogged soil near the surface but without standing water for most of the year

Wetland – a vegetated ecosystem where water is a dominant factor in its development and existence

Wetlands (Cowardin et al.) – are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes (2) the substrate is predominantly undrained hydric soil and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year. Wetland Boundary– the point on the ground at which a shift from wetlands to nonwetlands or aquatic habitats occurs; these boundaries usually follow contours

Wetland Function – a process or series of processes that take place within a wetland that are beneficial to the wetland itself, the surrounding ecosystems, and people

Wetland Soil– a soil that has characteristics developed in a reducing atmosphere, which exists when periods of prolonged soil saturation result in anaerobic conditions; hydric soils that are sufficiently wet to support hydrophytic vegetation are wetland soils

Wetland vegetation– the sum total of macrophytic plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present; hydrophytic vegetation occurring in areas that also have hydric soils and wetland hydrology may be properly referred to as wetland vegetation

Appendix F – Conformity of report with BMP Protocol

The BMP review protocol established by the Water Quality Goal Implementation Team (WQGIT, 2015) outlines the expectations for the content of expert panel reports. This appendix references the specific sections within the report where panel addressed the requested protocol criteria. Note: The Wetland Expert Panel originally convened under a prior version of the BMP Protocol.

1. **Identity and expertise of panel members***: See Chapter 1.*

2. **Practice name or title:** *Four wetland BMPs are recommended for Phase 6: Wetland Restoration (re-establishment), Wetland Creation (establishment), Wetland Enhancement, and Wetland Rehabilitation. See Table 2 and Appendix C for more information.*

3. **Detailed definition of the practice*:** See Table 2 and Appendix C.*

4. **Recommended N, P and TSS loading or effectiveness estimates:** *This panel provided recommendations for upland treatment efficiency and acre ratios for the Phase 6 Wetland Restoration BMP. See Table 12.*

5. **Justification of selected effectiveness estimates***: See Chapters 4 and 5 for narrative description of the panel's*
    - ***a.*** **List of data sources considered and description of how each data source was considered:**
    - *b.* **Identify data sources that were considered, but not used in determining practice effectiveness estimates:**
    - *c.* **Documentation of uncertainties in the published literature:**
    - *d.* **Documentation of how the Panel addressed negative results or no pollution reduction as a result of implementation of a specific practice:**

6. **Description of how best professional judgment was used, if applicable, to determine effectiveness estimates:** *See Chapters 4 and 5.*

7. **Land uses to which BMP is applied:** *All agricultural land uses and land use groups for Wetland Restoration and Wetland Creation. Wetland Enhancement and Wetland Rehabilitation are applicable to the two Phase 6 wetland land uses: Floodplain and Other.*

8. **Load sources that the BMP will address and potential interactions with other practices:** *See Chapters 4 and 5.*

9. **Description of pre-practice and post-practice circumstances, including the baseline conditions for individual practices:**

10. **Conditions under which the practice performs as intended/designed:**

11. **Temporal performance of BMP including lag times between establishment and full functioning**.

12. **Unit of measure:** *Acres restored/created/enhanced/rehabilitated*

13. **Locations in CB watershed where the practice applies:** *Applicable anywhere in the Chesapeake Bay Watershed where site conditions are amenable or eligible for re-establishment, establishment, enhancement or rehabilitation of wetlands. See Chapter 7 for guidance on when these practices may not be desirable (e.g., these BMPs should not compromise existing high quality habitat resources).*

14. **Useful life; practice performance over time**: *The existing credit duration for Wetland Restoration in Phase 5 is 15 years and this panel does not provide a revision to that value. The credit duration of 15 years is fine for all four BMPs, however the next expert panel or the Wetland Workgroup may recommend increasing or decreasing this credit duration for some or all of the BMPs if they feel a change is warranted.*

15. **Cumulative or annual practice:** *Cumulative.*

16. **Recommended description of how practice could be tracked, reported, and verified:** *See Chapter 6. The CBP partnership also has approved BMP verification guidance as part of its BMP Verification Framework, available online at* *http://www.chesapeakebay.net/about/programs/bmp/verification_guidance*

Also, see Appendix C for more information about BMP reporting for annual progress runs through NEIEN.

17. **Guidance on BMP verification***: See Chapter 6 for summary; see existing Wetlands BMP Verification guidance online for more information:* *http://www.chesapeakebay.net/about/programs/bmp/verification_guidance*

18. **Description of how the practice may be used to relocate pollutants to a different location**

19. **Suggestion for review timeline; when will additional information be available that may warrant a re-evaluation of the practice effectiveness estimates**

20. **Outstanding issues that need to be resolved in the future and a list of ongoing studies, if any:** *A new expert panel is recommended for priority consideration by the WQGIT and Wetland Workgroup to be formed and launched in 2017. The new panel should consider*

improved effectiveness estimates for the new Phase 6 BMPs: Wetland Creation, Wetland Enhancement and Wetland Rehabilitation.

21. **Documentation of dissenting opinion(s) if consensus cannot be reached:** *Not applicable*

22. **Operation and Maintenance requirements and how neglect alters the practice effectiveness estimates**

23. **A brief summary of BMP implementation and maintenance costs estimates, when this data is available through existing literature:** *This provision was added to the BMP Protocol in the version approved by the WQGIT in July 2015, after the panel's literature review was underway. This panel did not identify cost estimates at this time but cost estimates are available in peer-reviewed and gray literature. Additional data is expected to be available if the search is expanded to included constructed wetlands or beyond voluntary wetland restoration activities to include compensatory mitigation.*

24. **Technical appendix:** *See Appendix C*

Appendix G. Compilation of partnership comments received on report, with summary responses

Comments received as of December 8, 2016 are provided below (verbatim).

Upon review of the comments, the Panel Coordinator determined that no comments required significant overhaul or changes to the substance of the panel's recommendations, which would require feedback and discussion from the full panel. The Panel Coordinator communicated with the Panel Co-Chairs and a subset of panel members as edits were made in response to comments. To accommodate an expedited review and approval timeframe this appendix does not have responses for each individual comment received. When provided, the responses are in red.

Changes made to the report can be viewed in the "track-changes" version of the report posted in conjunction with this document. As such, revised sentences or sections are not re-stated here but a page reference is provided. However, the "track-changes" report will not be added as part of this appendix when the report and appendices are posted online.

Please note that references to page or table/figure numbers may change slightly and will not be corrected following WQGIT approval of the report.

District of Columbia, Department of Energy and Environment, submitted by Mary Searing

Please note that the District of Columbia has recently developed a wetlands registry, which should be used over the NWI to the extent possible. Please contact Jennifer Dietzen (cc'd here) for more information on the District's registry.

Thank you for the opportunity to review and comment on the Wetland Expert Panel report.

DC staff should immediately communicate and work with CBPO GIS staff on this (contacts were provided via email exchange). The panel's land use recommendations were approved in Fall 2015. Development and review of all Phase 6 land use data is in the final stages. The data can be viewed online: http://chesapeake.usgs.gov/phase6/map

Maryland Department of Environment, submitted by Dinorah Dalmasy

1. The wetland restoration BMP efficiencies are based on an average mean reduction from available literature sources, including studies on natural wetlands currently existing on the landscape. However, these efficiencies are not applied to the natural, existing wetlands in the model (i.e., the wetland land-use acres). Is there a reason for not applying same science and method to the natural existing wetlands as the restored wetlands? MDE recommends that the upland efficiencies be applied to the natural, existing wetlands as defined by the Phase 6 model land-use.

This possibility was discussed by the panel, but based on their understanding of factors used to set land-to-water factors, and the use of water quality monitoring data to calibrate the Phase 6 Watershed Model, the panel acknowledged that the effect of wetlands that exist on the landscape is implicitly captured within the Phase 6 Watershed Model. The timing of data availability for spatial data and the effort required to analyze and evaluate an explicit effect, which could be distinguished from the land-to-water factor, prevented that path and the application of the panel's recommendations as suggested would risk double-counting the benefit of existing wetlands.

2. The upland acres treated are based on assumptions related to the hydro-geologic province a given wetland is located in. These assumptions relate hydraulic conductivity of the wetland in question to upstream drainage areas. For instance, hydraulic conductivity of floodplain wetlands in the Piedmont is assumed to be low due to assumed stream channel incision from anthropogenic sources. To set upland treatment acres, MDE suggests using data that is currently available in the model, i.e., streambank geometry and erosion data inputs to the Phase 6 model and average wetland distance from the segment reach, instead of making assumptions regarding channel incision. For instance, if the stream erosion input data for the applicable land-river segment indicates that the modeled reach is not incised, a greater hydraulic conductivity could be assumed. Furthermore, in phase 5.3.2, to determine a sediment delivery factor from EOF to EOS, the average land-use distance to the modeled reach was used. The same rationale could be used for wetland acres in a segment, i.e., the further the average distance to the modeled reach, the less upland area the wetlands treat, and vice versa.

Thank you for the opportunity to review and comment on this Expert Panel Report. Let us know if you have any questions or need any clarification.

After follow-up conversations with Jeff White, it was clarified that the second point was related to the first one, i.e. that the suggested methods in the second paragraph should be used to determine the area of upland treated by existing wetlands, per the first comment, and are thus not suggested as an alternative to the values recommended in Table 12 by the panel for the Phase 6 Wetland Restoration BMP.

We greatly appreciate MDE's comments, which are excellent ideas. Unfortunately, they cannot be incorporated into the Watershed Model within the timeframe necessary. MDE should discuss further with Gary Shenk (USGS, CBP Modeling Coordinator) or Modeling Workgroup leaders if desired.

Maryland Department of Agriculture, submitted by Alisha Mulkey

- The Panel recommends a loading rate analogous to forest (rather than % efficiency) for TN, TP, and TSS for nontidal wetlands? If yes, will the NWI or other data layers determine the extent available of non-tidal wetlands in a county, or is a jurisdiction expected to report that detail to NEIEN? Correct, the loading rate for the new wetland land uses is equal to Forest in the Phase 6 modeling tools. Jurisdictions have the option to provide improved, more recent data if available for the purpose of defining acres of existing wetlands. Otherwise, NWI will be used determine the acres. The land uses were then subject to the same development and review as all the Phase 6 land uses. Only the BMP acres are reported through NEIEN.

  - The language (pg. 45-46) on wetlands as a land use versus other options is very "soft". Most of this section was adapted from fall 2015 memo to the WQGIT...the land uses were approved so I wanted to document the arguments we used last year. I realize the panel is simply making recommendations but more context on the likely plan for P6 could be helpful. I think you're asking for more info about how the land use acres are determined? Box 1 (p25-26) has a little more info on this, but we wanted to keep it fairly general for the panel report audience. I'd defer to any documentation from the modeling or GIS team for more detailed or technical information.

- Table 9 and the following narrative suggest the Panel proposes the mean % reduction of "all" is the best available option due to limited literature. Are these proposed efficiencies for wetland restoration only? Correct, only for Phase 6 wetland restoration BMP.

- Similarly Table 12 (pg 58) reports a % efficiency but also includes an upland acre treatment component, for "other" and "floodplain". It is hard to decipher what wetland types and categories (creation, restoration, etc.) these values are relevant to? Only for wetland restoration; the other 3 categories have placeholders rates until a future panel works on there other cetegroies.

- Table 13 appears specific to restoration in tidal areas. I have no knowledge of the "protocols" referenced in the Table. Is this a new level of detail to track and report? It's referring to the Shoreline Management BMP panel's protocols. For reporting through NEIEN you'd report wetland restoration in tidal areas as Shoreline Management. The partnership needs to consider how to keep the reporting as efficient as possible for other CBP purposes (e.g., so that tidal wetland restoration acres reported as Shoreline Mngmt through NEIEN are still counted for Watershed Agreement outcomes for wetland restoration/creation).

- Last section pg. 60 acknowledges several BMPs not addressed by the panel. What is the plan time forward to credit these remaining wetland options in P6? The Wetland Workgroup approved "placeholder" rates in September, so Wetland Creation, Wetland Enhancement and Wetland Rehabilitation are available for reporting in Phase 6, but the efficiency is equal to the average TN, TP and TSS reductions for the Phase 5 wetland restoration BMP and treats 1 upland acre per acre of implementation (same ratio as Phase 5.3.2 restoration BMP). I don't know what the specific timeframe will look like, but we hope the wetland workgroup and others work to develop the charge/scope for that panel early in 2017 so the panel can be formed and launched with minimal delay.

- Chapter 6, item #4 pg. 63 - this is not the protocol that MDA has ever used for reporting ag-related wetlands. Will our reporting options and details remain available? Chapter 6 is intended to be more general than just NEIEN since the CBP does track wetland BMPs for other purposes such as the Agreement outcomes. I'll defer to Erin on the specifics, but I don't believe we're changing anything besides adding multiple BMPs in NEIEN where there was only one in Phase 5.3.2. Maybe Appendix C helps?

- Erin: In reference to your question below, the only change to current reporting will be the addition of the Wetland Enhancement and Wetland Rehabilitation categories. Whatever process for reporting you have set-up with Denise Clearwater should not change. Denise sends DNR an Excel spreadsheet with the columns listed under 4. Tracking, and asks us to fill-in as much information as we can. Your process with Denise may be different. Chapter 6 was just an attempt to show the information reported to Bay Program for tracking wetland restoration progress.
- FYI - the items listed in #4 are collected annually by MDE and later reconciled with MDA; however, there are a number of issues with project details and timing that make this reconciliation difficult. MDA has a better tracking and reporting option for ag-related wetland practices and would prefer to use our existing system.

In summary, I found this report difficult to navigate in the short comment window requested. I would recommend an Executive Summary of tables to distinguish the proposed credits and a much improved Technical Appendix from Chapter 6 to assist myself and others for NEIEN reporting purposes. I completely agree but unfortunately ran out of time to write an Executive Summary. I can work to add an Executive Summary for the WQGIT-approved report. The Technical Appendix for Scenario Builder (Appendix C) is now available, which certainly adds more clarity for NEIEN reporting purposes.

Thanks for the opportunity to review.

Amy Jacobs, TNC, Wetland Workgroup Co-Chair

I have one request that I wanted to submit for your consideration as you finalize the report. What would be very helpful for the WWG and other wetland restoration practitioners would be a few examples of how the efficiencies and upland acres treated information translates to pounds of nutrients and sediment reduced/ credits in the model. I understand that this will depend on where the site is located and the landuse in that segment but even a high and low end example applied to the various wetland types and physiographic regions would be very helpful to help practitioners and managers understand the benefits of restoration and how they are being credited in the model. We agree some specific examples and materials could help; PA DEP made a similar request (see below for that response and Chapter 8 for newly added language).

PA DEP, submitted by Jill Whitcomb

Overall, the *Recommendations of the Wetland Expert Panel for the incorporation of wetland best management practices (BMPs) and land uses in the Phase 6 Chesapeake Bay Watershed Model* is a well written evaluation. Pennsylvania DEP wetlands staff met with Jeremy Hanson, Panel Coordinator on Wednesday, November 30 to work through the Wetlands Expert Panel (WEP) report. In attendance at this meeting was expert panel representation from Pennsylvania as well as other expert panel representation via conference call. We appreciate the time and efforts of Jeremy and Panel members to work with us and incorporate our comments in the report. Below summarizes the outstanding comments that were discussed at that meeting:

- Pennsylvania recommends the following language to be included in the Expert Panel report:
  "The statements and procedures outlined in this Expert Panel Report are intended to supplement existing jurisdictional requirements. Nothing in the Expert Panel Report shall affect jurisdictional regulatory and other legal requirements." Added to Chapter 2, page 7.
- Table 2 – move "re-establishing needed vegetation…" and "native wetland meadow planting" from Wetland Restoration examples to Wetland Rehabilitation examples. Done.
- Provide additional language to recognize that the recommended values for upland treatment acre ratios in Table 12 reflect best professional judgment. Given the inherent uncertainty, the Partnership should revisit those recommendations when additional data becomes available. Pennsylvania will accept the current in values in Table 12, with the above acknowledgment placed in the report. Edited the language preceding Table 12.
- The four BMP categories/definitions add potential for confusion as to how various state, federal, or non-governmental restoration activities should be tracked and reported.
  - The Partnership should consider available mechanisms to provide outreach and informational materials for the broader community that will be the implementers as well as the reporters of the BMP implementation. This may be similar to the resources provided to the stormwater community through the Chesapeake Stormwater Network. Added a "fifth" point in Chapter 8 with a recommendation for such materials. Specific types of materials and the mechanism for providing these materials are TBD, and should be discussed by the Wetland Workgroup and others interested in the materials.
- We have considerable concern regarding the Wetland Restoration BMP's recommended efficiencies compared with existing Riparian Forest Buffer BMP efficiencies. The existing efficiencies for Riparian Forest Buffer BMP's are greater than the recommended Phase 6 efficiencies for the Wetland Restoration BMP. This difference is contrary to a basic premise of the Wetland Expert Panel that wetlands provide additional water quality benefits compared to Forests (Chapter 1. Charge and membership of the expert panel). There is evidence to suggest that wetlands are more likely to intercept and reduce nutrients in groundwater pathways that are not within the root zone of a Forested Buffer[1], particularly on sites with legacy sediment or where streams have been relocated to valley margins[2].

This is a good point and some panel members have participated on past Forest Buffer expert panels for the CBP so the panel did discuss how it may relate to wetland BMPs. However, the panel's scope is limited to the wetland practices in its Charge and this issue falls to the partnership – specifically the WQGIT, Forestry Workgroup, in consultation with the Wetland Workgroup and Agriculture Workgroup – to consider. The most recent expert panel report to evaluate forest buffers was approved in October 2014 by the WQGIT. That panel concluded "there is insufficient new information on buffer efficiencies at this time to make comprehensive changes to the current set of efficiencies for buffers." They did provide an adjustment to TN removal for Forest Buffers established on both sides of the stream, but otherwise the effectiveness values applied to upland acres for the Riparian Forest Buffer (RFB) BMP remained unchanged from Simpson and Weammert (2009). As with the proposed Wetland Restoration BMP, the RFB practice is a land use change, plus additional treatment of a given ratio of upland acres. For the RFB practice, 4 upland acres are treated for each acre of buffer for TN; 2 upland acres are treated for TP and TSS. The most recent panel stated in its report that "the Panel realizes that buffer width and vegetation type are likely to be less important than whether a buffer actually treats nutrient-laden water (hydrologic flow path). The efficiencies for riparian buffers should be reconsidered when, but not before, these flow paths are better understood and can be accounted for in the Chesapeake Bay Watershed Model." (page 3, http://www.chesapeakebay.net/documents/Riparian_BMP_Panel_Report_FINAL_October_2014.pdf)

- This discrepancy could have some negative unintended consequences like installation of Forest Buffers to simply maximize reduction credits on sites where Wetland Restoration would be the appropriate ecosystem to restore. Practitioners may arbitrarily install a Forest Riparian Buffer on sites where Wetland Restoration would provide greater water quality benefits than what are expressed in the recommended BMP efficiencies.
    - There are improvements and co-benefits from wetland restoration BMPs that are not captured in the nitrogen, phosphorus, and sediment efficiency values. The efficiency values only offer part of the full picture of the benefits of wetland restoration. We've added some new language in Chapter 8 to this effect. It should also be noted here that there are ongoing efforts by the partnership to gather and build more info into planning tools such as CAST related to habitat benefits.
    - It is possible, yet not confirmed that the studies that were used to set the RFB values evaluated sites that would be better described as forested wetlands, and thus, set a skewed value for buffer efficiencies. This is not a critique of the practice or effectiveness values that were evaluated by experts and approved by the partnership using the best science and best professional judgment available at that time. However, the Partnership should look into any additional research and

information as well as interest in revisiting the current efficiencies for RFB. We suggest that the Forestry Workgroup and Wetland Workgroup collaborate to determine how to proceed, as well as collaborate on the formation of an expert panel, if one is necessary. Agree that the workgroups (and WQGIT) should take this into consideration as this goes beyond the Wetland Expert Panel's charge.

  - A stronger communication of uncertainty may also help practitioners to make informed decisions and to prioritize BMPs more effectively. This may include providing information about which BMP effectiveness values rely more heavily on best professional judgment or fewer empirical observations -- and are thus ready in the cycle of reevaluation by the partnership – and which BMP effectiveness values based on extensive empirical values and peer-reviewed data are less likely to warrant revision by the CBP in the near term. This is an overarching suggestion beyond the Wetlands Expert Panel report. We've added language preceding Table 12 as noted above, and support the suggestion that the partnership build on previous discussions of overall uncertainty in the modeling tools by exploring ways to depict or convey uncertainty to planners and decision-makers beyond the written expert panel reports alone. Albeit may only be feasible to express uncertainty qualitatively for many BMPs, the information would still supplement decision making.

- We generally agree that the conceptual model/framework is a good foundation moving forward. That said, there is room for improvement in specific values that have uncertainty such as the upland acre ratios. There also is opportunity, as well as a need, for development and improvement of tools and data to better understand prior-converted areas that may offer the best opportunities for targeted (and likely more effective) wetland restoration activities overall. This statement has been added to Chapter 8 (third point, bullet 5).

Thank you for the opportunity to comment.

[1] Sullivan, P.L., et al., CZ-tope at Susquehanna Shale Hills CZO: Synthesizing multiple isotope proxies to elucidate Critical Zone processes across timescal..., Chem. Geol. (2016), http://dx.doi.org/10.1016/j.chemgeo.2016.05.012

[2]Merritts, et al., 2011. Anthropocene streams and base-level controls from historic dams in the unglaciated mid-Atlantic region, USA. Philosophical Transactions of the Royal Society A: Mathematical., Physical and Engineering Sciences 369, no. 1938 (March 13, 2011): 976 -1009.

USACE Comments on "Wetlands and Wetland Restoration. Recommendations of the Wetland Expert Panel …,"First draft …11/22/2016. (Comments from CS and BB.)

Section	Comment / Suggested Revision	Rationale Red text with status/response from panel reps
General	Consider ways to reduce length of supporting text in Chapters 1-4 to only that necessary to support Chapters 5 onward	Document has substantial background information in first 43 pages that ultimately is of uncertain necessity to support recommendations. Unable to do this in short-time frame required
Cover Page	Add term "Non-tidal" at end or beginning of title	To clarify that this document refers almost explicitly to non-tidal wetlands Edit made (track-changes functions oddly with even simple additions to titles/sub-titles, so the line is in red font to indicate change)
Table of Contents	"List of Figures" need only include figure caption to first "." Remainder can be deleted (e.g., Fig 3 delete "Water infiltrates …"	Standard practice, although you may have to fight Microsoft Word to do so! Done, but yes – Word will fight back later.
p. iv	Add TSS	Acronym used in report Added
p. 1, para 2, line 3	Add word "position" after word "landscape"	To introduce term and for consistency with remainder of report. Added
p. 2, top bullet	Clarify whether impacts to other land uses also of concern for report	Confusing to reader Not added as this is directly from initial panel charge.
p. 4, "Reestablishment (restore)"	This definition must further define wetland reestablishment as a wetland that is planned, designed, and implemented so that it results in a wetland that resembles an ecological reference site based on characteristics of an intact wetland of the same type that exists naturally in the region. This definition should also indicate that the "Results in a gain in wetland acres AND FUNCTIONS".	Definition must not assume that a gain in wetland acres automatically results in a gain in function, and definition should be very clear and consistent with current USACE definition. Not added. This is the existing Phase 5.3.2 definition for the BMP, and the inconsistency you noted is one reason for this panel's formations and its recommendations.
p. 4, para. mid-way through page	After "same as forests" add something like "(forests in model include both wetland and upland forest areas at this time)"	Somewhat confusing as forested wetlands are a type of wetland, but not all forests are wetlands nor all wetlands forests Added
p. 5, "Former wetland or historic wetland"	This definition needs more details to identify that a former wetland habitat type previously existed at the specific site.	The available evidence that will be accepted must be described as collected from aerial photographs, prior delineations, historical maps, and forensic soil analysis. Added
p. 6, bottom paragraph, line 10	Add "(Table 2)" after "for CBP purposes."	Clarify to reader where information will be found Added
p. 7, top para., first sentence	Change sentence to "Some other practices also include wetland restoration,…"	Floodplain wetlands are a type of wetland as this report goes into great length to cover later. If concern is preventing double-counting benefits, then state that. Revision made with slightly different language
p. 7, Table 2, Row "Restoration"	Proposed BMP Category of "Restoration" should be relabeled as "Re-establishment"	To coincide with definitions provided above on "reestablishment(restore)" and "former wetland or historic

		wetland" above and reduce any confusion. The proposed definition should also include that re-establishment results in gain in wetland acres AND Functions. All acreage gain is functional gain, but not all function gain is acreage gain. We want to avoid adding words that confuse the division.
p. 7, Table 2 Row "Restoration," "Practice and Project Examples"	To table title add "on agricultural land" after "wetland BMPs"	All practices and examples referred to occur on ag land as best I can tell Added. The examples are ag practices, but the definitions are not limited to ag. I would not make this insertion.
p. 8, Table 2, Row "Creation," "Practice and Project …"	Consider deleting "tidal" wetland example or change it to "non-tidal"	Report otherwise appears to almost exclusively cover non-tidal wetlands Deleted "tidal"
p. 8, Table 2, Row "Rehabilitation," Practice and Project …"	Insert example change being made to a "moist soil management" wetland	Ongoing management wouldn't be restoration. Presumably a change is required such that new/modified wetland or impoundment would qualify as "rehabilitated" No edit as of 12/12/16, will need to follow-up if specific example needed, but this may be better addressed by next panel or in outreach resources provided as outlined in Chapter 8.
p. 9, top of page	Add sentence stating that compensatory mitigation projects are tracked separately by state and federal agencies.	Clarify that they're not "off the books", just not a restoration given TMDL credit Edit made
p. 10, bottom para., line 10	Add "grading down the floodplain" after "bringing up the stream bed"	Common practice in urban areas, also presumably practiced in agricultural settings (?) Added, but can remove if confirmed this isn't practiced in ag settings
p. 11, para. 2, line 5	After phrase "…not included in Table 5" add "because that topic is not included in the charge to the panel" or similar words	Assuming comment correct, this is important simple point – ag only (?) The sentence is discussing urban, edit not needed.
p. 13, para 2, line 8	After word "phosphorus" add "from eroded soils" prior to "to streams"	P content of regolith, bedrock, saprolite, etc. relatively low. It's erosion of soils containing P that matters. Added
p. 14, bullet 2, line 3-4	Change "thus often limiting in-stream biota" to "and have limited instream biota"	Headwater streams generally fewer aquatic species because of limited physical availability of aquatic habitat exacerbated by effects of occasional droughts that further limit life - even in absence of anthropogenic effects. Excess sediment is a factor limiting life there, but certainly not the only one nor even necessarily predominant one Added
p. 15, after top para	Add subheading above bullets, something like "Wetland HGM Types"	Improve readability Will add this later; adding a header now disrupts Figure 2 and causes ripple effect with page numbers we want to avoid right now
p. 15, para. 1 "Flats," line 2	After word "Accordingly," add "seasonal water tables"	As written, fails to identify winter wet summer dry factor of great importance to coastal plain flats. Added
p. 16, Figure 2	Change "physiographic regions" to "physiographic settings"	Many of these are not "physiographic regions" as that term commonly used Done

p. 16, Figure 2	Add reference for "physiographic regions"	These are not standard physiographic regions of geographers or geologists. Need to clarify their source. Done. GIS data for modified from Brakebill and Kelley (2000).
p. 17, "The Importance of Physiographic Setting"	Simplify this to "Physiographic Setting"	It actually doesn't clarify importance very well, but does explain the various relevant settings Edit not made as of 12/12/16.
p. 17, para. 3, line 4	Delete "the evolution of"	Not needed, confusing Done
p. 17, para. 3, line 9	After "(see Figure 2)" add something like "For the purposes of this report, 10 physiographic settings are recognized"	Improve readability, inform reader of bulleted paragraphs coming up. Added new sentence, also referring to Table C3 which cross-reference's the panels 9 regions with the HGMRs used in the Watershed Model.
p. 17, "Appalachian Plateau" paragraph, line 4	Add word "mudrock" after "sandstone"	Mudrocks (shale and siltstone)constitute decent proportion of rocks in region Added
p. 17-23	Either consistently include sentence on wetland areas in physiographic region for each and site source, or delete for all	Presented as end sentence for some settings but not others. Inconsistent. Also, if including, source of extant resources/loss estimate needed. Edit not made; ran out of time to make this change and the numbers are still subject to change as P6 land uses are finalized.
p. 18, Figure 3	Add to caption that glacial deposits present in northern PA and NY portion of watershed that are not depicted.	Important regional distinction, and mentioned later in report Added
p. 18, Figure 3	Consider deleting "saline water" from figure and caption	Information otherwise irrelevant to report, and then necessitates further explanation (i.e., originates from dissolution of salt deposits) Fine as-is, since this is modified from another source.
p. 19, "Appalachian Ridge and Valley" paragraph	Consider deleting three types of springs and text on these.	Information otherwise irrelevant to report. What is important is carbonate vs non-carbonate. Prefer to leave as-is.
p. 20, Figure 5	Add to caption that contact between physiographic provinces causes deeper than typical regolith in this particular case at toe of slope.	Graphic useful, but notable difference in rock type, structural geology, and other factors likely produce thicker wedge of colluvium/regolith at toe of slope compared to other valleys not at physiographic province boundaries Edit not made as 12/12/16; specific suggested language requested.
p. 20, "Blue Ridge Province" para, lines 4-5	Delete sentence "As a result, the groundwater system…"	Unnecessary and incorrect. Blue Ridge province has only limited sedimentary rock (Triassic Basins), is mostly metamorphic. Groundwater of Piedmont where sedimentary rock occurs is presumably typical of other provinces having relatively flat sedimentary rock (such as Appalachian Plateau). Groundwater of Piedmont in crystalline (metamorphic and a little bit of igneous) rock areas may be similar to groundwater in Blue Ridge (although latter has much greater vertial relief). Edit not made as 12/12/16. Need more input from panel members that wrote this first.
p. 21, top para., line 2	Change/amend sentence to state that Piedmont settings can include regolith 10s of	Although not soil, saprolite of fundamental importance for Piedmont in non-glaciated areas. Surficial aquifer at

	meters thick on hilltops. Also, add term saprolite to the paragraph and its definition.	contact in upland areas at base of saprolite/uppermost occurrence of crystalline rock. Edit not made as of 12/12/16; specific suggested language requested.
p. 21, Carbonate deposits	(None)	Of particular notoriety with regard to discriminating between physiographic provinces - which this isn't - versus a setting, which this is.
p. 22, Coastal Plain, line 5	Provide reference for subdivision of coastal plain.	These subdivisions not typically used by geologists, so reference is important. Reference perhaps: U.S. GEOLOGICAL SURVEY Open-File Report 93-40 (Water-Quality Assessment of the Delmarva Peninsula, Delaware, Maryland, and Virginia-Effects of Agricultural Activities on, and Distribution of, Nitrate and Other Inorganic Constituents in the Surficial Aquifer) Modified from Brakebill and Kelley (2000), as clarified with earlier edits to Figure 2.
p. 23, top para., line 8	Change "contamination by" to "polluted by"	Term contamination generally restricted to toxins Done
p. 25, Box 1, para 1, line 1	Change words "provides a summary of" to "provides methods …"	Last paragraph of box starting on 5th line ("With respect…") provides summary (also see comments below)
p. 25, Box 1, para 2, line 4	Provide reference for 2m elevation as discriminating elevation between tidal vs nontidal	Generally, tidal is fairly claimed up to spring high water such as Titus and Strange (2008) http://papers.risingsea.net/EPA-sea-level-rise-elevations-wetlands-ecosystems-2008.html
p. 25, Box 1,para 3, lines 1 & 4	Change physiographic "province" to physiographic "setting"	As per comments above. Changes made to key instances (tables, etc. as noted above). Can change other instances in text later, if needed, but need input from panelists first.
p. 25, Box 1,para 3, line 5	Break out new paragraph starting at "With respect…" or move this text into main body of report, and explicitly reference Table 6	This text doesn't cover methods (see comment above) but does summarize inventory from Table 6 Edit made. This box is not intended to cover methods in depth here, as that is covered in model documentation.
p. 26, Table 6, Coastal Plain row	Provide summary acreage for inner + outer, etc.	Can make this change later.
p. 26, Table 6, Karst Terrain	Add footnote that no karst terrain occurs in coastal plain province	It does occur in coastal plain further south (North Carolina southward) Not added; the table is specific to the Chesapeake Bay Watershed.
p. 27, para 1, Nitrogen…	Add to end of paragraph simple statement that wetlands have widest range of biogeochemical conditions on landscape with both oxidizing and reducing environments in close proximity. Wetlands have immense N transformation capability because ultimate sink is atmosphere.	Of fundamental importance to discriminate wetlands from uplands. While streams can also have anoxic substrates and anoxic water column, the total areas of these environments is small compared to that of wetlands. (Could instead cover this topic in para 1 of p 28 also). Added, but the new language could be better; specific suggestions welcome. We could add that N2 gas can be lost to the atmosphere to the previous statement about denitrification.
p. 28, para 2, line 2	Clarify that particulate N trapped on floodplains is poorly bioavailable compared to dissolved N forms	Of major importance - not all N species/forms of equal value in terms of treatment need. (Side note: TN is a particularly poor N metric as it lumps bioavailable (labile)

		and refractory N forms together as if the are equal in impact to waters). Added sentence.
p. 29, Phosphorus	Somewhere in this section that wetlands have finite P storage capability, once that reached, they release P. There is no gaseous P form of relevance such as there is for N	Points of fundamental importance. Two sentences added at bottom para of p29 and top para of p30.
p. 32, top para., line 12	Add word "slope" after "…limited human impacts to"	Floodplain wetlands conversely in some areas Added
p. 32, top para.	Add coverage of historic and extant wetlands on mined lands	Of local importance, and relevant here in biogeochemistry section As of 12/12/16 no change made; more context needed about "mined lands."
p. 32, bottom para, line 2	Add sentence on research on comparable wetlands outside watershed	Unclear why research needs to be spatially restricted to be of value
p. 33, Summary para., line 6	Clarify whether sloping wetlands that occur on floodplain valley sidewalls might be of great importance.	What these don't capture could then be treated in floodplain itself. Potentially combination of high value.
p. 44, 1st bullet (Wetlands provide …), line 1	Delete word "supplies" after water	Supplies implies human use only Done
p. 44, 3rd bullet, line 1	Delete "there is strong evidence demonstrating that"	Unnecessary. Fundamental point of entire document. Not done, you make a great point, but it's worth leaving the statement for repetition/emphasis.
p. 44, bullet 4, line 3	Change word "flooding" to "saturation"	Hydroperiod not restricted to flood conditions Done
p. 47, (3), Sentences 3 onward	These sentences ("The recommended wetland…") are fundamental explanation that should also be included near beginning of document	These sentences cleared up lots of confusion for me, should've been introduced earlier. Edit not made; unable to think of specific place to introduce these points earlier, unless we add an Executive Summary.
p. 48, paras 2, 3	Add sentence explaining why TN used as metric	I believe USEPA convention standard. However, arguably poor metric as lumps labile and refractory N forms such that obscures pollutant treatment capabilities of various ecosystems (and BMPs) No edit made as of 12/12/16; additional context and clarification needed.
p. 52, bullet 3	State what period of time averaged to determine treatment efficiences.	Presumably average over one year (?) to account for low N processing in winter but high in spring No edit made as of 12/12/16; waiting for clarification by specific panel member.
p. 54, Box 2	After "..effluent waters" add "and may be subject to periodic maintenance"	Not sure whether correct for ag wetlands, but thinking of SWM wetlands which are periodically dredged,grubbed, etc. Added, but new sentence reads awkwardly. Edited for grammar.
To read p. 54, para 3	Move sentences describing how carbonate bedrock combined into one class to "carbonate deposits" on p. 21	Needs to be earlier in document as displayed in Figure 2 Left alone, for now.
p. 56, Table 11	Change column heading "Physiographic Province" to "Physiographic Setting"	Consistency through document, plus these entries are not all physiographic provinces in traditional sense Edit made to table title and header row for Tables 10 and 11

p. 56, Table 11	State whether mined land wetlands considered in table	Of local importance in mined lands More info needed about mined lands
p. 60, para 1, last line	Add statement that accelerated rate of sea-level rise now means we're in for net loss of tidal wetlands in coming decades.	It is essentially impossible for watershed to now have increase in tidal wetlands to replace historic losses. We can't even keep what we have now due to drowning in place and erosion. No change made. Other CBP processes (Climate workgroup) and documents adequately speak to this issue, and absent additional language to address anticipated acreage and functional adverse effects of climate and human development on non-tidal wetlands, we should not include here
p. 63, "4 Tracking"	Reestablishment should track gains in functions as well as acres	Reestablishment does not always result in successfully establishing a highly functioning wetland. Often results in invasive species dominating the site and lower functioning site than the original area.
p. 68, para 2, last line	Change sentence to state that wetlands seen as sinks for N, but only temporary storage places for P	Substantial literature now on P release when P saturated (including when sediment capacity reached, as well as biogeochemical P release) Edit made
p. 69, para 2, line 3	Clarify that much of upland forest water budget is from precipitation (rather than surface or groundwater), thus lack interception opportunity of wetlands	While downstream loading rates from upland forests could be same as wetlands, their interception capability fundamentally different No edit as of 12/12/16. Specific suggested language is requested.
p. 69, bullet 1	Reword bullet to clarify why prioritization needed	TMDL seeking to provide nutrient load reductions, locals choose how to best do this based on many factors including cost. If decision which TMDL measure to pursue is chosen based on cost, total load reduction, and other factors, unclear why we need prioritization addressed here. It will depend on best opportunities in different places. We've added more language in response to PA DEP comment that expands more on this issue, so no change made to this bullet. Project costs and reductions in the modeling tools are certainly factors but the panel must acknowledge other factors that should play role in setting priorities.
p. 69, bullet 2	Delete term "shuffle zones", delete "an organic rich"	"Shuffle zones" not covered previously in document nor a commonly used term. Organic content of soils is function of other factors, including sedimentation rate, decay rates, etc., not necessarily groundwater/surface water interactions Alternate edit made. "Shuffle zone" is not explicitly defined but the context of the sentence is sufficient to convey the point.
p. 69, bullet 3	Add "soil depth, carbon content," prior to "mineralogy"	Mineralogy only one of several important factors Added
p. 69, bullet 4	Change to "Identify surface features indicating likely groundwater flow pathways and groundwatershed"	Subsurface feature investigation complex and probably costly (would be investigating structural geology and lithology, etc.) Edit made