Nutrient Management

Definitions and Recommended Nutrient Reduction Efficiencies of **Nutrient Management** For Use in Phase 6.0 of the Chesapeake Bay Program Watershed Model

Recommendations for Approval by the Water Quality Goal Implementation Team's Watershed Technical and Agricultural Workgroups

Submitted by the Phase 6.0 Nutrient Management BMP Expert Panel

Submitted to:
Agriculture Workgroup
Chesapeake Bay Program

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Contents

Acronyms

AAPFCO	Association of American Plant Food Control Officials
AgWG	Agriculture Workgroup
BMP	Best management practice
CBP	Chesapeake Bay Program
CBPO	Chesapeake Bay Program Office
CBPWM	Chesapeake Bay Program Watershed Model
CBW	Chesapeake Bay Watershed
CEAP	Conservation Effects Assessment Project
CRC	Chesapeake Research Consortium
CSNT	Corn Stalk Nitrate Test
DE	Delaware
EOF	Edge of Field
FSNT	Fall Soil Nitrate Test
HUC	Hydrologic Unit Code
ISNT	Illinois Soil Nitrogen Test
LGU	Land-Grant University
MD	Maryland
N	Nitrogen
NEIEN	National Environmental Information Exchange Network
NM	Nutrient management
NMP	Nutrient management plan
NRCS	USDA Natural Resources Conservation Service
NRI	National Resources Inventory
NY	New York
P	Phosphorus
PA	Pennsylvania
Panel	Nutrient Management Expert Panel
PSNT	Pre-sidedress Nitrate Test

QAPP	Quality Assurance Project Plan
TN	Total nitrogen
TP	Total phosphorus
USDA	U.S. Department of Agriculture
VA	Virginia
WTWG	Watershed Technical Workgroup
WQGIT	Water Quality Goal Implementation Team
WV	West Virginia

Summary of Recommendations

1 Introduction

Nutrient Management Plans (NMPs) are implemented on millions of acres of agricultural lands across the Chesapeake Bay Watershed (CBW). It is one of the oldest best management practices (BMPs) in agriculture and is the cornerstone of stewardship efforts by conservation groups, producers and jurisdictions. This document summarizes the Phase 6 Nutrient Management Expert Panel's recommendations for revised definitions and credits for nutrient management (NM). The Phase 6 NM Expert Panel (the Panel), whose members are identified in Table 1, proposes that the Chesapeake Bay Program's (CBP) existing definitions and credits associated with implementation of NM be replaced by independent sets of elements for nitrogen (N) and phosphorus (P) management due to the marked difference in the use, fate, and transport of these nutrients in agricultural systems. The structures for both N and P nutrient management are similar, however, with supplemental management elements stacked onto a required core set of management elements.

Table 1. CBP Phase 6.0 Nutrient Management Expert Panel Membership

Name	Jurisdiction	Affiliation	Role
Frank Coale	Maryland	University of Maryland	Panel Chair
Deanna Osmond	North Carolina	North Carolina State University	Panel Member
Doug Beegle	Pennsylvania	Penn State University	Panel Member
Jack Meisinger	Maryland	USDA-Agriculture Research Service	Panel Member
Tom Fisher	Maryland	University of Maryland Center for Environmental Science	Panel Member
Quirine Ketterings	New York	Cornell University	Panel Member
Chris Brosch	Delaware	Delaware Department of Agriculture	Watershed Technical Workgroup representative
Matt Johnston	Maryland	University of Maryland, CBPO	Modeling Team representative
Technical support provided by Mark Dubin (University of Maryland, CBPO), Lindsey Gordon (CRC Staffer), and Steve Dressing (Tetra Tech).			

CBPO – Chesapeake Bay Program Office; CRC – Chesapeake Research Consortium; USDA – U.S. Department of Agriculture

2 Practice Definitions

Nutrient management has four basic components: the nutrient source, rate, timing, and placement. Each of these four components of NM are managed at the field or sub-field scale in a manner to support crop productivity, achieve high nutrient use efficiency by the growing crop, and to minimize nutrient loss to the environment. The four components of NM planning interact with each other on a site-specific basis and are modified by site-specific field management, soil properties, and weather conditions. Thus, the Panel defines Nutrient Management as the implementation of a site-specific combination of nutrient source, rate, timing, and placement into a strategy that seeks to optimize agronomic and environmentally efficient utilization N and P. Improvement in nutrient-use efficiency necessitates documentation of NM implementation strategies that are suitable for independent verification.

Nutrient management also provides other important benefits to the agricultural and the environmental communities. These benefits include long-standing educational opportunities conducted in various venues for a wide variety of audiences that convey the fundamentals of NM and state-of-the-science practices and assessment tools. It is essential that an initial baseline for NM implementation is established that allows estimation of progress over time. Application of NM BMPs will interrelate with other agricultural nonpoint source BMPs and communication with other BMP Expert Panels is essential to define appropriate implementation and crediting.

Nutrient management for Phase 6.0 of the Chesapeake Bay Program Watershed Model (the Phase 6 model) is separated into independent sets of elements for nitrogen (N) and phosphorus (P) management due to the marked difference in the use, fate, and transport of these nutrients in agricultural systems. The structures for both N and P nutrient management are similar, however, with supplemental management elements stacked onto a required core set of management elements.

Practice Name(s)

- Nitrogen (N) Core Nutrient Management BMP
- Phosphorus (P) Core Nutrient Management BMP
- Nitrogen (N) Rate Supplemental Nutrient Management BMP
- Nitrogen (N) Placement Supplemental Nutrient Management BMP
- Nitrogen (N) Timing Supplemental Nutrient Management BMP
- Phosphorus (P) Rate Supplemental Nutrient Management BMP
- Phosphorus (P) Placement Supplemental Nutrient Management BMP
- Phosphorus (P) Timing Supplemental Nutrient Management BMP

Core Nutrient Management BMPs

The elements of the N Core Nutrient Management BMP are found in Table 2. Application of a N Core NM BMP efficiency modifies the crop- and land-use-specific N application rate goal, which is based on Land-Grant University (LGU) crop fertilization recommendations, as modified by the CBP partnership. In an effort to determine the most practicable methodology for allocating fertilizer N to satisfy crop- and land-use-specific N application rate goals, the Agriculture Workgroup compared the modified LGU recommendations for application of supplemental inorganic N fertilizer to an alternative approach based on county-level redistribution of AAPFCO N fertilizer sales data. This methodological comparison indicated that there were relatively small differences between the two methods for estimating supplemental N fertilizer applications, leading the Agriculture Workgroup to approve use of the redistributed AAPFCO fertilizer sales methodology in the Phase 6 Model. The Panel recommends that similar comparative analyses be conducted in the future to evaluate newly available fertilizer sales data and to further evaluate the redistributed fertilizer sales methodology's forecasting ability. Inconsistencies between estimates generated by the two methods should be investigated and rectified based on data source quality and consistency using contiguous or regional county-level data.

Table 2. Elements of the Nitrogen Core Nutrient Management BMP

NITROGEN Core Nutrient Management BMP (ALL core elements required to be implemented and verified)
N rate according to LGU recommendations at field management unit level
Manure analysis and volume - test value or book value
Spreader/applicator calibration
Yield estimates and cropping plan at field management unit level
Cropping and manure history at field management unit level

The elements of the P Core Nutrient Management BMP are found in Table 3. Application of a P Core NM BMP efficiency modifies the crop- and land-use-specific P application rate goal, which is based on LGU crop fertilization recommendations, as modified by the CBP partnership. In practice, LGU recommendations for P application are based on crop- and site-specific soil-test P concentration. Currently, soil-test P concentration data are not available to the CBP. The NM Expert Panel recommends that, in the future, crop- and site-specific soil-test P concentration data should be collected, aggregated to the appropriate scale, summarized to eliminate disclosure of private confidential business information, and utilized as the foundation for determining P application rate goals and the appropriate application of P Core NM BMPs. In the absence of soil-test P based application rate goals, county-level redistribution of CBW AAPFCO P fertilizer sales data may serve as a surrogate.

Field management shall be considered compliant with LGU P fertilization recommendations when P application recommendations resulting from site-specific environmental risk assessments (i.e. P Index, P Site Index, P Management Tool, etc.) allow higher P application rates than the standard LGU soil-test based recommendations, after accounting for the site-specific potential for P loss to streams. In another example, Virginia nutrient management planners may utilize a more restrictive method known as the Phosphorus Environmental Threshold (PET) in lieu of soil-test P based recommendations when evaluating application of organic nutrient sources. Using the PET method, P from organic sources may be applied to fields that test less than a regionally-specified degree of soil P saturation, as quantified by Mehlich 1 soil-test P concentration. By physiographic region, the PET soil-test P thresholds are: 135 ppm – Eastern Shore & Lower Coastal Plain; 136 ppm - Middle & Upper Coastal Plain & Piedmont; and 162 ppm - Ridge and Valley. Nitrogen applications cannot exceed crop N needs when using PET. Additional details may be found in “Virginia Nutrient Management Standards and Criteria”, as revised July 2014. Other examples may be similarly applicable.

The P Core NM BMP requires a P soil test at the field management unit level. This required element may be waived if, as in the case of Pennsylvania’s manure management guidelines, restrictions on manure application (rates, timing, and placement) are imposed that limit total P application rates and management to the same degree as if there was a high P soil test.

Table 3. Elements of the Phosphorus Core Nutrient Management BMP

PHOSPHORUS Core Nutrient Management BMP (ALL core elements required to be implemented and verified)
P rate according to LGU recommendations at field management unit level. This may include P recommendations resulting from assessments that allow higher P application rates where the risk of P loss is low.
P soil tests at field management unit level. The requirement for having a P soil test may be waived if restrictions on manure application are imposed that limit total P application rates and management to the same degree as if there was a high P soil test.
Manure analysis and volume - test value or book value
Spreader/applicator calibration
Yield estimates and cropping plan at field management unit level
Cropping and manure history at field management unit level

Nutrient Management Supplemental BMPs

The Nitrogen (N) Nutrient Management Supplemental BMPs involve applying an efficiency credit for the N NM Supplemental BMP elements only after satisfactory implementation of the N Core NM BMP. Multiple advanced site assessments and N management tools may be utilized to inform the application of the appropriate N adjustment practices, but do not represent a N efficiency credit in and of themselves. A list of example N site assessments and N management tools is given in Table 4. This list is not intended to be exhaustive. Rather, Table 4 presents examples of current techniques and tools that the Panel deems potentially useful in supporting crediting of changes in N management and recognizes that this listing will need to be updated over time as new tools and procedures are developed.

Advanced site assessments and application of N management tools that result in a verifiable implementation of a change in planned N application rate, N application timing or N application placement may result in a N NM Supplemental BMP efficiency credit. The actual crediting of the Supplemental NM BMPs requires placing a given BMP into either a N Rate, or N Timing, or N Placement NM Supplemental BMP category (Tables 5 through 7). One single NM Supplemental BMP efficiency may be credited for each of the N Rate, N Timing, and N Placement categories. The actual values for these NM Supplemental BMP efficiency credits are presented later in this report (Table 14). Supplemental N NM BMP efficiency credits for N rate, N timing, and N placement are additive.

Table 4. Examples of advanced N site assessments and N management tools that may be used to support implementation of changes in originally planned N application rate, N application placement, and/or N application timing. Additional assessment techniques and tools may be utilized to support implemented changes in N management.

Advanced N Assessment Tools
PSNT
Manure analysis < 3 years old
On-farm replicated research
CSNT
N-loss risk assessments & models - Ammonia loss
Yield mapping
ISNT
On-farm strip trials
N-loss risk assessments & models - Leaching loss
FSNT
N-loss risk assessments & models - Denitrification losses
Whole farm balances
In-season sensors/remote sensing in general
Geo-spatial mapping

Example elements of the N Rate NM Supplemental BMP are listed in Table 5. Additional N management practices that result in reductions in the rate of applied N may be applicable.

Table 5. Elements of the Nitrogen (N) Rate Nutrient Management Supplemental BMP

N Rate Adjustment Practice (implementation of one or more BMPs required)
N rate less than LGU recommendations
Split N applications for reduced total rate
Variable rate N application

Example elements of the N Placement NM Supplemental BMP are listed in Table 6. Subsurface injection or incorporation applies only to inorganic fertilizer N. Incorporation or injection of manure is addressed by the Phase 6 Manure Injection & Incorporation Expert Panel report with the following practices: Manure Injection, Manure Incorporation High Disturbance, and Manure Incorporation Low Disturbance. Additional N management practices that result in purposeful physical placement of N sources such that that the potential for N loss to the environment is reduced and/or crop N-use efficiency is improved may be applicable.

Table 6. Elements of the Nitrogen (N) Placement Nutrient Management Supplemental BMP

N Placement Adjustment Practice (implementation of one or more BMPs required)
Subsurface injection or incorporation of applied Inorganic N
N application setbacks from water

Example elements of the N Timing NM Supplemental BMP are listed in Table 7. Additional N management practices that result in the enhanced precision of the timing of application of N sources that reduces the potential for N loss to the environment and/or improves crop N-use efficiency may be applicable.

Table 7. Elements of the Nitrogen (N) Timing Nutrient Management Supplemental BMP

N Timing Adjustment Practice (implementation of one or more BMPs required)
Split N applications
PSNT

The Phosphorus (P) Nutrient Management Supplemental BMPs involve applying an efficiency credit for the P NM Supplemental BMP elements only after satisfactory implementation of the P Core NM BMP. Multiple advanced site assessments and P management tools may be utilized to inform the application of the appropriate P adjustment practices, but do not represent a P efficiency credit in and of themselves. A list of example P site assessments and P management tools is given in Table 8. This list is not intended to be exhaustive. Rather, Table 8 presents examples of current techniques and tools that the Panel deems potentially useful in supporting crediting of changes in P management and will need to be updated over time as new tools and evaluative procedures are developed.

Advanced site assessments and application of P management tools that result in a verifiable implementation of a change in planned P application rate, P application timing or P application placement may result in a P NM Supplemental BMP efficiency credit. The actual crediting of the Supplemental NM BMPs requires placing a given BMP into either a P Rate, or P Timing, or P Placement NM Supplemental BMP category (Tables 9 through 11). One single P NM Supplemental BMP efficiency may be credited for each of the P Rate, P Timing, or P Placement categories. The actual values for these NM Supplemental BMP credits are presented later in the report (Table 15). NM Supplemental BMP efficiency credits for P rate, P timing, and P placement are additive.

Table 8. Examples of advanced P site assessments and P management tools that may be used to support implementation of changes in originally planned P application rate, P application placement, and/or P application timing. Additional assessment techniques and tools may be utilized to support implemented changes in P management.

Advanced P Assessment Tools
Soil test P remediation/declining
Soil tests < 3 years old
P Index assessment
Grid soil sampling
Manure analysis < 3 years old
On-farm replicated research
Yield mapping
On-farm strip trials
Whole farm balances
Geo-spatial mapping

Example elements of the P Rate NM Supplemental BMP are listed in Table 9. Additional P management practices that result in reductions in the rate of applied P may be applicable.

Table 9. Elements of the Phosphorus (P) Rate Nutrient Management Supplemental BMP

P Rate Adjustment Practice (implementation of one or more BMPs required)
P-based manure rate based on annual crop P removal
P rate less than LGU recommendations
Variable rate P
Split P applications

Example elements of the P Placement NM Supplemental BMP are listed in Table 10. The P placement practices of subsurface injection or incorporation apply only to inorganic fertilizer P. Incorporation or injection of manure P is addressed by the Phase 6 Manure Injection & Incorporation Expert Panel report with the following practices: Manure Injection, Manure Incorporation High Disturbance, and Manure Incorporation Low Disturbance. Additional P management practices that result in the purposeful physical placement of P sources such that the potential for P loss to the environment is reduced may be applicable.

Table 10. Elements of the Phosphorus (P) Placement Nutrient Management Supplemental BMP

P Placement Adjustment Practice (implementation of one or more BMPs required)
Subsurface injection or incorporation of applied inorganic P
P application setbacks from water

Example elements of the P Timing NM Supplemental BMP are listed in Table 11. Additional P management practices that result in the enhanced precision of the timing of application of P sources that reduces the potential for P loss to the environment may be applicable.

Table 11. Elements of the Phosphorus (P) Timing Nutrient Management Supplemental BMP

P Timing Adjustment Practice (implementation of one or more BMPs required)
P application in lower P-loss risk season

Figure 1 illustrates how the N Core NM BMP and the N NM Supplemental BMPs are combined for credit. As described above, N Supplemental BMPs can only be credited if the N Core NM BMP is implemented and verified. The N NM Supplemental BMPs do not result in additional credit unless implementation of adjustments in N rate, N placement, or N timing is verified. The N NM Supplemental BMPs are assigned to three groups: N Rate Adjustment Practices, N Placement Adjustment Practices, and N Timing Adjustment Practices. The NM Supplemental BMP efficiency credit for each of these three groups can be obtained if implementation of at least one effective practice from each group is verified. For example, if implementation of the N Core NM BMP is verified and implementation of both N application setbacks from water (a N placement adjustment) and variable rate N application (a N rate adjustment) are verified, efficiency credits may be claimed for the N Core NM and additional efficiency credit may be claimed for both the N Placement NM Supplemental BMP and the N Rate NM Supplemental BMP. In this example, no additional credit may be claimed for the N Timing NM Supplemental BMP.

Figure 2 illustrates how the P Core NM BMP and the P NM Supplemental BMPs are combined for credit. As described above, P Supplemental BMPs can only be credited if the P Core NM BMP is implemented and verified. The P NM Supplemental BMPs do not result in additional credit unless implementation of adjustments in P rate, P placement, or P timing is verified. The P NM Supplemental BMPs are assigned to three groups: P Rate Adjustment Practices, P Placement Adjustment Practices, and P Timing Adjustment Practices. The NM Supplemental BMP efficiency credit for each of these three groups can be obtained if implementation of at least one effective practice from each group is verified. For example, if implementation of the P Core NM BMP is verified and implementation of both P application setbacks from water (a P placement adjustment) and P-based manure rate based on annual crop P removal (a P rate adjustment) are verified, efficiency credits may be claimed for the P Core NM and additional efficiency credit may be claimed for both the P Placement NM Supplemental BMP and the P Rate NM Supplemental BMP. In this example, no additional credit may be claimed for the P Timing NM Supplemental BMP.

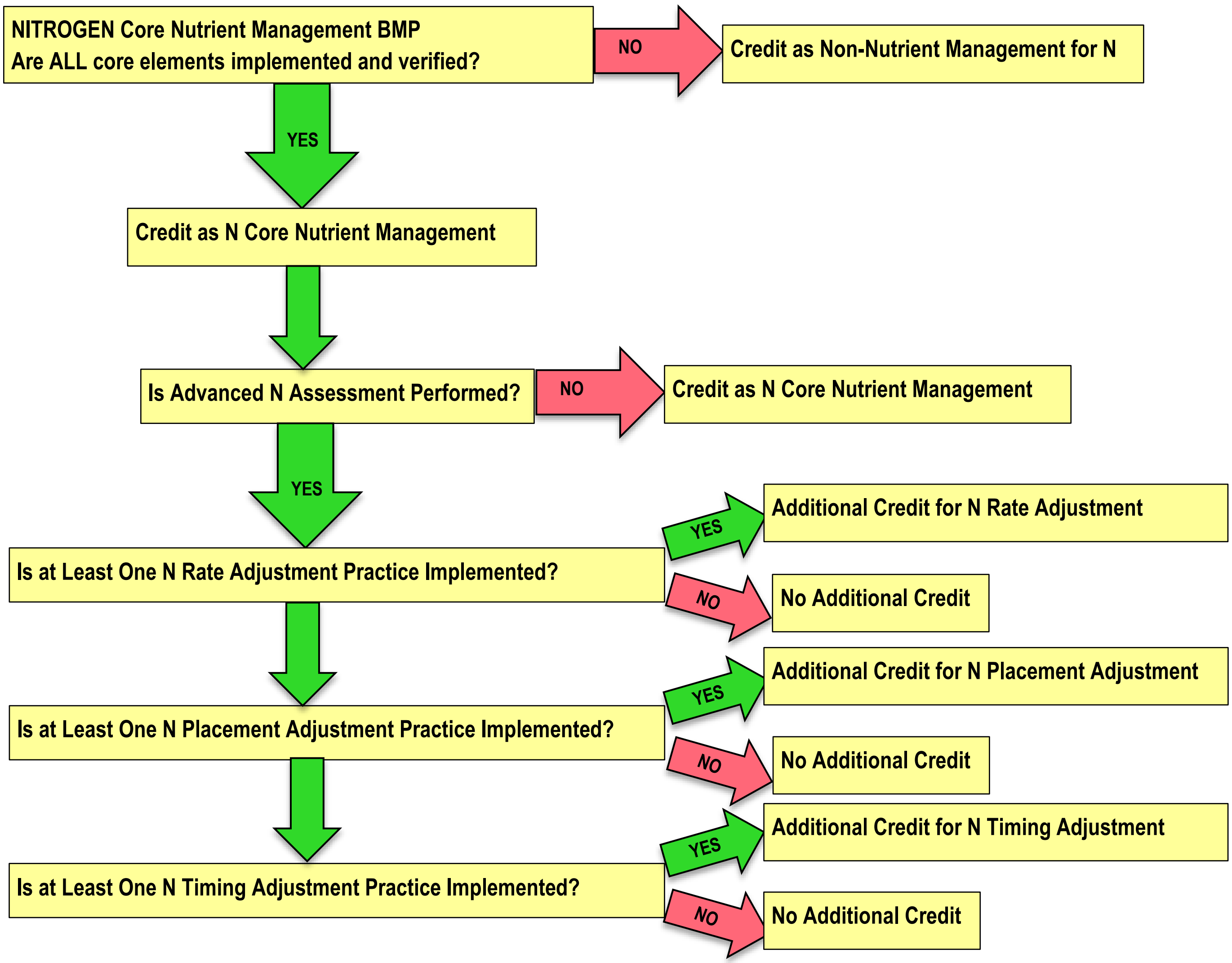

Figure 1. Linkage of Core and Supplemental N Nutrient Management Practices

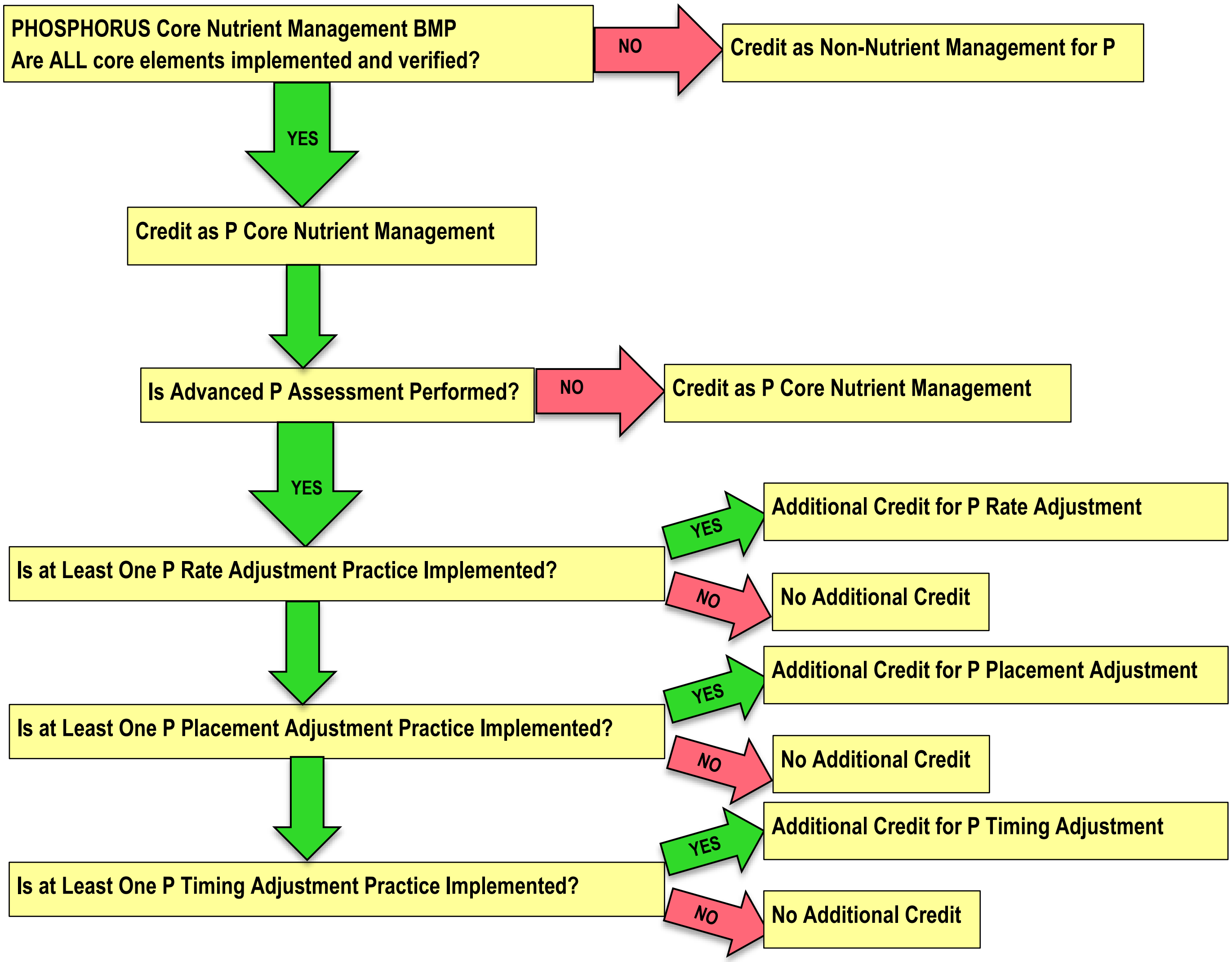

Figure 2. Linkage of Core and Supplemental P Nutrient Management Practices

2.1 NM Core and Supplemental Element Detailed Definitions

To better enable the CBP partnership and state agency partners to understand and apply the recommendations of the NM Panel to their unique programs and production systems, the following section provides additional descriptive details to each of the NM Core BMPs and Supplemental NM BMPs.

2.2 Nitrogen Core NM BMP Elements

- All five elements are required to be implemented and verified at the field management unit level to receive credit.
- N rate according to LGU recommendations at field management unit.
    - The elements of the N Core Nutrient Management BMP are found in Table 2. Application of a N Core NM BMP efficiency modifies the crop- and land-use-specific N application rate goal, which is based on Land-Grant University (LGU) crop fertilization recommendations, as modified by the CBP partnership. In an effort to determine the most practicable methodology for allocating fertilizer N to satisfy crop- and land-use-specific N application rate goals, the Agriculture Workgroup compared the modified LGU recommendations for application of supplemental inorganic N fertilizer to an alternative approach based on county-level redistribution of AAPFCO N fertilizer sales data. This methodological comparison indicated that there were relatively small differences between the two methods for estimating supplemental N fertilizer applications,

leading the Agriculture Workgroup to approve use of the redistributed AAPFCO fertilizer sales methodology in the Phase 6 Model. The Panel recommends that similar comparative analyses be conducted in the future to evaluate newly available fertilizer sales data and to further evaluate the redistributed fertilizer sales methodology's forecasting ability. Inconsistencies between estimates generated by the two methods should be investigated and rectified based on data source quality and consistency using contiguous or regional county-level data.
    - If applied N application rates are below the applicable LGU prescribed rates, and/or the CBP partnership modified application rates, the N application system may still qualify for credit as an equivalent N Core system if it meets the remaining four N Core elements.
    - A "field management unit" is described by the NM Panel as a common land management unit as defined by the farm operator with a similar annual crop production and management systems, and associated nutrient application system. The field management unit can represent any field, collection of multiple fields, or sub-portions of a single field that are managed the same way, with similar history and cropping practices.
- Manure analysis and volume – test value or book value.
    - Estimation of manure produced or nutrient analysis of that manure must be used in the planning process.
    - It is preferred that both manure volume and nutrient analyses be derived from manure sample testing using standard laboratory protocols.
    - In the absence of laboratory manure analysis data, published manure nutrient analyses from LGUs, national agricultural agencies (ex. USDA-ARS, USDA-NRCS), national or regional farm service organizations (ex. Mid-West Plan Service), or historical analyses generated from very similar, local and consistently managed industry-contracted operations may be used.
    - If a laboratory manure analysis is used to adjust the nutrient application, it must be less than three-years old and preferably the manure analysis was within one-year of the application.
- Spreader/applicator calibration.
    - The equipment being used to perform the nutrient applications by the farm operator needs to be documented and verified that the machine(s) have been calibrated either according to manufacturer specifications or by standard calibration practices within one year of the application.
    - The custom applicator and equipment calibration certifications for commercial applicators can be used as an equivalent verification documentation for calibrated nutrient applications.
- Yield estimates and cropping plan at field management unit level.
    - Annual yield estimates for field management units should be based on field yield samples, calibrated electronic yield monitors, or field specific grain elevator receipts.
    - Historic yield goals are determined using a LGU or state standardized method of averaging annual yields over time to account for annual variability (e.g. average yield is based on best three out of the past 5 years).
    - A less preferred but equivalent method is to use standard USDA soil productivity book values for estimating applicable yields.
    - The cropping plan refers to the planting and harvesting of the specific crop(s) for which the field nutrient applications were based. An example of a field that would <u>not</u> qualify under this required element is when the nutrient application was based on the plant requirements for grain corn but, due to in-season management decisions, the field was planted to soybeans instead.
- Cropping/manure history at field management unit level.
    - As part of developing a planned nutrient application rate, the farm operator or custom applicator considered legume residual N credits based on LGU or national agricultural service (ex. USDA) recommendations.
    - The manure application history during the crop rotation must be considered, including appropriate manure mineralization crediting.
    - Verified documentation of manure mineralization N credits are included as part of the nutrient balance to account for at least the three prior years.
    - Legume residual N credits are included as part of the nutrient balance to account for at least the immediately preceding year.
- Federal and/or state certified Nutrient Management Plan not required.
    - The NM Panel did not define the N Core NM BMP to require a comprehensive and/or certified Nutrient Management Plan (NMP) in order to receive the BMP credit. Rather, independent documentation and verification that all of the required elements of the N Core NM BMP were implemented is required.

- The five elements that constitute the N Core NM BMP may or may not be components of a formal Nutrient Management Plan.
- States may propose equivalent practices to satisfy these requirements that must be approved by the Agriculture Workgroup.

2.3 Phosphorus Core NM BMP Elements

- All six elements are required to be implemented and verified at the field management unit level to receive credit.
- P rate according to LGU recommendations at field management unit level. This may include P recommendations resulting from assessments that allow higher P application rates where the risk of P loss is low.
  - Application of a P Core NM BMP efficiency modifies the crop- and land-use-specific P application rate goal, which is based on LGU crop fertilization recommendations, as modified by the CBP partnership. In practice, LGU recommendations for P application are based on crop- and site-specific soil-test P concentration. Currently, soil-test P concentration data are not available to the CBP. The NM Expert Panel recommends that, in the future, crop- and site-specific soil-test P concentration data should be collected, aggregated to the appropriate scale, summarized to eliminate disclosure of private confidential business information, and utilized as the foundation for determining P application rate goals and the appropriate application of P Core NM BMPs.
  - In the absence of soil-test P based application rate goals, county-level redistribution of CBW AAPFCO P fertilizer sales data may serve as a surrogate.
  - If applied P application rates are below the applicable LGU prescribed rates, and/or the CBP partnership modified application rates, the P application system may still qualify for credit as an equivalent P Core NM system if it meets the remaining five P Core elements.
  - A "field management unit" is described by the NM Panel as a common land management unit as defined by the farm operator with a similar annual crop production and management systems, and associated nutrient application system. The field management unit can represent any field, collection of multiple fields, or sub-portions of a single field that are managed the same way, with similar history and cropping practices.
- P soil tests at field management unit level. The requirement for having a P soil test may be waived if restrictions on manure application (rates, timing, placement), are imposed that limit P application rates and management to the same degree as if there was a high P soil test.
  - A soil laboratory analysis is required to be obtained from the field management unit using standard protocols.
  - If a laboratory soil analysis being used to adjust the nutrient application, it must be less than three-years old, and preferably within one-year of the application.
  - In the absence of an available soil P laboratory analysis, P nutrient applications may be based on annual crop removal at the field management unit level as an equivalent P Core element based on applicable LGU recommendations.
- Manure analysis and volume – test value or book value.
  - Estimation of manure produced or nutrient analysis of that manure must be used in planning process.
  - In the absence of laboratory manure analysis data, published manure nutrient analyses from LGUs, national agricultural agencies (ex. USDA-ARS, USDA-NRCS), national or regional farm service organizations (ex. Mid-West Plan Service), or historical analyses generated from very similar, local and consistently managed industry-contracted operations may be used.
  - If a laboratory manure analysis being used to adjust the nutrient application, it must be less than three-years old, and preferably within one-year of the application.
- Spreader/applicator calibration
  - The equipment being used to perform the nutrient applications by the farm operator needs to be documented and verified that the machine(s) have been calibrated either according to manufacturer specifications or by standard calibration practices within one year of the application.
  - The custom applicator and equipment calibration certifications for commercial applicators can be used as an equivalent verification documentation for calibrated nutrient applications.
- Yield estimates and cropping plan at management unit level
  - Annual yield estimates should be based on field yield samples, calibrated electronic yield monitors, or field specific grain elevator receipts.
  - Historic yield goals are determined using a LGU or state standardized method of averaging annual yields over

    - time to account for annual variability (e.g. average yield based on the best three out of the past 5 years).
    - A less preferred but equivalent method is to use standard USDA soil productivity book values for estimating applicable crop yield.
    - The cropping plan refers to the planting and harvesting of the specific crop(s) for which the field nutrient applications were based. An example of a field that would <u>not</u> qualify under this required element is when the nutrient application was based on the plant requirements for grain corn but, due to in-season management decisions, the field was planted to soybeans instead.
- Cropping/manure history at field management unit level
    - As part of developing a planned nutrient application rate, the farm operator or custom applicator considered legume residual N credits based on LGU or national agricultural service (ex. USDA) recommendations.
    - The manure application history during the crop rotation must be considered, including appropriate manure mineralization crediting.
    - Verified documentation of manure mineralization N credits are included as part of the nutrient balance to account for at least the three prior years.
    - Legume residual N credits are included as part of the nutrient balance to account for at least the immediately preceding year.
- Federal and/or state certified Nutrient Management Plan not required.
    - The NM Panel did not define the N Core NM BMP to require a comprehensive and/or certified Nutrient Management Plan (NMP) in order to receive the BMP credit. Rather, independent documentation and verification that all of the required elements of the N Core NM BMP were implemented is required.
    - The five elements that constitute the N Core NM BMP may or may not be components of a formal Nutrient Management Plan.
- States may propose equivalent practices to satisfy these requirements that must be approved by the Agriculture Workgroup.

2.4 Nitrogen NM Supplemental BMPs

- Advanced N assessment Tools.
    - Need documentation of use of one or a combination of these tools.
    - These tools should guide implementation of N rate, placement, or timing.
    - Conducting these assessments or using these tools have no impact unless they lead to a change in implementation of N rate, N placement or N application timing.
    - This list is not exhaustive or comprehensive, and only represents a selection of examples that would constitute tools resulting in an implementation change.
- N Rate Adjustment Practices.
    - By implementing one or more of the practices listed, an additional N credit will be applied. However, implementing more than one of the practices captured under each supplemental practice category will only result in one credit for the practice adjustment.
    - Within the N Rate Adjustment Practice, the rate of application can be less than the LGU recommendation or consistent with partnership approved rate applications, but in order to receive supplemental credit, the rate of application must be below the rate listed for the N Core NM BMP.
    - Split applications over time per crop. Total amount of N application may or may not change, but the application is divided into multiple, lower-rate applications throughout the year.
    - Variable rate N application implies that N is applied at a variety of different application rates within a management unit based on historical data of spatially variable crop response due to soil type, drainage, etc. or due to in-season data from optical crop sensors.
- N Placement Adjustment Practices.
    - Where the N nutrient source is physically located or placed relative to the soil surface.
    - Subsurface injection or incorporation of applied inorganic N.
    - Immediate incorporation generally means within 24 hours of application.

    - N application setbacks from water: purposefully not applying Nitrogen to cropped land area adjacent to surface water bodies.
    - Applies to both manure and fertilizer.
    - Credit applies to entire field management unit.
- N Timing Adjustment Practices.
    - Split applications over time per crop. Total amount of N does not change, but application is divided into multiple applications throughout the year.

2.5 Phosphorous NM Supplemental BMPs

- Advanced P assessment Tools.
    - Need documentation of use of one or a combination of these tools.
    - These tools should guide implementation of rate, placement, or timing.
    - Conducting these assessments or using these tools have no impact unless they lead to a change in implementation of rate, placement, or timing.
    - This list is not exhaustive or comprehensive, and only represents a selection of example that would constitute tools resulting in an implementation change.
- P Rate Adjustment Practices.
    - By implementing one or more of the practices listed, an additional P credit will be applied. However, implementing more than one of the practices captured under each supplemental practice category will only result in one credit for the practice adjustment.
    - Within the P Rate Adjustment Practice, the rate of application can be less than the LGU recommendation or consistent with partnership approved rate applications, but in order to receive supplemental credit, the rate of application must be below the rate listed for the P Core NM BMP.
    - Split applications over time per crop. Total amount of P application may or may not change, but the application is divided into multiple, lower-rate applications throughout the year.
    - Variable rate P application implies that P is applied at variety of different applications rates within the management unit based spatially variable crop response due to soil type, drainage, etc. or due to in-season data from optical crop sensors.
    - A P-based manure application rate equivalent to annual crop P removal is an equivalent rate adjustment practice.
- P Placement Adjustment Practices.
    - Where the P nutrient source is physically located or placed relative to the soil surface.
    - Subsurface injection or incorporation of applied inorganic N.
    - Immediate incorporation generally means within 24 hours of application.
    - Phosphorus application setbacks from water: purposefully not applying P to cropped land area adjacent to surface water bodies.
    - Applies to both manure and fertilizer.
    - Credit applies to entire field management unit.
    - Application of manure on different fields based on the P Index assessment that results in manure application on a lower P Index rated field rather than a higher P Index rated field.
- P Timing Adjustment Practices.
    - Split applications over time per crop. Total amount of P does not change, but application is divided into multiple applications throughout the year.
    - P application in lower P-loss risk season.
    - Purposeful change the timing of manure application based on the P Index assessment that results in manure application at a time during the calendar year when the P Index assessment indicates a lower risk for P loss.

3 Effectiveness Estimates

This section begins with a brief summary of the approved N and P effectiveness estimates, or efficiencies, for N and P Core NM BMPs and N and P NM Supplemental BMPs. This summary is followed by a discussion of the rationale and use of specific data values from the available literature to develop the recommended efficiencies. Finally, details are provided on how the recommended efficiencies for Core NM BMPs and the NM Supplemental BMPs can be combined to reflect actual N and P management at a specific location.

3.1 Summary of Effectiveness Estimates

All numeric values for Core NM BMP efficiencies and NM Supplemental BMP efficiencies have been defined by the Panel.

3.1.1. N Core NM BMPs

The Panel's proposed efficiencies for N Core NM BMPs for each applicable agricultural land use category are given in Table 12. These efficiencies are based on state LGU recommendations, as modified by the CBP partnership, and apply to the nutrient application rate goal, or input side, of nutrient management modeling scheme. Each efficiency value represents a multiplicative modifier of the crop- and land-use-specific N application rate goal utilized in the CBP models.

Table 12. Core N Nutrient Management Efficiency Values

Land Use	Nutrient Management BMP	
	Nitrogen Core *Non-Nutrient Management* BMP Efficiency	Nitrogen Core *Nutrient Management* BMP Efficiency
Full Season Soybeans	1.20	1.00
Grain w/ Manure	1.30	1.00
Grain w/o Manure	1.20	1.00
Legume Hay	1.20	1.00
Silage w/ Manure	1.40	1.00
Silage w/o Manure	1.20	1.00
Small Grains and Grains	1.20	1.00
Small Grains and Soybeans	1.20	1.00
Specialty Crop High	1.30	1.00
Specialty Crop Low	1.20	1.00
Other Agronomic Crops	1.10	1.00
Other Hay	1.00	1.00
Pasture	1.00	1.00

3.1.2. P Core NM BMPs

The Panel's proposed efficiencies for P Core NM BMPs for each applicable agricultural land use category are given in Table 13. These efficiencies are based on state LGU recommendations, as modified by the CBP partnership, and apply to the nutrient application rate goal, or input side, of the nutrient modeling scheme for both NM and non-NM acres. Each efficiency value represents a multiplicative modifier of the crop- and land-use-specific P application rate goal utilized in the CBP models. For crops and land uses in which manure is applied, manure applications that result in manure P application rates that are greater than or equal to the crop-specific P application need results in the prohibition of application of additional fertilizer P. An exception to the prohibition of supplemental fertilizer P addition following manure application is the utilization of relatively small quantities of starter fertilizer P, typically applied subsurface in the planting row, according to LGU recommendations. For crops and land uses in which manure is applied, the total quantity of manure P associated with the total manure application rate should be allocated to the subject acreage.

Table 13. Core P Nutrient Management Efficiency Values

Land Use	Nutrient Management BMP	
	Phosphorus Core *Non-Nutrient Management* BMP efficiency	Phosphorus Core *Nutrient Management* BMP efficiency
Full Season Soybeans	1.50	1.00
Grain w/ Manure	3.00	1.00
Grain w/o Manure	1.50	1.00
Legume Hay	1.00	1.00
Silage w/ Manure	3.00	1.00
Silage w/o Manure	1.50	1.00
Small Grains and Grains	1.50	1.00
Small Grains and Soybeans	1.50	1.00
Specialty Crop High	2.00	1.00
Specialty Crop Low	2.00	1.00
Other Agronomic Crops	1.50	1.00
Other Hay	1.00	1.00
Pasture	1.00	1.00

3.1.3. N Nutrient Management Supplemental BMPs

The Panel's proposed efficiencies for N NM Supplemental BMPs for each applicable agricultural land use category are given in Table 14. These efficiencies apply multiplicative modifiers to edge-of-stream delivery of N, on the output side of the CBP modeling scheme, and can only be applied if the requirements for N Core NM BMP are met.

Table 14. N Nutrient Management Supplemental BMP Efficiency Values

Land Use	Nutrient Management BMP		
	N Rate *Supplemental* BMP Efficiency	N Placement *Supplemental* BMP Efficiency	N Timing *Supplemental* BMP Efficiency
Full Season Soybeans	1.00	1.00	1.00
Grain w/ Manure	0.85	0.95	0.90
Grain w/o Manure	0.95	0.97	0.95
Legume Hay	1.00	1.00	1.00
Silage w/ Manure	0.85	0.95	0.90
Silage w/o Manure	0.95	0.97	0.95
Small Grains and Grains	0.95	0.97	0.90
Small Grains and Soybeans	0.95	0.97	0.90
Specialty Crop High	0.85	0.95	0.95
Specialty Crop Low	0.95	0.97	0.95
Other Agronomic Crops	0.95	0.97	0.95
Other Hay	1.00	1.00	1.00
Pasture	1.00	1.00	1.00

3.1.4. P Nutrient Management Supplemental BMPs

The Panel's proposed efficiencies for P NM Supplemental BMPs for each applicable agricultural land use category are given in Table 15. These efficiencies apply multiplicative modifiers to edge-of-stream delivery of P, on the output side of the CBP modeling scheme, and can only be applied if the requirements for P Core NM BMP are met.

Table 15. P Nutrient Management Supplemental BMP Efficiency Values

Land Use	Nutrient Management BMP		
	P Rate ***Supplemental*** **BMP Efficiency**	**P Placement** ***Supplemental*** **BMP Efficiency**	**P Timing** ***Supplemental*** **BMP Efficiency**
Full Season Soybeans	0.95	0.90	0.99
Grain w/ Manure	0.90	0.80	0.80
Grain w/o Manure	0.95	0.90	0.99
Legume Hay	0.99	0.90	0.99
Silage w/ Manure	0.90	0.80	0.80
Silage w/o Manure	0.95	0.90	0.99
Small Grains and Grains	0.95	0.90	0.99
Small Grains and Soybeans	0.95	0.90	0.99
Specialty Crop High	0.95	0.90	0.99
Specialty Crop Low	0.95	0.90	0.99
Other Agronomic Crops	0.95	0.90	0.99
Other Hay	1.00	1.00	1.00
Pasture	1.00	1.00	1.00

3.2 Justification for Effectiveness Estimates

The Panel developed the proposed Phase 6 NM efficiency estimates through a synthesis of applicable scientific literature (see References section) and the collective best professional judgment of the NM Panel members (see Table 1). The membership of the Panel represents over 150 years of direct involvement in research, implementation and education on agricultural nutrient management practices. The entire body of research represented by the citations presented in the References section provided the foundation for the Panel's professional assessment of the effectiveness of the proposed NM BMPs. The efficiency factors presented for the Core NM BMPs and the NM Supplemental BMPs represent either a collection of required elements or represent the impact of numerous applicable on-site management practices. Therefore, in order to develop broadly pertinent NM BMP efficiency factors, multiple sources of information and data were necessarily synthesized through the expert lens of the Panel.

For both N and P BMPs, nutrient management practices are implemented at either the field or sub-field level. The diverse landforms, hydrology, climate and cropping systems of the agricultural landscapes in the CBW have a multitude of impacts on biogeochemical transformations of N and P in the agro-ecosystem. Changes in hydrological pathways alone can have dramatic effects on nutrient loads to streams when viewed from the Atlantic Coastal Plain to the Appalachian Plateau. Therefore, site-specific physical conditions and management factors have a strong influence on the effectiveness of imposed conservation practices. Nutrient management BMP effectiveness must represent the average condition over a wide range of real-world scenarios. Thus, it was incumbent upon the Panel to distill numerous lines of evidence to arrive at a single efficiency value for each of the N and P BMPs that could be applied equitably across the CBW.

3.3 Method for Applying Core and Supplemental BMP Efficiencies

Application of the N Core NM BMP efficiency modifies the crop- and land-use-specific N application rate goal, which is based on LGU crop fertilization recommendations, as modified by the CBP partnership. These efficiencies apply to the nutrient application rate goal, or input side, of CBP nutrient modeling scheme for both NM and non-NM acres. Each efficiency value represents a multiplicative modifier of the crop- and land-use-specific N application rate goal utilized in the CBP models.

Application of efficiency credits for N NM Supplemental BMP elements requires satisfactory implementation of all respective N Core NM BMP elements. The N NM Supplemental BMP efficiencies apply multiplicative modifiers to edge-of-stream delivery of N, on the output side of the CBP modeling scheme, and can only be applied if the requirements for N Core NM BMP are met. Multiple advanced site assessments and N management tools may be utilized to inform the application of appropriate N adjustment practices, but do not represent a N efficiency credit in and of themselves. Advanced site assessments and application of N management tools that result in implementation of a verifiable change in planned N application rate, N application timing, or N application placement may result in a N NM Supplemental BMP efficiency credit. Supplemental N NM BMP efficiency credits for N rate, N timing, and N placement are additive. Only one Supplemental BMP efficiency for N rate, one Supplemental BMP efficiency for N timing, and one Supplemental BMP efficiency for N placement may be applied.

Application of the P Core NM BMP efficiency modifies the crop- and land-use-specific P application rate goal, which is based on LGU crop fertilization recommendations, as modified by the CBP partnership. These efficiencies apply to the nutrient application rate goal, or input side, of the nutrient modeling scheme for both NM and non-NM acres. Each efficiency value represents a multiplicative modifier of the crop- and land-use-specific P application rate goal utilized in the CBP models. For crops and land uses in which manure is applied, manure applications that result in manure P application rates that are greater than or equal to the crop-specific P application need results in the prohibition of application of additional fertilizer P. For crops and land uses in which manure is applied, the total quantity of manure P associated with the total manure application rate is allocated to the subject acreage.

Application of efficiency credits for P NM Supplemental BMP elements requires satisfactory implementation of all respective P Core NM BMP elements. The P NM Supplemental BMP efficiencies apply multiplicative modifiers to edge-of-stream delivery of P, on the output side of the CBP modeling scheme, and can only be applied if the requirements for P Core NM BMP are met. Multiple advanced site assessments and P management tools may be utilized to inform the application of the appropriate P adjustment practices, but do not represent an P efficiency credit in and of themselves. Advanced site assessments and application of P management tools that result in a verifiable implementation of a change in planned P application rate, P application timing, or P application placement may result in a P NM Supplemental BMP efficiency credit. Supplemental BMP efficiency credits for P rate, P timing, and P placement are additive. Only one Supplemental BMP efficiency for P rate, one Supplemental BMP efficiency for P timing, and one Supplemental BMP efficiency for P placement may be applied.

The approach for applying both core and supplemental nutrient management efficiency values is summarized in

Table 16. Figure 3 and Figure 4 illustrate the decision tree for assigning credits.

Table 16. Summary of Method for Applying Nutrient Management BMP Efficiencies

Nutrient Management BMP	**Action of BMP**	**How the math works**
Nitrogen Core **Non-Nutrient Management** BMP efficiency	modifies N application rate goal on the nutrient input side	efficiency is multiplied by the LGU N application rate goal
Nitrogen Core **Nutrient Management** BMP efficiency	modifies N application rate goal on the nutrient input side	efficiency is multiplied by the LGU N application rate goal
N Rate Supplemental BMP efficiency	modifies edge of field N loss to the stream on the outflow side	efficiency is multiplied by the calculated edge of field N load
N Placement Supplemental BMP efficiency	modifies edge of field N loss to the stream on the outflow side	efficiency is multiplied by the calculated edge of field N load
N Timing Supplemental BMP efficiency	modifies edge of field N loss to the stream on the outflow side	efficiency is multiplied by the calculated edge of field N load
Phosphorus Core **Non-Nutrient Management** BMP efficiency	modifies P application rate goal on the nutrient input side	efficiency is multiplied by the LGU P application rate goal
Phosphorus Core **Nutrient Management** BMP efficiency	modifies P application rate goal on the nutrient input side	efficiency is multiplied by the LGU P application rate goal
P Rate Supplemental BMP efficiency	modifies edge of field P loss to the stream on the outflow side	efficiency is multiplied by the calculated edge of field P load
P Placement Supplemental BMP efficiency	modifies edge of field P loss to the stream on the outflow side	efficiency is multiplied by the calculated edge of field P load
P Timing Supplemental BMP efficiency	modifies edge of field P loss to the stream on the outflow side	efficiency is multiplied by the calculated edge of field P load

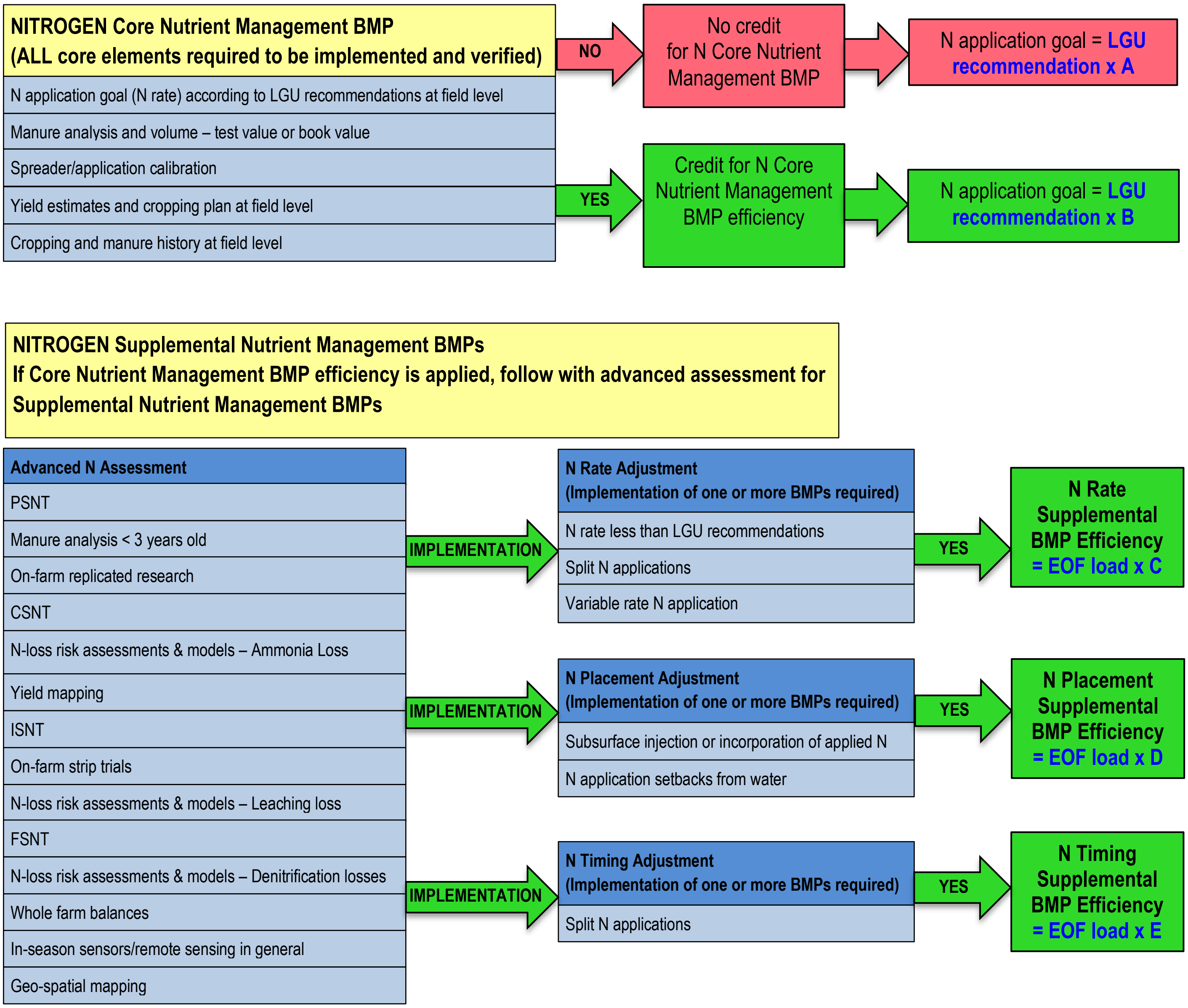

Figure 3. Assignment of N Nutrient Management Credits. Variables A and B refer to the land use specific N Core Non-Nutrient Management BMP efficiency and the N Core Nutrient Management BMP efficiency, respectively, as presented in Table 12. Variables C, D and E refer to the land use specific N Rate Supplemental BMP efficiency, the N Placement Supplemental BMP efficiency and the N Timing Supplemental BMP efficiency, respectively, as presented in Table 14.

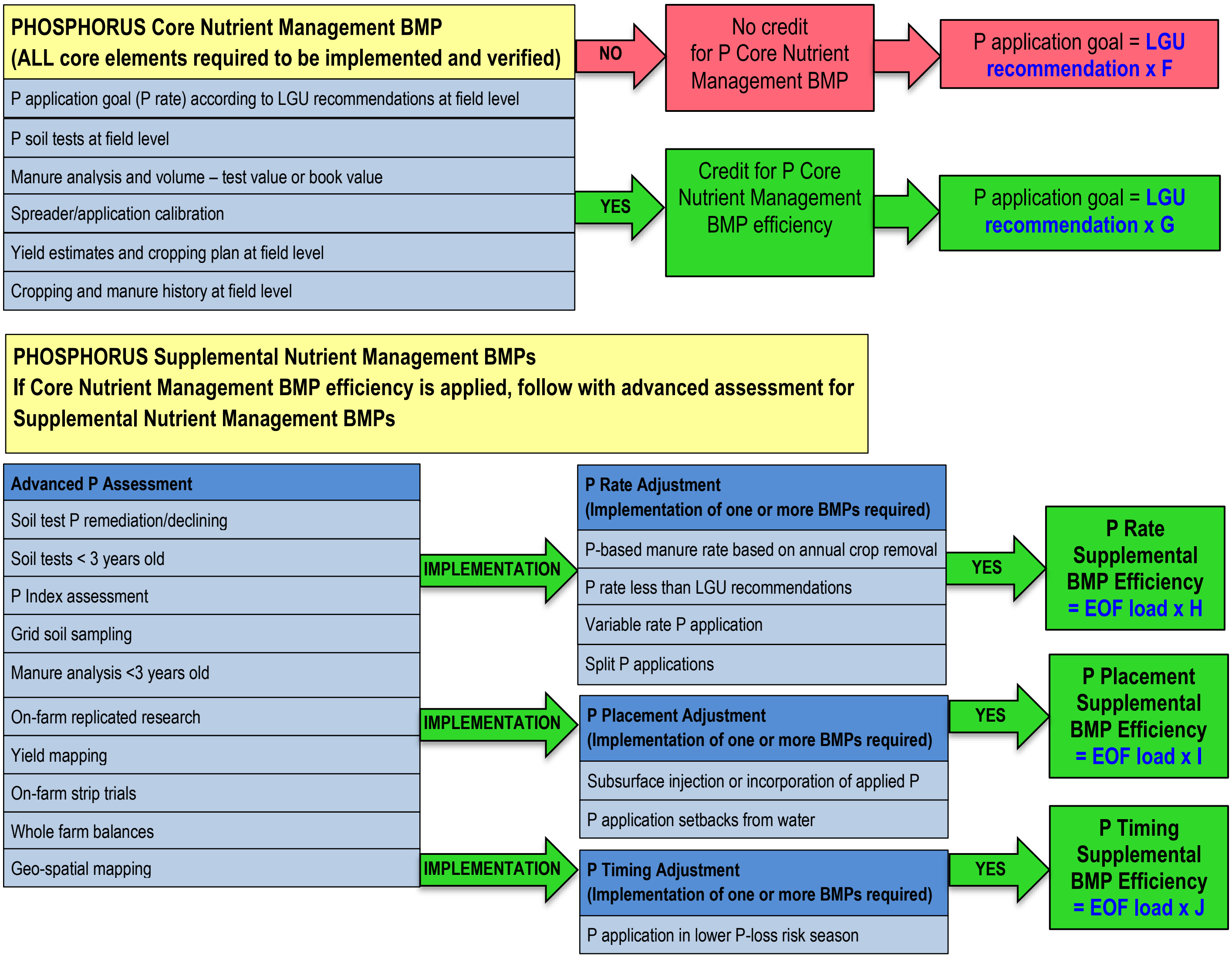

Figure 4. Assignment of P Nutrient Management Credits. Variables F and G refer to the land use specific P Core Non-Nutrient Management BMP efficiency and the P Core Nutrient Management BMP efficiency, respectively, as presented in Table 13. Variables H, I and J refer to the land use specific P Rate Supplemental BMP efficiency, the P Placement Supplemental BMP efficiency and the P Timing Supplemental BMP efficiency, respectively, as presented in Table 15.

4 Review of Literature and Data Gaps

4.1 The Available Science for N BMPs

Crop- and land-use-specific N application rate goal should be based on LGU crop fertilization recommendations, as modified by the CBP partnership. In an effort to determine the most practicable methodology for allocating fertilizer N to satisfy crop- and land-use-specific N application rate goals, the Agriculture Workgroup compared the modified LGU recommendations for application of supplemental inorganic N fertilizer to an alternative approach based on county-level redistribution of AAPFCO N fertilizer sales data. This methodological comparison indicated that there were relatively small differences between the two methods for estimating supplemental N fertilizer applications, leading the Agriculture Workgroup to approve use of the redistributed AAPFCO fertilizer sales methodology in the Phase 6 Model. The Panel maintains that LGU recommendations should continue to serve as the foundation for crop and landuse-specific N application goals and suggests that similar comparative analyses be conducted in the future as new fertilizer sales data become available. Inconsistencies between estimates generated by the two methods should be further investigated and rectified based on data source quality and consistency with contiguous or regional county-level data.

Nutrient management practices are implemented at either the field or sub-field level. The diverse landforms, hydrology, climate and cropping systems of the agricultural landscapes in the CBW have a multitude of impacts on biogeochemical transformations of N in the agro-ecosystem. Changes in hydrological pathways alone can have dramatic effects on crop N utilization efficiency and N loads to streams when viewed from the Atlantic Coastal Plain to the Appalachian Plateau. Therefore, site-specific physical conditions and management factors have a strong influence on the effectiveness of imposed conservation practices. Nutrient management BMP effectiveness must represent the average condition over a wide range of real-life scenarios. Thus, it was incumbent upon the Panel to distill numerous lines of evidence to arrive at a single efficiency value for N BMPs that could be applied equitably across the CBW.

4.2 The Available Science for P BMPs

Similar to N, crop and landuse-specific P application rate goal should be based on LGU crop fertilization recommendations, as modified by the CBP partnership. However, in practice, LGU recommendations for P application are based on crop- and site-specific soil-test P concentration. Currently, soil-test P concentration data are not available to the CBP. The NM Expert Panel recommends that, in the future, crop- and site-specific soil-test P concentration data should be collected, aggregated to the appropriate scale, summarized to eliminate disclosure of private confidential business information, and utilized as the foundation for determining P application rate goals and the appropriate application of P Core NM BMPs. In the absence of soil-test P based application rate goals, county-level redistribution of AAPFCO P fertilizer sales data may serve as a surrogate. An essential assumption that must be imposed when county-level redistribution of AAPFCO P fertilizer sales data is utilized in lieu of site-specific soil-test P concentration data is the assumption of a county-average soil-test P concentration. Currently, a “medium” soil-test P condition was assumed for all situations and locations. Imposition of the “medium” soil test P assumption across the entire CBW is a gross over-simplification of the complex site-specific biogeochemical processes and on-site management practices that determine P fate and transport in the agro-ecosystem. The CBP should strive to rectify this shortcoming in future iterations of the modeling suite.

As stated above relative to N, nutrient management practices are implemented at either the field or sub-field level. The diverse landforms, hydrology, climate and cropping systems of the agricultural landscapes in the CBW have a multitude of impacts on biogeochemical transformations of P in the agro-ecosystem. Therefore, site-specific physical conditions and management factors have a strong influence on the effectiveness of imposed conservation practices. Nutrient management BMP effectiveness must represent the average condition over a wide range of real-life scenarios. Thus, it was incumbent upon the Panel to distill numerous lines of evidence to arrive at a single efficiency value for the P BMPs that could be applied equitably across the CBW.

5 Application of Practice Estimates

5.1 Load Sources

Nutrient management can be applied to specified land uses everywhere within the Chesapeake Bay watershed. The N Core BMP and the P Core BMP, as well as the N and P Supplemental BMPs, apply to each of the partnership approved Phase 6 agricultural land uses listed in

Table 17.

Table 17. Land Uses to Which the Nutrient Management Practices Apply

Land Use	Description
Full Season Soybeans	Soybeans ineligible for double cropping
Grain with Manure	Corn or sorghum for grain eligible for manure application and ineligible for double cropping
Grain without Manure	Corn or sorghum for grain ineligible for manure application and ineligible for double cropping
Silage with Manure	Corn or sorghum for silage eligible for manure application and ineligible for double cropping
Silage without Manure	Corn or sorghum for silage ineligible for manure application and ineligible for double cropping
Legume Hay	Legume forage crops eligible for manure
Small Grains and Grains	Small grains and grains other than corn or sorghum eligible for manure and ineligible for double cropping
Small Grains and Soybeans	Soybeans double cropped with small grains and ineligible for manure
Specialty Crop High	Specialty crops with relatively high nutrient inputs with some crops eligible for manure
Specialty Crop Low	Specialty crops with relatively low nutrient inputs with some crops eligible for manure
Other Agronomic Crops	Other high commodity row crops such as tobacco, cotton, etc., with some crops eligible for manure
Other Hay	Non-legume forage crops eligible for manure
Pasture	Grazed land that receives direct manure deposition from animals

5.2 Practice Baseline

The Panel recommends that historic implementation on a state-by-state basis be based on the premise that the baseline of 1985 is set at zero, or near zero acres for N Core NM BMP implementation and the highest level of implementation be represented at 2015 reported implementation acreages. Similarly, the zero baseline for the P Core NM BMP should be set to the date when each state introduced P-based NM requirements and the highest level of implementation be represented at 2015 reported implementation acreages. Due to the differences between state Nutrient Management program initiation dates and implementation reporting for the six-state partnership, the "baseline" year is recommended to reflect these state partnership differences. Thus, the initial Nutrient Management implementation year for each state will be unique.

The increasing level of historic implementation between the state Nutrient Management program initiation year and the 2015 reported implementation acreages represent two points in time on a state-by-state basis. The intervening annual representation of implementation acreages may be represented as a linear progression, in the absence of robust implementation data. Historic implementation estimation shall consider additional sources of N and P reduction credits commensurate with State QAPPs currently in place, given they are consistent with the BMPs and efficiency credits described by the Nutrient Management Expert Panel.

In cooperation with the CBPO, a state-by-state representation of reported NM implementation is included as Appendix A. The state-by-state representation was developed for historical N Core NM and P Core NM BMP implementation.

Historical N Core NM BMP implementation methodology:

- Assume straight-line interpolation between 2015 Progress acres and a starting year for each state.
- Starting year was evaluated by looking at historic NEIEN data to determine when states started reporting information.

- 2015 Progress has acres on crop, pasture and hay. Interpolation was made for each of these categories.
- Interpolation was made in each county.
- Assume all acres on crops for NY, PA, and WV only apply to crop acres eligible for receiving manure.
- Assume all acres on crops for DE, MD and VA can be distributed to crop acres with or without manure.
- All acres assumed to qualify for N Core NM BMP.

Historical P Core NM BMP implementation methodology would be similar to the N Core NM BMP implementation methodology above, except for variable starting years for each state.

A second independent source of data representing historic Nutrient Management implementation has been requested from the USDA Natural Resources Conservation Service (NRCS) Conservation Effects Assessment Project (CEAP) based on the two existing reports published on the Chesapeake Bay Watershed. The requested information will be evaluated on a HUC-4 scale based upon the CEAP program's methodology of interviewing producers at randomly selection field points from the Natural Resources Inventory (NRI) lists. To date, analysis of the CEAP data at the HUC-4 scale across the CBW has not been conducted.

In utilizing the Panel's practice recommendations for tracking and reporting practice implementation, the Panel recommends that acres, or percentage of acres, be reported by Phase 6 land use, or grouping of similar land uses, by year as an annual practice. Nutrient Management Core N and P are stand-alone practices which should be tracked and reported separately. Likewise, advanced supplemental N and P practices should be tracked and reported separately, but only when the corresponding Core N or P elements have been met by the Panel's recommended practice definitions.

The Panel's recommendation for tracking and reporting NM BMP implementation is that acres, or percentage of acres, be reported by Phase 6 land use, or grouping of similar land uses, by year as an annual practice. The N Core NM BMP and P Core NM BMP are stand-alone practices which should be tracked and reported separately. Likewise, advanced N and P Supplemental NM BMPs should be tracked and reported separately, but only when the requirements for reporting the corresponding N Core BMP or P Core BMP have been met.

5.3 Hydrologic Conditions

The Panel represented NM BMPs that can be applied across all hydrologic conditions in the CBW.

5.4 Sediment

Panel report specifically does not address sediment losses or reductions resulting from implementation of NM BMPs.

5.5 Species of Nitrogen and Phosphorus

The Panel report focused on total N and total P and did not specify species of N or P.

5.6 Geographic Considerations

The Panel report represented NM BMPs that can be applied across all geographic areas of the CBW.

5.7 Temporal Considerations

The Panel report represented NM BMPs that may or may not have temporal considerations depending on the sequence of BMP implementation within the constraints of farm management operations.

5.8 Practice Limitations

There are no limitations to the application of NM BMPs. These practices may be applied to all agricultural land use categories in the CBW.

5.9 Potential Interactions with other Practices

The Panel recognizes that NM BMPs interact with all other agricultural practices for all agricultural land use categories in the CBW.

6 Practice Monitoring and Reporting

6.1 Phase 6.0 Nutrient Management Tracking, Verification, and Reporting

The Panel recommends that NM BMP implementation tracking, verification, and reporting on a county-by-county or state-by-state basis be based on the premise that they represent annual Non-Visual Assessment BMPs. BMP implementation will be reported annually to the CBPO in the number of acres meeting the definitions and qualifications set forth by the NM Panel in this report for NM Core N and P BMPs, as well as applicable NM Supplemental N and P BMPs.

Nutrient Management BMPs represent an historic and ever-changing suite of BMPs for the CBP modeling tools over the history of the Program. As such, NM BMPs are included in the jurisdiction's verification plans that were submitted to the CBP in late 2015. As with all BMPs, the jurisdictions will be expected to document their verification protocols and procedures in their QAPP for NM BMPs that are reported to the CBPO for nitrogen and phosphorous crediting reductions under the recommended BMPs. The jurisdictions will be determine if modifications of those verification plans are required after this expert panel recommendation report is approved by the CBP partnership following the BMP Protocol, and before the jurisdictions are able to start submitting these BMPs in the Phase 6 modeling tools. As the states consider how to verify NM BMPs and as they document those procedures in their QAPP, state partners should follow the existing Agriculture Workgroup's BMP Verification guidance.

http://www.chesapeakebay.net/about/programs/bmp/additional_resources

The AgWG's current verification guidance breaks BMPs into three general categories: Visual Assessment BMPs (Single Year), Visual Assessment BMPs (Multi-Year), and Non-Visual Assessment BMPs. The complete AgWG guidance is quite extensive (79 pages long, including all tables and its own appendices) and is not restated in this section. The panel is not proposing any new or unique aspects of BMP verification for purposes of the BMPs described in this report. This section simply explains how the recommended BMPs correspond to the existing BMP verification guidance.

As described in this report, nutrient application management is part of a larger nutrient management system or plan that often involves multiple management and physical components (e.g., animal waste storage, manure injection and incorporation, etc.) which can be visually assessed over time. NM practices also incorporate non-visual components (e.g. nutrient application rate, timing, and placement) in addition to management plans or other documentation as needed under applicable state or federal agricultural permits and/or programs. Thus, nutrient management systems can reasonably be verified using elements of both the Non-Visual Assessment and Visual Assessment (Multi-Year) categories described by the AgWG.

Each state will determine the most appropriate methods for verifying BMP implementation given their specific priorities, programs, needs, and capacity. For example, one state may lean more heavily on the Visual Assessment (Multi-Year) elements by leveraging existing site visits to farms to also verify that the composting facility meets applicable state or federal standards and specifications. Or, the state may determine that available records are detailed enough to provide sufficient verification through spot-checks. Ideally the state will leverage elements of both categories to verify that the physical treatment system is operating as intended, and that the data in their records are accurate and up-to-date.

To verify the NM Core N and Core P BMPs recommended in this report for nitrogen and phosphorous reduction credits in the Phase 6 CBWM, jurisdictions can reasonably follow the AgWG's guidance for Non-Visual Assessment BMPs. Verification for Non-Visual Assessment BMPs depend more on oversight and checks on operational records or documentation rather than visual assessment of a physical structure.
The nitrogen and phosphorous reductions for NM Core BMPs described in this report are to be based on the verified required elements of the Core N and Core P following the AgWG's guidance for non-visual assessment BMPs. Since it is an annually reported BMP, the most important criteria (i.e. NM Core N and Core P elements) should be documented somewhere in records available to the applicable state agency. Given the close association between nutrient application

management and other CBP-approved BMPs (e.g., animal waste storage systems, manure transport, etc.) the state agency can potentially verify the type and amount of nutrients that were managed via one or both of the NM Core management systems described by the panel. If the state agency finds that even this basic information cannot be verified through its spot-checks or other annual BMP verification procedures described in its QAPP, then the BMP cannot satisfy the definitions and expected nitrogen reductions described in this report.

When the state agency has more detailed NM information available for both reporting and verification purposes, then they may be able to report the given nutrient application system under both the defined NM Core N and P BMPs, as well as one or more of the NM Supplemental N and P BMPs. By providing separate BMPs based on additional rate, timing, and placement application management systems for the higher nitrogen and phosphorous reductions, the panel provides a framework with additional built-in elements of BMP verification. If records available to the applicable state agency do not document the implementation of additional nutrient application changes for rate, timing, and/or placement described by the panel for the NM Supplemental N and P BMPs, then the given system should not be reported under the corresponding Supplemental BMP, but could potentially still meet the criteria of the Core N and/or Core P BMPs using the more basic information that is available. By assigning lower estimated reductions when only basic information is available, it is less likely that a reported treatment system will not provide the estimated nitrogen and phosphorous reductions developed by the panel. This reinforces the basis of BMP verification, i.e. that the reported practice is implemented and operating as intended. With more detailed information about the nutrient application management factors, verified according to the AgWG's guidance, the partnership can have more confidence that the given nutrient application system is operating more effectively to limit excess nitrogen and phosphorous from the environment.

For more information about the CBP Partnership's BMP Verification Framework

The full CBP partnership BMP Verification Framework is available online (scroll down to October 2014 Basinwide BMP Verification Framework Document):

http://www.chesapeakebay.net/about/programs/bmp/additional_resources

The current Agriculture Workgroup's BMP Verification Guidance is included in Appendix B of the full Framework Document. For the AgWG's guidance only, go here:

http://www.chesapeakebay.net/documents/Appendix%20B%20-Ag%20BMP%20Verification%20Guidance%20Final.pdf

6.2 Future Verification of Nutrient Management Practices

The Panel envisions that potential opportunities may exist in the future for utilizing alternative forms of BMP verification, including examples such as remote sensing from satellite, aerial, and drone imagery, aggregated fertilizer industry sales information, and aggregated manure hauler/broker data.

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Appendix A: Technical Requirements for Reporting and Simulating Nutrient Management BMPs in the Phase 6 Watershed Model

Background: In June, 2013 the Water Quality Goal Implementation Team (WQGIT) agreed that each BMP expert panel would work with CBPO staff and the Watershed Technical Workgroup (WTWG) to develop a technical appendix for each expert report. The purpose of the technical appendix is to describe how the expert panel's recommendations will be integrated into the modeling tools including NEIEN, Scenario Builder and the Watershed Model.

Q1. What are the individual nutrient management practices a jurisdiction may report in the Phase 6 Watershed Model?

A1. The individual practices along with their definitions are provided below.

Nitrogen Core NM

Applications of nitrogen are made in accordance to ALL the following elements:

- Land-grant university recommendations for nitrogen applications at field level
- Manure analysis and volume using either test or book values to determine nitrogen content
- Calibration of spreader/applicator
- Yield estimates and cropping plan at the field level
- Cropping and manure application history at the field level

Phosphorus Core NM

Applications of phosphorus are made in accordance to ALL the following elements:

- Land-grant university recommendations for phosphorus at the field level. This may include recommendations resulting from advanced assessment (i.e. P Index, etc.) that recommend higher P application rates where the risk of P loss is low.
- Soil test for phosphorus levels at the field level. This requirement may be waived if restrictions on manure applications (rate, timing, and placement) are imposed that limit P application rates and management to the same degree as if the soil test result for phosphorus was in the "high" category.
- Manure analysis and volume using either test or book values to determine phosphorus content
- Calibration of spreader/applicator
- Yield estimates and cropping plan at the field level
- Cropping and manure history at the field level

Nitrogen Rate Supplemental NM

Applications of nitrogen are made in accordance to all elements of the Nitrogen Core practice, and one or more of the following practices are implemented resulting in a reduction in application rate of nitrogen:

- Nitrogen application rate made at less than land-grant university recommendations
- Nitrogen applications split across the growing season resulting in lower than planned applications
- Nitrogen applications are made using variable rate goals resulting in lower than planned applications.

Nitrogen Placement Supplemental NM

Applications of nitrogen are made in accordance to all elements of the Nitrogen Core practice, and one or more of the following practices are implemented resulting in better placement and utilization of nitrogen:

- Applications of inorganic nitrogen are injected into the subsurface or incorporated into the soil
- Applications of nitrogen are made with setbacks from surface water features

Nitrogen Timing Supplemental NM

Applications of nitrogen are made in accordance to all elements of the Nitrogen Core practice, and are split across the growing season into multiple applications to increase utilization of nitrogen.

Phosphorus Rate Supplemental NM

Applications of phosphorus are made in accordance to all elements of the Phosphorus Core practice, and one or more of the following practices are implemented resulting in a reduction in application rate of phosphorus:

- Applications of manure are based upon annual crop removal of phosphorus rather than nitrogen
- Applications of phosphorus are made at less than land-grant university recommendations
- Phosphorus applications are made using variable rate goals resulting in lower than planned applications
- Applications of phosphorus are split across the growing season resulting in lower than planned applications.

Phosphorus Placement Supplemental NM

Applications of phosphorus are made in accordance to all elements of the Phosphorus Core practice, and one or more of the following practices are implemented resulting in better placement and utilization of nitrogen:

- Applications of inorganic phosphorus are injected into the subsurface or incorporated into the soil
- Applications of phosphorus are made with setbacks from surface water features

Phosphorus Timing Supplemental NM

Applications of phosphorus are made in accordance to all elements of the Phosphorus Core practice, and are made in seasons with a lower risk of phosphorus loss.

Q2. What are the nutrient reductions associated with core practices?

A2. Each acre reported under the core practices will have an application goal adjusted slightly from land-grant university recommendations. For example, an acre of corn not receiving manure (a crop in the Grain without Manure land use) under the Nitrogen Nutrient Management Core practice will have an application goal of 0.92 lbs of nitrogen/bushel/acre. The modified land-grant university applications will be increased by the multipliers provided in the tables below for each acre NOT under the Nutrient Management Core practice. For example, an acre of corn not receiving manure (a crop in the Grain without Manure land use) NOT under the Nitrogen Nutrient Management Core practice will have an application goal of 1.10 lbs of nitrogen/bushel/acre (or 0.92 X 1.20).

Core N Nutrient Management Application Goal Multipliers

Land Use	**Nutrient Management BMP**	
	Nitrogen Core ***Non-Nutrient Management***	**Nitrogen Core** ***Nutrient Management***
Full Season Soybeans	1.20	1.00
Grain w/ Manure	1.30	1.00
Grain w/o Manure	1.20	1.00
Legume Hay	1.20	1.00
Silage w/ Manure	1.40	1.00
Silage w/o Manure	1.20	1.00
Small Grains and Grains	1.20	1.00
Small Grains and Soybeans	1.20	1.00
Specialty Crop High	1.30	1.00
Specialty Crop Low	1.20	1.00
Other Agronomic Crops	1.10	1.00
Other Hay	1.00	1.00
Pasture	1.00	1.00

Core P Nutrient Management Application Goal Multipliers

Land Use	Nutrient Management BMP	
	Phosphorus Core *Non-Nutrient Management*	Phosphorus Core *Nutrient Management*
Full Season Soybeans	1.50	1.00
Grain w/ Manure	3.00	1.00
Grain w/o Manure	1.50	1.00
Legume Hay	1.00	1.00
Silage w/ Manure	3.00	1.00
Silage w/o Manure	1.50	1.00
Small Grains and Grains	1.50	1.00
Small Grains and Soybeans	1.50	1.00
Specialty Crop High	2.00	1.00
Specialty Crop Low	2.00	1.00
Other Agronomic Crops	1.50	1.00
Other Hay	1.00	1.00
Pasture	1.00	1.00

Q3. What are the nutrient reductions associated with the supplemental practices?

A3. Each supplemental practice will be credited as a percent reduction to estimated runoff from the appropriate land use. These percent reductions are listed in the tables below.

Nitrogen Supplemental Percent Reductions to Land Use Runoff

Land Use	Nutrient Management BMP		
	N Rate Supplemental	N Placement Supplemental	N Timing Supplemental
Full Season Soybeans	0%	0%	0%
Grain w/ Manure	15%	5%	10%
Grain w/o Manure	5%	3%	5%
Legume Hay	0%	0%	0%
Silage w/ Manure	15%	5%	10%
Silage w/o Manure	5%	3%	5%
Small Grains and Grains	5%	3%	10%
Small Grains and Soybeans	5%	3%	10%
Specialty Crop High	15%	5%	5%
Specialty Crop Low	5%	3%	5%
Other Agronomic Crops	5%	3%	5%
Other Hay	0%	0%	0%
Pasture	0%	0%	0%

Phosphorus Supplemental Percent Reductions to Land Use Runoff

Land Use	Nutrient Management BMP		
	P Rate Supplemental	P Placement Supplemental	P Timing Supplemental
Full Season Soybeans	5%	10%	1%
Grain w/ Manure	10%	20%	20%
Grain w/o Manure	5%	10%	1%
Legume Hay	1%	10%	1%
Silage w/ Manure	10%	20%	20%
Silage w/o Manure	5%	10%	1%
Small Grains and Grains	5%	10%	1%
Small Grains and Soybeans	5%	10%	1%
Specialty Crop High	5%	10%	1%
Specialty Crop Low	5%	10%	1%
Other Agronomic Crops	5%	10%	1%
Other Hay	0%	0%	0%
Pasture	0%	0%	0%

Q4. Can a state report an acre of supplemental nutrient management on an acre that does not fulfill the definition of the core practices?

A4. No. The panel recommended that every acre of supplemental nutrient management must also fully meet the definition of the core practice.

Q5. If an acre utilizes multiple strategies listed under a single supplemental practice's definition, should it be reported twice? For example, if a producer both sets back applications of nitrogen from surface waters AND injects inorganic nitrogen below the soil surface, should a state report the acre twice as qualifying for the Nitrogen Supplemental Placement practice?

A5. No. The panel recommended that each acre can only qualify once for each of the BMPs. However, an acre can qualify for all four types of BMPs at once. For example, an acre could be reported under the core practice and all three supplemental practices for nitrogen and phosphorus if appropriate.

Q6. How should a state report these practices to NEIEN?

A6. States should report the following information:

- *BMP Name:* Nitrogen Core NM ; Phosphorus Core NM; Nitrogen Supplemental Rate NM; Nitrogen Supplemental Timing NM; Nitrogen Supplemental Placement NM; Phosphorus Supplemental Rate NM; Phosphorus Supplemental Timing NM; Phosphorus Supplemental Placement NM
- *Measurement Name:* Acres
- *Land Use:* Approved NEIEN agricultural land use classes; if none are reported, the default will be CROP

- *Geographic Location:* Approved NEIEN geographies: County; County (CBWS Only); Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4); State (CBWS Only)

- *Date of Implementation:* Year plan was active.

Q7. Are all nutrient management practices annual?

A7. Yes. States should report the total number of acres qualifying under each practice type each year.

Q8. Can states take credit for practices on pasture?

A8. No. The panel specifically recommended reductions to application goals and runoff estimates on non-pasture acres only.

Appendix B: Methods to Estimate Historic Implementation

The Panel recommends that historic implementation on a state-by-state basis be based on the premise that the baseline of 1985 is set at zero, or near zero acres for Nutrient Management Core N and Core P implementation, and the highest level of implementation be represented at 2015 reported implementation acreages. Due to the differences between state Nutrient Management program initiation dates and implementation reporting for the six-state partnership, the "baseline" year is recommended to reflect these state partnership differences. Thus, the initial Nutrient Management implementation year for each state will be unique.

The increasing level of historic implementation between the state Nutrient Management program initiation year and the 2015 reported implementation acreages represent two points on a state-by-state basis. The intervening annual representation of implementation acreages may be represented as a linear progression if there is a paucity of implementation data, or inferred by state implementation data representative of the definitions of nutrient management proposed by the panel. Historic implementation estimation shall consider additional sources of nitrogen and phosphorous reduction credits commensurate with State Quality Assurance Project Plans (QAPPs) currently in place, given they are consistent with the BMPs and efficiency credits described by the Nutrient Management Expert Panel.

In cooperation with the Chesapeake Bay Program Office, a state-by-state representation of Nutrient Management reported implementation following the Panel's recommendations for historic implementation levels in default of additional state implementation data was presented both to the Panel and the Agriculture Workgroup as part of the preliminary Panel recommendation report and review and approval by the Agriculture Workgroup in May 19, 2016.. The state-by-state representation was developed for N Core Nutrient Management only, and with the following methodology:

- Assume straight-line interpolation between 2015 Progress acres and a starting year for each state.
- Starting year was evaluated by looking at historic NEIEN data to determine when states started reporting information.
- 2015 Progress has acres on crop, pasture and hay. Interpolation was made for each of these categories.
- Interpolation was made in each county.
- Assume all acres on crops for NY, PA, and WV only apply to crop acres eligible for receiving manure.
- Assume all acres on crops for DE, MD and VA can be distributed to crop acres with or without manure.
- All acres assumed to qualify for core N.
- No acres yet determined for core P.

Figure B-1 illustrates the relationship between state reporting of historic data through NEIEN and the methodology described above.

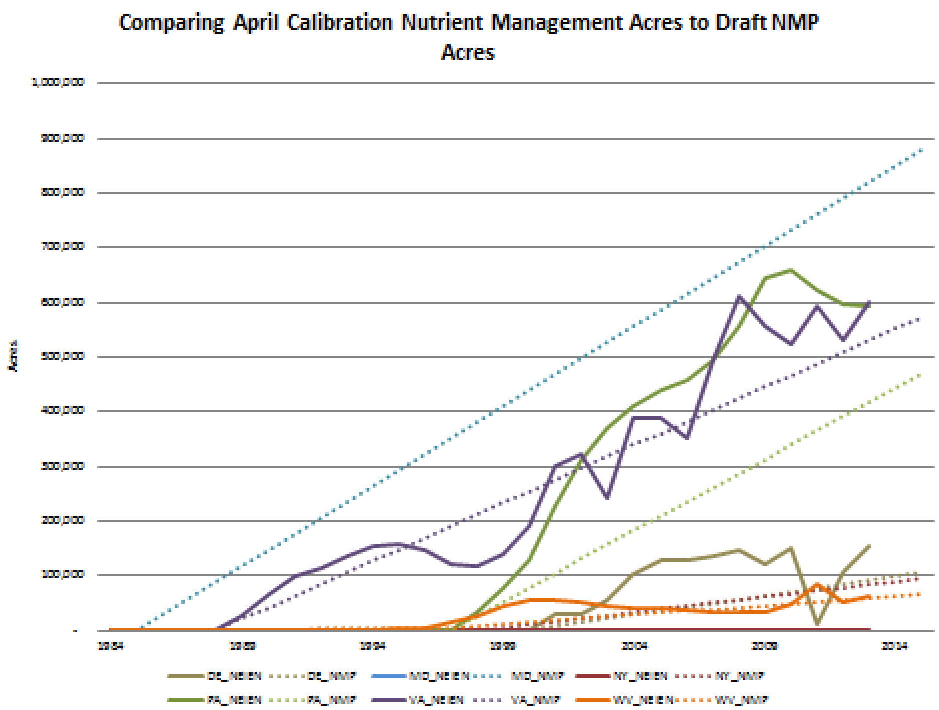

Figure B-1. Comparing April Calibration Nutrient Management Acres to Draft NMP Acres

A second independent source of representing historic Nutrient Management implementation has been requested from the USDA Natural Resources Conservation Service (NRCS) Conservation Effects Assessment Project (CEAP) based on the two existing reports published on the Chesapeake Bay Watershed. Tables 2.7 and 2.8 from the 2013 CEAP report summarize nitrogen and phosphorus management practices and percent of cropped acres within each category for the Chesapeake Bay region, respectively (USDA 2013).

In utilizing the Panel's practice recommendations for tracking and reporting practice implementation, the Panel recommends that acres, or percentage of acres, be reported by Phase 6 land use, or grouping of similar land uses, by year as an annual practice. Nutrient Management Core N and P are stand-alone practices which should be tracked and reported separately. Likewise, advanced supplemental N and P practices should be tracked and reported separately, but only when the corresponding Core N or P elements have been met by the Panel's recommended practice definitions.

Table 2.7. Nitrogen management practices and percent of cropped acres within each category for the Chesapeake Bay region, 2003-06 and 2011 (USDA 2013).

Nitrogen*	**2003-06 acres**	**2011 acres**	**2003-06 percent**	**2011 percent**
No N applied to any crop in rotation	214,000	87,000	5	2
For acres where N is applied:			95	98
Commercial Fertilizer Only	2,457,000	2,177,000	60	51
Manure with or without Commercial Fertilizer	1,608,000	2,089,000	40	49
Rate of application:				
Acres receiving commercial fertilizer and/or manure applications:				
All crops in rotation meet the nitrogen rate criteria described in text			32	23
Some but not all crops in rotation meet the nitrogen rate criteria described in text			54	71
No crops in rotation meet the nitrogen rate criteria described in text			13	6
Acres receiving commercial fertilizer applications only:				
All crops in rotation meet the nitrogen rate criteria described in text			42	35
Some but not all crops in rotation meet the nitrogen rate criteria described in text			52	62
No crops in rotation meet the nitrogen rate criteria described in text			6	3
Acres receiving manure with or without commercial fertilizer applications:				
All crops in rotation meet the nitrogen rate criteria described in text			17	9
Some but not all crops in rotation meet the nitrogen rate criteria described in text			59	82
No crops in rotation meet the nitrogen rate criteria described in text			24	9
Time of application:				
Acres receiving commercial fertilizer and/or manure applications:				
All crops in rotation have application of nitrogen fertilizer less than 21 days before planting			50	36
Some but not all crops have application of nitrogen fertilizer within 21 days before planting			34	50
No crops in rotation have application of nitrogen fertilizer within 21 days before planting			11	11
Acres receiving commercial fertilizer applications only:				
All crops in rotation have application of nitrogen fertilizer less than 21 days before planting			69	59
Some but not all crops have application of nitrogen fertilizer within 21 days before planting			15	25
No crops in rotation have application of nitrogen fertilizer within 21 days before planting			9	13
Acres receiving manure with or without commercial fertilizer applications:				
All crops in rotation have application of manure less than 21 days before planting			18	12
Some but not all crops have application of manure within 21 days before planting			66	78
No crops in rotation have application of manure within 21 days before planting			16	10
Method of application:				
Acres receiving commercial fertilizer and/or manure applications:				
All crops in rotation have N applied with incorporation or banding/foliar/spot treatment			34	27
Some but not all crops in rotation have N applied with incorporation or banding/foliar/spot treatment			45	55
No crops in rotation have N applied with incorporation or banding/foliar/spot treatment			21	18
Acres receiving commercial fertilizer applications only:				
All crops in rotation have N applied with incorporation or banding/foliar/spot treatment			41	37
Some but not all crops in rotation have N applied with incorporation or banding/foliar/spot treatment			34	44
No crops in rotation have N applied with incorporation or banding/foliar/spot treatment			25	19
Acres receiving manure with or without commercial fertilizer applications:				
All crops in rotation have manure applied with incorporation or banding/foliar/spot treatment			22	16
Some but not all crops in rotation have manure applied with incorporation or banding/foliar/spot treatment			63	67
No crops in rotation have manure applied with incorporation or banding/foliar/spot treatment			16	17
Rate *and* timing *and* method of application (excludes acres not receiving nitrogen)				
All crops meet the nitrogen rate criteria described in text and application within 3 weeks before planting with incorporation or banding/foliar/spot treatment			13	7
Some but not all crops meet the nitrogen rate criteria described in text or application within 3 weeks before planting with incorporation or banding/foliar/spot treatment			87	93
Nitrogen *and* Phosphorus				
Crop rotation phosphorus and nitrogen rates meet criteria described in text and all applications occur within 3 weeks before planting and include incorporation or banding/foliar/spot treatment, including acres with no nitrogen or phosphorus applied			8	5

Note: Percents may not add to 100 because of rounding.

* These estimates include adjustments made to the reported data on nitrogen and phosphorus application rates from the survey because of missing data and data entry errors. In the case of phosphorus, the 3-year data period for which information was reported was too short to pick up phosphorus applications made at 4- and 5-year intervals between applications, which is a common practice for producers adhering to sound phosphorus management techniques. Since crop growth, and thus canopy development which decreases erosion, is a function of nitrogen and phosphorus, it was necessary to add additional nitrogen when the reported levels were insufficient to support reasonable crop yields throughout the 52 years in the model simulation. For additional information on adjustment of nutrient application rates, see "Adjustment of CEAP Cropland Survey Nutrient Application Rates for APEX Modeling," available at http://www.nrcs.usda.gov/technical/nri/ceap).

Table 2.8. Phosphorus management practices and percent cropped acres within each category for the Chesapeake Bay region, 2003-06 and 2011 (USDA 2013).

Phosphorus*	2003-06 acres	2011 acres	2003-06 percent	2011 percent
No P applied to any crop in rotation	43,000	<1	1	<1
For acres where P is applied:			99	100
Commercial Fertilizer Only	2,414,000	2,264,000	60	52
Manure with or without Commercial Fertilizer	1,608,000	2,089,000	40	48
Rate of application:				
Acres receiving commercial fertilizer and/or manure applications:				
Rotation meets the phosphorus rate criteria described in text			54	57
Some but not all crops in the rotation meet the phosphorus rate criteria described in text			46	43
Acres receiving commercial fertilizer applications only:				
Rotation meets the phosphorus rate criteria described in text			68	76
Some but not all crops in the rotation meet the phosphorus rate criteria described in text			32	24
Acres receiving manure with or without commercial fertilizer applications:				
All crops in rotation meet the phosphorus rate criteria described in text			32	35
Some but not all crops in the rotation meet the phosphorus rate criteria described in text			68	65
Time of application:				
Acres receiving commercial fertilizer and/or manure applications:				
All applications of phosphorus fertilizer less than 21 days before planting			53	42
Some but not all applications of phosphorus fertilizer within 21 days before planting			34	38
No applications of phosphorus fertilizer within 21 days before planting			13	19
Acres receiving commercial fertilizer applications only:				
All applications of phosphorus fertilizer less than 21 days before planting			75	69
Some but not all applications of phosphorus fertilizer within 21 days before planting			13	18
No applications of phosphorus fertilizer within 21 days before planting			12	11
Acres receiving manure with or without commercial fertilizer applications:				
All applications of phosphorus fertilizer less than 21 days before planting			16	13
Some but not all applications of phosphorus fertilizer within 21 days before planting			67	59
No applications of phosphorus fertilizer within 21 days before planting			16	28
Method of application:				
Acres receiving commercial fertilizer and/or manure applications:				
All applications of phosphorus include incorporation or banding/foliar/spot treatment			42	37
Some but not all applications of phosphorus include incorporation or banding/foliar/spot treatment			28	30
No applications of phosphorus include incorporation or banding/foliar/spot treatment			30	32
Acres receiving commercial fertilizer applications only:				
All applications of phosphorus include incorporation or banding/foliar/spot treatment			51	53
Some but not all applications of phosphorus include incorporation or banding/foliar/spot treatment			19	26
No applications of phosphorus include incorporation or banding/foliar/spot treatment			31	22
Acres receiving manure with or without commercial fertilizer applications:				
All applications of phosphorus include incorporation or banding/foliar/spot treatment			28	21
Some but not all applications of phosphorus include incorporation or banding/foliar/spot treatment			42	35
No applications of phosphorus include incorporation or banding/foliar/spot treatment			30	44
Rate *and* timing *and* method of application (excludes acres not receiving phosphorus):				
All applications meet the phosphorus rate criteria described in text and application within 3 weeks before planting with incorporation or banding/foliar/spot treatment			22	21
Some but not all applications meet the phosphorus rate criteria described in text or application within 3 weeks before planting with incorporation or banding/foliar/spot treatment			78	79
Nitrogen *and* Phosphorus				
Crop rotation phosphorus and nitrogen rates meet criteria described in text and all applications occur within 3 weeks before planting and include incorporation or banding/foliar/spot treatment, including acres with no nitrogen or phosphorus applied			8	5

Note: Percents may not add to 100 because of rounding.

* These estimates include adjustments made to the reported data on nitrogen and phosphorus application rates from the survey because of missing data and data entry errors. In the case of phosphorus, the 3-year data period for which information was reported was too short to pick up phosphorus applications made at 4- and 5-year intervals between applications, which is a common practice for producers adhering to sound phosphorus management techniques. Since crop growth, and thus canopy development which decreases erosion, is a function of nitrogen and phosphorus, it was necessary to add additional phosphorus when the reported levels were insufficient to support reasonable crop yields throughout the 52 years in the model simulation. (For additional information on adjustment of nutrient application rates, see "Adjustment of CEAP Cropland Survey Nutrient Application Rates for APEX Modeling," available at http://www.nrcs.usda.gov/technical/nri/ceap).

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Appendix C: Nutrient Management Phase 6.0 Expert Panel Charge Document

Recommendations for the Nutrient Management Phase 6.0 Expert Panel

Prepared for the Chesapeake Bay Program Partnership's Agriculture Workgroup by the Nutrient Management Phase 6.0 Expert Panel Establishment Group

March 19, 2015

Background

The current version of the Chesapeake Bay Program (CBP) partnership's Watershed Model (Phase 5.3.2 or P5.3.2) credits Crop Group Nutrient Application Management (or Tier 1), under the following definition: "Documentation exists for manure and/or fertilizer application management activities in accordance with basic land grant university (LGU) recommendations. This documentation supports farm-specific efforts to maximize growth by application of nitrogen (N) and phosphorus (P) with respect to proper nutrient source, rate, timing and placement for optimum crop growth consistent with LGU recommendations. Particular attention is paid to: (1) standard, realistic farm-wide yield goals; (2) credit for N sources (soil, sod, past manure and current-year applications); (3) P application rates consistent with LGU recommendations based on soil tests for fields without manure; and (4) N based application rates consistent with LGU recommendations for fields receiving manure."

Enhanced Nutrient Management and Decision Agriculture BMPs are currently represented in the P5.3.2 Model. However, these practices are expected to be replaced by Nutrient Application Management Tier 2 and Tier 3 practices respectively, which are being finalized by the Nutrient Management P5.3.2 Expert Panel in spring 2015.

- Proposed Tier 2
  The implementation of field-specific nutrient application management efforts to maximize growth by application of nitrogen (N) and phosphorus (P) with respect to proper nutrient source, rate, timing and placement for optimum crop growth consistent with LGU recommendations incorporating a P risk assessment tool.

- Proposed Tier 3
  The implementation of subfield-specific nutrient application management efforts to maximize growth by application of nitrogen (N) and phosphorus (P) with respect to proper nutrient source, rate, timing and placement for optimum crop growth incorporating sub-field monitoring and operational practices to further refine the LGU recommendations for the specific farm site and conditions.

The Nutrient Management Expert Panel Establishment Group (EPEG) was formed to:

- Identify priority tasks for the Phase 6.0 (P6.0) Nutrient Management Expert Panel (EP),
- Recommend areas of expertise that should be included on the Nutrient Management EP, and
- Draft the Nutrient Management EP's charge for the review process.

From February 18, 2015 through March 6, 2015 the EPEG met 3 times by conference call and worked collaboratively to complete this charge for presentation to the Agriculture Workgroup

(AgWG) on March 18-19, 2015. Final approval of the charge was obtained by online polling of all members. Members of the EPEG are listed in Table 1.

Table 1. Nutrient Management Expert Panel Establishment Group membership and affiliations.

Member	Affiliation
Beth McGee	Chesapeake Bay Foundation
Chris Brosch	Virginia Tech
Doug Goodlander	Pennsylvania Department of Environmental Protection
Frank Coale	University of Maryland
Jack Meisinger	U.S. Department of Agriculture-Agricultural Research Service
Jason Keppler	Maryland Department of Agriculture
EPEG Support Staff	
Emma Giese	Chesapeake Research Consortium
Mark Dubin	University Maryland
Steve Dressing	Tetra Tech, Inc.

Method

The Nutrient Management EPEG developed its recommendations in accordance with the process specified by the AgWG (AgWG 2014). This process is informed by the strawman proposal presented at the December 11, 2014 AgWG meeting, the Water Quality Goal Implementation Team (WQGIT) Best Management Practice (BMP) protocol, input from existing panelists and chairs, and the process recently undertaken by the AgWG to develop the charge for the Manure Treatment Technologies EP.

The collective knowledge and expertise of EPEG members formed the basis for the recommendations contained herein. A number of EPEG members have had experience on BMP expert panels, including the P5.3.2 Nutrient Management EP. Other EPEG members have knowledge and/or expertise in state and federal programs, the Chesapeake Bay model, and nutrient management practices within the Chesapeake Bay watershed.

Communication among EPEG members was by conference call and email. All decisions were consensus-based.

Recommendations for Expert Panel Member Expertise

The AgWG expert panel organization process directs that each expert panel is to include eight members, including one non-voting representative each from the Watershed Technical Workgroup (WTWG) and Chesapeake Bay Program modeling team. Panels are also expected to include three recognized topic experts and three individuals with expertise in environmental and water quality-related issues. A representative of USDA who is familiar with the USDA-Natural Resources Conservation Service (NRCS) conservation practice standards should be included as one of the six individuals who have topic- or other expertise.

In accordance with the WQGIT BMP protocol, panel members should not represent entities with potential conflicts of interest, such as entities that could receive a financial benefit from Panel recommendations or where there is a conflict between the private interests and the official responsibilities of those entities. All Panelists are required to identify any potential financial or other conflicts of interest prior to serving on the Panel. These conditions will minimize the risk that Expert Panels are biased toward particular interests or regions.

The Nutrient Management EPEG recommends that the P6.0 Nutrient Management EP should include members with the following areas of expertise:

- Nutrient management planning and agronomy.
- Expertise in farm- and field-level nutrient risk assessment tools for N and P.
- Experience with carrying out research projects relating to nutrient management.
- Expertise in fate and transport of N and/or P in agricultural systems.
- Knowledge of nutrient management practices implemented in the Bay jurisdiction(s).
- Knowledge of how BMPs are tracked and reported, and the Chesapeake Bay Program partnership's modeling tools.
- Experience with verification of nutrient management plans and other forms of nutrient management.
- Knowledge of relevant USDA-NRCS practice codes or standards.

Expert Panel Scope of Work

The general scope of work for the Nutrient Management P6.0 EP(s) will be to define and configure the Nutrient Management BMPs in the P6.0 model. Specifically, the Nutrient Management EPEG recommends the following five charges with associated tasks for the P6.0 Nutrient Management EP:

1. Review the P5.3.2 definitions and effectiveness estimates for the implementation of component practices of Nutrient Management and make adjustments or modifications as needed for Phase 6.0.
    a) Consider the current P5.3.2 Tier system used for identifying levels of nutrient management implementation activities to be credited to the model, and
    b) Recommend if the current proposed Tier process should remain or if a more component oriented process for crediting nutrient management practices is more appropriate.
2. Determine how nutrient management practices can be applied to the P6.0 land uses, taking into consideration the mass balance data and nutrient spreading routine in Scenario Builder.
3. If possible, make recommendations using multi-year vs. annual model representation of soil nutrient residuals for calculation of available nutrients to meet crop requirements on an annual basis.
4. Collaboration with the Cropland Irrigation Management EP on fertigation will be critical to ensure that recommendations are complementary as well as to avoid double-counting and ensure effective reporting of practices.

This scope of work addresses nutrient management reduction efficiencies for N and P.

Under the first charge, the Nutrient Management Phase 6.0 (P6.0) Expert Panel will review the P5.3.2 definitions and effectiveness estimates for the implementation of component practices of Nutrient Management and make adjustments or modifications as needed for Phase 6.0. This charge is necessary because the P6.0 model features a change in land use categories, a possible change in the baseline condition, and some likely changes in how BMPs are applied. While the EPEG considers the tiered approach to be an improvement over the previous P5.3.2 approach to nutrient management, there is interest in considering an alternative approach for P6.0. Both a tiered approach and practice-specific approach have pros and cons associated with reporting implementation and determining efficiency values. Items 1a and 1b specify that the P6.0 EP will consider the current Tier system used for identifying levels of nutrient management implementation activities to be credited to the model and recommend if the current proposed Tier process should remain or if a more component oriented process for selecting nutrient management practices is more appropriate. Nutrient management Tiers 1-3 are described in the *Background* section of this document.

The second charge directs the P6.0 EP to determine how nutrient management practices can be applied to the P6.0 land uses. Factors to consider when performing tasks under this charge include the baseline conditions assumed by the model (e.g., with or without nutrient management), the nutrient spreading routine and improved mass balance data for Scenario Builder, and potential variation in crediting for different land uses.

Residual nutrients are not adequately accounted for by the P5.3.2 model. Under the third charge, the P6.0 EP will consider management of residual nutrients and how they are carried over to subsequent years in the P6.0 model. This will require close coordination with the Chesapeake Bay modeling team which is ultimately responsible for developing the capability to add this important feature to the model.

Collaboration with the P6.0 Cropland Irrigation Management EP is specified under the fourth charge to ensure that recommendations from the two panels are complementary and that practice reporting and crediting are accurate. Either panel could address fertigation, but both panels should have a role in determining the final recommendations.

Timeline and Deliverables

Early summer 2015 - Panel stakeholder kickoff meeting

Summer 2015 – Based on their written EPEG charge, the panel will develop a proposed scope of work including BMP structure and type, draft BMP definition(s), and initial elements of the BMP such as associated components and conservation practices, and USDA-NRCS associated CP codes. Initially identified literature citations will be included to provide a range of potential effectiveness values that the panel will consider and supplement with further evaluation. The panel will present their provisional BMP paper to the AgWG, WTWG, and WQGIT for informational purposes, and for initial partnership comments on the proposed direction of the panel's evaluation. The paper will not represent a full recommendation report, and the partnership will not be asked for formal approval at this time.

Prior to October 1, 2015 – In the absence of a Partnership approved panel recommendation report, the CBPO modeling team will request a decision by the Agriculture Workgroup, Watershed Technical Workgroup, and the Water Quality Goal Implementation Team of whether the BMP will be represented using the existing Phase 5.3.2 definitions, the approved recommendations of the Phase 5.3.2 Panel report if applicable, or the Phase 6.0 panel's provisional paper, in the Phase 6 Beta Scenario Builder tool to meet an early October deadline.

Spring 2016 – **Final date** for panel to release full recommendations for approval by the AgWG, WTWG, and WQGIT.

Early summer 2016 – If approved by the partnership, panel recommendations are final and will replace the interim representation of the BMP in the final version of the Phase 6 modeling tools.

Phase 6.0 BMP Verification Recommendations:

The panel will utilize the Partnership approved ***Agricultural BMP Verification Guidance***[1], as the basis for developing BMP verification guidance recommendations that are specific to the BMP(s) being evaluated. The panel's verification guidance will provide relevant supplemental details and specific examples to provide the Partnership with recommended potential options for how jurisdictions and partners can verify nutrient management practices in accordance with the Partnership's approved guidance.

References

AgWG. 2014. Agriculture Workgroup expert panel organization – DRAFT January 8, 2014. Agriculture Workgroup, Chesapeake Bay Program.

Attachment 1: Outline for Final Expert Panel Reports

- Identity and expertise of Panel members
- Practice name/title
- Detailed definition(s) of the practice
- Recommended nitrogen, phosphorus, and sediment loading or effectiveness estimates
  - Discussion may include alternative modeling approaches if appropriate
- Justification for the selected effectiveness estimates, including
  - List of references used (peer-reviewed, unpublished, etc.)
  - Detailed discussion of how each reference was considered, or if another source was investigated, but not considered.
- Description of how best professional judgment was used, if applicable
- Land uses to which the BMP is applied
- Load sources that the BMP will address and potential interactions with other practices

[1] http://www.chesapeakebay.net/documents/Appendix%20B%20-Ag%20BMP%20Verification%20Guidance%20Final.pdf

- Description of pre-BMP and post-BMP circumstances, including the baseline conditions for individual practices
- Conditions under which the BMP works:
  - Should include conditions where the BMP will not work, or will be less effective. An example is large storms that overwhelm the design.
  - Any variations in BMP effectiveness across the watershed due to climate, hydrogeomorphic region, or other measureable factors.
- Temporal performance of the BMP including lag times between establishment and full functioning (if applicable)
- Unit of measure (e.g., feet, acres)
- Locations within the Chesapeake Bay watershed where this practice is applicable
- Useful life; effectiveness of practice over time
- Cumulative or annual practice
- Description of how the BMP will be tracked, reported, and verified:
  - Include a clear indication that this BMP will be used and reported by jurisdictions
- Suggestion for a review timeline; when will additional information be available that may warrant a re-evaluation of the estimate
- Outstanding issues that need to be resolved in the future and a list of ongoing studies, if any
- Documentation of any dissenting opinion(s) if consensus cannot be reached
- Operation and Maintenance requirements and how neglect alters performance

Additional Guidelines

- Identify ancillary benefits and unintended consequences
- Include negative results
  - Where studies with negative pollution reduction data are found (i.e. the BMP acted as a source of pollutants), they should be considered the same as all other data.
- Include results where the practice relocated pollutants to a different location. Examples include where a practice eliminates a pollutant from surface transport but

moves the pollutant into groundwater, or where the practice will move manure from the farm credited for the practice to another farm more in need of nutrients.

In addition, the Expert Panel will follow the “data applicability” guidelines outlined Table 1 of the Water Quality Goal Implementation Team *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model*.

Appendix D: Approved Nutrient Management Expert Panel Meeting Minutes

To be included in final report.

Appendix E: Consolidated Response to Comments on: Definitions and Recommended Nutrient Reduction Efficiencies of Nutrient Management for Use in Phase 6.0 of the Chesapeake Bay Program Watershed Model (2016)

To be included in final report.

Appendix F: Conformity with WQGIT BMP Protocol

The BMP review protocol established by the Water Quality Goal Implementation Team (WQGIT 2014) outlines the expectations for the content of expert panel reports. This appendix references the specific sections within the report where the panel addressed the requested protocol criteria.

1. **Identity and expertise of panel members:** *See Table 1in Section1.*

2. **Practice name or title:**
   - *Nitrogen (N) Core Nutrient Management BMP*
   - *Phosphorus (P) Core Nutrient Management BMP*
   - *Nitrogen (N) Rate Supplemental Nutrient Management BMP*
   - *Nitrogen (N) Placement Supplemental Nutrient Management BMP*
   - *Nitrogen (N) Timing Supplemental Nutrient Management BMP*
   - *Phosphorus (P) Rate Supplemental Nutrient Management BMP*
   - *Phosphorus (P) Placement Supplemental Nutrient Management BMP*
   - *Phosphorus (P) Timing Supplemental Nutrient Management BMP*

3. **Detailed definition of the practice:** *See Section 2 for detailed definitions of Core and Supplemental N and P Nutrient Management BMPs.*

4. **Recommended N, P and sediment effectiveness estimates:** *See Table 12 (Core N Nutrient Management Efficiency Values),*

5.

6. *Table* 13 *(Core P Nutrient Management Efficiency Values), Table 14 (N Nutrient Management Supplemental BMP Efficiency Values), and Table 15 (P Nutrient Management Supplemental BMP Efficiency Values) in Section 3.1 for recommended TN and TP reductions for use in the Phase 6.0 Watershed Model. The panel did not recommend a sediment reduction rate for Nutrient Application Management.*

7. **Justification of selected effectiveness estimates:** *See Section 3.2 for justification of the effectiveness estimates.*

8. **List of references used:** *See Section 7 for the full list of references.*

9. **Detailed discussion on how each reference was considered:** *See Sections 3.2 and 4 for details on the review of available science.*

10. **Land uses to which BMP is applied:** *See Table 12 (Core N Nutrient Management Efficiency Values) in Section 3.1.1,*

11.

12. *Table* 13 *(Core P Nutrient Management Efficiency Values) in Section 3.1.2, Table 14 (N Nutrient Management Supplemental BMP Efficiency Values) in Section 3.1.3, Table 15 (P Nutrient Management Supplemental BMP Efficiency Values) in Section 3.1.4,*

Table 17 *(Land Uses to Which the Nutrient Management Practices Apply) in Section 5.1 for applicable agricultural land uses.*

13. Load sources that the BMP will address and potential interactions with other practices: *See*

Table 17 *(Land Uses to Which the Nutrient Management Practices Apply) in Section 5.1 for applicable load sources.*

14. **Description of pre-BMP and post-BMP circumstances and individual practice baseline:** *See Sections 2, 3, and 5.2.*

15. **Conditions under which the BMP works, including conditions where the BMP will not work, or will be less effective:** *See Section 5.*
    a. **Variations in BMP effectiveness across the watershed due to climate, hydrogeomorphic region, or other measureable factors.** *See Sections 5.3 through 5.8.*

16. **Temporal performance of BMP including lag times between establishment and full functioning:** *See Section 5.7.*

17. **Unit of measure:** *Acres or percentage of acres implementing practice.*

18. **Locations in Chesapeake Bay watershed where the practice applies:** *All acres of the applicable land uses in*

Table 17 *(Section 5.1) in the Bay watershed.*

19. **Useful life of the BMP:** *Nutrient Application Management is intended to be represented as an annual practice, so for the purposes of this report, however, the useful life of the practice is 1 year.*

20. **Cumulative or annual practice:** *Annual.*

21. **Description of how BMP will be tracked, reported, and verified:** *See Section 6 for a discussion of how Nutrient Application Management should be tracked and reported to the Bay Program. More details are also available in the Scenario Builder Technical Appendix (Appendix A).*

22. **Ancillary benefits, unintended consequences:** *The Panel did not review Nutrient Application Management for external environmental benefits. The Panel did not identify any unintended consequences.*

23. **Timeline for a re-evaluation of the panel recommendations:** *There is currently no specific plan to re-evaluate Panel recommendations.*

24. **Outstanding issues that need to be resolved in the future and list of ongoing studies, if any:** *See Section 2 for a discussion of data needs and Section 4 for a discussion of future research needs.*

25. **Documentation of dissenting opinion(s):** *While no dissenting opinions were expressed or recorded, significant notes related to recommendations were recorded in Appendix B (Approved Nutrient Management Expert Panel Meeting Minutes).*

26. **Operation and maintenance requirements and how neglect alters performance:** *The requirements and performance are covered by the state programs, which in their own way document these elements.*