Final BMP Panel Report
Definitions and Recommended Nutrient Reduction Efficiencies of

Nutrient Management Practices

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

Submitted by the Phase 6.0 Nutrient Management BMP Expert Panel
Approved as Amended by the AgWG: October 20, 2016
Water Quality Goal Implementation Team (WQGIT)
October 25, 2016

Phase 6 Nutrient Management Expert Panel

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Watershed Technical Workgroup	
Chris Brosch	Delaware Dep. of Agriculture
CBP Modeling Team	
Matt Johnston	University of Maryland, CBPO
Agriculture Workgroup Coordinator	
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The Charge Presented to the Phase 6 Nutrient Management Expert Panel

General Scope

Define and configure the nutrient management (NM) BMPs in the Phase 6 model.

Specific Charges

1. Review the Phase 5.3.2 definitions and effectiveness estimates and evaluate the "Tier System" for identifying NM BMP implementation.

2. Determine how NM BMPs can be applied to the new Phase 6 land uses with a focus on nutrient mass balance and nutrient spreading routines.

3. Make recommendations to account for soil residual nutrients and how soil residual nutrient concentrations should be credited to annual crop nutrient requirements.

4. Collaborate with the Cropland Irrigation Management Expert Panel on fertigation effectiveness and accounting practices.

5. Address NM reduction efficiencies for nitrogen (N) and phosphorus (P).

Phase 6 Nutrient Management Expert Panel: Summary Conclusions

1. Nitrogen (N) and phosphorus (P) assessments are handled similarly but separately.

2. Historical base-line conditions (i.e.1985) are used as a uniform reference point for pre-BMP, non-nutrient management conditions.

3. Core Nutrient Management BMP efficiency multipliers for N and P are based on state LGU recommendations, as modified by CBP state partners, and represent land-use and cropping system specific N and P application rates.

4. Core Nutrient Management BMP efficiency multipliers for N and P modify the nutrient application rate goals.

5. Supplemental Nutrient Management BMP efficiency multipliers for rate, timing and placement of N and P are additive to the Core Nutrient Management BMPs for N and P, but can not be applied without application of the Core BMPs.

6. Supplemental Nutrient Management BMP efficiency multipliers modify the edge of field nutrient loss to the receiving stream.

7. All BMP multipliers (n=130) for N and P are numeric variables that have been defined by the Nutrient Management Expert Panel.

8. LGU recommendations for P application are based on soil-test P concentration. Soil P concentration data are not available to CBP but should be collected and utilized in the future. In the absence soil-test P based application rate goals, county-level redistribution of CBW P fertilizer sales data may serve as a surrogate.

Phase 6 Nutrient Management BMPs

Core Nutrient Management BMPs

Nitrogen Core Nutrient Management BMP

Phosphorus Core Nutrient Management BMP

Supplemental Nutrient Management BMPs

Nitrogen Rate Supplemental Nutrient Management BMP
Nitrogen Placement Supplemental Nutrient Management BMP
Nitrogen Timing Supplemental Nutrient Management BMP

Phosphorus Rate Supplemental Nutrient Management BMP
Phosphorus Placement Supplemental Nutrient Management BMP
Phosphorus Timing Supplemental Nutrient Management BMP

Nitrogen Nutrient Management BMPs

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

NO → No credit for N Core Nutrient Management BMP → N application goal = **LGU recommendation x A**

YES → Credit for N Core Nutrient Management BMP efficiency → N application goal = **LGU recommendation x B**

NITROGEN Supplemental Nutrient Management BMPs
If Core Nutrient Management BMP efficiency is applied, follow with advanced assessment for Supplemental Nutrient Management BMPs

Advanced N Assessment
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

IMPLEMENTATION →

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

YES → **N Rate Supplemental BMP = EOF load x C**

IMPLEMENTATION →

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

YES → **N Placement Supplemental BMP = EOF load x D**

IMPLEMENTATION →

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

YES → **N Timing Supplemental BMP = EOF load x E**

Phosphorus Nutrient Management BMPs

PHOSPHORUS Core Nutrient Management BMP (ALL core elements required to be implemented and verified)
P application goal (P rate) according to LGU recommendations at field level
P soil tests at field level
Manure analysis and volume
Spreader/applicator calibration
Yield estimates and cropping plan at field level
Cropping and manure history at field level

NO → No credit For P Core Nutrient Management BMP → P application goal = **LGU recommendation x F**

YES → Credit for P Core Nutrient Management BMP efficiency → P application goal **= LGU recommendation x G**

PHOSPHORUS Supplemental Nutrient Management BMPs
If Core Nutrient Management BMP efficiency is applied, follow with advanced assessment for Supplemental Nutrient Management BMPs

Advanced P Assessment
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

IMPLEMENTATION →

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

YES → **P Rate Supplemental BMP = EOF load x H**

IMPLEMENTATION →

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

YES → **P Placement Supplemental BMP = EOF load x I**

IMPLEMENTATION →

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

YES → **P Timing Supplemental BMP = EOF load x J**

Nutrient Management BMP Multipliers

Nutrient Management BMP	BMP Efficiency Variable	Action of BMP	How the math works
Nitrogen Core **Non-Nutrient Management** BMP multiplier	A	modifies N application rate goal on the nutrient input side	multiplier of the LGU N application rate goal
Nitrogen Core **Nutrient Management** BMP multiplier	B	modifies N application rate goal on the nutrient input side	multiplier of the LGU N application rate goal
Nitrogen Rate Supplemental BMP multiplier	C	modifies edge of field N loss to the stream on the outflow side	multiplier of the calculated edge of field N load
Nitrogen Placement Supplemental BMP multiplier	D	modifies edge of field N loss to the stream on the outflow side	multiplier of the calculated edge of field N load
Nitrogen Timing Supplemental BMP multiplier	E	modifies edge of field N loss to the stream on the outflow side	multiplier of the calculated edge of field N load
Phosphorus Core **Non-Nutrient Management** BMP multiplier	F	modifies P application rate goal on the nutrient input side	multiplier of the LGU P application rate goal
Phosphorus Core **Nutrient Management** BMP multiplier	G	modifies P application rate goal on the nutrient input side	multiplier of the LGU P application rate goal
Phosphorus Rate Supplemental BMP multiplier	H	modifies edge of field P loss to the stream on the outflow side	multiplier of the calculated edge of field P load
Phosphorus Placement Supplemental BMP multiplier	I	modifies edge of field P loss to the stream on the outflow side	multiplier of the calculated edge of field P load
Phosphorus Timing Supplemental BMP multiplier	J	modifies edge of field P loss to the stream on the outflow side	multiplier of the calculated edge of field P load

Development of Phase 6 Nutrient Management BMP Multipliers

- 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.
- 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.
- 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.
- It was essential to distill numerous lines of evidence to arrive at a single BMP multiplier for each of the N and P BMPs that could be applied equitably across the CBW.

Development of Phase 6 Nutrient Management BMP Multipliers

Multipliers for the Core NM BMPs and the NM Supplemental BMPs represent:

1. A collection of required elements, or

2. The impact of numerous applicable on-site management practices.

In order to develop broadly pertinent NM BMP multipliers, multiple sources of information and data were necessarily synthesized.

Nitrogen Nutrient Management BMPs

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

NO → No credit for N Core Nutrient Management BMP → N application goal = **LGU recommendation x A**

YES → Credit for N Core Nutrient Management BMP efficiency → N application goal = **LGU recommendation x B**

NITROGEN Supplemental Nutrient Management BMPs
If Core Nutrient Management BMP efficiency is applied, follow with advanced assessment for Supplemental Nutrient Management BMPs

Advanced N Assessment
PSNT
Manure analysis < 3 years old
On-farm replicated research
CSNT
N-loss risk assessments & models - Ammonia loss
Yield mapping
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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

IMPLEMENTATION →

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

YES → **N Rate Supplemental BMP = EOF load x C**

IMPLEMENTATION →

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

YES → **N Placement Supplemental BMP = EOF load x D**

IMPLEMENTATION →

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

YES → **N Timing Supplemental BMP = EOF load x E**

Nutrient Management BMP Multipliers

Nutrient Management BMP	BMP Multiplier Variable	Full Season Soybeans	Grain w/ Manure	Grain w/o Manure	Legume Hay	Silage w/ Manure	Silage w/o Manure	Small Grains and Grains	Small Grains and Soybeans	Specialty Crop High	Specialty Crop Low	Other Agronomic Crops	Other Hay	Pasture
Nitrogen Core **Non-Nutrient Management** BMP multiplier	A	1.20	1.30	1.20	1.20	1.40	1.20	1.20	1.20	1.30	1.20	1.10	1.00	1.00
Nitrogen Core **Nutrient Management** BMP multiplier	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Nitrogen Rate Supplemental BMP multiplier	C	1.00	0.85	0.95	1.00	0.85	0.95	0.95	0.95	0.85	0.95	0.95	1.00	1.00
Nitrogen Placement Supplemental BMP multiplier	D	1.00	0.95	0.97	1.00	0.95	0.97	0.97	0.97	0.95	0.97	0.97	0.97	1.00
Nitrogen Timing Supplemental BMP multiplier	E	1.00	0.90	0.95	1.00	0.90	0.95	0.90	0.90	0.95	0.95	0.95	0.95	1.00
Phosphorus Core **Non-Nutrient Management** BMP multiplier	F	1.50	3.00	1.50	1.00	3.00	1.50	1.50	1.50	2.00	2.00	1.50	1.00	1.00
Phosphorus Core **Nutrient Management** BMP multiplier	G	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Phosphorus Rate Supplemental BMP multiplier	H	0.95	0.90	0.95	0.99	0.90	0.95	0.95	0.95	0.95	0.95	0.95	1.00	1.00
Phosphorus Placement Supplemental BMP multiplier	I	0.90	0.80	0.90	0.90	0.80	0.90	0.90	0.90	0.90	0.90	0.90	0.90	1.00
Phosphorus Timing Supplemental BMP multiplier	J	0.99	0.80	0.99	0.99	0.80	0.99	0.99	0.99	0.99	0.99	0.99	0.99	1.00

Agriculture Workgroup NM Panel Report Amendment: Approved October 20, 2016

Nitrogen Core NM On-Site Manure Analysis

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

- 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.

Agriculture Workgroup NM Panel Report Amendment: Approved October 20, 2016

Nitrogen Core NM Estimated Manure Analysis

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

- 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.

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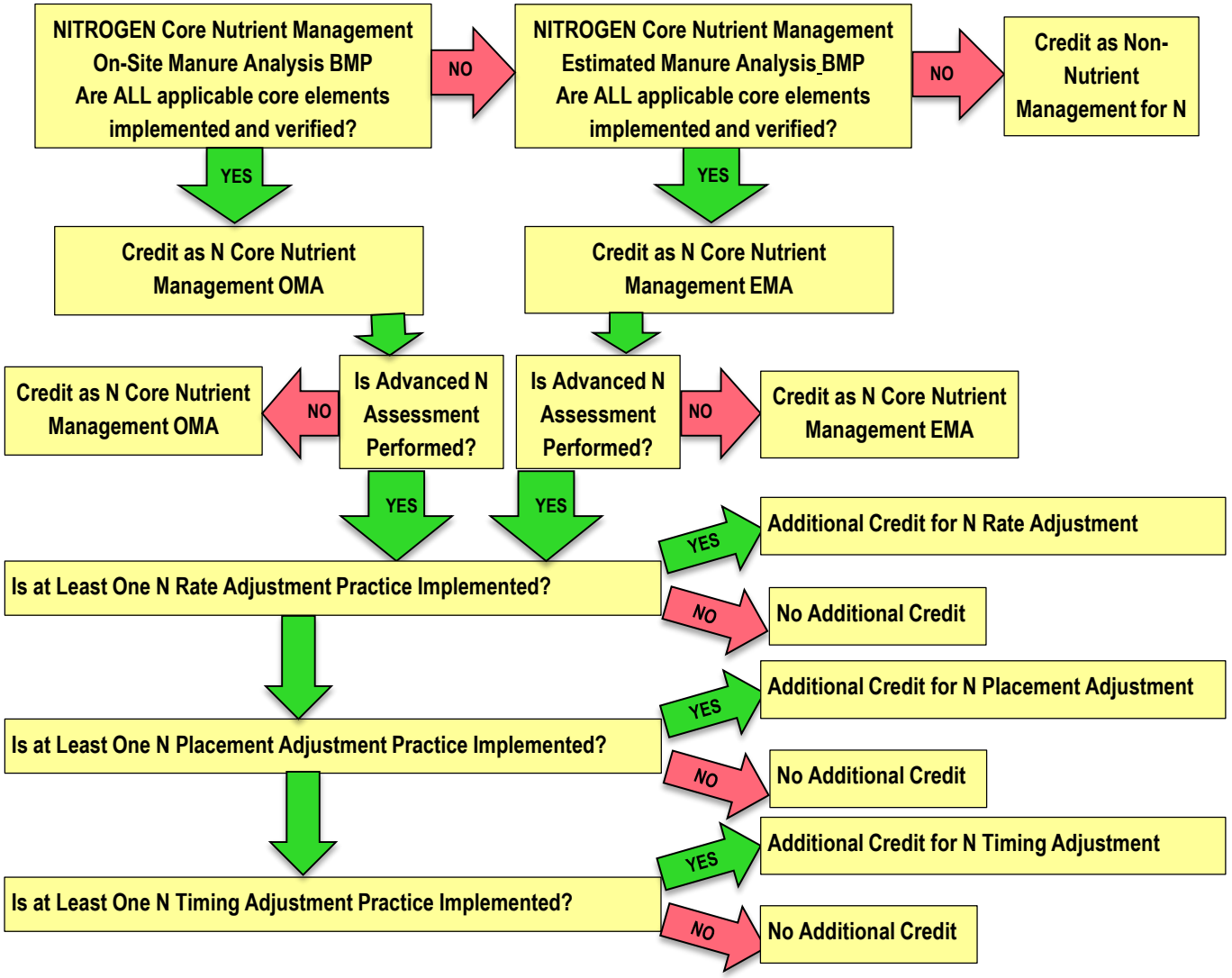

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Land Use	Nutrient Management BMP		
	Nitrogen Core Non-Nutrient Management BMP Application Rate Multiplier	Nitrogen Core Nutrient Management Estimated Manure Analysis Rate Multiplier	Nitrogen Core Nutrient Management On-Site Manure Analysis Rate Multiplier
Full Season Soybeans	1.20	1.10	1.00
Grain w/ Manure	1.30	1.15	1.00
Grain w/o Manure	1.20	1.10	1.00
Legume Hay	1.20	1.10	1.00
Silage w/ Manure	1.40	1.20	1.00
Silage w/o Manure	1.20	1.10	1.00
Small Grains and Grains	1.20	1.10	1.00
Small Grains and Soybeans	1.20	1.10	1.00
Specialty Crop High	1.30	1.15	1.00
Specialty Crop Low	1.20	1.10	1.00
Other Agronomic Crops	1.10	1.05	1.00
Other Hay	1.00	1.00	1.00
Pasture	1.00	1.00	1.00

Agriculture Workgroup NM Panel Report Amendment: Approved October 20, 2016

Phosphorus Core NM On-Site Soil & Manure Analysis

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

- 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.

- **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.

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Phosphorus Core NM Estimated Soil & Manure Analysis

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

- 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 testing 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.

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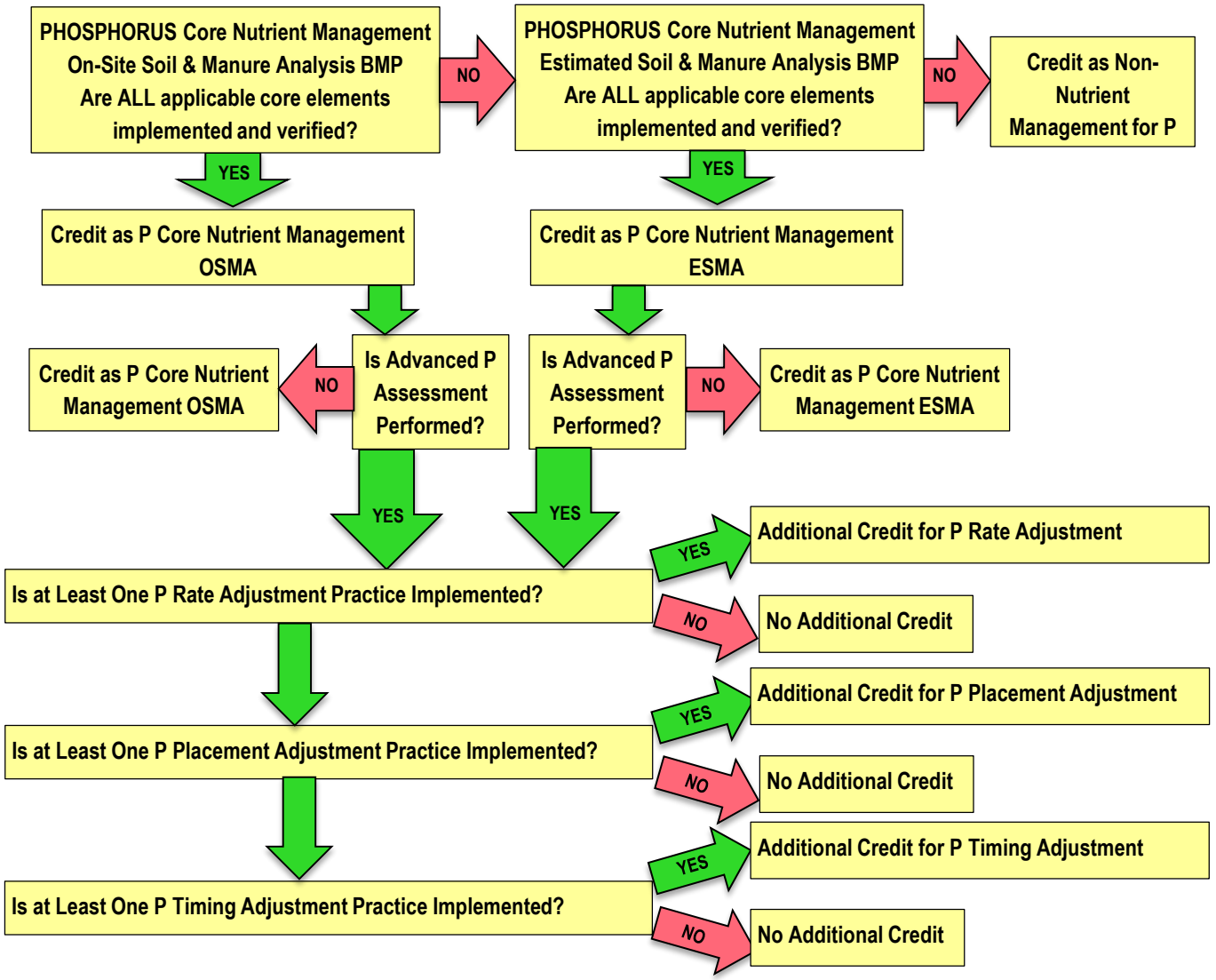

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Land Use	Nutrient Management BMP		
	Phosphorus Core Non-Nutrient Management BMP Application Rate Multiplier	Phosphorus Core Nutrient Management Estimated Manure Analysis Rate Multiplier	Phosphorus Core Nutrient Management On-Site Manure Rate Multiplier
Full Season Soybeans	1.50	1.25	1.00
Grain w/ Manure	3.00	2.00	1.00
Grain w/o Manure	1.50	1.25	1.00
Legume Hay	1.00	1.00	1.00
Silage w/ Manure	3.00	2.00	1.00
Silage w/o Manure	1.50	1.25	1.00
Small Grains and Grains	1.50	1.25	1.00
Small Grains and Soybeans	1.50	1.25	1.00
Specialty Crop High	2.00	1.50	1.00
Specialty Crop Low	2.00	1.50	1.00
Other Agronomic Crops	1.50	1.25	1.00
Other Hay	1.00	1.00	1.00
Pasture	1.00	1.00	1.00


Finish Line
Just Ahead