FINAL Report
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Consensus Recommendations for Improving the Tracking, Reporting, and Verification of Urban Nutrient Management Practices in the Chesapeake Bay Watershed

Dylan Burgevin, Kevin Du Bois, Michael Goatley, Marty Hurd, Arianna Johns, Kay Alexander, Peter Landschoot, Cecilia Lane, David Montali, Gonzalo Ortiz, Frank Schneider, Denise Uzupis

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Prepared by:

David Wood and Michele Berry, Chesapeake Stormwater Network

Executive Summary

The Urban Nutrient Management Expert Panel Report was first approved in 2013. This Panel was convened to revisit the 2013 recommendations to ensure that the science remained up-to-date, and that the Chesapeake Bay Program Partnerships approach to simulating urban fertilizer application and best practices reflects the best available data.

After an evaluation of other potential data sources and reporting approaches, the Panel recommends the continuation of the approved non-farm fertilizer application method for urban pervious acres, adopted by the USWG in 2023 with one proposed change: the addition of construction, and solar pervious land use acres to the denominator of the non-farm fertilizer application rate equation.

The approved method therefore begins with collecting the entire record of AAPFCO data for non-farm fertilizer sales data. If a state has data after the last available year of AAPFCO data (currently 2016), those data will be used for the additional years provided. If a state does not have more recent data, the most recent available year of data will be held steady and carried forward through time. Outliers are removed at the county scale, then a 3-year rolling average is taken. Urban fertilizer application rates (pounds per acre) are calculated as the total mass of nutrients divided by the total acres in turfgrass, plus construction, plus solar pervious for each state and year.

The Panel also conducted an update of the 2013 scientific literature review, identifying an additional 35 papers published between 2012 and 2024 on the N and P dynamics in turfgrass systems, and the fertilization practices that influence them. Overall, the updated literature largely re-affirms the core principles of N and P dynamics underpinning the 2013 Expert Panel report. Urban and suburban lawns are largely retentive of nutrients, particularly N. Losses that do occur, particularly for nitrogen, regardless of fertilization regime, but driven by hotspots and hot moments – locations in the landscape and specific times that are especially prone to disproportionately high nutrient export. High rates of N fertilization increase the risk of these hotspots and hot moments, which are otherwise influenced by the timing and location of the fertilizer application. Management of turfgrass designed to reduce detrimental water quality impacts should therefore focus primarily on rate, timing, and placement.

To reflect these findings, the Panel proposed a re-structuring of the existing urban nutrient management BMPs. The Panel recommends three BMPs:

- BMP #1: Urban Nutrient Management Plan With a Soil Test
- BMP#2: Urban Nutrient Management Plan Without a Soil Test
- BMP#3: Non-Fertilized Turfgrass

Table 1. Summary of Recommended Urban Nutrient Management BMPs

	TN Reduction	TP Reduction	Credit Duration
BMP #1	6 %	4.5 %	3 years
BMP #2	6 %	4.5 %	1 year
BMP #3	7 %	9 %	1 year

The first BMP provides nutrient reductions for written urban nutrient management plans developed by a trained expert and based on a soil test, that reduce the risk of nutrient export of the remaining fertilizer applied due to following best practices for rate, timing, and location of fertilizer along with proper clipping management. The second BMP accounts for signed homeowner pledges, and adherence to an urban nutrient management plan in the absence of a soil test. The final BMP provides nutrient reductions for well-managed turf that does not receive fertilizer application, but maintains healthy turf coverage and appropriate management activities, as defined. The Panel provided new guidance for improved record-keeping and verification to assist in tracking and reporting efforts.

In addition to the benefits of the 3 BMPs, the Panel evaluated data on non-farm fertilizer sales trends to identify signals that may be due to state-wide fertilizer legislation. Non-farm fertilizer TP sales declined by an average of 55% between 2010-2020. That is consistent with the estimated Bay-wide effect of the P fertilizer legislation predicted by the 2013 Panel – a decline in non-farm fertilizer TP sales of 60%. The 2013 Panel did not anticipate statewide declines in TN sales, but this Panel found non-farm fertilizer TN sales have declined by an average of 35% between 2010 and 2020. These declines in TN and TP sales are both reflected in the state fertilizer application rates developed by the Chesapeake Bay Program Office, which are adjusted downward as the sales continue to decline.

During its review, the Panel also sought data sources that might improve the Watershed Model's P sensitivities for pervious acres but ultimately did not find any data to support specific changes or improvements. They support the current approach and process to evaluate these methods and decisions in the future as new data become available.

The Panel recommends future investment in more widespread soil testing from non-agricultural soils. More broadly, the Panel recognizes that urban nutrient management is only one component of healthy urban and suburban soils. The Panel recommends that future efforts focus on understanding and synthesizing the range of factors affecting soil health and its implications for runoff and nutrient management.

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The following report documents the review and proposed updates to the tracking, reporting, verification and calculation of pollutant reduction credits for urban nutrient management practices, as previously approved by the Chesapeake Bay Program's Urban Stormwater Workgroup (USWG, 2013).

1. Charge and Roster of the Working Group

The Urban Nutrient Management expert panel report was first approved in 2013. In the years since, the Chesapeake Bay Program has adopted a new BMP verification framework and made multiple adjustments to how nutrients are applied in the urban sector of their modeling tools. With these changes, crediting urban nutrient management has remained a challenge, due largely to data limitations. To evaluate whether updates were needed to the core urban nutrient management practices approved by the original panel, the Urban Stormwater Workgroup (USWG) convened the following panel of experts to review the latest science and practice. The members of the team are provided in Table 2.

Table 2. Members of the Urban Nutrient Management Expert Panel (2024/5)	
Panelist	***Affiliation***
Cecilia Lane	District Dept. of Energy and Environment (DOEE)
Frank Schneider & Denise Uzupis	Pennsylvania Dept. of Agriculture
Martin Hurd	Fairfax County, VA
Dylan Burgevin	Maryland Dept. of the Environment
Arianna Johns & Kay Alexander	Virginia Dept. of Environmental Quality
Dave Montali	Tetra Tech
Kevin Du Bois	Department of Defense
Michael Goatley	Virginia Tech
Gonzalo Ortiz	Virginia Tech, Virginia DCR
Peter Landschoot	Pennsylvania State University (emeritus)
David Wood & Michele Berry	CSN (Panel co-facilitators)

The charge of the panel is to review and update the available science on the nutrient removal performance associated with different approaches to urban nutrient management. In doing so, the USWG specifically requests that the Panel investigate the following variables that may influence the performance, tracking, and verification of the practice:

- Evaluate the effectiveness of state fertilizer legislation in reducing the application of nitrogen and phosphorus on urban turf grass.
    - Consider how urban fertilizer sales data are used to inform baseline N and P loads to urban turfgrass, and determine if the methods are accurately capturing trends in fertilizer use.
    - Determine if there are other data sources that can inform urban nutrient application rates, and the impacts of fertilizer legislation
    - As-needed, develop a proposed alternative crediting mechanism, or provide justification for maintaining or making minor modifications to current approach.

- Evaluate options and implications for providing nutrient reductions for large, non-fertilized lands.

    - Evaluate options for reducing nutrient loads to non-fertilized turfgrass acres. This could include the feasibility of a unique land use, an efficiency BMP, etc.
    - Establish streamlined methods of tracking and reporting that would allow this type of credit without undue burden on the local and state agencies
    - Work with the Modeling Workgroup (MWG) and Wastewater Treatment Workgroup (WWTWG) to determine if there are other sources of urban nutrients that can be quantified and accounted for, that are not currently part of the modeling system, that help to explain and account for non-fertilized lands (organic inputs, gray infrastructure discharges, etc.).
    - Determine how remaining nutrients get distributed when acres are reported as non-fertilized.

- Evaluate potential approaches to streamline tracking, reporting, and verification of both individual urban nutrient management plans, and any pollutant removal associated with state-wide fertilizer legislation.

- Update the characterization of urban nutrient management trends and behaviors.
    - Consider factors including the extent of turf cover, factors influencing risk of nutrient export, turf trends and projections, and human behavior.

- Provide guidance to the CBP Modeling Team to aid in the development of the Phase 7 Watershed Model
    - Work with the USWG to provide requested feedback on urban nutrient application and physical process simulation, including P export pathways, and P sensitivities.
    - Determine whether the urban fertilizer application method developed by the Phase 1 Task Force should be revised or continued.

Beyond this specific charge, the panel is asked to;

- Take an adaptive management approach to refine the accuracy of its removal rates, including any recommendations for further monitoring research that would fill critical management gaps.

- Critically analyze any unintended consequences associated with the nutrient management credit and any potential for double or over-counting of the credit.

While conducting its review, the Panel shall follow the procedures and process outlined in the BMP review protocol, as amended (WQGIT, 2015).

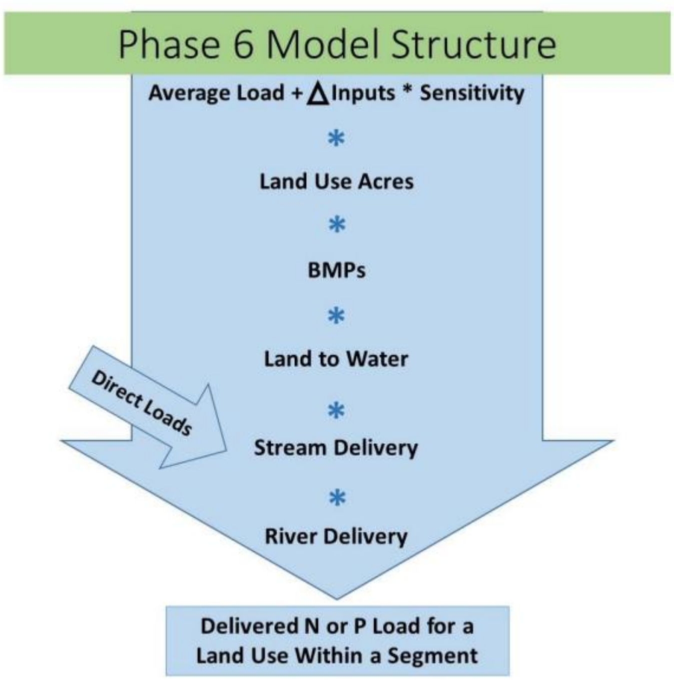
2. Simulating Urban Nutrients in the Phase 6 Chesapeake Bay Model

Basic Model Structure

The Chesapeake Bay Program uses a suite of models that work together to estimate changes to tidal water quality in the Chesapeake Bay. Best management practices are simulated as part of the Watershed Model, which estimates the amount of N, P and sediment that reaches the Chesapeake Bay from its tributaries and watershed. The Watershed Model is currently in its "Phase 6" version, which is updated every two years according to rules established by the Chesapeake Bay Program partnership through collaboration of the Water Quality Goal Implementation Team (WQGIT), Modeling Workgroup, Bay Program modelers and other partners.

The Phase 6 Model differs in structure from previous models in that its physical simulation components are greatly simplified (Figure 1). This structure allows for better stakeholder understanding of the processes, speeds up computations, and results in a demonstrably better agreement with water quality observations.

Figure 1. Phase 6 Watershed Model Structure.



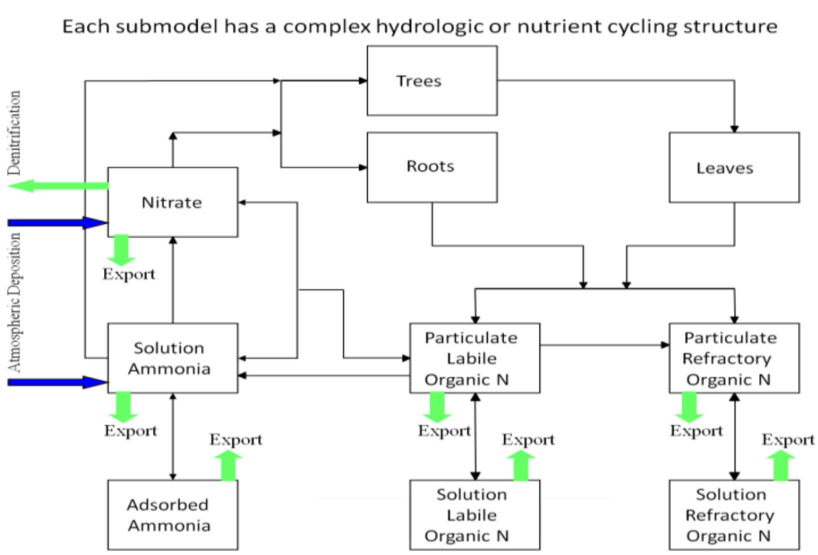
For lawns and turf, average loading rate data were taken from the Land Use Loading Literature Review Task Summary and Results technical memo (Sievers, 2014). The data used from the memo originally came from the National Stormwater Quality Database (NSQD). Inputs for turf come from non-farm fertilizer sales data (discussed in the following section), and modified by sensitivity factors for atmospheric deposition, fertilizer, crop uptake, and vegetative cover.

Phosphorus on turfgrass was simulated in Phase 5 using the Pervious Quality Constituent (PQUAL) module. PQUAL has a surface build-up and wash-off component, in addition to concentration coefficient models for subsurface loads. The PQUAL concentration coefficients are user-specified constants that are independent of inputs and thus have no simulated sensitivity. As a decision of the Modeling Workgroup, PQUAL concentration coefficients were assigned a sensitivity in Phase 5.3.2 such that reducing all inputs to zero would result an export of half the calibrated nutrient load from that land use. This is equivalent to a relative sensitivity of 0.5. The 2013 Expert Panel reviewed the Phase 5.3.2 simulation of phosphorus on developed land and concluded that the response to the change in phosphorus inputs applied to pervious land was consistent with the limited empirical research available. From Section 5 of the 2013 Expert Panel Report, "The [Phase 5.3.2] model scenario reflected a 100 percent reduction in the phosphorus fertilizer applied to pervious land, and… the change in the urban load ranged between 6 and 17 percent, depending on the state, which appears to be consistent with the limited empirical research in the upper Midwest watersheds where fertilizer P restrictions have been enacted".

Due to the conclusions of the 2013 Expert Panel, the Phase 5.3.2 approach to P sensitivity simulation was carried forward into the Phase 6 Model.

N simulation was expanded to include sensitivities from SPARROW, in addition to AGCHEM (used in Phase 5.3.2). The AGCHEM module is a detailed simulation of the N cycle, simulating plant uptake, mineralization, nitrification, denitrification, sorption, litter fall, and other processes (Figure 2). Inorganic and organic forms of each are tracked. AGCHEM accepts inputs of N from multiple sources including atmospheric deposition, and inorganic fertilizer. Summarized results from AGCHEM were used for Phase 6 N sensitivities.

Figure 2. Conceptual Diagram Showing How N is Simulated for Pervious lands in the AGCHEM module



Nutrient Inputs to Turfgrass

Turfgrass fertilizer application rates vary through time and among states in the Phase 6 Model according to a process approved by the Bay Program's Urban Stormwater Workgroup. This approach represents one of the greatest changes from the 2013 Expert Panel Report. Following the recommendation from the 2013 Expert Panel to rely on state-reported trends in the nutrient content of non-farm fertilizer sales data to adjust nutrient inputs, the USWG approved a change in 2023 to the non-farm fertilizer application methodology.

Under the current approach, data are gathered from three sources: county-level non-farm commercial fertilizer sales data from the American Association of Plant Food Control Officials (AAPFCO); fertilizer sales data provided by each state; and county-level turfgrass acres provided by the Chesapeake Bay Program/USGS.

Once data are gathered, the mass of fertilizer nutrients (N and P) is summed for all counties that have a portion in the Chesapeake Bay Watershed. Similarly, the statewide turfgrass acres (from the turfgrass and tree canopy over turfgrass land use categories) are summed for all counties that have a portion in the watershed. AAPFCO data are used for the period from 1985-2016, while state-reported data are used for 2017-2020/21 (the most recent year available as of publication of this report).

Once the data are summed, the sales data are processed by removing data outliers at the county-scale and taking a 3-year rolling average in order to smooth the data and establish trends. Finally, the state-wide fertilizer nutrient mass divided by the state-wide turfgrass acres to determine the fertilizer application rate for each state.

Total estimated fertilizer applied in entire counties that are wholly or partially within the Chesapeake Bay Watershed in a given state is divided by the acres of turfgrass in those same counties.

Trends on Non-Farm Fertilizer Sales and Turfgrass Acres

When the 2013 Expert Panel Recommendations were released, non-farm fertilizer sales trends reported by industry sources demonstrated that substantial decreases in the overall amount of both N and P sold in lawn fertilizer between 2006-2010. At the time, non-farm fertilizer sales data from state agricultural agencies were extremely limited across the watershed, but was the preferred source for tracking trends moving forward.

In the years since the Panel report, trends in both TN and TP sales have continued, with sales declining in the years between 2010 and the present. Data from Scott's Miracle Gro (SMG) was obtained through 2014 by Dr. Ken Staver, a member of the 2013 Expert Panel, and showed trends that continued to show the declines observed between 2006-2010 (Table 3).

Table 3. Industry Reported Fertilizer Sales (in millions of pounds) in Bay States, 2006 to 2014[1]

	TN			TP		
	2006	*2010*	*2014*	*2006*	*2010*	*2014*
Pennsylvania	13.68	7.67	9.33	1.41	0.26	0.04
Maryland	6.57	3.60	2.52	0.68	0.10	0.00
Virginia	5.77	5.46	4.75	0.60	0.22	0.02
Delaware	0.86	1.21	0.85	0.09	0.04	0.00
West Virginia	0.64	0.55	0.36	0.07	0.02	0.01
DC	0.02	0.00	0.00	0.00	0.00	0.00
Total	**27.54**	**18.49**	**17.81**	**2.85**	**0.64**	**0.07**

1 Annual sales data reported by SMG (2014) for non-farm fertilizer sales by state. As of 2014, Scott's MiracleGro reported a 50% retail market share. Analysis performed by Gary Felton, and shared with the Expert Panel by Karl Berger.
2 Note that the statistics are provided for each state as a whole, and NOT the fraction of the state located within the Bay watershed. Data from New York was not provided.

These trends from industry are largely supported by trends from the state agricultural datasets and AAPFCO. Table 4 shows the reported fertilizer sales of TN and TP through time as reported by AAPFCO/the state agencies, up through the most recent year the data are available.

Table 4. State-Reported Non-Farm Fertilizer Sales (in millions of lbs) in Bay States, 2006 to 2020

State	TN				TP			
	2006	*2010*	*2014*	*2020*	*2006*	*2010*	*2014*	*2020*
Pennsylvania	16.22	17.71	15.00	14.00	1.92	1.58	1.19	1.18
Maryland	44.66	25.28	19.49	11.79	4.11	3.98	4.42	0.95
Virginia	19.78	15.53	14.66	13.33	3.09	1.93	1.31	1.35
Delaware	2.97	2.26	0.93	1.98	0.34	0.14	0.06	0.12
West Virginia	0.12	0.02	0.97	N/A	0.03	0.00	0.02	N/A
New York	4.97	3.58	3.76	N/A	0.66	0.33	0.31	N/A
Total	**88.72**	**64.38**	**54.81**	**41.10**	**10.15**	**7.96**	**7.31**	**3.60**

Data from Phase 6 Model, provided by Jessica Rigelman.
Note that the statistics are provided for each state as a whole, and NOT the fraction of the state located within the Bay watershed. DC does not report data to AAPFCO, non-farm fertilizer application rates are taken as an average of VA and MD.

It is worth noting that while the magnitude differs (suggesting perhaps Scotts was closer to a 30% retail market share), the trends in TN are very closely aligned, with both datasets showing a 35-38% decline in TN sales between 2006 and 2014. Both TP datasets also show declining sales trends, however, the TP phase-out was much more comprehensive in the Scott's data than in the state/AAPFCO data. One reason for this could be a potential lagging effect in TP phase-out following the enactment of new phosphorus legislation. With Maryland's phosphorus legislation taking effect in 2013, TP sales fell significantly between 2014 and 2020 after years of roughly steady sales. Another explanation could be that while Scott's committed to a complete phase-out of TP by 2013, this commitment was not held by other fertilizer companies in the region.

The other major factor affecting trends in non-farm fertilizer sales and application rates is the change in turfgrass acres across the Chesapeake Bay watershed. The acreage of turf cover has steadily increased in the Bay watershed over the last four decades as farms and forests have been converted into new development (Schueler, 2010). With new development, small parcels of turf cover are interspersed within a broader mosaic of land use that make it a challenge to characterize (Claggett et al., 2011). The Phase 6 model added a new category of urban pervious for turf grass beneath tree canopy. The estimated acreage of turf cover in each Bay state is provided in Table 5.

Table 5. Change in turfgrass acres, by state, from 2010-2020

	Turfgrass Acres		
	2010	*2020*	*% Change*
Pennsylvania	1,479,354	1,534,314	**4%**
Maryland	836,925	876,413	**5%**
Virginia	1,297,898	1,379,641	**6%**
Delaware	166,622	181,041	**9%**
West Virginia	148,228	163,033	**10%**
DC	11,232	11,596	**3%**
New York	570,301	597,462	**5%**
Total	4,510,560	4,743,500	**5%**

Turfgrass acres in the CAST-23 version of the Phase 6 Model.

3. Background on Existing Credit for State-wide Fertilizer Legislation

A major emphasis of the 2013 Expert Panel was defining state-wide P reduction credits for pervious lands to reflect the phase-out of P in fertilizer products following legislation passed in Maryland, Virginia and New York between 2010 and 2013. A common feature in all three states was the elimination of P in lawn maintenance fertilizer products. There are many other elements to each state law, and an updated summary is included in Section 5 of this report. Some include a ban on winter fertilization applications, expanded product labeling requirements, and prohibitions on applying fertilizer to impervious surfaces or near water features. Some states also establish a certification process for commercial applicators. Maryland also has specific requirements on the maximum individual application of N fertilizer, and a minimum requirement for slow-release N formulations.

The credit that the 2013 Panel established used the Chesapeake Bay Watershed Model as a starting point and ran a series of scenarios to reflect a 70% reduction in P fertilizer application rate for states that had adopted P fertilizer legislation, and a 60% reduction in P fertilizer application rate for all other states. The resulting P reduction credits are listed in Table 6.

Table 6. Recommended TP Load Reduction Credit from Pervious Lands Based on Fertilizer Legislation and Industry P Phase-Out

	TP Reduction (millions of lbs)	*% Change in Pervious Load*	*% Change in Urban Load*
Pennsylvania	0.046	-20.0	**-10.4**
Maryland	0.060	-25.1	**-8.6**
Virginia	0.125	-26.7	**-10.2**
Delaware	0.0018	-19.0	**-7.8**
West Virginia	0.0048	-21.1	**-4.4**
DC	0.0006	-21.2	**-3.6**
New York	0.012	-26.5	**-11.6**

Based on analysis by Gary Shenk, CBPO, April 10, 2012 using the CBWM Phase 5.3.2 model, assuming 0% P application rate, and multiplied by 0.7 for legislation states, and 0.6 for non-legislation states.
PA legislation was not yet passed at the time of this analysis.

The 2013 Panel acknowledged that the most appropriate method to verify P fertilizer reductions over time was to analyze the actual nutrient content in future non-farm fertilizer sales data. Therefore, in 2016, the automatic state credit lapsed and was replaced with state-reported estimates of P fertilizer applications to pervious land, as described in Table 4 in the previous section of this report.

While TN was not subject to any explicit bans in the legislation, or any formal industry phase-out, the panel also left room for future state-wide reductions if states could document a reduction in N fertilizer applications to pervious lands using the same approach as TP. This has since been addressed via the state-reported data, also outlined in Table 4.

4. Background on the Existing Credit for Individual Urban Nutrient Management Plans

Defining the BMP for Individual UNM Plans (2013)

The 2013 Expert Panel identified 11 site-based factors associated with a high risk of N and P export (Table 7). This approach was rooted in the understanding that most lawns in the urban landscape are reasonably retentive of nutrients under most conditions, with a small proportion of high-risk lawn conditions or behaviors responsible for most of the total nutrient export. Therefore, plans and behaviors targeting the high-risk landscapes will yield the greatest benefits to water quality.

Table 7. List of High Risk Conditions or Behaviors Likely to Contribute to Greater Nutrient Export from Turfgrass (2013 Expert Panel)
1. Owners are currently over-fertilizing beyond state or extension guidelines 2. P-saturated soils as determined by a soil analysis 3. Newly established turf 4. Steep slopes (more than 15%) 5. Exposed soil (more than 5% for managed turf, and 15% for unmanaged turf) 6. High water table (within 3 ft of surface) 7. Over-irrigated lawns 8. Soils that are shallow, compacted, or low water holding capacity 9. High use areas (e.g., athletic fields, golf courses) 10. Sandy soils (infiltration rate more than 2 inches per hour) 11. Adjacent to stream, river, or Bay (within 300 ft) 12. Karst terrain

In addition to defining the factors influencing nutrient export risk, the Panel developed a series of ten core lawn care practices that minimize the risk of N and P export (Table 8). The crux of these practices is optimizing the timing and rate of fertilizer application, while avoiding behaviors that could expedite the transport of excess nutrients to surface waters. These practices represent a mix of fertilizer application behaviors, and other, more general approaches to maintaining healthy turf that retains nutrients and sediments.

Table 8. List of 10 Core Urban Nutrient Management Practices (2013 Expert Panel)
1. Consult with the local extension service office, certified plan writer or applicator to get technical assistance to develop an effective urban nutrient management plan for the property, based on a soil test analysis 2. Maintain a dense vegetative cover of turf grass to reduce runoff, prevent erosion, and retain nutrients 3. Per the UNM plan, Choose not to fertilize, OR Adopt a Reduce Rate/Monitor Strategy, OR Apply less than a pound of N/ 1000 square feet per each individual application 4. Retain clippings and mulched leaves on the lawn and keep them out of streets and storm drains 5. Do not apply fertilizers before spring green up or after the grass becomes dormant 6. Maximize use of slow-release N fertilizer 7. Set mower height at 3 inches or taller 8. Immediately sweep or blow off any fertilizer that lands on a paved surface 9. Do not apply fertilizer within 15 to 20 feet of a water feature (depending on any applicable state regulations) and consider managing this zone as a perennial planting, meadow, grass buffer or forest buffer 10. Employ lawn practices to increase soil porosity and infiltration capability, especially along portions of the lawn that are used to convey or treat stormwater runoff

Combining the importance of targeting high risk lawns, with the core practices designed to mitigate nutrient export, the panel ultimately defined 3 BMPs for urban nutrient management plans:

Table 9. Nitrogen and P Reduction Credits for Qualifying Individual Urban Nutrient Management BMPs		
Turf Management Category	**Annual TN Reduction Rate[1]**	**Annual TP Reduction Rate[1]**
Low Risk Lawns	6%	3%
High Risk Lawns	20%	10%
Blended Rate[2]	9%	4.5%
1 Reduction rate applies to pervious land, regardless of fertilization regime (including non-fertilized lawns) 2 Blended rate is provided as a default if the risk is unknown. It assumes 80% of lawns fall into the low-risk category, and 20% fall into the high-risk category.		

Built into these pollutant removal rates was an understanding that natural factors like the timing and intensity of a rainfall event can influence the effectiveness of nutrient management plans. Further, the panel understood that homeowners and commercial applicators alike may vary greatly in how effectively they implement the core practices in the real world. Therefore, the rates reflect incomplete implementation of UNM plans.

Qualifying Criteria (2013)

The 2013 Expert Panel established the following conditions as a pre-requisite for an "Acceptable Urban Nutrient Management Plan":

- Each UNM plan must be prepared by a trained expert (e.g., certified plan writer), which may require soil testing and may also contain other practices to improve lawn health and aesthetics.
- The UNM plan must be consistent with the applicable UNM lawn care practices recommended in this report or existing state UNM requirements.
- Each UNM plan must clearly document the:
    - Start and end dates for the plan
    - Name, contact information and locator data for the owner, applicator and UNM planner
    - Acreage of turf and landscaping covered by the plan
    - Annual N and P fertilization rate, if any
    - Whether the turf is classified as high or low risk of nutrient export or is an unfertilized lawn (optional)
- The plan must contain a signed commitment by the owner that they intend to implement the plan.
- Commercial applicators can send a UNM template for the lawns they service as long as they follow the core UNM practices.
- Simpler homeowner pledges to implement the core UNM practices may also be considered acceptable in some states as long as they meet the commitment and reporting requirements. In general, the Panel recommends that the acreage of homeowner pledges should only qualify for the low risk UNM credit, given that they are harder to verify. The duration of pledges is limited to 3 years, but can be renewed.

It should be noted that the qualifying criteria provided significant flexibility to the UNM plan-writers to align the core practices with site-specific needs, rather than requiring all or any subset of specific practices to qualify. Further, no guidance was provided on determining the risk level for the site, implying that the presence of a single high-risk factor would qualify the plan for the High-Risk credit.

Individual UNM Plan Verification (2013)

The 2013 Expert Panel report was released prior to the development of the Chesapeake Bay Program's *Basin-Wide BMP Verification Framework*. That framework formally established a system to ensure that implemented BMPs designed to reduce pollution are functioning correctly and achieving the intended water quality improvements over time. While it pre-dated the Verification Framework, the Panel did understand that UNM plans represent a particular challenge for long-term accountability, as a voluntary intention to implement specific lawn care practices in the future, and not necessarily an assurance that they have actually been implemented on the lawn. To address this challenge, they recommended the following:

- The maximum duration of an individual UNM plan is up to three years, at which point it can be renewed based on affirmation from the owner or applicator that they are either (a) maintaining the plan or (b) or have modified the plan based on further professional feedback and (c) modified based on new soil sample information.

- If a UNM plan cannot be reconfirmed after three years, it will be considered lapsed, and the treated acreage should be deducted from the UNM planning agency database. Turf areas greater than one acre in size may require an on-site visit to assess turf condition and nutrient export risk.

The Panel also recommended the need for verification through statistical sub-sampling. In other words, the UNM planning agency (or delegated third party organization) would need to randomly sub-sample either plan writers or property owners with high nutrient export risk under a defined schedule to verify compliance with the UNM plan. The aggregate compliance rates derived from these surveys will be used to extrapolate UNM compliance rates for the community as a whole and make any adjustments or downgrades to the nutrient reduction performance for this practice.

However, the Panel could not agree on what elements of UNM could actually be inspected during an on-site visit, nor a numeric threshold for the intensity of sub-sampling to provide acceptable verification data. The Panel noted that the statistical rigor of any UNM subsampling effort should be consistent with the verification protocols being developed for agricultural nutrient management practices, while at the same time recognizing that limited capacity currently exists in the urban sector to assess what could amount to hundreds of thousands of properties. The Panel felt that creating better UNM sub-sampling procedures should be a major priority research and implementation priority in the next few years. That never came to fruition, though there are examples of statistical subsampling procedures used for verifying certain agriculture BMPs that may be used as an example.

Trends in UNM Plan Reporting

When the 2013 Expert Panel report was published, Bay states were anticipating widespread implementation of urban nutrient management plans. The Phase 2 Watershed Implementation Plans (WIPs), submitted to EPA in 2012 indicated intent to cover 45% of all urban pervious acres in the watershed with Urban Nutrient Management Plans by 2025, with some states (New York, Delaware, DC) committing to greater than 95% coverage.

Due largely to the burden of tracking and verifying individual urban nutrient management plans, implementation of the individual UNM Plan BMPs across states has instead largely declined since the report was released in 2013 (Table 10).

Table 10. Acres of credited Urban Nutrient Management Plans Reported for 2023 Progress

	Acres Credited	Pervious Acres	Percent Covered
Delaware	420	186,117	0.2%
Maryland[1]	689, 387	881,001	78.3%
New York[2]	815	598,476	0.1%
Virginia	87,568	1,416,155	6.2%
DC	0	11,696	0.0%
Pennsylvania	0	1,555,906	0.0%
West Virginia	0	169,220	0.0%
Total	778,280	4,818,571	16.2%

1 Maryland reported 263,393 acres of "Commercial Applicator" credit, and 425,995 acres of "DIY" credit.
2 New York provided High Risk and Low Risk splits. All other states claimed the Blended Rate (9% TN, 4.5% TP).

Maryland's reported acres are the result of a state-specific BMP established by the 2013 Expert Panel. At the time of the report, Maryland's lawn fertilizer legislation was the only in the watershed to meet criteria for nitrogen reductions. As a result of those regulations (MDA, 2013), commercial applicators in Maryland are required to use at least 7 out of the 10 core UNM practices. Consequently, the Panel determined that Maryland was eligible to take the "blended" UNM nitrogen credit (i.e., 9%) for the total acreage of lawns managed by commercial applicators that it can verify as conforming with the new regulations.

The Panel also decided that Maryland could also receive low risk UNM N credit (4.5%) for the acreage of home lawns managed by "do-it-yourselfers", as influenced by its new retail sales and labeling requirements. The smaller credit is warranted by the fact that only 4 of the 10 core UNM practices are implemented under this approach (i.e., several practices are still subject to homeowner discretion).

To prevent double-counting, Maryland was not eligible for state-wide N reduction credits (a limitation now in conflict with the Phase 6 non-farm fertilizer application methods, which applies reduced application rates across all states based on sales data). Maryland was also required to maintain records on training, certification and enforcement of commercial applicators subject to their new regulations, and will need to document how they measure the acreage of pervious land subject to commercial applicators and do-it-yourselfers.

5. Updated Review of Current Science and Practice

Nutrient Dynamics in Urban Turfgrass

The 2013 Expert Panel provided a comprehensive review of research to better understand the nutrient dynamics of turf grass "ecosystems" and their relationship to nutrient loads and downstream water quality. This Panel conducted an update of that review, identifying an additional 35 papers published between 2012 and 2024 on the N and P dynamics in turfgrass systems, and the fertilization practices that influence them. Overall, the updated literature largely re-affirms the core principles of N and P dynamics underpinning the 2013 Expert Panel report. Urban and suburban lawns are largely retentive of nutrients, particularly N. Losses that do occur, particularly for nitrogen, occur during hotspots and hot moments – locations in the landscape and specific times that are especially prone to disproportionately high nutrient export. High rates of N fertilization increase the risk of these hotspots and hot moments, which are otherwise influenced by the timing and location of the fertilizer application. Management of turfgrass designed to reduce detrimental water quality impacts should therefore focus primarily on rate, timing, and placement. This section will outline the key findings from the updated literature review.

Phosphorus Dynamics

The proliferation of legislation targeting P in fertilizer has decreased the sales and use of P (see Tables 2 and 3). As a likely consequence, there is far less new literature focused on P fertilization of turfgrass, since it is no longer a common practice for lawn maintenance. The new literature reviewed largely reinforced the P dynamics outlined in the 2013 report:

There are four potential pathways where P can be exported from urban lawns:

1. Leaching into groundwater (usually minor)
2. Soluble P in surface runoff
3. Sediment bound P in surface runoff
4. Organic matter (i.e., leaves and grass clippings) that reach adjacent impervious cover and are washed into the storm drain system

Phosphorus leaching is generally only a concern on shallow, sandy or artificially drained soils, as most P seldom leaches more than three feet through the soil (Daniels et al., 2010). Some urban soils may be saturated with respect to P, either because they have been fertilized for many years and/or because they reflect the legacy of past farming activity (Yuan et al., 2014). As these legacy nutrients build up, there is evidence that effective reduction of P levels in soil tests and P concentrations in runoff from such soils by ceasing P applications appears to involve lag times on the order of a decade or more, depending on the degree of soil P accumulation (Dodd et al., 2012). In these saturated conditions, soluble P can leave the soil in surface runoff without sediment (e.g., Maguire and Sims, 2002; Soldat and Petrovic, 2009).

A more significant loss-mechanism occurs when P attached to sediment and organic matter is exported by surface runoff. New research mostly reaffirms prior findings that P export from lawns is primarily driven by surface runoff. Recent research also reaffirmed that the key factors contributing to P loss from urban turfgrass were primarily hydrologic factors that increase runoff losses: compaction, frozen soils, high intensity storm events, steep slope, and connection to high density impervious cover

(Hobbie et al., 2017; Carey et al., 2012; Steir et al., 2012). The potential loss is greatest when turf is dormant and particularly when soils are frozen (Bierman et al., 2010a).

With regards to organic matter, turf grass clippings typically contain 2.0 to 5.0% P in dry matter tissue (Soldat and Petrovic, 2008, Guillard and Dest, 2003). Ray (1997) measured the P content of dead leaves at 1.5% of their dry weight. Soldat et al. (2009) notes that P can be released by dead vegetation. Dorney (1986) reported that 9% of total P in leaves was potentially leachable in 2 hours.

Various studies have evaluated P losses from fertilized lawns. Shuman (2004) noted that losses sharply increased as the P fertilizer application rate increased, but also noted that a certain amount of P loss was independent of fertilizer application. Soldat and Petrovic (2008) reviewed 12 studies and noted that P losses ranged from less than 1% to as much as 18%, depending on turf grass conditions and fertilizer timing. A newer study supported that general range, with TP lost as a percent of applied P ranging from 4-6% (King et al., 2012).

One point of emphasis the Panel deemed particularly relevant from the literature review is that P losses from fertilizer are more likely driven by localized hotspots in the landscape. Human-altered landscapes have been shown to be more likely to contain hotspots with high mean soil P and high P variability compared to natural sites (Bennet et al., 2004). Recent work on home/community gardens and urban farms suggests these sites are very nutrient inefficient and that P is applied well above recommended rates, leading to build up and loss (Small et al., 2019). Finally, P loss is greatest when storms occur shortly after P fertilizer applications (Soldat and Petrovic, 2008).

Soil Test Phosphorus Data

The Expert Panel was also interested in exploring the availability and limitations of using lab soil-test data from the Chesapeake Bay watershed to better understand the P content in urban and suburban turf. The Chesapeake Bay Program collected soil test data from five labs across the region, representing a mix of private and state-university labs. The focus of this effort was on agricultural soil analysis, but two labs, Pennsylvania State University, and the University of Delaware, did collect data from lawns.

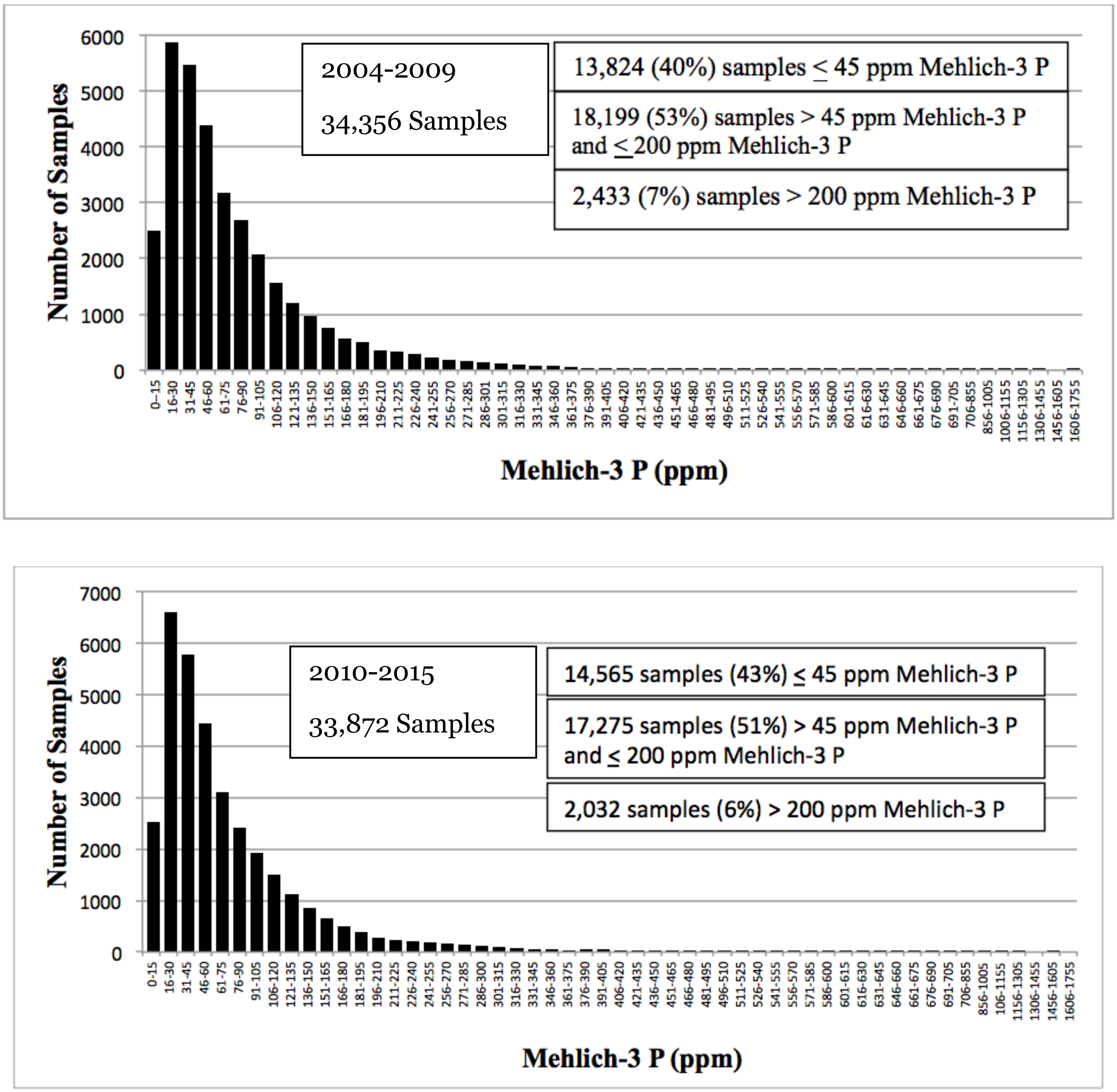
Table 11. Soil Test P Data from Turfgrass Reported to the Chesapeake Bay Program

Lab	**# of samples**	**Median P ppm**
University of Delaware	1190	97
Pennsylvania State University	1615	51

Data from 2014, Mehlich-3 P. Delaware data converted from P Fertility Index Value (FIV) to ppm.
Delaware data represents “Lawn and Garden”
Penn State Data represents Home Lawns, Industrial Lawns, Park Lawns, School Lawns, Athletic Fields, and Golf Courses

The Panel also discussed trends in soil test P data from Pennsylvania. Twelve years of home lawn samples submitted to Penn State's Agricultural Analytical Services Lab (AASL) between 2004 and 2015 (68,328 samples) were summarized in two 6-year increments to determine trends in soil Mehlich-3 P – a common test used to measure extracted P from soils.

Figure 3. Trends in Home Lawn Mehlich-3 P concentrations from Pennsylvania State University Soil Lab between 2004-2009, and 2010-2015 (Landschoot and Spargo, 2022).



Overall, there was not much of a trend between P content analyzed in 2004-2009 and 2010-2015. Both of these periods were prior to Pennsylvania's fertilizer legislation. Of the samples, about half in each timeframe were above 45-ppm, and 6-7% were above 200 ppm. The 200 ppm Mehlich-3 P level is a relatively arbitrary cutoff, but one that represents a point where significant P loss may be occurring (Landschoot and Spargo, 2022).

Due to the variability of P in soil, sampling irregularities, lack of updated research data, and possible P removal between testing episodes, P application may be recommended when Mehlic-3 P levels are below 20-45ppm to ensure healthy turf (Landschoot and Spargo, 2022; UF/IFAS, 2023)

The samples were submitted by homeowners and professional lawn fertilizer applicators. No attempt was made to solicit samples. Sims (2000) indicated that soil-test summary data from public laboratories may be biased because they do not include information from private labs and may represent only those individuals who care enough about the state of their lawns to test soil. However, Sims also stated that these data should not be ignored when striking trends emerge.

Overall, the Panel lacked the data needed to base large-scale changes to P simulation in the Phase 7 model based on soil test P data. Data would be needed from, at a minimum, each state (or preferably, county) in the watershed, and must have a consistently available record through time. The Panel emphasized the significant need for more soil test calibration studies on a regional basis, focused on urban and suburban turfgrass.

Nitrogen Dynamics

Research indicates that lawns are highly retentive of fertilizer N under typical application rates and lawn conditions. Groffman et al. (2004) found approximately 75% of fertilizer N was retained in urban lawns monitored in Baltimore. Kussow et al. (2012) found that lawn uptake is largely demand driven, with clipping production for grasses increased linearly up to 600 kg/ha/yr N application. At typical N application (150-300 kg/ha/yr), N supply was the determinant of growth rate, and nutrient uptake. Kaushal et al. (2011) used N isotopic ratio signatures to show watershed export of N is not directly proportional to fertilizer inputs in Baltimore watersheds. Though lawn fertilizer is a significant input to the watersheds – 37-59% of total N inputs in a Minnesota watershed study (Hobbie et al., 2016) - the isotopic signatures of stream N suggest sewage is a much more significant N loading source than lawn fertilizer. This has been supported by other studies in the region, with Nguyen and Venohr (2020) finding that sewer exfiltration TN is 11.2% of the urban load to groundwater

New research on N management is more robust than new research on P management. In particular, there is an increasing emphasis on more interdisciplinary studies evaluating the relationships between management, hydrology, and geomorphology. While the core research from the 2013 Expert Panel Report remains largely unchanged, there is increasing nuance surrounding the hotspots and hot moments that drive the majority of N losses from turfgrass systems. Best management practices are still centered around appropriate Rate, Timing, and Placement of fertilizer, with new understanding that they cannot be considered independent of each other (Cote and Gregoire, 2021).

There are four potential pathways where N can be exported from urban lawns:

1. Leaching of nitrate into groundwater
2. Loss of nitrate and ammonium in overland flow
3. Organic N (e.g., lawn clippings or N attached to eroded sediments that runs off or is blown over to adjacent impervious cover and is washed into the storm drain system,
4. Volatilization of ammonia into the atmosphere shortly after fertilization

The degree to which N is lost via these pathways is determined by a combination of factors, including the soils, topography, weather, turf conditions, and fertilizer management practices. The focus of this report is on fertilizer management, so this review will frame N dynamics in the context of fertilizer rate, timing, source, and placement.

Fertilizer Rate:

Studies that compared fertilized turfgrass landscapes to non-fertilized landscapes generally conclude that average N losses from sites with robust turf, managed in accordance with fertilization best practices, are similar to N losses from non-fertilized sites, but that fertilization creates the risk of hot spots and hot moments that do not exist at non-fertilized sites (Bachman et al., 2016; Lusk et al., 2018; Groffman et al., 2023).

Nitrate leaching can be a significant source of N export under certain lawn conditions, and is dependent on soil type, irrigation, grass species, rooting depth and fertilization rate and timing (Bowman et al., 2002; Pare et al., 2006). Some new work also suggests that nitrate leaching can increase over time following several years of consistently high N fertilizer application rates (Frank et al., 2016).

Prior analysis indicates relatively low N losses for lawns that received less than 130 lbs N/yr (or <3 lbs N/1000 square feet lawn). By contrast, N losses were significantly higher for lawns with N fertilizer treatments that exceeded the 3 lb threshold. Cary et al. (2012) found the threshold to be a bit higher, with 5% of applied N typically leached from established turfgrass with moderate application rates (around 4 lbs N/1000 square feet). Frank et al. (2016) also found that application rate plays a more significant role when soils become N saturated, suggesting that in those circumstances, the source or timing of N fertilizer is less important than reducing the annual rate of fertilization to control N leaching.

Other new research on fertilization rates shows a more complicated picture when it comes to how fertilization rates interact with other factors. One study measured nitrate-N losses in overland flow over 87 rainfall events from low and high maintenance lawns in the North Carolina piedmont (Spence et al., 2012). The authors found that the highly maintained lawns (fertilizer, irrigation and reseeding) generated slightly less runoff and N export (about 1% of N fertilizer applied) than lawns with a less intense maintenance regime (which still included fertilization). The authors did note that their test lawns were located on undisturbed and highly permeable soils, which may not be representative of all sites.

Bachman et al. (2016) found that concentrations of TN and nitrate in baseflow from a turf-dominated watershed were comparable to those measured in surrounding meadow and forest sites. Suchy et al. (2021) found that fertilizer application doesn't appear to inherently increase or decrease the potential of a lawn to act as a hotspot of N mobilization. Rather, they suggest that the lawns most at risk of N mobilization are those in close proximity to impervious surfaces. Another study found that fertilizer application rate had no overall effect on the average nitrate concentration in leachate or runoff, but that high nitrate concentrations in individual samples were ONLY found from fertilized lawns (Groffman et al., 2023). Finally, Cote and Gregoire (2021) found that N fertilization rate had no impact on leaching loss in loam, but that once it exceeded 90 lb/acre, N losses from sandy soils began to increase, and once it exceeded 180 lbs/acre N fertilization resulted in higher losses in clay soils.

Fertilizer Timing:

Nitrate leaching is greatest during the seasons of the year when the grass is dormant. Cool season turf grass typically goes dormant sometime in December and resumes growth at some point in February or March, depending on the severity of the winter. Warm season turf grass is in some form of dormancy from mid-October to mid-May. Cool season turf grass may also go dormant in the summer due to extensive drought or heat. Further, ground that is either saturated or frozen results in greater N losses via runoff (Guillard et al., 2008).

Scientific literature continues to support the importance of application timing in three key ways (Bachman et al., 2016; Cary et al., 2012; Cote and Gregoire, 2021):

- Fertilizer application in the dormant season significantly increases runoff losses.
- Splitting applications across the growing season reduces N export.
- Application prior to irrigation and/or rainfall events significantly increases N export.

While each of these factors were discussed in the 2013 Expert Panel Report to some extent, the biggest new development is the shifting focus to hot moments in nutrient losses from turf landscapes. Lawns are naturally retentive of N, and therefore, the majority of exports seem to be driven by high loss events, largely related to runoff caused by irrigation or high intensity rainfall events (Jani et al., 2020; Groffman et al., 2023; Rice and Horgan, 2017; Suchy et al., 2023).

Fertilizer Source:

New research emphasizes the importance of the source of N with regard to leachate. Most studies find a low proportion of total leachate derived from inorganic N fertilizer (Lusk et al., 2018), and place new focus on dissolved organic nitrogen as the primary source of leachate (Hall et al., 2016). While significant concentrations of particulate organic N have been measured in lawn runoff, the significance of this loss pathway is less clear when it comes to the total N export. While the particulate N concentrations for suburban lawns sampled by Spence et al. (2012) were high, the total particulate N load exported was less than 0.15 lbs/acre/yr, regardless of lawn maintenance regime.

Organic nitrogen may be derived from lawn clippings, leaves of trees and ornamental plantings, and eroded sediments that are blown or washed off lawns and into the storm drain system. For the purpose of this report, it should be noted that the high particulate organic N loads reported by Garn (2002) were attributed primarily to tree leaf litter, rather than grass clippings. Several authors have indicated organic nitrogen leaching to be an important N export mechanism (Daniels et al., 2010; Felton, 2007) given the rapid rate of decomposition and release of lawn organic matter, again emphasizing tree leaf litter as the dominant source. Each of these studies measured organic nitrogen at the catchment scale and emphasized the particular risk of N export from organic material that fell or was deposited on impervious surfaces like streets and sidewalks, where leachate was readily delivered to the storm drain catchment.

Other researchers have also shown that organic forms of N predominate over nitrate in residential catchment runoff (Garn, 2002; Spence et al., 2012). Lusk et al. (2018) found leachate samples composed of 90% dissolved organic N for both treatments and the control, with most derived from soil or existing biomass. Jani et al. (2020) similarly found that dissolved organic N was the dominant form found in runoff samples, comprising 46% of the total N, and correlated only to rainfall intensity, indicating it builds up in soils and organic detritus (leaf litter) and is flushed from soils in the residential catchment. This risk has been shown to be mitigated when organic matter is retained on turf (as opposed to being removed or swept to adjacent streets and sidewalks), if combined with reduced fertilizer application rates. Kopp and Guillard (2002) concluded that by retaining clippings on the lawn, N fertilization could be reduced by 50% or more without decreasing turf grass quality. A follow-up study by Kopp and Guillard (2005) notes that returning clippings "without a concomitant reduction in fertilizer application rates may lead to increased nitrate leaching losses" when clippings were returned.

The risk of nutrient export is reduced when slow-release fertilizer products are used during the growing season, compared to water soluble formulations. (Guillard and Kopp, 2004; Cohen et al., 1999; Quiroga-Garza et al., 2001; Lee et al., 2003; Felton, 2007; Bowman et al., 2002). Slow-release fertilizer formulations should be used with caution in the late fall, as the benefits of late-fall N applications from any source are generally less understood, particularly in cooler climates (Bauer et al., 2012), and because slow-release N sources may depend on moisture, temperature, and microbiological activity to become available for plant uptake or leaching, turf quality and nitrate leaching losses may be especially sensitive to N source effects in the fall (Mangiafico and Guillard, 2006; Zhang et al., 1998).

Fertilizer Placement:

The term "placement" in the context of fertilizer application often refers to whether the fertilizer is applied to the surface, or incorporated several inches into the soil to improve uptake. In this review, the term takes a broader meaning, referring to where on the landscape fertilizer is placed – including proximity to high-risk export features (impervious cover and surface waters), on new or old lawns, and slope.

The 2013 Expert Panel concluded that several risk factors sharply increased the risk of overland flow and potential fertilizer export. The amount of runoff volume is largely determined by lawn slope, soil compaction, and turf density. For example, Garn (2002) found that runoff was as much as 50% greater in steeply sloping (20% or greater slope) urban lawns. Nitrogen loss was most closely associated with shallow and compacted soils that had low water storage capacity.

Over the past ten years, there has been much more research related to the importance of lawn location on N dynamics. The biggest takeaways:

- The age of the lawn is seen as increasingly important, with newly established lawns as well as lawns over 20 years old exhibiting the greatest risk of N export.
- The positioning of the lawn in the flow pathway is an important factor, including proximity to impervious cover and areas with high foot traffic.

As referenced earlier, some work has shown that the impacts of fertilization rate and timing are dampened by location factors, such as proximity to impervious surfaces, swales, or areas with low infiltration rates (Suchy et al., 2021). Further, more interdisciplinary studies have found that areas with high foot traffic, and where the lawn meets the impervious surface (areas with low infiltrative capacity but high potential for denitrification) are a high priority target for evaluating how sites are graded and soils are managed, because they represent potential hotspots (Groffman et al., 2023). The importance of impervious surface connection was also found in cases where fertilizer was applied to gardens (Small et al., 2023), providing further evidence of this effect.

Nitrogen export can also be influenced by the age of the lawn. Chen et al. (2013) showed a "cup pattern", where N losses decreased after the initial turf establishment through approximately year 20, then began to increase again. The predicted cause of this pattern has to do with the combined effects of changing microbial activity associated with the succession of turfgrass ecosystems, and the growth efficiency and biochemical process rates in the soils over time. Easton and Petrovic (2008) noted that N losses were greatest in newly established turf, and like P, there seems to be more evidence that soils can become effectively N-saturated, leading to a need to reduce N application rates after 20-25 years (Frank et al., 2016; Smith et al., 2018; Lusk et al., 2018).

Status of Fertilizer Legislation and Evaluating Effectiveness

At the time the 2013 Expert Panel report was written, three states in the watershed (MD, NY, and VA) and DC had enacted P fertilizer legislation. In 2022, Pennsylvania also enacted legislation prohibiting P in turf fertilizers, and placing restrictions around the timing and rate of N application. An updated summary of each state law is provided in Table 12.

Table 12. Comparison of Bay State Fertilizer Legislation

Key Element	**MD**	**NY**	**VA**	**DC** [3]	**PA**
Year Enacted/Effective	2011/13	2011/12	2011/14	2012/13	2022/24
Rate					
P Ban on Lawn Maintenance Fertilizer	Yes	Yes	Yes	No	Yes
Product Labeling Requirement	Yes	Yes	Yes	Yes	Yes
Organic/Biosolids Exemption	No	No	Yes	No	Yes
Retail Display Requirements	No	Yes [1]	No	Yes	No
Maximum N Fertilizer Application	Yes	No	No	Yes	Yes
Slow-Release N Requirements	Yes	No	No	Yes	Yes
Specialty Product Exemptions [2]	Yes	Yes	Yes	No	Yes
Certification for Commercial Applicators	Yes	No	Yes	No	No
Enforcement and Fines	Yes	Yes	Yes	Yes	No
Timing					
Starter Lawn Exemption	Yes	Yes	Yes	No	Yes
Winter Application Ban	Yes	Yes	No	Yes	No [4]
Placement					
Prohibit Application on Paved Surfaces	Yes	Yes	Yes	Yes	Yes
Prohibit Application on or Near Surface Water Features	Yes	Yes	Yes	Yes	Yes

1. P containing fertilizer can be sold, but must be separated from zero-P fertilizer and marked with clear signage.
2. Exemptions vary by state, but include: when soil test indicates a need for P, during establishment or repair, and during the first growing season
3. DC legislation only applies to lawn care professionals. It bans P application unless a soil test identifies a deficiency, but homeowner adherence to legislation is voluntary.
4. PA restricts winter application to 0.5 lb N/1000sq ft between December 15th and March 1st. Maryland allows slow-release N applied by Lawn Care Professionals at maximum rate of 0.5 lb/1000 sq ft.

Evaluations of the effectiveness of fertilizer legislation is limited, despite P-bans proliferating across the country over the past decade. The best available study, out of Minnesota, was available to the 2013 panel. Research following Minnesota's P ban found that the legislation was effective at reducing the amount of P applied in the coverage areas (48% reduction in the first 3 years), but that there were yet to be any documented changes in water quality. They also found that P-free fertilizer comprised 82% of lawn fertilizers used by weight at the 3-year mark, and that there were no documented reports of the law being enforced (Minnesota Department of Agriculture, 2007).

Other more recent studies from Florida and Washington were less comprehensive. In Washington, while there were no significant overall reductions in P as measured through a surface lake water quality monitoring program, there were localized county-level improvements in Snohomish County (Deniston, 2024). In Florida, fertilizer ordinances differed by locality, and the study concluded that water quality trends improved in regions with winter ordinances. While there were some improvements for localities with summer-bans, the trends were not as strong (Reisinger et al., 2023). While these two studies indicate a potential association between fertilizer legislation and improving water quality, because they do not measure changes in fertilizer application rates or sales, they do not translate as readily to the Chesapeake Bay Program's UNM practices.

The other point of note is related to awareness of fertilizer legislation when it is not implemented as an outright ban. The 2013 Panel noted that one of the limitations of the new laws is that they did not allocate funds for expanded education and outreach to make their residents aware of the various nutrient management provisions of their respective laws. An interdisciplinary study in Maryland has since found that in a survey of 3,836 households, only 102 (2.7%) indicated that they were highly aware of the Maryland Lawn Fertilizer Law (Groffman et al., 2023).

The Panel also considered updated information on fertilization behavior as a potential indication of adherence to core urban nutrient management best practices. These data were highly variable but suggest little change in overall behavior of residents with regard to lawn-care best practices. Data from the Chesapeake Bay Stewardship Index (2023) took a random sampling of over 4,000 Chesapeake Bay residents and found that 39% of residents apply fertilizer at least twice per year and that 30% of residents blow or rake grass clippings onto impervious surfaces. When it comes to consulting lawn care professionals or fertilizer product instructions when making fertilization decisions, 28% of the 2,000 residents who fertilize their lawns said that they rely on their own experience, rather than looking at product instructions or consulting a professional. By comparison, 18% said they use bag labels, and 32% consult a lawn care professional, while the rest were unsure. Data from the Northern Virginia Clean Water Partners Survey (2024) finds similar trends in fertilization behavior, with 74% of residents with a lawn reporting that they apply fertilizer at least once a year, only 11% reporting that they use a soil test recommendation when fertilizing, and 35% reporting that they either sweep grass clippings into the street or storm drain.

Evaluating Sensitivity to State-wide Reductions to Nutrient Inputs

The Panel also wanted to evaluate how the 2013 assumptions regarding state-wide declines in N and P application would affect urban pervious loads. The 2013 report used a series of Chesapeake Bay Watershed Model runs (on Phase 5.3.2) to evaluate a range of nutrient application scenarios. The 2013 Panel found that a 60% reduction in P fertilizer application would produce a P reduction on pervious land ranging from 19.0% to 21.2%, or about 20% overall. They also found that a 20% reduction in average N fertilizer input would produce a 6% decrease in pervious loads.

This Panel repeated the analysis using the 2024 No Action scenario (no BMPs), to determine the impact of reducing application rates on urban pervious loads. This analysis found that the Model was similarly sensitive to P reductions, though much more variable. It also seems to be much less sensitive to changes in N. The analysis showed that a 60% reduction in P fertilizer application would produce a P reduction on pervious land ranging from 7% (WV) to 40% (MD), with an average of 31% overall. They also found that a 20% reduction in average N fertilizer input would produce a 1% decrease in pervious loads.

Table 13. Percent change in delivered N loads from pervious developed lands in states based on reduced fertilizer application rates

State	Loading Rate (lb/acre)	20% Reduction	60% Reduction	100% Reduction
DE	13.23	0.8%	2.6%	4.3%
DC	4.71	1.1%	3.4%	5.5%
MD	8.93	1.1%	3.5%	5.8%
NY	9.22	0.4%	1.5%	2.5%
PA	11.74	0.5%	1.4%	2.4%
VA	7.1	1.0%	3.0%	4.9%
WV	7.92	0.0%	0.0%	0.0%

Based on CAST-23 data using 2013 No Action Scenario EOS loads. Loading rate represents an average of "turfgrass" and "tree canopy over turfgrass".

Table 14. Percent change in delivered P loads from pervious developed lands in states based on reduced fertilizer application rates

State	Loading Rate (lb/acre)	20% Reduction	60% Reduction	100% Reduction
DE	0.61	9.8%	29.5%	49.2%
DC	0.62	12.9%	40.3%	67.7%
MD	0.97	13.4%	40.2%	67.0%
NY	0.51	5.9%	17.6%	29.4%
PA	0.52	5.8%	17.3%	26.9%
VA	0.97	11.3%	34.0%	56.7%
WV	0.41	2.4%	6.8%	9.8%

Based on CAST-23 data using 2013 No Action Scenario EOS loads. Loading rate represents an average of "turfgrass" and "tree canopy over turfgrass".

6. Recommendations for Urban Nutrient Management BMPs

The proposed urban nutrient management BMPs will be re-structured to better align with the current data reporting methodology and the best understanding of the fertilizer management practices impacting nutrient export from urban and suburban turfgrass. The Panel recommends three BMPs, in addition to the reduction in turfgrass loads resulting from state-wide reductions in pounds of fertilizer sold (and presumably, applied). The first BMP provides additional reductions for written urban nutrient management plans developed by a trained expert and based on a soil test, that reduce the risk of nutrient export of the remaining fertilizer applied due to following best practices for rate, timing, and location of fertilizer along with proper clipping management. The second BMP accounts for signed homeowner pledges, and adherence to an urban nutrient management plan in the absence of a soil test. The final BMP provides nutrient reductions for well-managed turf that does not receive fertilizer application, but maintains healthy turf coverage.

Automatic Fertilizer Application Rate Adjustment

All states will earn the benefits of reduced fertilizer rates, as accounted for by the state-reported fertilizer sales data. As covered in Tables 13 and 14, reductions in applied N and P result in reductions in urban pervious loads in the Model. All states will be eligible for these reductions, regardless of whether the state has passed legislation, or currently relies on AAPFCO for sales data. This benefit would not be reported as a BMP, as it is handled in the nutrient input stage, but to illustrate the impact, non-farm fertilizer TN application rate has declined by an average of 35% between 2010 and 2020, while non-farm fertilizer TP application rate has declined by an average of 53% during the same period. Given the sensitivities to each nutrient, that represents a decrease in delivered urban pervious loads of approximately 1.5% TN and 19% TP compared to 2010.

BMP #1: Urban Nutrient Management Plan w/ Soil Test

Definition:

The Urban Nutrient Management Plan with Soil Test BMP provides nutrient reductions for an urban nutrient management plan written by a trained professional, that is based on a soil test and follows a series of core turf fertilizer management practices for N and P, related to the Rate, Timing, and Placement of fertilizer, in addition to several Clipping Management practices. For the purposes of this report, a soil test is defined as a basic soil test from an accredited lab that, at a minimum, assesses P, K, and pH. The core practices remain in close alignment with a subset of the ones established by the 2013 Expert Panel, updated to reflect the latest information regarding fertilizer management.

Supplemental Rate Practices:

- Application of N in alignment with Extension guidelines
- Application of P in accordance with soil needs as established by a soil test, including during establishment and repair.

Supplemental Timing Practices:

- Avoid application of N or P outside of the growing season
    - October 31-March 1
- Apply slow-release N
- Apply N at annual Extension application rate suggested by Extension, split into two or three applications during the growing season when turf is actively growing
- Avoid N or P application within 48 hours prior to runoff-inducing rainfall or irrigation event

Supplemental Location Practices:

- Avoid application of N or P within 15-20 ft of a water feature
- Avoid application of N or P to impervious surface, severely compacted soil, or steep slopes

Clipping Management Practices:

- Retain grass clippings and mulched leaves on the turf and keep them out of streets and storm drains.
- Set mower heights at 3 inches or higher for lawns. If adjustments are needed for specific management contexts (based on type of turf, or mowing frequency), they can be addressed in QAPPs or related documentation.

Nutrient Reduction Efficiencies

Table 15. Revised Nutrient Reduction Credits for Qualifying UNM Plans With a Soil Test Per Acre of Residential, Commercial, Institutional or Public Land

	Nitrogen	Phosphorus
Percent Reduction of Pervious Load	6%	4.5%

To establish the updated nutrient reduction efficiencies for Urban Nutrient Management Plans, the panel used the same mass-balance approach as the 2013 Panel, with updated assumptions to reflect the core practices being addressed by the BMP. Overall, the goal was to establish rates that were consistent with:

- The Chesapeake Bay Watershed Model assumptions for pervious land
- Major findings from research on nutrient export from lawns; and
- To avoid or minimize “double-counting” of the automatic fertilizer application rate reductions tied to non-farm fertilizer sales data.

To conduct the analysis, the Panel held the following assumptions:

- To avoid double counting of nutrient reductions, the mass balance calculation did not assume any additional reduction in N and P export as a result of lowered N and P application rates under UNM plans (i.e., since N fertilizer application rates are already at, or below extension guidelines across all Chesapeake Bay states and widespread legislation now prohibits P application for lawn maintenance, both of which are accounted for under the automatic state-wide N and P rate reductions). This is consistent with the approach from the 2013 Expert Panel for P, expanded to include N now that state-wide N application rates are also adjusted based on annual sales-data.
- Phase 6 pervious land fertilizer application rates and export sensitivity from the CBWM are used as the baseline for the load reductions.
- A major portion of the total load from pervious land is not subject to any reduction by UNM practices. The non-removable load was defined as twice the average load from forest land in CBWM.
- A small fraction of the residual load was available for potential reduction by UNM practices. The residual load was defined as the total load less the fertilizer input load and less the non-removable load.
- Only 10% (N) and 10% (P) of the residual load could be reduced by UNM practices that are not directly related to the fertilization rate.

Qualifying Criteria for BMP#1:

The Expert Panel recommends the following conditions as a pre-requisite for an "Acceptable Urban Nutrient Management Plan BMP with a Soil test":

- Each UNM plan must be prepared by a trained expert (e.g., certified plan writer or applicator), and based on findings from a soil test. The plan may also contain other practices to improve lawn health and aesthetics.
- The UNM plan must address fertilizer rate, timing, placement, and clipping management and be consistent with the applicable UNM lawn care practices recommended in this report or existing state UNM requirements.
- Each UNM plan must clearly document the:
    - Start and end dates for the plan
    - Name, contact information and locator data for the owner, applicator and UNM planner
    - Acreage of turf and landscaping covered by the plan
    - Annual N and P fertilization rate
    - Timing of N and P fertilization
    - Presence of slopes > 20% and/or compacted soils present within the fertilized area
- The plan must contain a signed commitment by the owner that they intend to implement the plan.
- Commercial applicators can send a UNM template for the lawns they service as long as they follow the core UNM practices.

The definition of a "trained professional" may be determined by each state, but could include certified nutrient management planners or applicators, extension agency partners, or agency staff who understand how to interpret a soil test result and received training on, and are well-versed in, the core UNM practices. States with legislation covering the core elements for supplemental Rate, Timing, Location, and Clipping Management, and using certified applicator programs to provide outreach, training, and verification of adherence to the legislation are eligible for BMP #1 credit for acres reported via the certified applicators program. It is not a requirement to maintain a certified applicator program to use this BMP.

The Panel agreed that plans developed by trained experts and based on soil tests would increase the confidence that the plan would be implemented effectively, and that risk of nutrient export would be reduced for a period of up to three years. Extension agencies suggest soil testing every three years as best practice. Therefore, the Panel recommends a credit duration of 3 years for this BMP.

BMP #2: Urban Nutrient Management Plan without a Soil Test

Definition:

The Urban Nutrient Management Plan without a Soil Test BMP provides nutrient reductions for turfgrass managed in adherence with the core UNM best practices, but which lack soil test data or a written plan developed by a trained expert. This BMP would be used to capture signed homeowner pledges that establish a commitment to adhere to best practices for N and P, related to the Rate, Timing, and Placement of fertilizer, in addition to several Clipping Management practices. The core practices are the same as those in BMP#1, with minor modifications to account for the lack of soil testing.

Supplemental Rate Practices:

- Application of N in alignment with Extension guidelines
- No application of P for lawn maintenance. P application in accordance to Extension guidelines for establishment and repair.

Supplemental Timing Practices:

- Avoid application of N or P outside of the growing season
    - October 31-March 1
- Apply slow-release N
- Apply N at annual Extension application rate suggested by Extension, split into two or three applications during the growing season when turf is actively growing
- Avoid N or P application within 48 hours prior to runoff-inducing rainfall or irrigation event

Supplemental Location Practices:

- Avoid application of N or P within 15-20 ft of a water feature

- Avoid application of N or P to impervious surface, severely compacted soil, or steep slopes

Clipping Management Practices:

- Retain grass clippings and mulched leaves on the turf and keep them out of streets and storm drains.
- Set mower heights at 3 inches or higher for lawns. If adjustments are needed for specific management contexts (based on type of turf, or mowing frequency), they can be addressed in QAPPs or related documentation.

Nutrient Reduction Efficiencies

Table 16. Revised Nutrient Reduction Credits for Qualifying UNM Plans without Soil Test Per Acre of Residential, Commercial, Institutional or Public Land

	Nitrogen	Phosphorus
Percent Reduction of Pervious Load	6%	4.5%

The Panel agreed that because both BMP#1 and BMP#2 must follow the same core practices, and because the reduction efficiencies remain conservative, that it was appropriate for both BMPs to earn the same efficiencies. However, due to reduced confidence that these plans would be effectively implemented without guidance from a trained expert, or the collection of soil test data to better understand the lawns risk of nutrient export, the Panel recommends a credit duration of one year (an annual practice) for this BMP. Therefore, signed homeowner pledges would need to be renewed annually for a property to maintain their credit.

Qualifying Criteria for BMP#2:

The Expert Panel recommends the following conditions as a pre-requisite for an "Acceptable Urban Nutrient Management Plan BMP without a Soil Test":

- A signed pledge from a property owner or turfgrass manager, committing to follow the 10 core UNM best practices described in the Definitions.
- The pledge must address fertilizer rate, timing, placement, and clipping management and be consistent with the applicable UNM lawn care practices recommended in this report or existing state UNM requirements.
- Each signed pledge must clearly document the:
    - Start date for the pledge
    - Name and contact information for the pledge-signer
    - County in which the property is located
    - Acreage of turf covered by the plan

The Panel emphasized that beyond meeting the criteria outlined above, states would have the flexibility to determine how to collect homeowner pledges and the format those pledges could take. It is recommended that educational materials be provided as part of pledge outreach efforts to ensure homeowners are aware of any relevant legislation and state-specific guidelines, along with resources that could reduce barriers to implementation. Example homeowner pledge templates and outreach materials are included in Attachment E.

BMP #3: Non-Fertilized Turfgrass

Definition and Qualifying Conditions:

The third BMP provides a small additional reduction for properties effectively maintaining healthy turfgrass to reduce nutrient export without the use of fertilizer. These turf acres must be actively managed turf (not successional), often under a "mow-only" designation. The Watershed Model applies fertilizer to all acres equally across a state, so turf managed without fertilizer experience muted benefits from the automatic rate reductions.

However, it is important that the fertilization regime is in alignment with best practice in order to maintain proper soil health and avoid soil exposure that can lead to excess losses via runoff. This strategy relies on soil mineralization, lawn clippings and atmospheric deposition to supply the N inputs needed for growth and is effective as long as turf cover remains dense. Therefore, qualification for this BMP requires the following:

- Each BMP must clearly document the:
    - Year being claimed as "Non-fertilized"
    - Name, contact information and locator data for the owner, and landscape manager/responsible entity
    - Acreage of turf and landscaping covered by the practice
    - Date of last fertilizer application (if applicable)
- There must contain a signed commitment by the owner/property manager that they intend to adhere to the following clipping management practices:
    - Grass clippings must remain on-site to ensure cycling of nutrients
    - Mower heights should be set at 3 inches or higher for lawns. If adjustments are needed for specific management contexts (based on type of turf, or mowing frequency), they can be addressed in QAPPs or related documentation
    - Turf must demonstrate absence of exposed soil (less than 15% exposed)

Nutrient Reduction Efficiencies:

Table 17. Revised Nutrient Reduction Credits for Qualifying Non-Fertilized Turfgrass Per Acre of Residential, Commercial, Institutional or Public Land		
	Nitrogen	Phosphorus
Percent Reduction of Pervious Load	7%	9%

To establish the updated nutrient reduction efficiencies for Non-Fertilized Turfgrass, the Panel used the same mass-balance approach described above for the UNM BMP, with updated assumptions to reflect the additional potential benefit of a non-fertilized condition for healthy turfgrass.

This practice provides an additional reduction compared to UNM Plans because it reduces the risk of accidental nutrient export hotspots that can occur when fertilizer is applied with improper application timing, spreader calibration or fertilizer placement. Due to the risk of double-counting rate-based benefits from the automatic N-application rate adjustments described earlier in Section 6 of this report the panel made the conservative assumption that the Non-Fertilized Turf BMP could further reduce potential P input losses by 3% and N input losses by 1%. These values are based on the low end of the range based on available literature cited in Section 5.

7. Recommendations for Inspection and Verification

The ultimate decision regarding how to verify BMP implementation is between each state and EPA and is documented in the QAPPs. While the Expert Panel does not make final decisions regarding inspection and verification requirements, they are tasked with recommending best practices, and considerations for record keeping that will hopefully ease the process.

Automatic Fertilizer Application Rate Adjustment: Verification

Individual states should retain primary responsibility for reporting, tracking and verification for this credit. States should continue to document trends in non-farm P and N fertilizer sales on an annual basis. The Chesapeake Bay Program Office should retain responsibility for processing the raw fertilizer sales data and converting it into pervious land load changes into CAST during each version update.

Given the variability in annual non-farm fertilizer sales trends, the Panel recommends continual and incremental improvements to the non-farm fertilizer datasets to help future efforts parse the impacts. One recommendation is to more explicitly account for exempted specialty products in non-farm fertilizer sales data. A better understanding of which non-farm fertilizers are used as starter products, garden/specialty use, and lawn maintenance would be a significant benefit.

BMP #1: Urban Nutrient Management Plan w/ Soil Test Verification

To provide better verification guidance for urban nutrient management, the Panel elected to borrow frameworks from both the stormwater sector verification guidance (USWG, 2014) and the agriculture sector verification guidance (AGWG, 2014).

As an operational BMP rather than a structural one, this BMP falls into the Agriculture Workgroup's definition of "Non-Visual":

Non-Visual Assessment BMP: A practice that cannot typically be visually assessed because it is a type of management system or enhanced approach, rather than a physical BMP. This class of BMPs is more challenging to verify since it does not have a physical presence on the landscape. However, considerable nutrient and sediment reductions are possible in well implemented plans that can last either a single season or multiple years.

As in 2013, this Panel remains concerned about how effectively property owners and commercial applicators might implement Urban Nutrient Management Plan practices in the real world. Quite simply, what is written in a UNM plan, or established in legislation and training programs, may not be implemented on the lawn. In particular, applicators may not calibrate spreaders effectively, or may elect to follow some UNM practices, but not others, based on personal preferences and other reasons. The Panel partially accounted for incomplete implementation in the recommended reduction rates, but this should also be a consideration in developing a verification program.

With non-visual assessments, it is important to ensure processes for effective recordkeeping that allows for an initial verification assessment based upon office records:

What Record Keeping is Recommended?

In most cases, the UNM planning agency will have primary responsibility for tracking the aggregate acreage of UNM implemented in their jurisdiction. The Panel recommends they keep the following records over time:

- Electronic or hard copy of the individual UNM plan or lawn maintenance program
- Property owner contact information and street and watershed address
- A UNM contact database so that they can communicate by mail or e-mail, and send at least one reinforcement message to each UNM owner/applicator each year.
- A UNM tracking database to track required data elements for NEIEN reporting and the status of UNM plans over time
- Documentation of procedures, and guidance for defining, and documenting triggers for more detailed investigation and/or ultimate pass/fail determinations (i.e. application rate >10% over extension recommended, significant variance in application rate compared to prior years).

Several states currently rely on certified applicator programs as a means of providing training to fertilizer applicators, and collecting annual reports regarding the pounds of nutrients applied. The Panel believes these are effective systems for collecting data and can provide a first step toward UNM plan verification. These systems typically collect the following information:

- Name of the fertilizer applicator
- Size of the area fertilized
- Date(s) of nutrient application
- Address/location of client including county

- Rate of application (for example 4 pounds of fertilizer per 1,000 square feet)
- Total amount of fertilizer used per application
- Nutrient analysis of the fertilizer product used
- An original or legible copy of the fertilizer label

It is recommended that several additional data points be entered to assist with assessment of adherence to the BMP, including:

- Date of last soil test and P results
- Checklist of high-risk features that are present in the application area (high IC, new construction, surface waters, steep slopes)

A sample record keeping form is provided in Appendix B for reference.

Statistical Subsampling

Statistical subsampling is an appropriate approach to reduce time and burden on plan reviews. This can be done at the office scale, only requiring follow-up with the property owner or landscape manager/applicator when triggered by large annual fertilizer application variances, or apparent deviations are detected that could suggest lack of adherence to the plan.

The UNM planning agency (or delegated third party organization) will also need to randomly sub-sample either fertilizer applicators/landscape managers or property owners under a defined schedule to verify compliance with the UNM plan. The aggregate compliance rates derived from these surveys will be used to extrapolate UNM compliance rates for the community as a whole and make any adjustments or downgrades to the nutrient reduction performance for this practice.

Since the 2013 report, there has been some work to better define the statistical sampling frequency required to establish an appropriate level of confidence in verification rates. The ultimate goal is to review enough plans to achieve the 80% confidence level, in conjunction with achieving a ±10 percent confidence interval (e.g., The UNM Plan BMPs were successfully implemented with a 75% ±10% [65%-85%]). An example of how to establish appropriate sampling intervals can be found in Appendix C.

BMP #2: Urban Nutrient Management Plan without a Soil Test

As an annual BMP, UNM pledges must be re-reported every year. To avoid large swings in implementation, the Panel recommends the following recordkeeping to assist with annual outreach efforts to collect pledges:

- Electronic or hard copy of the individual UNM pledge
- Database with pledge contact information and location so agencies/partners can communicate by mail or e-mail, and send at least one reinforcement message to each contact annually when it is time to renew the pledge.

- A UNM tracking database to track required data elements for NEIEN reporting and the status of UNM pledges over time

Documentation of procedures and guidance for outreach and education efforts used to reach new homeowners would also be beneficial for the long-term success of the program.

BMP #3: Non-Fertilized Turfgrass Verification

While many of the general principles covered for UNM Plan verification apply for Non-Fertilized Turfgrass, there is added complexity due to the fact that the qualifying condition for the practice is the absence of fertilizer application. Therefore, it is recommended that this BMP be an annual practice, that must be reported each year to ensure that acres are current, contact information of the property manager is up to date, and management regimes have not been adjusted. It is also recommended that a randomized sub-sampling of sites be visually inspected to ensure turf health and cover to ensure no detrimental impacts due to the lack of fertilization that could result in increased runoff losses of residual nutrients. The following are potential visual indicators of turf health in adherence with BMP #3 criteria:

- Turfgrass ground cover – evaluation of treated area for bare patches
- Turfgrass density – visual estimate of grass shoots per unit area
- Turfgrass stress – visual assessment of impacts due to disease, drought, or other stressor resulting in discoloration, or die-off
- Surface Compaction – Turf injury due to high traffic and surface compaction
- Clipping Management – evidence of clippings removed or swept to impervious surfaces

If an on-site verification inspection indicates evidence of poor soil health, it is recommended that a follow-up soil test be taken to demonstrate P levels are within the recommended range. At this point, an Urban Nutrient Management Plan may be needed, and the practice may need to be re-reported as a UNM Plan (BMP #1).

8. Other Technical Recommendations

After an evaluation of other potential data sources and reporting approaches, the Panel has recommended the continuation of the approved non-farm fertilizer application method for urban pervious acres, adopted by the USWG in 2023 with one proposed change: the addition of construction, and solar pervious land use acres to the denominator of the non-farm fertilizer application rate equation. This addition of solar pervious reflects that the new solar pervious land use loading rate was set as equal to turfgrass, per a December 2024 decision of the Urban Stormwater Workgroup. This loading rate assumes some level of fertilization. Regarding construction, the Panel recognizes that the high rates of fertilization for temporary and permanent establishment of turfgrass on construction sites is likely a contributing factor to the P sales due to the exemptions for turf establishment in existing state legislation. The Erosion and Sediment Control Expert Panel (2014) found that the mean application rate in the Bay states for TP is 74 lbs per acre, and TN is 114 lbs per acre, most of which is water-soluble and in readily available forms. Several fertilizer applications can be made during the course of most construction operations. While data were not available that would allow the Panel to distribute a proportion of the non-farm fertilizer mass to construction acres in manner the Panel was comfortable with, the addition of construction acres to the turfgrass loading rate equation provides recognition that some proportion of the non-farm fertilizer sales are likely accounted for in the high land use loading rates for construction.

Therefore, the panel recommends use of the entire record of AAPFCO data (up through 2016 as of the publishing of this report) for non-farm fertilizer sales data. They also recommend a data smoothing method that removes outliers at the county-scale, then takes a 3-year rolling average. If a state has data after the last available year of AAPFCO data (currently 2016), those data will be used instead of holding the 2016 rate constant. If a state does not have more recent data, the most recent available year of data will be held steady and carried forward through time. Urban fertilizer application rates (pounds per acre) are calculated as the total mass of nutrients divided by the total acres in turfgrass, plus construction, plus solar pervious for each state and year.

The Panel also recommends an amendment to how DC's non-farm fertilizer application rate is established. The current method uses an average of the MD and VA application rate for DC. In order to better represent development patterns in the District, the Panel recommends basing fertilizer application rates in the District on an average of the immediate adjacent counties with similar development patterns: Arlington, Alexandria, and Falls Church.

During its review, the Panel sought data sources that might improve the Watershed Model's P sensitivities for pervious acres but ultimately did not find any data to support specific changes or improvements. They support the current approach, as well as process to evaluate these methods and decisions in the future as new data become available.

Finally, the Panel recommends investment in more widespread soil testing from non-agricultural soils. The Panel would highly value soil tests from urban and suburban lawns that can be tied to the county of origin and that can provide a representative sample of developed, pervious soils in the region to eventually shift the model's P simulations in response to actual soil data.

9. Consideration of Unintended Consequences

One of the tasks of each Expert Panel is to evaluate the potential for unintended consequences that could result from implementation of their recommendations. While the Panel feels these risks are minimal, there are two potential consequences that merit mentioning:

First, is the potential double-counting of load reductions resulting from Non-Fertilized Turfgrass BMP reporting. By opting to simulate this practice as a percent reduction efficiency, the Panel has simplified the tracking and reporting of the practice. However, because decisions not to fertilize should theoretically result in declining non-farm fertilizer sales, and subsequently lower application rates, there is a small chance of double-counting the benefits of reduced application rates on these properties. To address this concern, the Panel has taken a very conservative approach to its nutrient reduction recommendations, opting to base its percent reductions for this BMP on the low end of potential N and P export from turfgrass.

Second, the administrative and sampling requirements to develop an effective UNM Plan places a greater financial burden on property owners opting to take that step. With higher nutrient reduction efficiencies assigned to Non-Fertilized Turfgrass BMPs, the small potential exists that some property owners may elect that practice over a UNM Plan BMP, even if it may not be the best choice for their turfgrass. To mitigate this possibility, the Panel has opted to make the Non-Fertilized Turf BMP an annual practice and provided recommended visual indicators of turf stress that could suggest increased risk of runoff-driven nutrient export, thus triggering a UNM Plan or expiration of the BMP.

10. Future Research Recommendations

The Panel recognizes that urban nutrient management is only one component of healthy urban and suburban soils. The Panel recommends that future efforts focus on understanding and synthesizing the range of factors affecting soil health and its implications for runoff and nutrient management. Specifically, the Panel recommends the following priorities:

Compaction and Runoff from Turfgrass

- Factors affecting soil compaction and permeability in turfgrass systems
- Implications for runoff generation and current engineering assumptions regarding runoff coefficients in turfgrass.
- Examples of approaches to account for soil compaction
- Evaluation of best practices for soil amendments and decompaction

Urban Nutrient Management and Ecosystem Health

- Synthesis of research on the ecosystem services of healthy urban/suburban soils, including biological relationships that may influence nutrient cycling, and carbon sequestration potential.

Human Dimensions of Soil Health

- Update on behavior change science in relation to soil testing and fertilization practices including successful approaches for engagement.

Impact of Urban Gardening and Small Scale Urban Agriculture

- Some literature in this report identified the potential for residential and community-scale gardening activities as a potential urban fertilizer hotspot. More research on their contribution, and approaches for better management to reduce impact are needed.

11. References

Agriculture Workgroup (AGWG). 2014. Chesapeake Bay Program Agriculture Workgroup's Agricultural BMP Verification Guidance. Chesapeake Bay Program (CBP) Partnership. Annapolis, MD.

Bachman, M., S. Inamdar, S. Barton, J.M. Duke, D. Tallamy, and J. Bruck. 2016. A comparative assessment of runoff nitrogen from turf, forest, meadow, and mixed landuse watersheds. Journal of the American Water Resources Association 52(2): 349-408.

Barton, L., and T.D. Colmer. 2006. Irrigation and fertilizer strategies for minimising nitrogen leaching from turfgrass. Agric. Water Manage: 80(1-3):160-175.

Bauer, S., D. Lloyd, B.P. Horgan, and D.J. Soldat. 2012. Agronomic and Physiological Response of Cool-Season Turfgrass to Fall-Applied Nitrogen. *Crop Science:* 52(1): 1-10. https://doi.org/10.2135/cropsci2011.03.0124

Bennett, E.M., S.R. Carpenter, and M.K. Clayton. 2004. Soil phosphorus variability: scale dependence in an urbanizing agricultural landscape. Landscape Ecology (2004). DOI 10.1007/s10980-004-3158-7.

Bierman, P., B. Horgan, C. Rosen, and A. Hollman. 2010a. Effects of phosphorus fertilization and turfgrass clipping management on phosphorus runoff. University of Minnesota. Final Report to Minnesota Pollution Control Agency.

Bierman, P., B. Horgan, C. Rosen, A. Hollman and P. Pagliari. 2010b. Phosphorus runoff and turf grass as affected by phosphorus fertilization and clipping management. Journal of Environmental Quality. 39:282-292.

Bowman, C., C. Cherney, and T. Rufty. 2002. Fate and transport of nitrogen applied to warm season turfgrasses. Crop Science. 42: 833-841.

Carey, R., G. Hochmuth, C. Martinez, T. Boyer, V. Nair, M. Dukes, G. Toor, A. Shober, J. Cisar, L. Trenholm, and J. Sartain. 2012. A Review of Turfgrass Fertilizer Management Practices: Implications for Urban Water Quality. Horttechnology. 22. 280-291.

Chen, H., T. Yang, Q. Xia, D. Bowman, D. Williams, J.T. Walker, and W. iShi. 2018. The extent and pathways of nitrogen loss in turfgrass systems: age impacts. Sci. Total. Environ: 637-638:746-757.

Chesapeake Bay Stewardship Index. 2023. Stewardship Index Survey Data: Yard & Garden. https://www.chesapeakebehaviorchange.org/survey-data.

Cohen, S., A. Svrjcek, T. Durburow, and N. Barnes. 1999. Water quality impacts by golf courses. Journal of Environmental Quality. 28(3): 798-809.

Cote, L, and G. Gregoire. 2021. Reducing nitrate leaching losses from turfgrass fertilization of residential lawns. Journal of Environmental Qual. 50:1145-1155.

Daniels, W., M. Goatley, R. Maguire and D. Sample. 2010. Effects of fertilizer management practices on urban runoff water quality. Crop and Environmental Sciences. Occoquan Watershed Monitoring Lab. Virginia Tech.

Deniston, P. 2024. Assessing the Efficacy of the Washington Ban on Phosphorus Fertilizer. WWU Honors College Senior Projects. 858.

Dorney, J.R. 1986. Leachable and total phosphorus in urban street tree leaves. Water, Air and Soil Pollution. 28:439-443.

Easton, Z and A. Petrovic. 2008a. Determining phosphorus loading rates based on land use in an urban watershed. p. 43-62 in Nett et al. (eds) The fate of turfgrass nutrient and plant protection chemicals in the urban environment. American Chemical Society. Washington, DC.

Easton, Z and A. Petrovic. 2008b. Determining nitrogen loading rates based on land use in an urban watershed. p. 63-82 in Nett et al. (eds) The fate of turfgrass nutrient and plant protection chemicals in the urban environment. American Chemical Society. Washington, DC.

Erosion and Sediment Control (ESC) Expert Panel. 2014. Recommendations of the Expert Panel to Define Removal Rates for Erosion and Sediment Control Practices. Chesapeake Bay Program Partnership. Annapolis, MD.

Felton, G. 2007. Review of research related to nitrogen losses from turfgrass with focus on the mid Atlantic. University of Maryland, College Park, MD.

Felton, G. 2012. Personal Communication on lawn care company fertilization rates in Maryland. University of Maryland Cooperative Extension. College Park, MD.

Fissore, C., L.A. Baker, S.E. Hobbie, J.Y. King, J.P. McFadden, K.C. Nelson, and I. Jakobsdotter. 2011. Carbon, nitrogen, and phosphorus fluxes in household ecosystems in the Minneapolis-Saint Paul, Minnesota urban region. Ecological Applications, 21(3): 619-639.

Frank, K.W., K.M. O'Reilly, J.R. Crum, and R.N. Calhoun. 2006. The fate of nitrogen applied to a mature Kentucky bluegrass turf. Crop Sci. 46:209-215.

Frank, K.W., J.R. Crum, J. M. Bryan, and A.D. Hathaway. 2016. Fifteen years of nitrogen leaching from a Kentucky bluegrass turf. Crop Science: 56(6):3338-3344.

Garn, H. 2002. Effects of lawn fertilizer on nutrient concentrations in runoff from lakeshore lawns, Lauderdale Lakes, Wisconsin. USGS Water Resources Investigation Report 4130. United States Geological Survey.

Geng, X., K. Guillard, and T.F. Morris. 2014. Relating turfgrass growth and quality to frequently measured soil nitrate. Crop Science: 54: 366-382

Groffman, P, N. Law, K. Belt, L. Band and T. Fisher. 2004. Nitrogen fluxes and retention in urban watershed ecosystems. Ecosystems. 7(4):393-403.

Groffman, P.M., A.K. Suchy, D.H. Locke, R.J. Johnston, D.A. Newburn, A.J. Gold, L.E. Band, J. Duncan, J.M. Grove, J. Kao-Kniffin, H. Meltzer, T. Ndebele, J. O'Neil-Dunne, C. Polsky, G.L. Thompson, H. Wang, and E. Zawojska. 2023. Hydro-bio-geo-socio-chemical interactions and the sustainability of residential landscapes. PNAS Nexus: 2:1-11.

Guillard, K. and W. Dest. 2003. Extractable soil phosphorus concentrations and creeping bentgrass response on sand greens. Crop Science. 43:272-281. Guillard, K. and K. Kopp. 2004. Nitrogen fertilizer from and associated nitrate leaching for cool season turf. Journal of Environmental Quality. 33:1822-1827.

Guillard, K. and K. Kopp. 2004. Nitrogen fertilizer form and associated nitrate leaching from cool-season lawn turf. Plant Science Articles. 11.

Guillard, K. et al. 2008. New England regional nitrogen and phosphorus fertilizer and associated management practice recommendations for lawns based on water quality considerations. Turfgrass Nutrient Management Bulletin. B-100. University of Connecticut, Department of Plant Science.

Herrmann, D.L., and M.L. Cadenasso. 2017. Nitrogen retention and loss in unfertilized lawns across a light gradient. Urban Ecosyst: 20:1319-1330.

Hobbie, S., J.C. Finlay, B.D. Janke, D.A. Nidzgorski, D.B. Millet, and L.A. Baker. 2017. Contrasting nitrogen and phosphorus budgets in urban watersheds and implications for manaing urban water pollution. PNAS 114(16): 4177-4182.

Kaushal, S., P. Groffman, L. Band, E. Elliott, C. Shields, and C. Kendall. 2011. Tracking Nonpoint Source Nitrogen Pollution in Human-Impacted Watersheds. Environmental Science & Technology. 45(19): 8225-8232.

Hall, S.J., M.A. Baker, S.B. Jones, J.M. Stark, and D.R. Bowling. 2016. Contrasting soil nitrogen dynamics across a montane meadow and urban lawn in a semi-arid watershed. Urban Ecosystems: 19: 1083-1101.

Heymann, K., Xing, B., Keiluweit, M., and J.S. Ebdon. 2017. Influence of dissolved organic carbon from natural and synthetic fertilizers on phosphate leaching from a sand-based golf green. Int. Turfgrass Soc. Res. J. 13:103–112

Jani J., Y-Y. Yang, M.G. Lusk, G.S. Toor. 2020. Composition of nitrogen in urban residential stormwater runoff: Concentrations, loads, and source characterization of nitrate and organic nitrogen. PLoS ONE 15(2).

King, K., R. Harmel, H. Torbert and J. Balogh. 2001. Impact of a turfgrass system on nutrient loading to surface waters. JAWRA. 37(8): 629-638.

King, K., J.C. Balogh, S.G. Agrawal, C.J. Tritabaugh, and J.A. Ryan. 2012. Phosphorus concentration and loading reductions following changes in fertilizer application and formulation on managed turf. Journal of Environmental Monitoring: 14: 2929-2938.

Kopp, K. and K. Guillard. 2002. Clipping management and nitrogen fertilization of turf grass growth. nitrogen utilization, and quality. Crop Science: 42:1225-1331.

Krimsky, L.S., M. G. Lusk, H. Abeels, and L. Seals. 2021. Sources and concentrations of nutrients in surface runoff from waterfront homes with different landscape practices. Total Environment: 750:142320.

Kussow, W. 2008. Nitrogen and soluble phosphorus losses from an upper Midwest lawn in The fate of turfgrass nutrients and plant protection chemicals in the urban environment. Pages 1-19. American Chemical Society.

Kussow, W.R., D.J. Soldat, W. C. Kreuser, and S.M. Houlihan. 2012. Evidence, regulation and consequences of nitrogen-driven nutrient demand by turfgrass. ISRN Agronomy: 2012:1-9.

Landschoot, P., and J. Spargo. 2022. How much soil phosphorus is in Pennsylvania's Lawns. Presentation to the Expert Panel. January 10, 2025.

Lee. D. C. Bowman and D. Cassel. 2003. Soil inorganic nitrogen under fertilized bermudagrass turf. Crop Science. 43(1): 247-257.

Lusk, M., G. Toor, P. Inglett. 2018. Characterization of dissolved organic nitrogen in leachate from a newly established turfgrass lawn. Water Research 131: 52-61.

Maguire, R. and J. Sims. 2002. Measuring agronomic and environmental soil phosphorus saturation and predicting phosphorus leaching with Mehlich 3. Soil Science Society of America Journal. 66:2033-2039.

Martinez, N.G., N. D. Bettez, and P.M. Groffman. 2014. Sources of variation in home lawn soil nitrogen dynamics. Journal of Environmental Quality: 43:2146-2151.

MDA. 2013. Proposed fertilization application requirements for land not used for agricultural purposes. Section 15.20.10 Subtitle 20, Soil and Water Conservation. Title 15. Maryland Department of Agriculture.

Minnesota Department of Agriculture. 2007. Effectiveness of the Minnesota Phosphorus Lawn Fertilizer Law. Report to the Minnesota State Legislature. Minneapolis, MN.

Northern Virginia Clean Water Partners. 2024. 2024 Annual Summary: Survey Results. https://www.onlyrain.org/_files/ugd/200411_aed8a812bb9e4ac2a47e6cfb6cfdcd1e.pdf

Pare, K., H. Chantigny, K. Carey, W. Johnston and J. Dionne. 2006. Nitrogen uptake and leaching under annual bluegrass ecotypes and bentgrass species: a lysimeter experiment. Crop Science. 46: 847-853.

Quiroga-Garza, H., G, Picchioni and M. Remmenga. 2001. Bermudagrass fertilized with slow-release nitrogen sources: I. Nitrogen uptake and potential leaching losses. Journal of Environmental Quality. 30:440-448.

Raciti, S., P. Groffman, and T. Fahey. 2008. Nitrogen retention in urban lawns and forests. Ecological Applications. 18(7):1615-1626.

Ray, H. 1997. Street dirt as a phosphorus source for urban stormwater. MS thesis. Department of Civil Engineering, University of Alabama-Birmingham, Birmingham, Alabama.

Reisinger, A.J., M.D. Dukes, B.V. Iannone III, J.B. Unruh, and S.J. Smidt. 2023. Effects of Urban Fertilizer Ordinances on Water Quality. Institute of Food and Agricultural Sciences at the University of Floriday. Gainesville, FL.

Rice, P.J., and B.P. Horgan. 2017. Off-site transport of nitrogen fertilizer with runoff from golfcourse fairway turf: A comparison of creeping bentgrass with a fine fescue mixture. Science of the Total Environment: 580: 533-539.

Scotts MiracleGro Company (SMC). 2014. National Turfgrass Fertilization Statistics. Data shared with Gary Felton.

Schueler, T. 2010. The clipping point: turf cover estimates for the Chesapeake Bay watershed and management implications. Technical Bulletin No. 8. Chesapeake Stormwater Network. Baltimore, MD.

Shenk, G. 2012. Presentation to Expert Panel on how CBWM Phase 5.3.2. simulates nutrient dynamics on pervious land. US EPA Chesapeake Bay Program. February, 2012.

Shuman, L. 2004. Phosphorus and nitrate nitrogen in runoff following fertilizer application to turfgrass. Journal of Environmental Quality. 31: 1710-1715.

Sims, T.J. 2000. The role of soil testing in environmental risk assessment for phosphorus. P. 57-81. *In* A. N. Sharpley (ed.) Agriculture and phosphorus management: The Chesapeake Bay. CRC Press LLC. Boca Raton.

Small, G., P. Shrestha, G. Suzanne Metson, K. Polsky, I. Jimenez, and A. Kay. 2019. Excess phosphorus from compost applications in urban gardens creates potential pollution hotspots. Environ. Res. Commun. 1(2019)091007.

Small, G.E., N. Martensson, B.D. Janke, and G.S. Metson. 2023. Potential for high contribution of urban gardens to nutrient export in urban watersheds. Landscape and Urban Planning: 229: 104602.

Smith, R.M., J.C. Williamson, D.E. Pataki, J. Ehleringer, and P. Dennison. 2018. Soil carbon and nitrogen accumulation in residential lawns of the Salt Lake Valley, Utah. Oecologia: 187:1107-1118.

Soldat, D. and A. Petrovic. 2009. The fate and transport of phosphorus in turfgrass ecosystems. Crop Science. 48:2051-2065.

Spence, P., D. Osmond, W. Childres, J. Heitman and W. Robarge. 2012. Effects of lawn maintenance on nutrient losses via overland flow during natural rainfall events. JAWRA. 48(6): 1-16.

Steinke, K., W.R. Kussow, and J.C. Stier. 2014. Potential contributions of mature prarie and turfgrass to phosphorus in urban runoff. Journal of Environmental Quality. 42:1176-1184.

Stier, J., D. Soldat, T. Samples, and J. Sorochan. 2012. Nutrient Runoff from Urban Lawns. Virginia Turfgrass Journal. Sep/Oct 2012. 30-34.

Suchy, A. K., P. Groffman, L. Band, J. Duncan, A. Gold, J. Morgan Grove, D. Locke, and L. Templeton. 2021. A landscape approach to nitrogen cycling in urban lawns reveals the interaction between topography and human behavior. Biogeochemistry 152: 73-92.

Suchy, A.K., P.M. Groffman, L.E. Band, J.M. Duncan, A.J. Gold, J. M. Grove, D. H. Lock, L. Templeton, and R. Zhang. 2023. Spatial and Temporal Patterns of Nitrogen Mobilization in Residential Lawns. Ecosystems: 26:1524-1542.

University of Florida Institute of Food and Agricultural Sciences (UF/IFAS). 2023. Turfgrass Nutrition: Soil Testing and Interpretation. *Plant Nutrition Oversight Committee Memo*. https://bmp.ifas.ufl.edu/media/bmpifasufledu/pdfs/Turfgrass_Nutrition_Soil_Testing_Supporting_Science_PNOC_02132023.pdf

Urban Stormwater Workgroup (USWG). 2013. Recommendations of the Expert Panel to Define Removal Rates for Urban Nutrient Management. Chesapeake Bay Program (CBP) Partnership. Annapolis, MD.

Urban Stormwater Working Group (USWG). 2014. Final recommended guidance for verification of urban stormwater BMPs. Chesapeake Bay Program (CBP) Partnership. Annapolis, MD.

USWG. 2016. Process for Handling Urban BMP Decision Requests. USWG Memo Approved February 2016.

Water Quality Goal Implementation Team (WQGIT). 2016. Revised protocol for the development, review and approval of loading and effectiveness estimates for nutrient and sediment controls in the Chesapeake Bay Watershed Model. US EPA Chesapeake Bay Program. Annapolis, MD.

Yang, Y-Y. and G.S. Toor. 2017. Stormwater runoff driven phosphorus transport in an urban residential catchment: Implications for protecting water quality in urban watersheds. Scientific Reports: 8:11681.

Zhang, M., M. Nyborg, and S.S. Malhi. 1998. Comparison of controlled-release nitrogen fertilizers on turfgrass in a moderate temperature area. *HortScience* 33(7): 1203-1206.

Zhou, W. A. Troy, and M. Grove. 2008. Modeling residential lawn fertilization practices: Integrating high resolution remote sensing with socioeconomic data. Env. Management: 41:742-752.

Appendix A. Mass Balance Calculations for Establishing Reduction Credit

Purpose of Analysis

Establish proposed UNM BMP rates that are consistent with:

- CBWM modeling assumptions for pervious land
- The major findings from the research on nutrient export from lawns
- Do not double count the Level 2 credit for state-wide N and P Bans

Technical Assumptions

- Use Average CBWM loads for pervious lands from Phase 6
- Maintain consistency with assumptions regarding fertilizer inputs and input sensitivity
- Stick with a weighted unit acre of pervious land (same rate, fertilized/unfertilized), consistent with current CBWM approach
- Maintain basic assumption of 20% High risk vs 80% Low risk lawns - while the high/low risk splits are not maintained in the final BMP, a weighted avg is used for non-residual benefit calculation. The best available data is from NY, and conclude 18% High risk, so maintaining 20% remains conservative.

UNM Plan Analysis

STEP 1 Mass Balance Check

- Composite N Load from Pervious = 9.22 lb/acre/year
- Average Inputs (fertilizer only): 9.90 lb/acre/year
- Input sensitivity: 4% of Total N = 0.37 lb/acre/year
- Non-Input portion of load: 8.85 lb/acre/year (remaining load delivered independent of fertilizer inputs via surface runoff, interflow and groundwater)

STEP 2: Estimate UNM Impact on Fertilizer Inputs

Targeted Application Benefits to Inputs –

The 2013 panel assumed that TN rate reduction was accounted for in this step. If we are reducing TN inputs primarily via Level 1, providing additional benefits via reduced inputs would be effectively double-counting benefits. To account for this, the assumption has been revised downward to assume that the remaining supplemental practices collectively do not result in additional rate-based export benefits. This is consistent with how P was handled in 2013 to account for the state-wide P credits.

9.90 lbs * 0% loss = 0.00 lb/acre/year

Targeted Application Benefits on non-input loads

Non-input load = 8.85 lb/acre/year

Assume portion of non-input load cannot be reduced by UNM. We use the assumption that this is twice the avg load for Forest land (1.68 lb/acre/yr in P6 model documentation). This is based on turf having approximately the same N concentration as forest, but twice the runoff volume.

Subtract 2 x 1.68 from non-input load

8.85 - 3.36 = 5.49 lb/acre/year

Conservative assumption that these affect a max of 10% of the residual load through supporting dense and healthy turf cover:

Max additional UNM reduction of 0.55 lb/acre/year

STEP 3: Total Reductions from Steps 3 and 4:

0% Additional Loss of Inputs: 0.00 lb/acre/year

Residuals: 0.55 lb/acre/year

Total: 0.55 lb/acre/year – this is equivalent to a 6% TN reduction benefit

This number is equal to the current low risk rate, which provides a conservative remaining benefit for additional actions targeting effective fertilizer application and clipping management on residual loads.

PHOSPHORUS Check

STEP 1 Mass Balance Check

- Composite P Load from Pervious = 0.77 lb/acre/year
- Average Inputs (fertilizer only): 1.61 lb/acre/year
- Input sensitivity: 51% of Total P = 0.39 lb/acre/year
- Non-Input portion of load: 0.38 lb/acre/year (remaining load delivered independent of fertilizer inputs via surface runoff, interflow and groundwater)

STEP 2: Estimate UNM Impact on Fertilizer Inputs

Targeted Application Benefits to Inputs –

The 2013 panel avoided double-counting by assuming no additional reductions to fertilizer inputs from the individual UNM practices. This has not changed with the new Level 1 plan, so the assumed input losses are set at 0% for Level 2.

0.77 lbs * 0% loss = 0.00 lb/acre/year

Targeted Application Benefits on non-input loads

Non-input load = 0.38 lb/acre/year

Assume portion of non-input load cannot be reduced by UNM. We use the assumption that this is twice the avg load for Forest land (0.08 lb/acre/yr in P6 model documentation). This is based on turf having approximately the same P concentration as forest, but twice the runoff volume.

Subtract 2 x 0.08 from non-input load

0.38 - 0.16 = 0.22 lb/acre/year

Conservative assumption that these affect a max of 14% of the residual load through supporting dense and healthy turf cover:

Max additional UNM reduction of 0.031 lb/acre/year

STEP 3: Total Reductions from Steps 3 and 4:

0% Additional Loss of Inputs: 0.00 lb/acre/year

Residuals: 0.031 lb/acre/year

Total: 0.031 lb/acre/year – this is equivalent to a 4% TP reduction benefit

Non-Fertilized Turf Analysis

STEP 1 Mass Balance Check

- Composite N Load from Pervious = 9.22 lb/acre/year
- Average Inputs (fertilizer only): 9.90 lb/acre/year
- Input sensitivity: 4% of Total N = 0.37 lb/acre/year
- Non-Input portion of load: 8.85 lb/acre/year (remaining load delivered independent of fertilizer inputs via surface runoff, interflow and groundwater)

STEP 2: Estimate UNM Impact on Fertilizer Inputs

Targeted Application Benefits to Inputs –

For UNM Plans, it is assumed that all rate reductions are accounted for by the automatic rate adjustments, and therefore, additional benefits to input reductions were set at 0. For Non-fertilized turf, we are explicitly attempting to capture the potential additional benefits of eliminating fertilizer application. To account for this, the assumption has been revised back upward to assume that non-fertilization of healthy turfgrass can further reduce loss of 1% from fertilizer inputs. This value is based on a conservative estimate of the range of potential losses from N inputs (1-5%).

9.90 lbs * 1% loss = 0.10 lb/acre/year

Targeted Application Benefits on non-input loads

Non-input load = 8.85 lb/acre/year

Assume portion of non-input load cannot be reduced by UNM. We use the assumption that this is twice the avg load for Forest land (1.68 lb/acre/yr in P6 model documentation). This is based on turf having approximately the same N concentration as forest, but twice the runoff volume.

Subtract 2 x 1.68 from non-input load

8.85 - 3.36 = 5.49 lb/acre/year

Conservative assumption that these affect a max of 10% of the residual load through supporting dense and healthy turf cover:

Max additional UNM reduction of 0.55 lb/acre/year

STEP 3: Total Reductions from Steps 3 and 4:

1% Additional Loss of Inputs: 0.10 lb/acre/year

Residuals: 0.55 lb/acre/year

Total: 0.65 lb/acre/year – this is equivalent to a 7% TN reduction benefit

PHOSPHORUS Check

STEP 1 Mass Balance Check

- Composite P Load from Pervious = 0.77 lb/acre/year
- Average Inputs (fertilizer only): 1.61 lb/acre/year
- Input sensitivity: 51% of Total P = 0.39 lb/acre/year
- Non-Input portion of load: 0.38 lb/acre/year (remaining load delivered independent of fertilizer inputs via surface runoff, interflow and groundwater)

STEP 2: Estimate UNM Impact on Fertilizer Inputs

Targeted Application Benefits to Inputs –

The primary mechanism for additional reductions in Non-Fertilized Turf is a reduction in input. The assumption is that this practice provides an additional reduction in applied fertilizer. While theoretically, this would take the practice to 100% application reduction, the panel acknowledges that some benefit is already provided by the automatic rate adjustment, and that the fact of the potential double-counting must be particularly carefully mitigated through conservative assumptions. The assumption here is that the zero application scenario further reduces potential P losses by 3%, which is on the conservative end of the range established by Soldat and Petrovic (2009) of 1-18%, and King et al. (2012) of 4-6%.

1.61 lbs * 3% loss = 0.048 lb/acre/year

Targeted Application Benefits on non-input loads

Non-input load = 0.39 lb/acre/year

Assume portion of non-input load cannot be reduced by UNM. We use the assumption that this is twice the avg load for Forest land (0.08 lb/acre/yr in P6 model documentation). This is based on turf having approximately the same P concentration as forest, but twice the runoff volume.

Subtract 2 x 0.08 from non-input load

0.39 - 0.16 = 0.23 lb/acre/year

Conservative assumption that these affect a max of 10% of the residual load through supporting dense and healthy turf cover:

Max additional UNM reduction of 0.023 lb/acre/year

STEP 3: Total Reductions from Steps 3 and 4:

0% Additional Loss of Inputs: 0.048 lb/acre/year

Residuals: 0.023 lb/acre/year

Total: 0.071 lb/acre/year – this is equivalent to a 9% TP reduction benefit

Appendix C.

Maryland Department of Agriculture
Agriculture | Maryland's Leading Industry
Office of Resource Conservation
Nutrient Management Program

Larry Hogan, Governor
Boyd K. Rutherford, Lt. Governor
Joseph Bartenfelder, Secretary
Julianne A. Oberg, Deputy Secretary

The Wayne A. Cawley, Jr. Building
50 Harry S. Truman Parkway
Annapolis, Maryland 21401
www.mda.maryland.gov

410.841.5959 Baltimore/Washington
410.841.5950 Fax
800.492.5590 Toll Free

To: Fertilizer Applicator Business License Holders

From: Maryland Department of Agriculture
Nutrient Management Program

Date: Originally published April 29, 2014

RE: Sample Reporting Form Data

Following is an example of a form that would meet Maryland Department of Agriculture (MDA) record-keeping requirements for fertilizer applications. Please note that if you apply pesticides, additional information must be kept as required by your Pesticide Applicator's License. This form is only an example. You may keep records in any format, as long as the following information is maintained: applicator's name, date and location of the application, analysis of the fertilizer applied, rate of the fertilizer application, and the total amount of fertilizer applied. A soil test that is not more than 3 years old is required in order to apply P_2O_5 unless either a patch product is used, or you are starting a lawn after the soil has been disturbed, such as by construction or tillage. Copies of the soil test report and the fertilizer label should be kept in the office. Although reporting is by county, license holders may look up the 12 digit watershed code by entering the address in the Watershed locator tool on the website at www.mda.maryland.gov/fertilizer.

Sample Record Keeping Form

Applicator:	Jim Jones	**Date of last soil test:** 3/1/14
Owner:	Bob Smith	**County**
Address:	123 Any Street Anytown, MD 12345	
Size of Area:	5,000 sq ft	
Telephone:	410-123-4567	
Customer Number:	98765	
Date of Service:	3/15/14	
Fertilizer Analysis:	0-0-7	
Application Rate:	4 lb/1,000 sq. ft.	
Total Amount of Fertilizer Used:	20 lbs	
Comments:		

TETRA TECH

MEMO

To:	Cassandra Davis, Lauren Townley
Cc:	Lucinda Power, Rebecca Hindin, Jeff Sweeney, Norm Goulet, David Wood
From:	Eugenia Hart, Jon Harcum
Date:	September 1, 2020
Subject:	CBP Technical Support TD #13: Draft statistical survey procedures for developed sector BMP verification

1.0 Summary

This technical memorandum presents the draft statistical survey procedures for developed sector best management practice (BMP) verification under Technical Direction (TD) #13. The goal of the project is to refine New York's developed sector BMP verification protocols for the Chesapeake Bay watershed by selecting a statistically random subsample to validate the existence and performance of BMPs where large implementation numbers do not allow for the verification of each individual BMP.

Section 2.0 of this memo presents the BMPs to be included in New York State Department of Environmental Conservation's (DEC's) revised BMP verification protocols for the developed sector. Section 3.0 presents the draft statistical sample design to be applied for verification and Section 4.0 presents a summary of how the statistical sample design will be incorporated into New York's *Quality Assurance Project Plan Procedures for Collecting, Reporting and Verifying Wastewater and Developed Sector Data in the Chesapeake Bay Watershed* (NYSDEC 2019).

2.0 BMP Inclusion Approach

The BMPs to be included in the statistical survey procedures for the developed sector were identified using the Nonpoint Source BMP Database description provided by DEC, New York's *Phase III Watershed Implementation Plan* (WIP) for the Chesapeake Bay (NYSDEC 2020) and New York's *Quality Assurance Project Plan Procedures for Collecting, Reporting and Verifying Wastewater and Developed Sector Data in the Chesapeake Bay Watershed* (QAPP) (NYSDEC 2019). The BMPs are discussed in more detail in Sections 2.1 and 2.2 and Table 1 presents a summary of all developed sector BMPs considered for inclusion.

2.1 Included BMPs

The BMPs identified by the Phase III WIP as "those proposed to meet the 2025 developed sector target" (NYSDEC 2020) include stormwater performance standard runoff reduction BMPs, stormwater performance standard stormwater treatment BMPs, urban nutrient management plans, and urban forestry (forest buffers, tree planting) (NYSDEC 2020); however, other types of BMPs are also implemented in the watershed.

New York has historically only submitted BMPs associated with construction stormwater general permits to the Environmental Protection Agency's (EPA's) Chesapeake Bay Program (CBP) for annual progress but the revised verification protocols for the developed sector will apply to almost all BMPs implemented outside of multiple separate storm sewer system (MS4) areas and federal facilities. New York is currently developing a BMP database to track all BMPs implemented in the watershed and is planning on reporting all implemented BMPs to the CBP in the future.

DEC's BMP database is set up to input developed sector BMPs into seven different templates (construction stormwater, harvested forest, regional planning, urban forestry, Water Quality Improvement Projects [WQIPs], MS4s, and federal facilities). The BMPs types from these seven templates that are included in the verification protocols include (see Table 1):

- Impervious surface reduction
- Stormwater performance standard (runoff reduction)
- Stormwater performance standard (stormwater treatment)
- Forest harvesting practices
- Septic connections
- Urban stream restoration
- Urban nutrient management
- Wetland enhancement/rehabilitation
- Forest buffers
- Forest planting
- Tree planting
- Grass buffers

2.2 Excluded BMPs

Erosion and sediment control practices are not included in the verification protocols. Section 7.1.1.2 of the existing QAPP states that "Because the Chesapeake Bay Program does not differentiate between types of erosion and sediment control practices for purposes of the Chesapeake Bay Watershed Model, New York only reports the total acreage treated by erosion and sediment control practices". All construction sites that disturb greater than one acre in New York require a construction stormwater general permit. The permit requires Level 2 erosion and sediment control on 100% of construction areas (NYSDEC 2020 and NYSDEC 2019). New York reports its annual acres of construction and there is no further need for verification based on 100% implementation and inspection of erosion and sediment control.

Septic system pumping is another BMP that will not be included in the verification protocols. DEC does not expect significant nitrogen reductions from onsite wastewater treatment systems (OWTS) and does not currently track, report or verify OWTS BMPs in the Chesapeake Bay watershed (NYSDEC 2019).

BMPs associated with the MS4 permits in Binghamton and Elmira will also not be included in the verification protocols because there is an existing tracking and reporting requirement through the MS4 permit. Section 7.1 of the verification QAPP states "the MS4 Program requires post-construction BMPs to be implemented by regulated municipalities as part of the fulfillment of Minimum Control Measure 5 (MCM5) in their permits. Procedures to track and inventory post-construction stormwater practices are required" (NYSDEC 2019). New York's MS4 permits are currently being revised. If the updated permits are available prior to the final revision of the verification protocols, language will be included to describe the MS4 inspection requirements including the types of BMPs to be inspected and the frequency of inspection.

BMPs at federal facilities will not be included because these facilities have their own verification procedures.

Table 1. BMPs considered for inclusion in the developed sector verification protocols

BMP Template	BMP Name/ID	Include in survey (Yes/No)	Additional information
Construction stormwater	Impervious surface reduction Stormwater Performance Standard (Runoff Reduction) • Bioretention/raingardens • Infiltration practices • Permeable pavement • Urban filter strips • Vegetated open channels Stormwater Performance Standard (Stormwater Treatment) • Filtering practices • Wet ponds and wetlands	Yes	• Stormwater performance standard BMPs will be sampled as two groups (runoff reduction and stormwater treatment) rather than being sampled as each individual type of BMP associated with each performance standard BMP (e.g., bioretention, infiltration, filtering practices, etc…) • Erosion & sediment control will not be included because it is already reported at 100%
Harvested forest	Forest harvesting practices	Yes	• Not yet reported
Regional planning	Septic connections Stormwater management BMPs (includes runoff reduction and stormwater treatment practices) Urban stream restoration Urban nutrient management Wetland enhancement/rehabilitation	Yes	• Not yet reported
Urban forestry	Forest buffer Forest planting Tree planting (stormwater treatment – runoff reduction)	Yes	• Not yet reported
WQIP (Water Quality Improvement Project)	Stormwater management BMPs (includes runoff reduction and stormwater treatment practices) Stream BMPs Forest Buffers Forest planting Grass buffers Wetland enhancement/rehabilitation	Yes	• Not yet reported
MS4	Various BMPs	No	• Not yet reported • BMPs associated with MS4 permits in Binghamton and Elmira will not be included in the verification protocol because there is an existing tracking and reporting requirement through the MS4 permit.
Federal facilities	Various BMPs	No	• Not included. Federal facilities have their own verification procedures.

2.3 Number and Type of Sites

DEC has provided the following estimates of the types and number of developed sector BMPs expected to be reported in New York's BMP database for the Chesapeake Bay watershed. The actual numbers of each BMP type are unknown at this time, therefore, the statistical survey design (see Section 3.0) was developed using a synthetic dataset of estimated numbers. The BMPs types and estimated number of BMPs used to develop the statistical survey procedures are described below:

- Construction Stormwater – Approximately 300 construction projects will be added to the database. Each construction project will have, at a minimum, a runoff reduction and/or stormwater treatment BMP.
- Harvested Forest – This practice represents timber sales on DEC state forest. Annual forest harvesting BMPs are approximately 10 to 30 per year.
- Regional Planning – The regional planning boards are currently conducting a survey to send to municipalities to estimate the amount of BMPs being implemented in the watershed outside of MS4 areas.
- Urban Forestry – Approximately 10 to 15 projects with possible tree planting BMPs.
- WQIP – Approximately 40 projects. It is difficult to estimate the amount of BMPs for each WQIP project as they vary significantly from stream restoration to green infrastructure implementation.

3.0 Statistical Sample Design

The statistical sample design for the verification procedures is based on the numeric verification goals outlined in the CBP's *Urban Stormwater Verification Guidance* (CBP 2014), the types of BMPs DEC is planning to report, and the number of BMPs to be reported. These deciding factors are discussed below and are combined to determine the required sample size for verification.

3.1 Sample design goal

New York's developed sector QAPP (NYSDEC 2019) discusses DEC's current effort to perform verification on a sample of their BMP inventory at least once during the credit duration/lifespan of the BMP. The QAPP states:

> "Non-MS4 communities may elect to reduce the scope of their visual inspections by subsampling a representative fraction of their local BMPs and applying the results to their entire population of BMPs that are credited in the model. The sub-sampling method will be designed to have at least an 80% confidence level that the BMPs are reported accurately. There are several well accepted approaches to determining the sample size. These include using a census for a small population of BMPs, imitating a sample size of similar studies, using published tables, and/or applying formulas to calculate a sample size" (NYSDEC 2019).

The above approach to sample a representative fraction of the local BMPs is supported by the *Urban Stormwater Verification Guidance* (CBP 2014).

Tetra Tech consulted with Tom Schueler and David Wood of the Chesapeake Stormwater Network who are members of the CBP's developed sector Expert Panel as well as Jeff Sweeney at CBP and Norm Goulet, chair of the Urban Stormwater Workgroup. In a joint discussion with DEC staff and the aforementioned individuals, it was recommended that the 80% confidence level be used in conjunction with achieving a ±10 percent confidence interval (e.g., stormwater runoff reduction BMPs were successfully implemented with a 75% ±10% [65%-85%]).

3.2 Impact of site type on sample design

The differences in the number and type of sites (see Section 2.3) was also noted in the above conversation. Because of these differences, it was determined that two separate random selection processes be created for two groups of sites: 1) construction stormwater sites and 2) other developed sector sites.

Construction stormwater sites. Random selection of construction stormwater sites will be performed in a fashion similar to the approach used for selecting agricultural sites in the statistical survey procedures for agricultural sector BMP verification developed in 2016 (Tetra Tech 2016). The similar approach is the result of the larger number (300-400) of construction stormwater sites in comparison to the number of sites for the other developed sector site types. This approach involves the following steps:

- Create an inventory of known sites and county location.
- Create an inventory of BMPs implemented at each site.
- Randomly select one site from each county.
- Randomly select additional sites, one at a time, until the targeted number of BMPs have been selected for verification.
    - Sites are targeted based on the county-level stratification. Counties with more BMPs will have more sites identified for verification.
- All BMPs at a given site are inspected.
    - Inspecting all BMPs at a site will usually result in over sampling for some BMP types.

Other developed sector sites. The process for selecting other developed sector sites is similar to construction stormwater excepts sites will be stratified by site type (harvested forest, regional planning, urban forestry, WQIP) instead of county.

3.3 Sample size

Based on the sample design discussion provided in Section 3.1, the objective of the verification monitoring study is designed to estimate the proportion of properly implemented BMPs to within ±10 percent confidence interval with an 80% confidence level.

USEPA (2001) presents a method for computing the confidence intervals for distributions that follow a binomial distribution, such as BMP inspections with a pass/fall outcome and have a finite population from which samples are drawn. The benefit of this method is that smaller samples can be drawn, thereby reducing stakeholder cost and burden in comparison to the “large-population” approach. In addition, evidence (i.e., based on a previous survey) that can inform the likely proportion of BMPs passing can also be used to inform the sample size needed to meet the above objective. If no information is available, the sample size calculation should be based on a proportion of 50 percent. It might be reasonable to assume that a higher proportion of BMPs would pass an inspection.

Table 2 presents the half-width confidence interval for a variety of population sizes (30, 50, 100, 200, 300, 400), sampling efforts (5%, 10%, 15%, 20%, 25%, 30%, 40%, 50%, 60%), and proportion of BMPs passing (perc. meet. = 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.90) for an 80 percent confidence level. As stated in the previous paragraph, if no information is available to inform the likely proportion of BMPs passing, then the user should select the column, “80% Conf. Level (w/ perc. meet. = 0.5)”. The green checks indicate sampling scenarios that meet the study objectives.

DEC’s stormwater permitting section does not currently know the percentage of BMPs expected to pass inspection, therefore, it is assumed that 50% of the practices will pass. This value may change with more knowledge gained in future years (see Section 4.0).

Based on the lack of information regarding BMP success rate and the half-width confidence interval information presented in

Table 2, an example of the verification sampling procedure for construction stormwater BMPs is presented here. Suppose DEC inspected 30 of 300 construction stormwater runoff reduction BMPs and found that 15 sites had passed the inspection (i.e., p=0.50). In this case, it can be stated that with 80% confidence, the percentage of sites correctly implementing runoff reduction is 50 ± 11%. On the other hand, suppose 15 sites were inspected and 12 sites passed (p=0.80). In this case, it can be stated that with 80% confidence, the percentage of sites correctly implementing runoff reduction is 80 ± 13%. Neither one of these sampling options is acceptable as they do not meet the requirement of 80% confidence level ± 10% (see Table 2).

However, if DEC inspected 45 of 300 runoff reduction BMPs and found that 23 sites passed inspection (i.e., p=0.50), it can be stated with 80% confidence that the percentage of sites correctly implementing runoff reduction is 50 ±9%. This sample size is acceptable, with 15% sampling of the population of 300 and a percent meeting of 0.5 (50%). This sample size meets the 80% confidence level ± 10% as can be seen by the green check under the 15% sample size for 300 entities with perc. meet.=0.50 (Table 2). Based on the information presented in Table 2, an acceptable sampling scenario for New York’s 300-400 construction stormwater BMPs falls between 10% (for 400 BMPs) and 15% (for 300 BMPs).

The examples above are based on construction stormwater BMPs but this same methodology can also be applied to the “other developed sector sites” discussed in Section 3.2.

Table 2. Binomial confidence interval for varying sampling efforts and estimated probabilities of success

Sample Lev.	Number of Entities Implementing Practice	Minimum Selection Target	Half-width Confidence Interval (+/-d, %)								
			80% Conf. Level (w/ perc. meet. = 0.5)	80% Conf. Level (w/ perc. meet. = 0.55)	80% Conf. Level (w/ perc. meet. = 0.6)	80% Conf. Level (w/ perc. meet. = 0.65)	80% Conf. Level (w/ perc. meet. = 0.7)	80% Conf. Level (w/ perc. meet. = 0.75)	80% Conf. Level (w/ perc. meet. = 0.8)	80% Conf. Level (w/ perc. meet. = 0.85)	80% Conf. Level (w/ perc. meet. = 0.9)
5% Sample	30	2	44%	44%	43%	42%	40%	38%	35%	31%	26%
	50	3	36%	36%	35%	34%	33%	31%	29%	26%	22%
	100	5	28%	28%	27%	27%	26%	24%	22%	20%	17%
	200	10	20%	20%	19%	19%	18%	17%	16%	14%	12%
	300	15	16%	16%	16%	15%	15%	14%	13%	12%	10%
	400	20	14%	14%	14%	13%	13%	12%	11%	10%	8%
10% Sample	30	3	35%	35%	34%	33%	32%	30%	28%	25%	21%
	50	5	27%	27%	27%	26%	25%	24%	22%	19%	16%
	100	10	19%	19%	19%	18%	18%	17%	15%	14%	12%
	200	20	14%	14%	13%	13%	12%	12%	11%	10%	8%
	300	30	11%	11%	11%	11%	10%	10%	9%	8%	7%
	400	40	10%	10%	9%	9%	9%	8%	8%	7%	6%
15% Sample	30	5	26%	26%	26%	25%	24%	23%	21%	19%	16%
	50	8	21%	21%	20%	20%	19%	18%	17%	15%	12%
	100	15	15%	15%	15%	15%	14%	13%	12%	11%	9%
	200	30	11%	11%	11%	10%	10%	9%	9%	8%	6%
	300	45	9%	9%	9%	8%	8%	8%	7%	6%	5%
	400	60	8%	8%	7%	7%	7%	7%	6%	5%	5%
20% Sample	30	6	23%	23%	23%	22%	21%	20%	19%	17%	14%
	50	10	18%	18%	18%	17%	17%	16%	14%	13%	11%
	100	20	13%	13%	13%	12%	12%	11%	10%	9%	8%
	200	40	9%	9%	9%	9%	8%	8%	7%	6%	5%
	300	60	7%	7%	7%	7%	7%	6%	6%	5%	4%
	400	80	6%	6%	6%	6%	6%	6%	5%	5%	4%
25% Sample	30	8	19%	19%	19%	19%	18%	17%	16%	14%	12%
	50	13	15%	15%	15%	15%	14%	13%	12%	11%	9%
	100	25	11%	11%	11%	11%	10%	10%	9%	8%	7%
	200	50	8%	8%	8%	7%	7%	7%	6%	6%	5%
	300	75	6%	6%	6%	6%	6%	6%	5%	5%	4%
	400	100	6%	6%	5%	5%	5%	5%	4%	4%	3%
30% Sample	30	9	18%	18%	18%	17%	16%	15%	14%	13%	11%
	50	15	14%	14%	14%	13%	13%	12%	11%	10%	8%
	100	30	10%	10%	10%	9%	9%	8%	8%	7%	6%
	200	60	7%	7%	7%	7%	6%	6%	6%	5%	4%
	300	90	6%	6%	6%	5%	5%	5%	5%	4%	3%
	400	120	5%	5%	5%	5%	4%	4%	4%	3%	3%
40% Sample	30	12	14%	14%	14%	14%	13%	12%	11%	10%	9%
	50	20	11%	11%	11%	11%	10%	10%	9%	8%	7%
	100	40	8%	8%	8%	7%	7%	7%	6%	6%	5%
	200	80	6%	6%	5%	5%	5%	5%	4%	4%	3%
	300	120	5%	5%	4%	4%	4%	4%	4%	3%	3%
	400	160	4%	4%	4%	4%	4%	3%	3%	3%	2%
50% Sample	30	15	12%	12%	11%	11%	11%	10%	9%	8%	7%
	50	25	9%	9%	9%	9%	8%	8%	7%	6%	5%
	100	50	6%	6%	6%	6%	6%	6%	5%	5%	4%
	200	100	5%	5%	4%	4%	4%	4%	4%	3%	3%
	300	150	4%	4%	4%	4%	3%	3%	3%	3%	2%
	400	200	3%	3%	3%	3%	3%	3%	3%	2%	2%
60% Sample	30	18	10%	10%	9%	9%	9%	8%	8%	7%	6%
	50	30	7%	7%	7%	7%	7%	6%	6%	5%	4%
	100	60	5%	5%	5%	5%	5%	5%	4%	4%	3%
	200	120	4%	4%	4%	4%	3%	3%	3%	3%	2%
	300	180	3%	3%	3%	3%	3%	3%	2%	2%	2%
	400	240	3%	3%	3%	2%	2%	2%	2%	2%	2%

4.0 Impact on QAPP

4.1 Semi-regulated construction stormwater BMPs

The draft statistical survey procedures presented in Section 3.0 of this memo will apply to the semi-regulated construction stormwater BMPs outside of MS4 areas as discussed in Section 7.2.2 of New York's developed sector QAPP, which discusses the verification of developed sector BMP data in New York's portion of the Chesapeake Bay watershed (NYSDEC 2019). These BMPs fall under the construction stormwater general permit. Construction stormwater BMPs are currently given full performance credit for the first five years of the BMP's lifespan and then receive a 20% downgrade for each year over the next five years (NYSDEC 2019). The draft sampling survey procedures outlined in this memo will alter this existing process by performing visual inspections on a statistical subsample of all construction stormwater BMPs after the fifth year of their lifespan.

The existing language can be removed from the QAPP and Section 7.2.2 of the QAPP will include a reference to a new appendix (Appendix 1) that will outline the updated verification protocols for semi-regulated BMPs in the developed sector. Table 5 and Table 10.7 in the QAPP currently present the jurisdiction verification protocol design table for construction stormwater BMPs outside of MS4 areas (see Figure 1). Section E of Table 5 (and Table 10.7) will be updated to include a reference to Appendix 1 of the QAPP, which will also describe the methods for conducting field inspections via statistical subsample.

This is similar to the method used to include statistical subsampling in the *Upper Susquehanna Coalition Quality Assurance Project Plan Procedures for Collecting, Reporting, and Verifying Nonpoint Source Data in the Chesapeake Bay Watershed* (Upper Susquehanna Coalition 2019) for verification of agricultural BMPs. The agriculture statistical survey methodology was included as an appendix to the existing nonpoint source QAPP. Construction stormwater BMPs will be surveyed in a similar fashion to the agricultural BMPs because of their larger number (300-400). A percentage of sites will be verified across the watershed at a proportion consistent with the number of sites at the county level. DEC staff in each county will be verifying the BMPs.

Table 3 presents a summary of the draft verification requirements for construction stormwater BMPs.

Verification Element	Description
BMP or Group	Construction Stormwater
Geographic Scope	Outside of MS4 localities
A. WIP Priority	Medium
B. Data Grouping	
C. BMP Type	Post Construction BMPs
D. Initial Inspection	
Method	Field Visit
Frequency	Once
Who Inspects	Qualified Inspector - a person that is knowledgeable in the principles and practices of erosion and sediment control, such as a licensed Professional Engineer, Certified Professional in Erosion and Sediment Control (CPESC), Registered Landscape Architect, or other Department endorsed individual(s).
Documentation	Construction Stormwater Notice of Intent and Notice of Termination
E. Follow-up Check	
Follow-up Inspection	Field inspection of statistical sub-sample TBD
Who Inspects	TBD
Documentation	Verification/Inspection Form

Figure 1. Jurisdiction verification protocol design table: construction stormwater (Table 5 in NYSDEC 2019 QAPP).

4.2 Other developed sector BMPs

Section 8 of the QAPP states that New York does not currently report forestry data but is in the process of developing a data collection (NYSDEC 2019). This is also true for the regional planning, urban forestry and WQIP BMPs listed in Table 1. In addition to the construction stormwater BMPs, the statistical sampling procedures presented in Section 3.0 (to be included in Appendix 1) will also be applied to these "other" developed sector BMPs that have not historically been reported to the CBP (see Section 2.3). Section 8 of the QAPP will be revised to include regional planning, urban forestry and WQIP BMPs and will reference the statistical sampling procedures in Appendix 1.

These "other" urban BMPs in New York's nonpoint source database are fewer in number than the construction stormwater BMPs and will likely be combined by type across the different programs and BMP templates rather than county (see Section 3.2) unless there are larger amounts of the BMPs than previously thought. These practices are still in the process of being inventoried, therefore, exact counts are unknown. These other developed sector BMPs may not need partitioning across counties because of their small numbers. For these other BMPs, "county" will be swapped out for "BMP template" type (i.e., harvested forest, regional planning, urban forestry and WQIP) as presented in Table 1. Staff associated with each of the particular programs will be verifying the BMPs (e.g., DEC and regional planning staff).

The statistical subsampling methodology presented in Section 3.0 can be applied to these other developed sector BMPs as well. However, it should be noted that statistical subsampling may not be necessary for these BMPs. If large numbers of these types of BMPs do not exist as they do for construction stormwater, a better option may be to inspect 100% of these BMPs at the end of their lifespan rather than as a percentage of the total number of BMPs. For example, all BMPs with a 5-year lifespan will be inspected after year 5. Section 4.3 below describes the adaptive management that will guide the sampling and verification process as new information becomes available.

Although BMPs implemented in MS4 permitted areas and at federal facilities will not be included in the updated verification protocols because they have existing programs for reporting and verifying BMPs, it should be noted that New York's MS4 permit is currently being revised. If a final version of the updated MS4 permit is available before the final updates to the developed sector QAPP are completed, a summary of any changes to the MS4 permit's reporting and verification program will be included.

Table 3 presents a summary of the draft verification requirements for each of the developed sector BMP types.

Table 3. Draft verification requirements for each of the developed sector BMP types

Program type	Practice type	Initial verification (via desktop inventory)	Follow-up or re-verification (via visual inspection)
Construction stormwater	Multi-year	100% (DEC will confirm the number of existing practices on the ground)	Statistical subsample of 10-15% of randomly selected practices in the watershed (see Table 2 for guidance), distributed across all counties. Sampling percentage may change based on an adaptive management approach (see Section 4.3).
Harvested forest Regional planning Urban forestry WQIP	Multi-year	100% (DEC will confirm the number of existing practices on the ground)	Statistical subsample of a percentage (see Table 2 for guidance) of these BMPs as a group across program type rather than county OR inspect 100% of these BMPs at the end (after 5th year) of their lifespan. Sampling percentage and procedure may

Program type	Practice type	Initial verification (via desktop inventory)	Follow-up or re-verification (via visual inspection)
			change based on an adaptive management approach (see Section 4.3).

4.3 Adaptive Management

Because of the lack of knowledge regarding the current number of developed sector BMPs on the ground and uncertainty regarding the expected percentage of BMPs to pass inspection, the draft statistical subsampling design presented in Section 3.0 was based on a statistically conservative assumption that 50% of the BMPs will pass inspection. In reality, these numbers will change as New York's verification program begins and more knowledge is gained. Regardless of the initial sampling method used, an adaptive management approach will be applied to the verification program to ensure that sampling rates remain within range of the target of 80% confidence level ± 10% as presented in Section 3.0.

Table 4 will be included in Appendix 1 of the revised QAPP to be used to guide future sample size selections. DEC staff can use Table 4 to pick the correct sampling values based on the 80% confidence level ±10%.

Table 4 is the same as Table 2 but does not have the green checkmarks indicating the acceptable sampling scenarios. DEC can use this table to apply appropriate sampling scenarios once they have a better understanding of the percentage of BMPs expected to pass inspection. The current percentage of BMPs expected to pass inspection is assumed to be 50% because there is no information available, but the actual percentage is likely different than 50%.

As implementation and verification of developed sector BMPs progresses, the percent meeting and other information will be used to help assess the need to alter the sampling approach. As New York's verification program becomes more robust, the actual percent meeting (perc. meet. in

Table 4) will become known and can replace the 50% assumption. The 80% confidence level ±10% will still be required but the perc. meet. will be adjusted to the columns to the right to reflect the actual percent meeting (e.g., 55 – 90%). Adjustments will be made as necessary to ensure that verification goals are met. The sample size can and likely will change over time. Subsampling will start on the left of

Table 4 (using 50% perc meet.) and likely move to the right with a larger perc meet. as the actual percentage of BMPs passing inspection becomes available. DEC can adaptively manage the sample size over time as the increasing perc. meet. will reduce the necessary sample size to meet the 80% confidence level ±10%. The percentage of BMPs sampled will vary depending on the number of practices (e.g., a larger number of BMPs will have a smaller sampling percentage; a smaller number of BMPs will have a larger sampling percentage).

Table 4. Binomial confidence interval for varying sampling efforts

Sample Lev.	Number of Entities Implementing Practice	Minimum Selection Target	Half-width Confidence Interval (+/-d, %)								
			80% Conf. Level (w/ perc. meet. = 0.5)	80% Conf. Level (w/ perc. meet. = 0.55)	80% Conf. Level (w/ perc. meet. = 0.6)	80% Conf. Level (w/ perc. meet. = 0.65)	80% Conf. Level (w/ perc. meet. = 0.7)	80% Conf. Level (w/ perc. meet. = 0.75)	80% Conf. Level (w/ perc. meet. = 0.8)	80% Conf. Level (w/ perc. meet. = 0.85)	80% Conf. Level (w/ perc. meet. = 0.9)
5% Sample	30	2	44%	44%	43%	42%	40%	38%	35%	31%	26%
	50	3	36%	36%	35%	34%	33%	31%	29%	26%	22%
	100	5	28%	28%	27%	27%	26%	24%	22%	20%	17%
	200	10	20%	20%	19%	19%	18%	17%	16%	14%	12%
	300	15	16%	16%	16%	15%	15%	14%	13%	12%	10%
	400	20	14%	14%	14%	13%	13%	12%	11%	10%	8%
10% Sample	30	3	35%	35%	34%	33%	32%	30%	28%	25%	21%
	50	5	27%	27%	27%	26%	25%	24%	22%	19%	16%
	100	10	19%	19%	19%	18%	18%	17%	15%	14%	12%
	200	20	14%	14%	13%	13%	12%	12%	11%	10%	8%
	300	30	11%	11%	11%	11%	10%	10%	9%	8%	7%
	400	40	10%	10%	9%	9%	9%	8%	8%	7%	6%
15% Sample	30	5	26%	26%	26%	25%	24%	23%	21%	19%	16%
	50	8	21%	21%	20%	20%	19%	18%	17%	15%	12%
	100	15	15%	15%	15%	15%	14%	13%	12%	11%	9%
	200	30	11%	11%	11%	10%	10%	9%	9%	8%	6%
	300	45	9%	9%	9%	8%	8%	8%	7%	6%	5%
	400	60	8%	8%	7%	7%	7%	7%	6%	5%	5%
20% Sample	30	6	23%	23%	23%	22%	21%	20%	19%	17%	14%
	50	10	18%	18%	18%	17%	17%	16%	14%	13%	11%
	100	20	13%	13%	13%	12%	12%	11%	10%	9%	8%
	200	40	9%	9%	9%	9%	8%	8%	7%	6%	5%
	300	60	7%	7%	7%	7%	7%	6%	6%	5%	4%
	400	80	6%	6%	6%	6%	6%	6%	5%	5%	4%
25% Sample	30	8	19%	19%	19%	19%	18%	17%	16%	14%	12%
	50	13	15%	15%	15%	15%	14%	13%	12%	11%	9%
	100	25	11%	11%	11%	11%	10%	10%	9%	8%	7%
	200	50	8%	8%	8%	7%	7%	7%	6%	6%	5%
	300	75	6%	6%	6%	6%	6%	6%	5%	5%	4%
	400	100	6%	6%	5%	5%	5%	5%	4%	4%	3%
30% Sample	30	9	18%	18%	18%	17%	16%	15%	14%	13%	11%
	50	15	14%	14%	14%	13%	13%	12%	11%	10%	8%
	100	30	10%	10%	10%	9%	9%	8%	8%	7%	6%
	200	60	7%	7%	7%	7%	6%	6%	6%	5%	4%
	300	90	6%	6%	6%	5%	5%	5%	5%	4%	3%
	400	120	5%	5%	5%	5%	4%	4%	4%	3%	3%
40% Sample	30	12	14%	14%	14%	14%	13%	12%	11%	10%	9%
	50	20	11%	11%	11%	11%	10%	10%	9%	8%	7%
	100	40	8%	8%	8%	7%	7%	7%	6%	6%	5%
	200	80	6%	6%	5%	5%	5%	5%	4%	4%	3%
	300	120	5%	5%	4%	4%	4%	4%	4%	3%	3%
	400	160	4%	4%	4%	4%	4%	3%	3%	3%	2%
50% Sample	30	15	12%	12%	11%	11%	11%	10%	9%	8%	7%
	50	25	9%	9%	9%	9%	8%	8%	7%	6%	5%
	100	50	6%	6%	6%	6%	6%	6%	5%	5%	4%
	200	100	5%	5%	4%	4%	4%	4%	4%	3%	3%
	300	150	4%	4%	4%	4%	3%	3%	3%	3%	2%
	400	200	3%	3%	3%	3%	3%	3%	3%	2%	2%
60% Sample	30	18	10%	10%	9%	9%	9%	8%	8%	7%	6%
	50	30	7%	7%	7%	7%	7%	6%	6%	5%	4%
	100	60	5%	5%	5%	5%	5%	5%	4%	4%	3%
	200	120	4%	4%	4%	4%	3%	3%	3%	3%	2%
	300	180	3%	3%	3%	3%	3%	3%	2%	2%	2%
	400	240	3%	3%	3%	2%	2%	2%	2%	2%	2%

5.0 References

CBP (Chesapeake Bay Program). 2014. *Urban Stormwater Verification Guidance*. Chesapeake Bay Program Water Quality Goal Implementation Team's BMP Verification Committee. Annapolis, MD.

NYSDEC (New York State Department of Environmental Protection). 2020. *Final Phase III Watershed Implementation Plan New York Chemung and Susquehanna River Basins*. Division of Water Bureau of Watershed Resource Management. Albany, NY.

NYSDEC (New York State Department of Environmental Protection). 2019. *Quality Assurance Project Plan Procedures for Collecting, Reporting and Verifying Wastewater and Developed Sector Data in the Chesapeake Bay Watershed*. Division of Water Bureau of Watershed Resource Management Chesapeake Bay Watershed Program. Albany, NY.

Tetra Tech. 2016. Appendix 1. Statistical Sampling Approach to Agricultural BMP Verification in New York State in *Upper Susquehanna Coalition Quality Assurance Project Plan Procedures for Collecting, Reporting, and Verifying Nonpoint Source Data in the Chesapeake Bay Watershed* by Upper Susquehanna Coalition. Owego, NY.

USEPA (United States Environmental Protection Agency). 2001. *Techniques for Tracking, Evaluating, and Reporting the Implementation of Nonpoint Source Control Measures: Urban*. U.S. Environmental Protection Agency, Office of Water. EPA-841-B-00-007. January. https://www.epa.gov/sites/production/files/2015-10/documents/urban_0.pdf

Upper Susquehanna Coalition. 2019. *Upper Susquehanna Coalition Quality Assurance Project Plan Procedures for Collecting, Reporting, and Verifying Nonpoint Source Data in the Chesapeake Bay Watershed*. Owego, NY.

<u>Appendix D</u>
Technical Requirements for Tracking and Reporting Urban Nutrient Management BMPs in CAST

Approved by the WTWG: November 6, 2025

Background: The Water Quality Goal Implementation Team's approved *Protocols for the Development, Review and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model* (2021) establishes that in an effort for the CBP partnership to more efficiently approve the technical requirements for NEIEN and CAST that are required by each Expert Panel report, the CBP Modeling Team will work with the Expert Panel members and the WTWG to develop a technical appendix that describes changes that will be made to the modeling and reporting tools to accommodate the BMP(s).

Q1. What are the CAST definitions for the Urban Nutrient Management BMPs:

A.1. **UNM with a Soil Test:** Turfgrass managed according to an urban nutrient management plan written by a trained professional, that is based on a soil test and follows a series of core turfgrass fertilizer management practices for N and P, related to the Rate, Timing, and Placement of fertilizer, in addition to several clipping management practices.

- Note: NEIEN will include a UNM with a Soil Test (3-year) and UNM with a Soil Test (1-year) practice. This is to ease reporting and communication in states that aggregate UNM plan acres annually but still require soil testing. Both the 3-year and 1-year BMP will map to the same practice (UNM with a Soil Test) in CAST.

UNM without a Soil Test: Turfgrass managed according to best fertilization practices for N and P, related to the Rate, Timing, and Placement of fertilizer, in addition to several Clipping Management practices, but which lack soil test data or a written plan developed by a trained expert. This BMP includes signed homeowner pledges that establish a commitment to adhere to the defined best practices.

Non-Fertilized Turfgrass: Managed turfgrass that effectively maintains healthy turf coverage without the application of fertilizer and through proper clipping management.

Q2. What are the pollutant removal efficiencies a jurisdiction can claim for qualifying acres under each BMP?

A2.

	TN Reduction	**TP Reduction**
UNM w/ a Soil Test 3-year	6 %	4.5 %
UNM w/ a Soil Test 1-year	6%	4.5%
UNM without a Soil Test	6 %	4.5 %
Non-Fertilized Turfgrass	7 %	9 %

Q3. What is the credit duration for each UNM BMP?

A3.

	Credit Duration
UNM w/ a Soil Test 3-year	3 years
UNM w/ a Soil Test 1-year	Annual
UNM without a Soil Test	Annual
Non-Fertilized Turfgrass	Annual

Q4. What does a jurisdiction need to report to receive credit for UNM Plans?

A4.
BMP Name: UNM w/ Soil Test, UNM without Soil Test, Non-Fertilized Turf
Acres: number of acres of qualifying UNM plans or pledges within geographic reporting unit
Location: Approved NEIEN geographies: Latitude/Longitude of approximate centerpoint of acres; County, Hydrologic Unit Code (HUC12, HUC10, HUC8, HUC6, HUC4), State
Date of Implementation: Date the plan was written, pledge was signed, etc.
Land Use: Eligible land uses include Turfgrass, Tree Canopy Over Turfgrass, Solar Pervious (MS4, CSS, and Non-Regulated)

Q5. Does a jurisdiction need to report acreage of UNM plans every year to receive credit in the model for existing plans?

A5. Only for the two annual BMPs (UNM without a Soil Test, and Non-Fertilized Turfgrass). Jurisdictions should report the number of acres under these two BMPs to the Chesapeake Bay Program each year to receive credit in the model. UNM With a Soil Test is good for 3 years, and can be renewed with a new soil test and passed inspection.

Q6. Can a jurisdiction report other stormwater BMPs on the same acre covered by an urban nutrient management plan BMP?

A6. Yes. The UNM BMP will be credited in CAST along with other urban BMPs on the same acre. While multiple urban BMPs can be placed on the same acre, the realized edge-of-stream nutrient reductions are adjusted by CAST to address the diminishing returns that occur when two or more BMPs treat the same acre. Most stormwater BMPs are designed based on the runoff generated from impervious areas in their drainage area, and not the runoff from pervious areas.

Q7. *Can multiple UNM BMPs be combined on the same acre?*

A7. No. Each UNM BMP represents mutually exclusive management conditions. Only 1 BMP can be reported on an acre in a given year.

Q8. Are jurisdictions eligible for state-wide nutrient reduction credit if it has passed urban nutrient management legislation?

A8. No additional state-wide BMP reductions are provided for states with fertilizer or UNM legislation. Reductions in fertilizer application rates driven by legislation are captured by AAPFCO/state-reported fertilizer sales data submitted to the Chesapeake Bay Program Office.

Q9. Are homeowner pledges eligible for credit under one of the UNM BMPs?

A9. Yes, signed homeowner pledges will be eligible for credit under the UNM without a Soil Test BMP, as well as the Non-Fertilized Turfgrass BMP. Beyond meeting the qualifying criteria outlined in Section 6, states have the flexibility to determine if they will collect homeowner pledges and the format those pledges could take. New pledges must be re-submitted every year to maintain their credit.

Q10. *When do these recommendations take effect, and can I still report the Phase 6 UNM BMPs?*

A10. These recommendations take effect in Phase 7 Model. Phase 6 UNM BMPs are still available for reporting until the Phase 6 Model is sunset. The new BMPs will also be made available as a "planning BMP" in Phase 6 CAST and included as draft in the appendix for use in planning scenarios.

Q11. *Following the transition to Phase 7, will states be required to go back and report the P7 UNM for their entire history?*

A11. No. In NEIEN, for annual progress reporting, the Phase 6 UNM BMPs (Low, Medium and High Risk) will map directly to the UNM Plan w/o a Soil Test Practice. Once the Phase 7 model is officially adopted, states will no longer be able to report the Phase 6 practices.

Q12. *How are the eligible land uses simulated in P7 to ensure the Non-fertilized turfgrass BMP represents a change in management compared to the Pre-BMP condition?*

A12. Every acre of the eligible land use categories for the UNM BMPs (turfgrass, tree canopy over turfgrass, and solar pervious) is assumed to receive fertilizer. The updated non-farm fertilizer application methodology takes the state-wide fertilizer nutrient mass and divides it by the state-wide turfgrass acres, plus solar pervious acres and construction acres, to determine the non-farm fertilizer application rate for each state.

Appendix E. Example Urban Nutrient Management Homeowner Pledge

Urban Nutrient Management Online Pledge Submission

Urban Nutrient Management Pledge

By completing this survey, I pledge to use the top 10 urban nutrient management practices to protect water quality and use fertilizer sparingly.

Top 10 BMPs for Lawns and Turfgrass in New York

1. Avoid spillage of fertilizer and turfgrass clippings onto impervious surfaces.
2. Return clippings to turf to recycle nutrients (not applicable on golf course putting greens).
3. Avoid late-season applications (after mid-October) of all nitrogen sources and avoid high rate early-spring applications of water soluble (quick release) nitrogen sources.
4. Per NYSDEC regulation: Avoid fertilizer applications within 20 feet of water *unless*
    (a) there is a 10 foot buffer of vegetation between the management area and waterbody, or
    (b) a spreader guard or other control device is used (then the closest you can get is 3 feet)
5. Conduct soil testing to establish nutrient requirements for non-nitrogen nutrients (MLSN Guidelines preferred). Note: phosphorus application is controlled under a NYSDEC regulation.
6. If turf has desirable function, growth, and quality, fertilizer (of any kind) is not required.
7. Set mower height at 3.5 inches or taller.
8. Fertilizer applications should not be made when soil temperatures are under 50° Fahrenheit.
9. Maximize use of slow-release nitrogen fertilizer, especially on sandy soils.
10. If more assistance is needed, work with a professional to develop a UNMP based on a soil test analysis.

For questions or concerns, email urbannutrients@u-s-c.org

When you submit this form, it will not automatically collect your details like name and email address unless you provide it yourself.

* Required

1. First and Last Name *

Enter your answer

2. Address *

Enter your answer

3. City *

Enter your answer

Credit: Upper Susquehanna Coalition

Appendix E. Example Urban Nutrient Management Homeowner Pledge

4. ZIP *

Enter your answer

5. Email Address *

Enter your answer

6. Phone Number *

Enter your answer

7. Approximate size of your yard *

Enter your answer

8. Units *

- ◯ Square Feet
- ◯ Acres

Submit

Credit: Upper Susquehanna Coalition