BMP Implementation: Integrating cost-effectiveness and co-benefits with nutrient efficiency

Water Quality Goal Implementation Team
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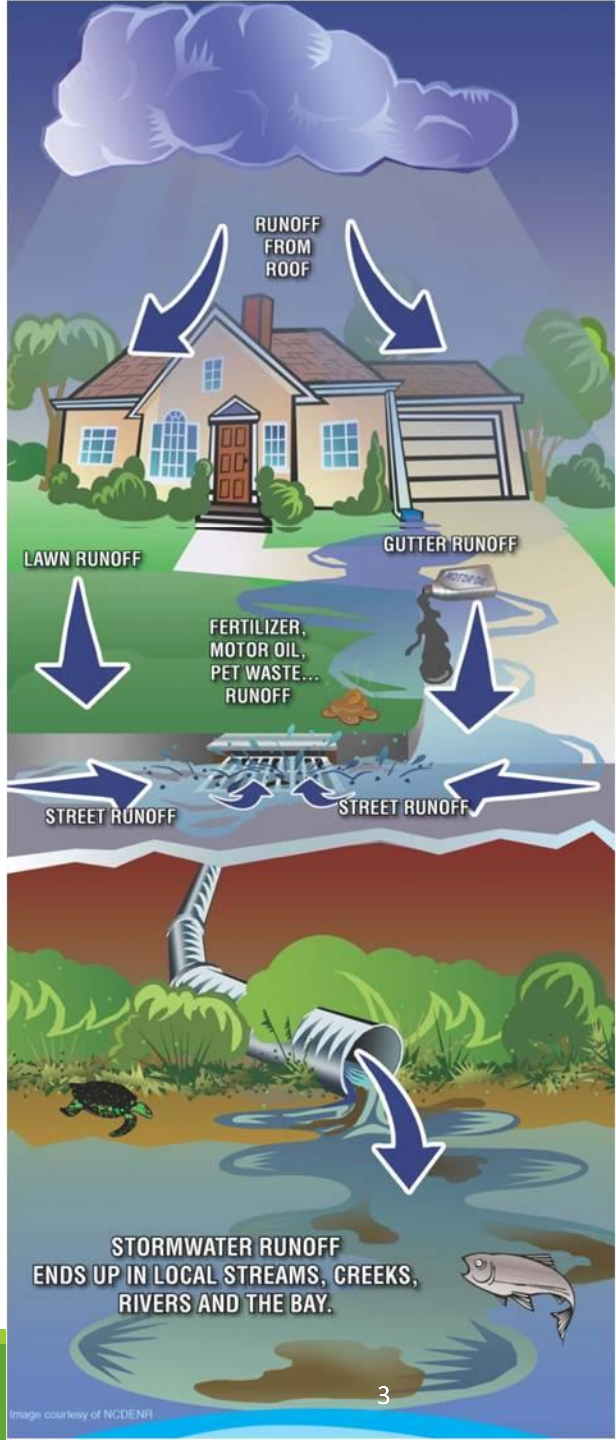
Cost effectiveness increases likelihood of BMP implementation

- Best management practices (**BMPs**) must be implemented to reduce nitrogen, phosphorus, and sediment loads to meet the requirements of the Chesapeake Bay Total Maximum Daily Load (**Bay TMDL**)
- **Local TMDLs** also are in place for those pollutants and for bacteria, PCBs and trash
- BMPs selected for implementation may be assessed on three factors:
  - can be more or less effective in reducing total pollutants
  - have a high or low unit cost of pollutant reduction
  - have **co-benefits** that meet local TMDLs and priorities, or not
- Cost effectiveness is important given limited funding for environmental improvements
- Implementing a BMP to achieve multiple objectives facilitates program and funding prioritization, and may result in a greater likelihood of implementation

Consequences of non-compliance

- Counties can meet their reductions, or not
- If not, counties could come under consent decrees, like Montgomery County did on April 13, 2018 for failing to meet the 20% impervious surface reduction by February 15, 2015
  - Montgomery County has a judgment of $300,000 due on December 31, 2020
  - This can be satisfied by completing MDE-approved Supplemental Environmental Projects
  - Failure to meet reductions has significant financial implications
- Counties must show they can pay for BMPs in their Financial Assurance Plan
  (https://www.montgomerycountymd.gov/water/stormwater/ms4.html)



Methods/Overview

1. Estimate cost effectiveness and co-benefits per BMP
2. For 2017 in Montgomery County: Compare the most implemented to the most cost-effective and the **bacteria co-benefit**
3. Match the N or P reduced by the BMPs in 2017 by applying more cost-effective BMPs that allow a comparison of acres impacted and costs for reducing the same amount of N or the same amount of P

Methods: BMP cost effectiveness

- **CAST** is the Chesapeake Bay Program Phase 6 model
  - Calculates the N, P and S load with a suite of BMPs
  - There is no output of load reduced per BMP, although this is required for MS4 reporting
- Jessica Rigelman and Olivia Devereux developed estimates of N, P and S reduction effectiveness and cost per unit reduced for each BMP using CAST
  - Used a series of BMP "isolation" model scenarios to calculate the pounds of N, P and S reduced per each BMP
  - The design of the scenarios isolates the load reduced from each BMP while including the interaction effects of other BMPs, and is useful for assessing relative differences among BMPs

Methods: BMP cost effectiveness, cont.

- **Isolation model**: Ran a scenario with all BMPs in it, then pulled each BMP out one-by-one
  - Computed the difference in load between the scenario with all the BMPs and the one without the target BMP
  - There are more than 300 BMPs, so that was a lot of scenarios!
- There are other methods for determining the load reduced per BMP
  - This method was used because it includes every BMP, even those that have not been previously implemented
  - The method also includes interaction effects and the land available for implementing the BMPs
- Resulting data are available on the CAST website, some interpretation is necessary

  https://public.tableau.com/profile/olivia.devereux#!/vizhome/BMPCost-Effectiveness/Nitrogen

BMP Isolation Scenario Example

Developed	Impervious Surface Reduction
Agriculture	Biofilters
Agriculture	Lagoon Covers
Agriculture	Tillage Management-Conservation
Developed	Erosion and Sediment Control Level 1
Developed	Mechanical Broom Technology - 1 pass/4 weeks
Developed	Nutrient Management Plan
Agriculture	Water Control Structures
	Plus all other BMPs approved by CBP for planning

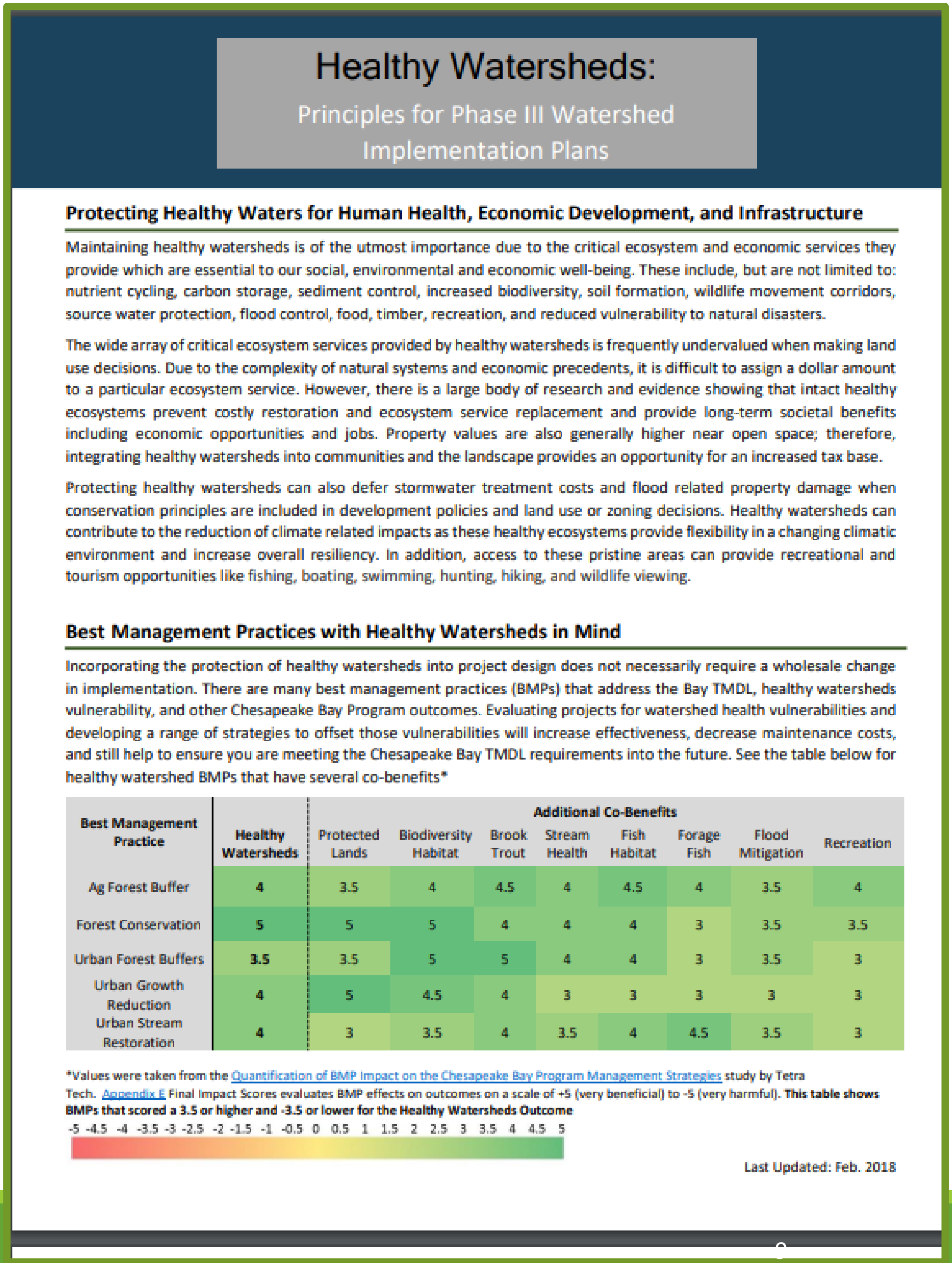
BMP Costs

- Costs are those incurred by both public and private entities
- Costs represent a single year of cost rather than the cost over the entire lifespan of the practice
- Costs are for all BMPs in a scenario, both those currently implemented as well as those planned
- These unit cost per BMP data support calculating the annualized cost per pound reduced per year

cost per Lb reduced per year = cost per unit of BMP / Lbs reduced per unit of BMP

Methods: Co-Benefits

- Co-benefits of implemented BMPs are assessed using qualitative impact scores developed for the Chesapeake Bay Program to support integrated implementation for multiple Chesapeake Bay Program Partnership management strategies
  - Scores can be used to indicate the anticipated impact of a BMP on a co-benefit
  - Information source: “Quantification of BMP Impact on the Chesapeake Bay Program Management Strategies” Tetra Tech (2017)
- There are 28 recognized co-benefits, fact sheets are available for 12 of them
- This analysis took the BMPs that were beneficial for **bacteria** and compared those to the most cost effective and most implemented BMPs



Healthy Watersheds:

Principles for Phase III Watershed Implementation Plans

Protecting Healthy Waters for Human Health, Economic Development, and Infrastructure

Maintaining healthy watersheds is of the utmost importance due to the critical ecosystem and economic services they provide which are essential to our social, environmental and economic well-being. These include, but are not limited to: nutrient cycling, carbon storage, sediment control, increased biodiversity, soil formation, wildlife movement corridors, source water protection, flood control, food, timber, recreation, and reduced vulnerability to natural disasters.

The wide array of critical ecosystem services provided by healthy watersheds is frequently undervalued when making land use decisions. Due to the complexity of natural systems and economic precedents, it is difficult to assign a dollar amount to a particular ecosystem service. However, there is a large body of research and evidence showing that intact healthy ecosystems prevent costly restoration and ecosystem service replacement and provide long-term societal benefits including economic opportunities and jobs. Property values are also generally higher near open space; therefore, integrating healthy watersheds into communities and the landscape provides an opportunity for an increased tax base.

Protecting healthy watersheds can also defer stormwater treatment costs and flood related property damage when conservation principles are included in development policies and land use or zoning decisions. Healthy watersheds can contribute to the reduction of climate related impacts as these healthy ecosystems provide flexibility in a changing climatic environment and increase overall resiliency. In addition, access to these pristine areas can provide recreational and tourism opportunities like fishing, boating, swimming, hunting, hiking, and wildlife viewing.

Best Management Practices with Healthy Watersheds in Mind

Incorporating the protection of healthy watersheds into project design does not necessarily require a wholesale change in implementation. There are many best management practices (BMPs) that address the Bay TMDL, healthy watersheds vulnerability, and other Chesapeake Bay Program outcomes. Evaluating projects for watershed health vulnerabilities and developing a range of strategies to offset those vulnerabilities will increase effectiveness, decrease maintenance costs, and still help to ensure you are meeting the Chesapeake Bay TMDL requirements into the future. See the table below for healthy watershed BMPs that have several co-benefits*

Best Management Practice	Healthy Watersheds	Additional Co-Benefits							
		Protected Lands	Biodiversity Habitat	Brook Trout	Stream Health	Fish Habitat	Forage Fish	Flood Mitigation	Recreation
Ag Forest Buffer	4	3.5	4	4.5	4	4.5	4	3.5	4
Forest Conservation	5	5	5	4	4	4	3	3.5	3.5
Urban Forest Buffers	3.5	3.5	5	5	4	4	3	3.5	3
Urban Growth Reduction	4	5	4.5	4	3	3	3	3	3
Urban Stream Restoration	4	3	3.5	4	3.5	4	4.5	3.5	3

*Values were taken from the Quantification of BMP Impact on the Chesapeake Bay Program Management Strategies study by Tetra Tech. Appendix E Final Impact Scores evaluates BMP effects on outcomes on a scale of +5 (very beneficial) to -5 (very harmful). **This table shows BMPs that scored a 3.5 or higher and -3.5 or lower for the Healthy Watersheds Outcome**

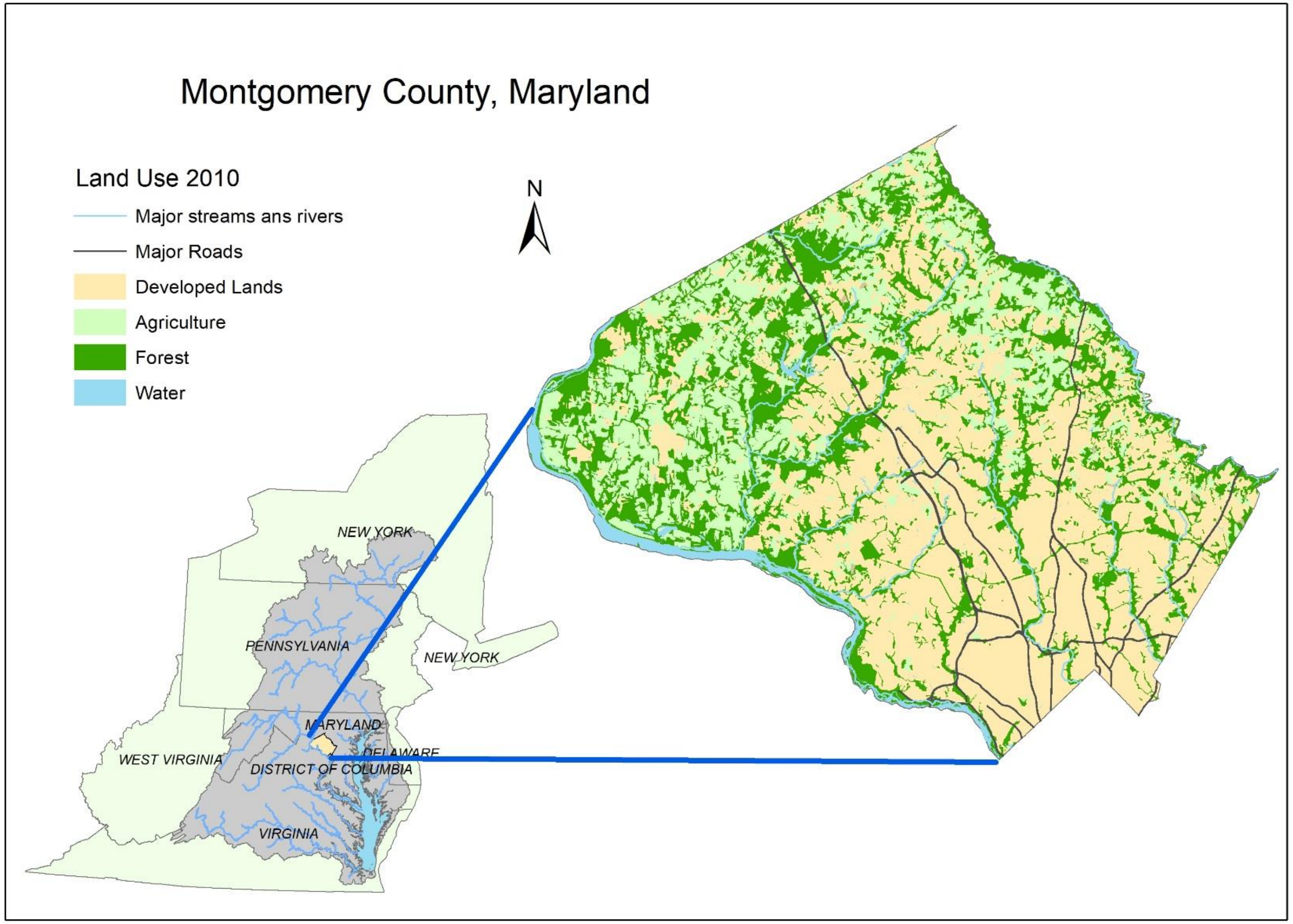
-5 -4.5 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

Last Updated: Feb. 2018

Methods- Site Selection

- Using a small watershed, illustrate the potential to reduce costs, improve nitrogen and phosphorus reductions, and impact co-benefits

- Montgomery, MD has a Phase I MS4 permit. It is predominantly urban but also has a significant Agricultural Reserve (93,000 acres). It is under a consent decree, and all other MD counties are watching it carefully. It is considered to be one of the bigger and better funded MS4s.



MS4 Permit and Bay TMDL

- The Agricultural Reserve is outside the MS4 service area, but is included in the Chesapeake Bay TMDL
- The MS4 permit drives implementation and the standard in MD is impervious surface restoration (ISR), not nutrient or sediment reductions
- There is no ISR credit for implementation of urban nutrient management or agricultural BMPs
- The stormwater division at MDE developed a crosswalk from Phase 5.3.2 Bay Program BMPs to ISR as part of the 2014 *Accounting of Stormwater Wasteload Allocations and Impervious Acres Treated*
- Overall, Montgomery County's urban project selection might not look optimized in terms of TN, TP and TSS, because the regulatory requirement is in terms of ISR

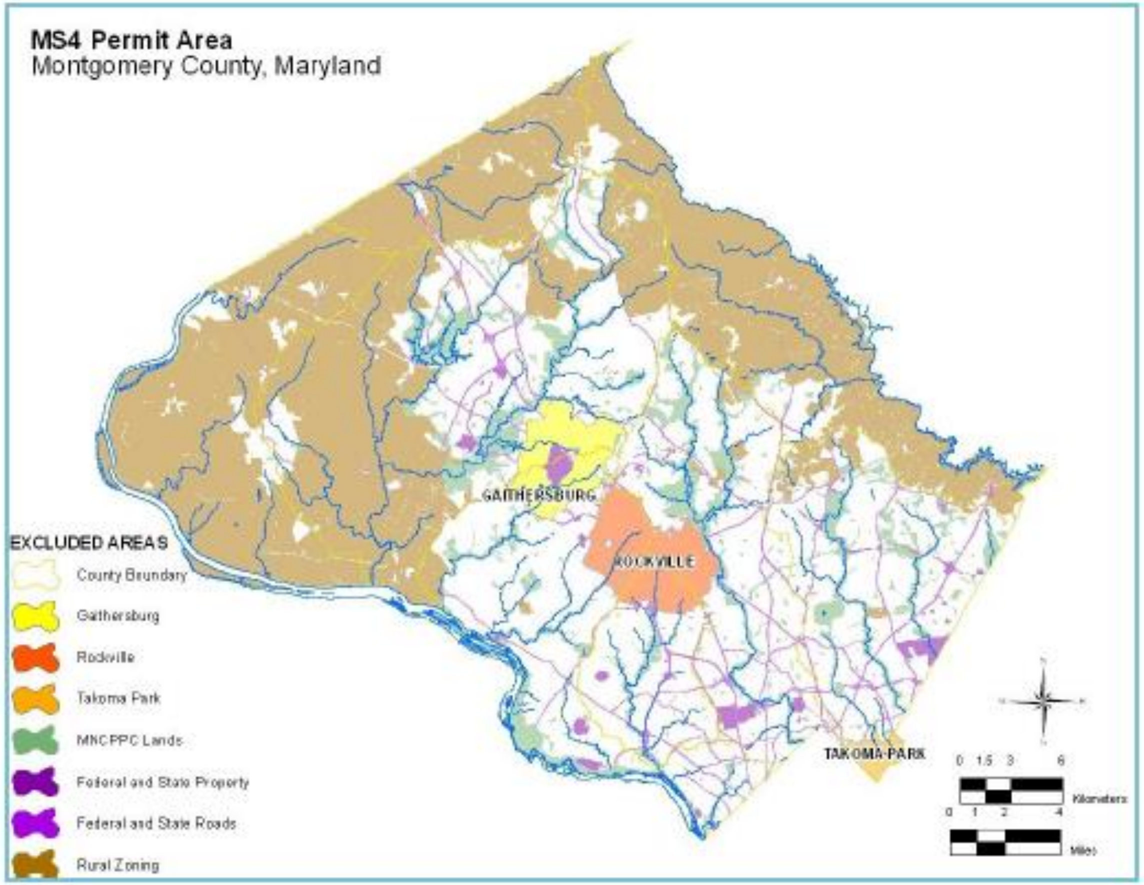
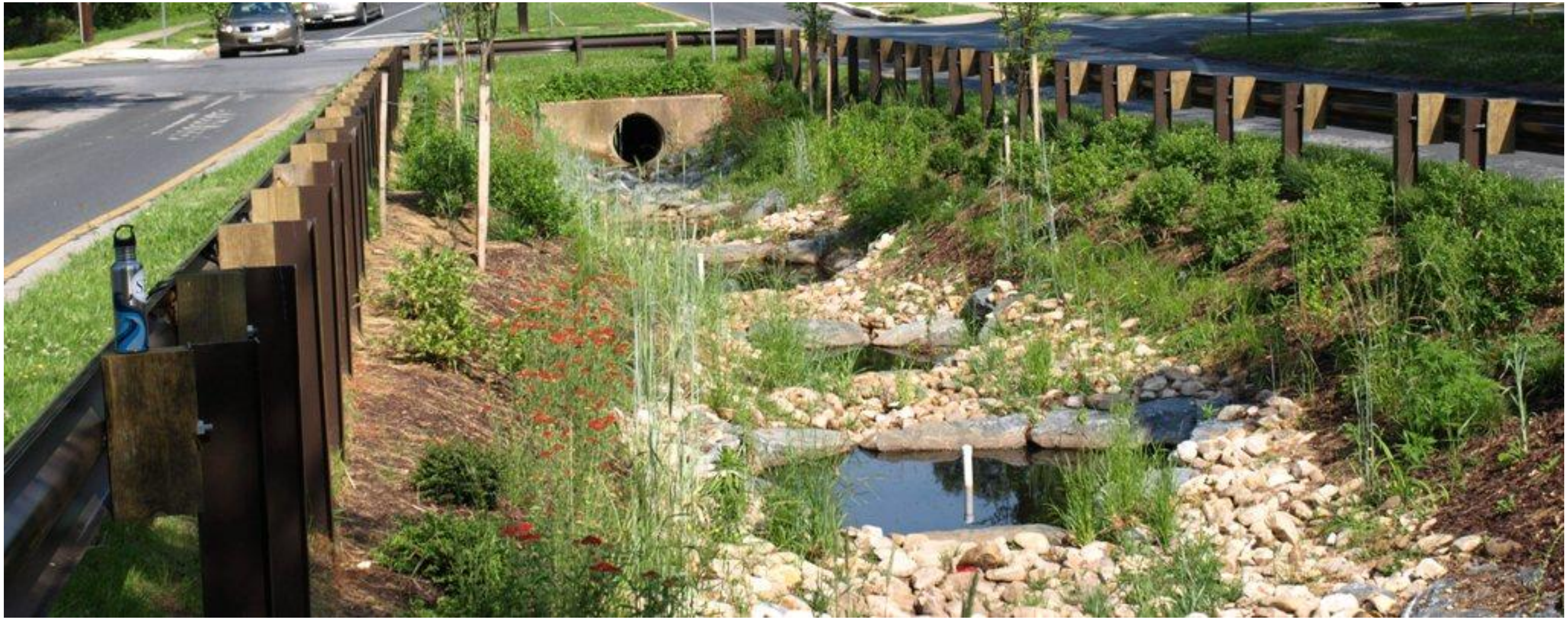


Figure 2.2: Areas outside the Montgomery County MS4 Permit Area

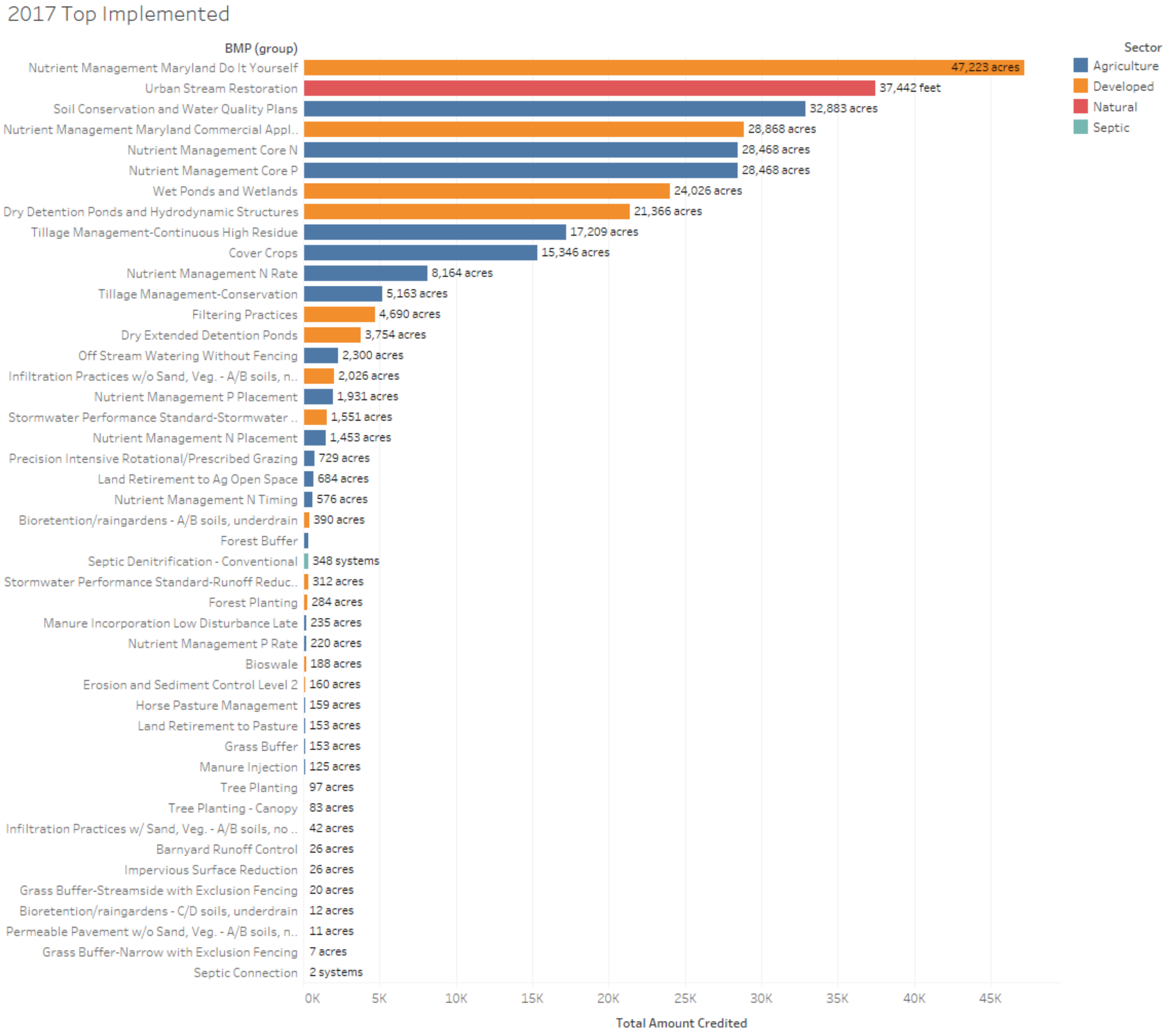
2012 Countywide Coordinated Implementation Strategy. The full report is available at: https://www.montgomerycountymd.gov/DEP/Resources/Files/ReportsandPublications/Water/Countywide%20Implementation%20Strategy/Countywide-coordinated-implemented-strategy-12.pdf

Methods Summary

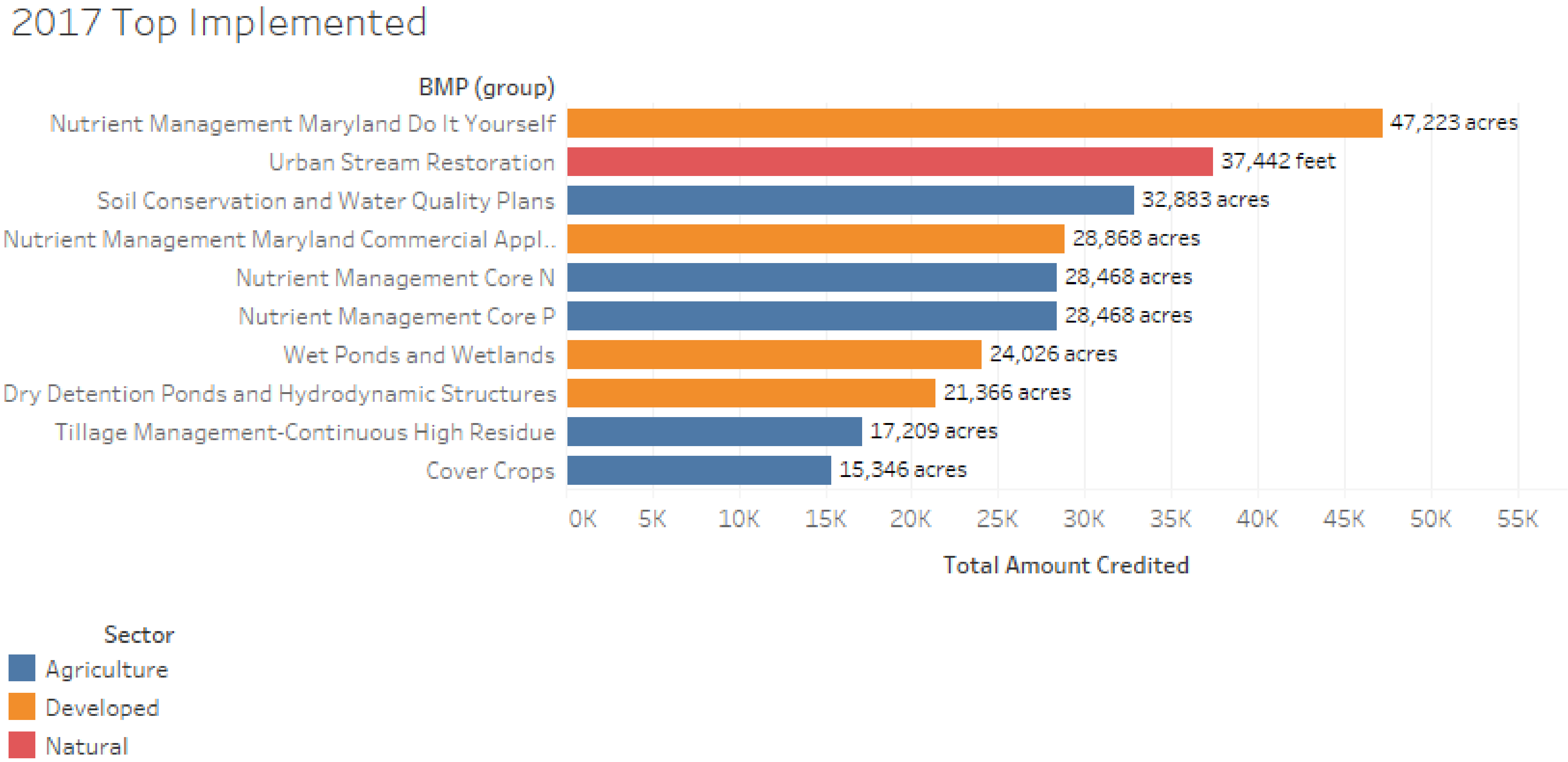
- Most implemented vs. most cost effective for top 5 BMPs
- Co-Benefits associated with most cost effective



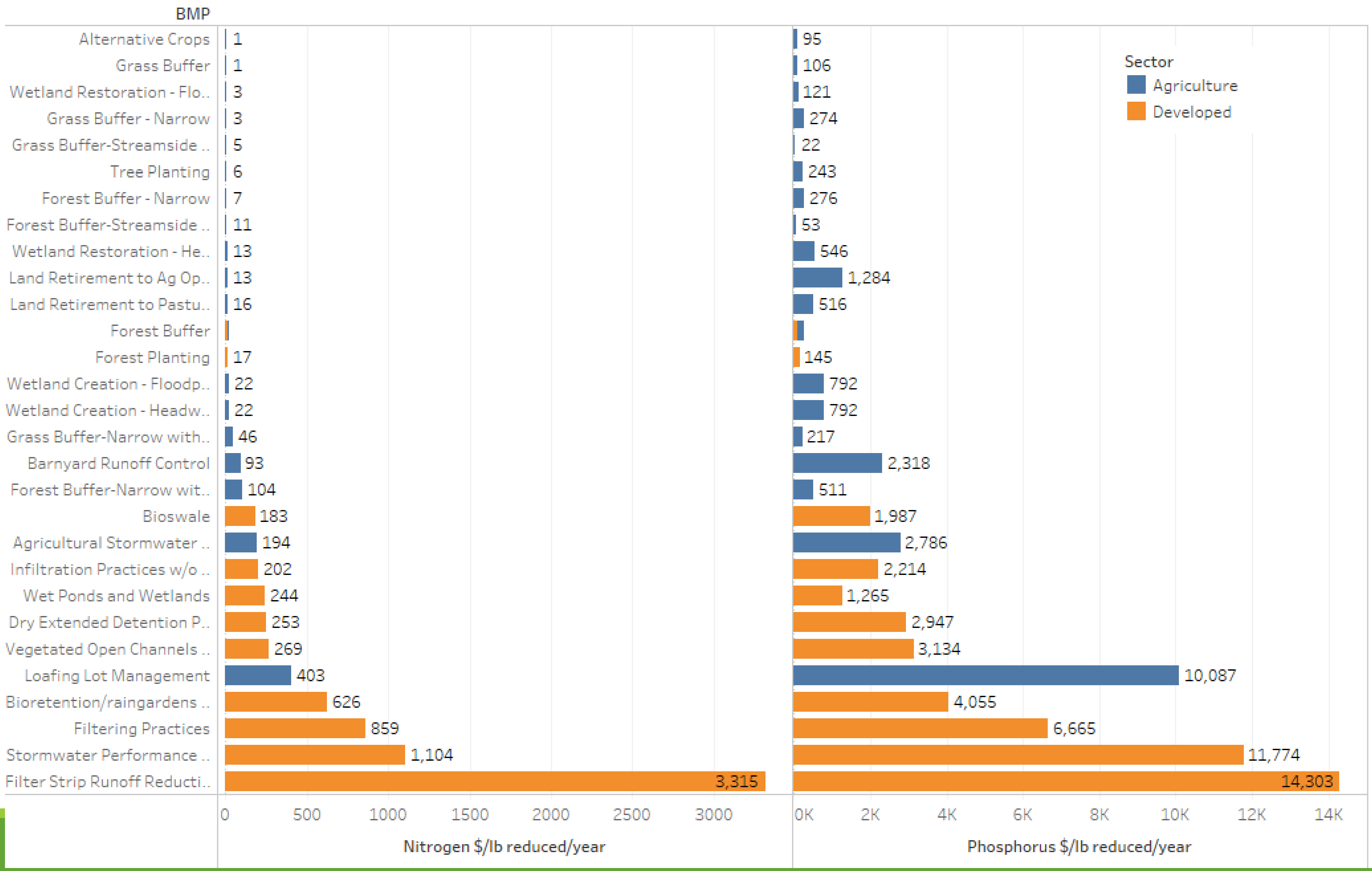
All BMPs Implemented in 2017



2017: Top 10 Implemented BMPs

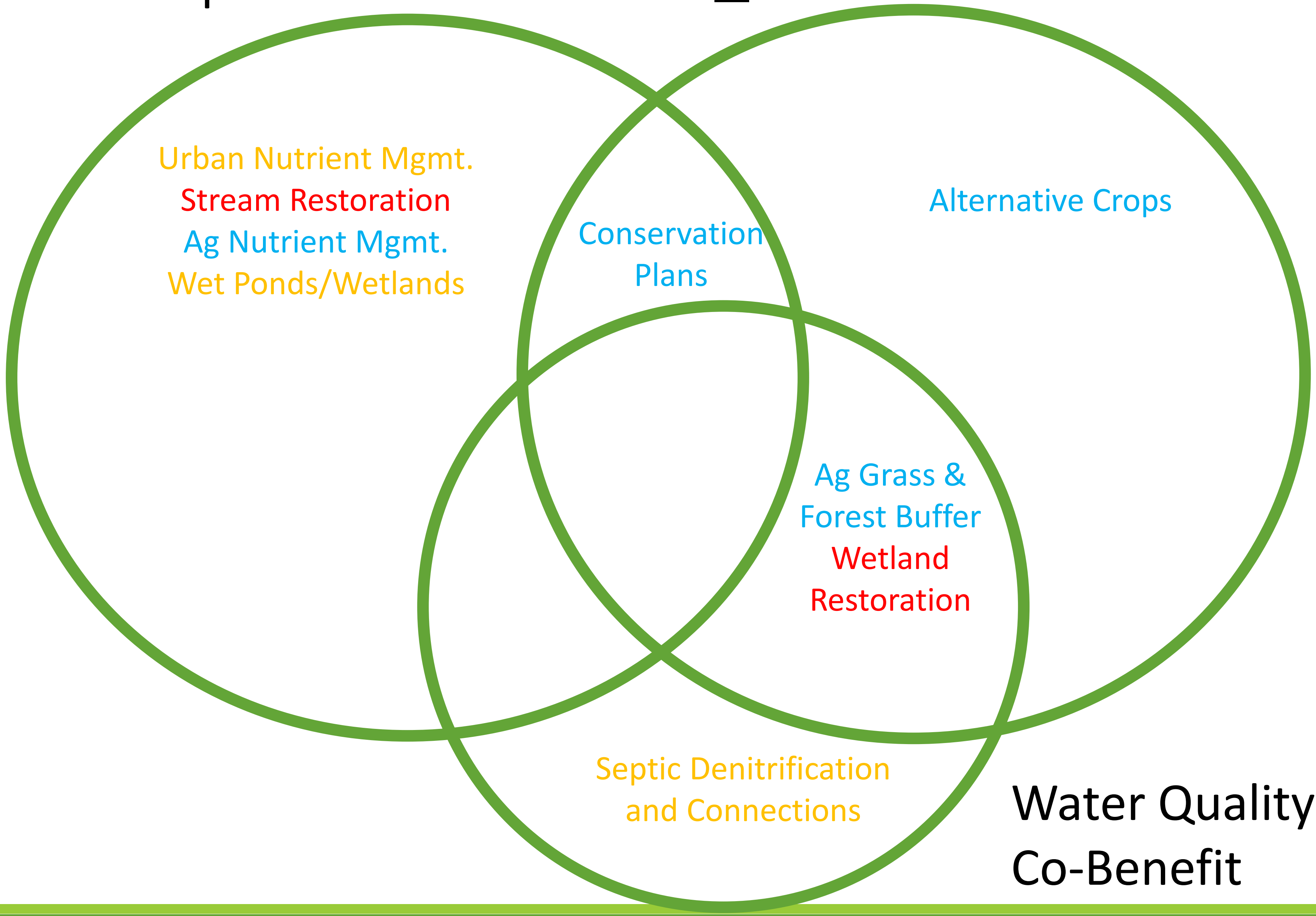


Cost per Lb Reduced

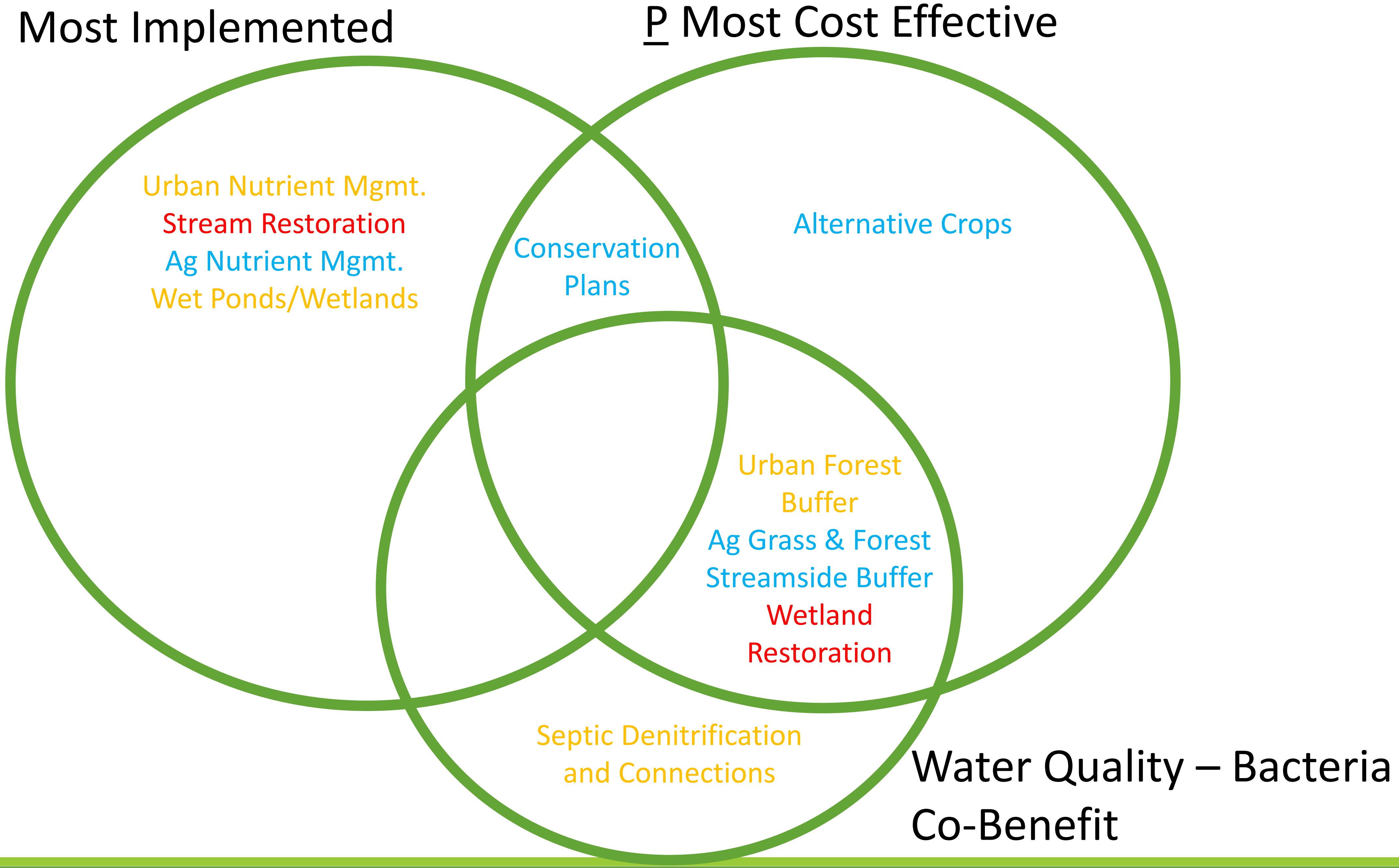


Most Implemented

N Most Cost Effective



Water Quality – Bacteria Co-Benefit


Most Implemented
P Most Cost Effective
Urban Nutrient Mgmt.
Stream Restoration
Ag Nutrient Mgmt.
Wet Ponds/Wetlands
Conservation Plans
Alternative Crops
Urban Forest Buffer
Ag Grass & Forest Streamside Buffer
Wetland Restoration
Septic Denitrification and Connections
Water Quality – Bacteria Co-Benefit

Results for Top 5 BMPs

Totals	Most Implemented	Most Cost Effective-TN	Most Cost Effective-TP
Nitrogen (Lbs)	107,897	107,897	66,842
Phosphorus (Lbs)	10,406	1,698	10,406
Annualized Cost	$15,800,421	$462,022	$6,141,997
Acres Treated	227,377	4,571	2,379

Developed ISR Cost Effectiveness BMPs

Nitrogen

- Bioswale
- Forest Buffer
- Tree Planting - Canopy
- Forest Planting
- Wetland Rehabilitation/Enhancement

Phosphorus

- Storm Drain Cleaning
- Forest Buffer
- Tree Planting - Canopy
- Forest Planting
- Wet Ponds and Wetlands

Results for Replacing with Developed Cost-Effective BMPs

Totals	Most Implemented	Developed Cost Effective-TN	Developed Cost Effective-TP
Nitrogen (Lbs)	107,897	107,897	77,891
Phosphorus (Lbs)	10,406	11,519	10,406
Annualized Cost	$15,800,421	$8,230,635	$3,408,496
Acres Treated	227,377	31,757	22,847

Results, cont.

- Possible to get a substantial cost savings and exceed the N or P reductions by using different BMPs
- Possible to limit the number of acres that BMPs treat and exceed the N or P reductions by using different BMPs
- In the example for top 5 BMPs:
  - Optimizing the P reduction results in exceeding the N goal of 107,897 by 365,862 pounds
  - Acres impacted is still less than those impacted in the 2017 progress scenario

Caveats

- Case study limitations: All geographic areas need to be managed differently
- Top 5 assessment looked at the extreme of using the absolutely most cost effective BMP and did not consider
  - If the land owner would make the land available for BMPs
  - Public will to implement BMPs
  - Constraints on funding sources – some funding sources pay for certain BMPs and not others
  - The disconnect between the MS4 requirement for ISR and the Bay TMDL nutrient and sediment reductions
- Cost per BMP varies by state
  - This analysis could be done with other costs if, for example, a local government wanted to supply those costs.
- The load reduced per BMP varies geographically
  - Analysis could be done at multiple scales for any area within the Chesapeake Bay Watershed
  - Results will vary because of the geographic variation in load reduced per BMP
    (e.g.: Urban Forest Buffers In Montgomery County, MD = $14 and in Richmond, VA = $0.47 per pound of N reduced)

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Supporting Information

BMP Costs

- Cost per BMP is available in CAST and are based on the following
  - Costs were prepared for EPA using existing data
  - Bay jurisdictions were provided with the opportunity to review and amend the unit costs for BMPs in the Phase 2 WIP
  - Costs are estimated in 2010 dollars
  - Capital and opportunity costs are amortized over the BMP lifespan and added to annual operations and maintenance (O&M) costs for a total annualized cost
  - The interest rate for capital and opportunity costs is 5%
  - Costs are those incurred by both public and provide entities
  - Costs represent a single year of cost rather than the cost over the entire lifespan of the practice
  - Costs are for all BMPs in a scenario, both those currently implemented as well as those planned

BMP Costs, cont.

- The cost formula is:

annual costs = (capital * annualization factor) + O&M costs + (land * annualization rate)

Where:

- annualization factor = $i/((1+i)^{n} - 1) + i$
- i = annualization rate, which is always 5%
- n = period of annualization (also called lifespan)

- These unit cost per BMP data support calculating the annualized cost per pound reduced per year

cost per Lb reduced per year = cost per unit of BMP / Lbs reduced per unit of BMP

- This information can enable targeting of the most effective BMPs at the lowest cost