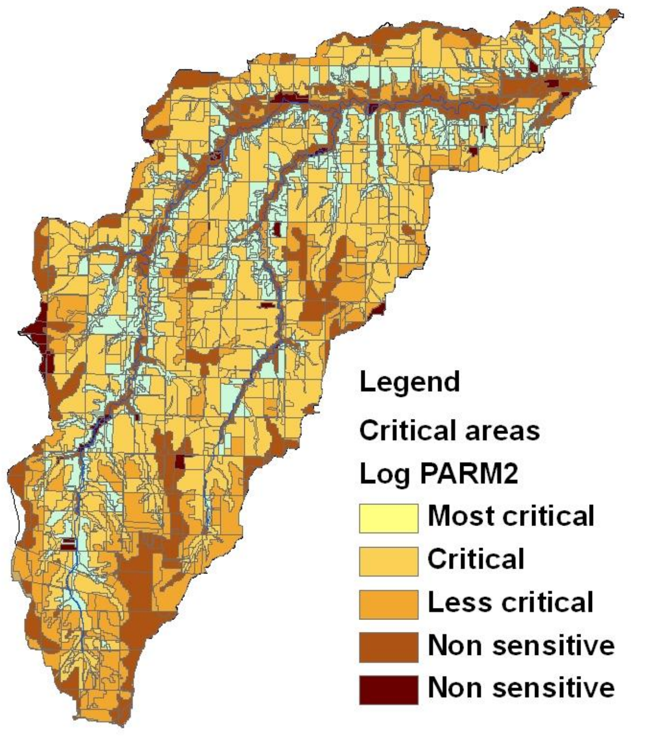
1. Introduction

- It is commonly assumed that BMPs in place during project planning are performing as originally intended.
- Without diligent operation and maintenance, BMPs and their effects probably will depreciate over time, resulting in less efficient pollution reduction.
- Recognition of this fact is important at the project planning phase, for both existing and planned BMPs.

1. Introduction

- Watershed planning must fully assess contributing causes and sources of pollution, then prioritize strategies to address the problems
- EPA nine key elements for 319 implementation projects:
  - Identify causes/sources of impairment;
  - Describe BMPs needed to achieve required load reductions;
  - Define critical areas where BMPs to be implemented; and
  - Estimate load reductions expected from BMPs



(USEPA 2008, 2013)

1. Introduction

- Achieving these requirements depends on accurate information on the performance levels of both BMPs already in place and BMPs to be implemented as part of the watershed project.
- BMPs credited during the planning phase of a watershed project will be expected to continue to provide planned water quality benefits as part of the overall plan to protect or restore a water body.

1. Introduction

- Verification that BMPs are still performing their functions at anticipated levels and if or how they have depreciated is essential:
  - To inform decisions about needs for additional BMPs;
  - To understand needs for repair of existing BMPs and maintenance of new BMPs; and
  - To use adaptive management to keep a project on track to achieve its overall goals.

2. Causes of depreciation

Natural variability

Climate and soil variations

2. Causes of depreciation

Natural variability

Seasonal dormancy

2. Causes of depreciation

Natural variability

Year-to-year variation in precipitation

2. Causes of depreciation

Natural variability

Increasing incidence of extreme weather and intense storms

2. Causes of depreciation

Lack of maintenance

Most BMPs require proper operation and maintenance

NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

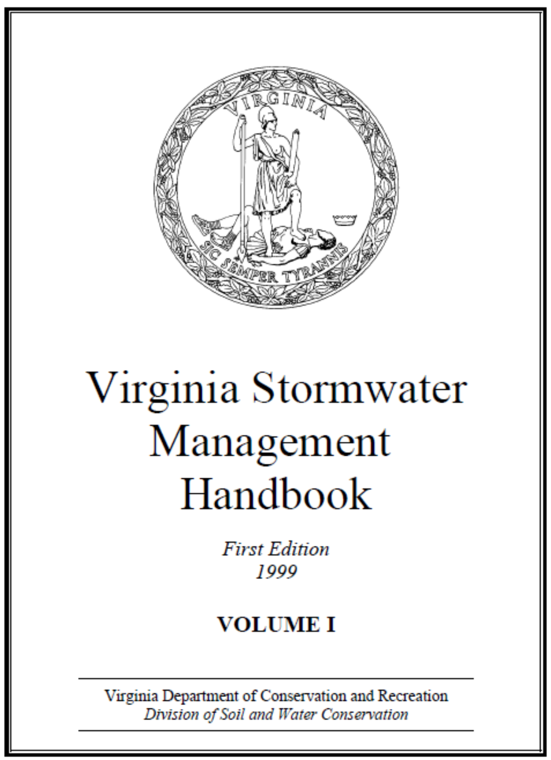
WATER AND SEDIMENT CONTROL BASIN
(No.)
CODE 638

- Maintenance of basin ridge height and outlet elevations,
- Removal of sediment that has accumulated in the basin to maintain capacity and grade,
- Removal of sediment around inlets to ensure that the inlet remains the lowest spot in the basin, and
- Regular mowing and control of trees and brush.

2. Causes of depreciation

Lack of maintenance

Most BMPs require proper operation and maintenance



Annual operation and maintenance inspection of wet ponds.

- Excessive sediment, debris, or trash accumulated at inlet,
- Clogging of outlet structures,
- Cracking, erosion, or animal burrows in berms, and
- >1 foot of sediment accumulated in permanent pool.

2. Causes of depreciation

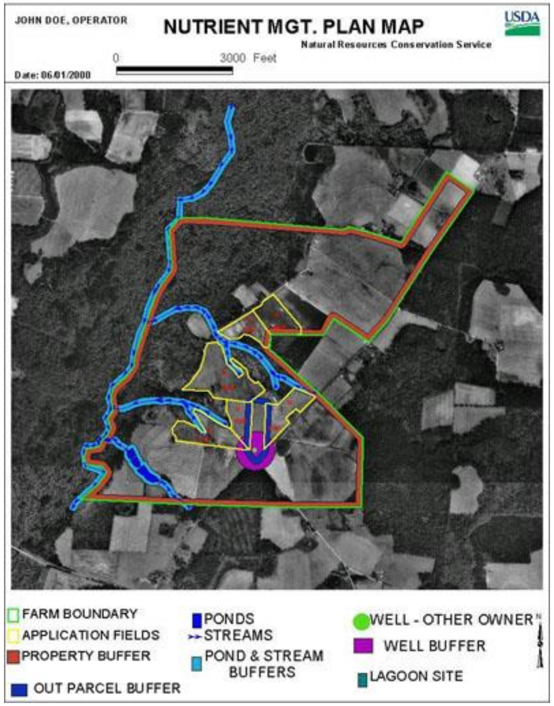
Lack of maintenance

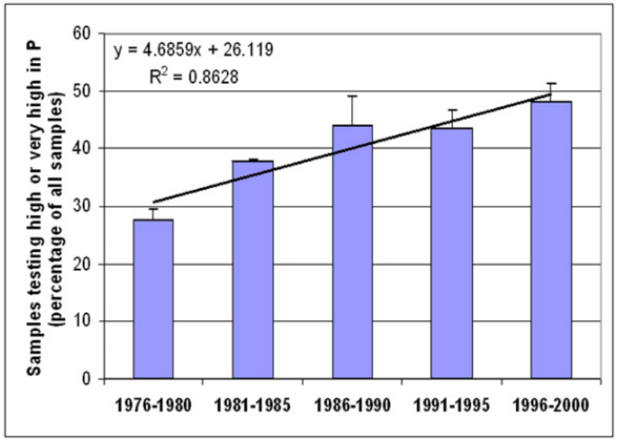
Detention pond sediment forebay

2. Causes of depreciation

Lack of maintenance

Nutrient management plan





2. Causes of depreciation

Lack of maintenance

- > 20% of implemented BMPs in a Utah watershed project no longer maintained or in use just 5 years after project completion. (Jackson-Smith et al. 2010)

- ~33% of 250 Maryland stormwater facilities surveyed not functioning as designed - most needed maintenance. Sedimentation was a major problem and had occurred at nearly half of the facilities; those problems could have been prevented with timely maintenance. (Lindsey et al. 1992)

- ~99% sediment was removed from cropland runoff when uniformly distributed over a grassed buffer area, but as concentrated flow paths developed over time (due to lack of maintenance), sediment removal dropped to 15–45 %. (Dosskey et al. 2002)

2. Causes of depreciation

Unforeseen consequences

Groundwater contamination from manure storage

White Clay Lake, Wisconsin, demonstration projects (1970s): a manure storage pit built according to prevailing specifications actually caused ground water contamination that threatened a farmer's well water.

2. Causes of depreciation

Unforeseen consequences

Manure incorporation vs. conservation tillage

2. Causes of depreciation

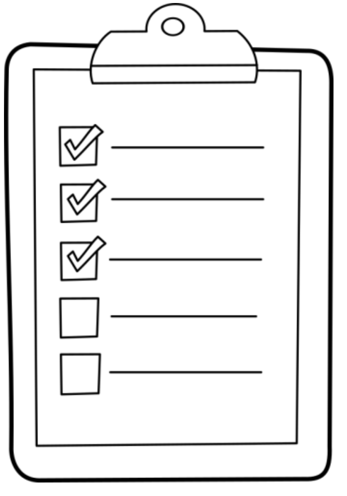
Unforeseen consequences

Control of peak vs. bankfull urban stormflows

Although large peak stormflows may be controlled effectively by detention storage, the duration of erosive and bankfull conditions are actually extended over longer time period. These flows accumulate downstream and increase peak flows along receiving waters. This diminishes the collective effectiveness of detention basins.
(Urbonas and Wulliman 2007)

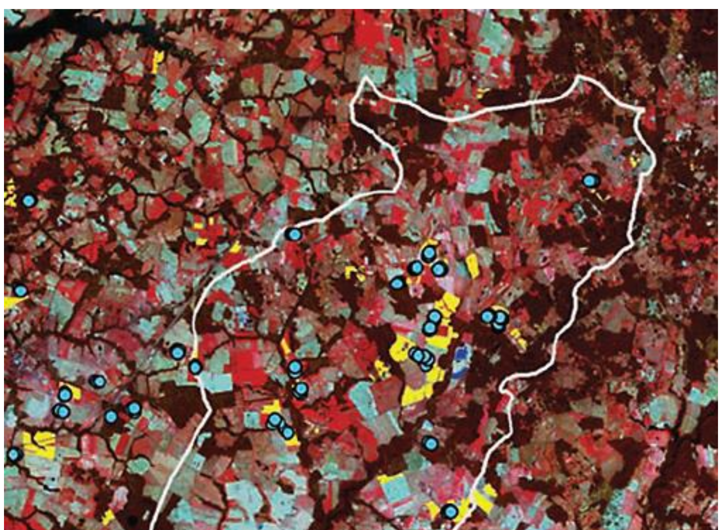
3. Assessment of depreciation

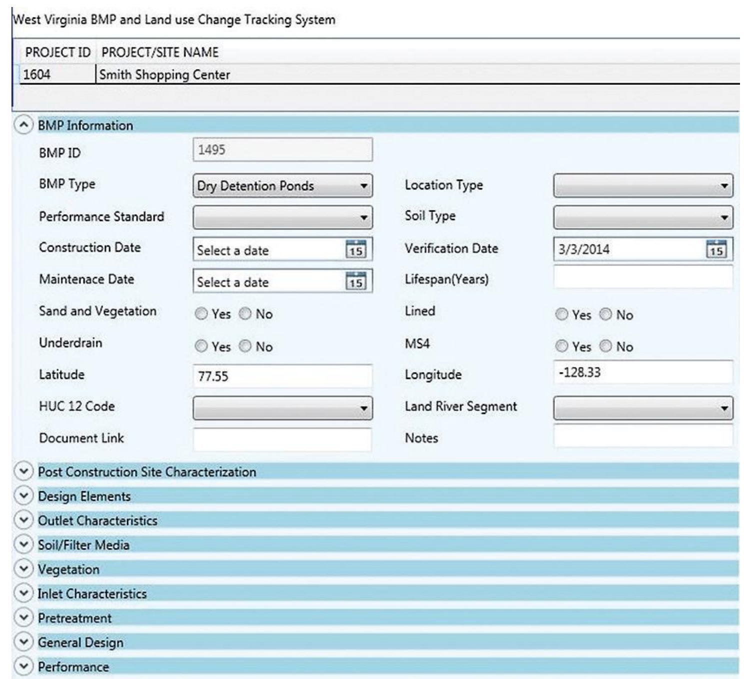
The first—and possibly most important—step in adjusting for depreciation of implemented BMPs is to determine its extent and magnitude through BMP verification.



3. Assessment of depreciation

BMP verification confirms that a BMP is in place and functioning properly as expected based on contract, permit, or other implementation evidence.





West Virginia BMP and Land use Change Tracking System

PROJECT ID	PROJECT/SITE NAME
1604	Smith Shopping Center

BMP Information

BMP ID	1495		
BMP Type	Dry Detention Ponds	Location Type	
Performance Standard		Soil Type	
Construction Date	Select a date	Verification Date	3/3/2014
Maintenace Date	Select a date	Lifespan(Years)	
Sand and Vegetation	Yes No	Lined	Yes No
Underdrain	Yes No	MS4	Yes No
Latitude	77.55	Longitude	-128.33
HUC 12 Code		Land River Segment	
Document Link		Notes	

Post Construction Site Characterization

Design Elements

Outlet Characteristics

Soil/Filter Media

Vegetation

Inlet Characteristics

Pretreatment

General Design

Performance

3. Assessment of depreciation

- A BMP verification process that documents the presence and function of BMPs over time should be included in all NPS watershed projects.
  - At the project planning phase, verification is important both to ensure accurate assessment of existing BMP performance levels and to determine additional BMP and maintenance needs.
  - Verification over time is necessary to determine if BMPs are maintained and operated during the period of interest.

3. Assessment of depreciation

Tech NOTES 11

National Nonpoint Source Monitoring Program

August 2014

Donald W. Meals, Steven A. Dressing, John Kosco, and Susan A. Lanberg. 2014. Land use and BMP tracking for NPS watershed projects. Tech Notes 11, June 2014. Developed for U.S. Environmental Protection Agency by Tetra Tech, Inc., Fairfax, VA, 31 p. Available online at *www.bae.ncsu.edu/programs/extension/wqg/319monitoring/tech_notes.htm.*

Through the National Nonpoint Source Monitoring Program **(NNPSMP)**, states monitor and evaluate a subset of watershed projects funded by the Clean Water Act Section 319 Nonpoint Source Control Program.

The program has two major objectives:

1. To scientifically evaluate the effectiveness of watershed technologies designed to control nonpoint source pollution
2. To improve our understanding of nonpoint source pollution

NNPSMP Tech Notes is a series of publications that shares this unique research and monitoring effort. It offers guidance on data collection, implementation of pollution control technologies, and monitoring design, as well as case studies that illustrate principles in action.

Land Use and BMP Tracking for NPS Watershed Projects

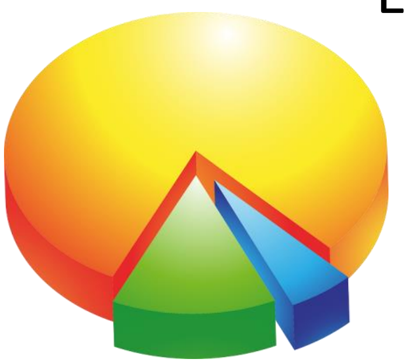
http://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/tech_notes.htm

3.a. Assessment for Project Planning

- Purpose: To develop accurate information on the performance levels of BMPs already in place to ensure that:
  - BMP crediting is accurate
  - Plans for additional BMPs complement existing BMPs to achieve water quality/quantity goals
- Develop a plan in collaboration with programs and individuals or groups implementing and managing the BMPs
  - Set a verification timeline that works with the BMP implementation timeline
  - Work within available resource limitations: set priorities

3.a. Assessment for Project Planning

- Factors to consider in setting priorities:
  - Absolute/relative load reductions and locations within pollutant delivery system
    - E.g., Chesapeake Bay Program



      - 100% initial verification of all BMPs
      - 10% follow-up verification of multi-year BMPs that contribute 5% or more of nutrient or sediment load reduction
      - 20% follow-up verification for permit-based BMPs
      - 5% follow-up verification of BMPs contributing <5%
  - Critical source areas and subwatersheds

3.a. Assessment for Project Planning

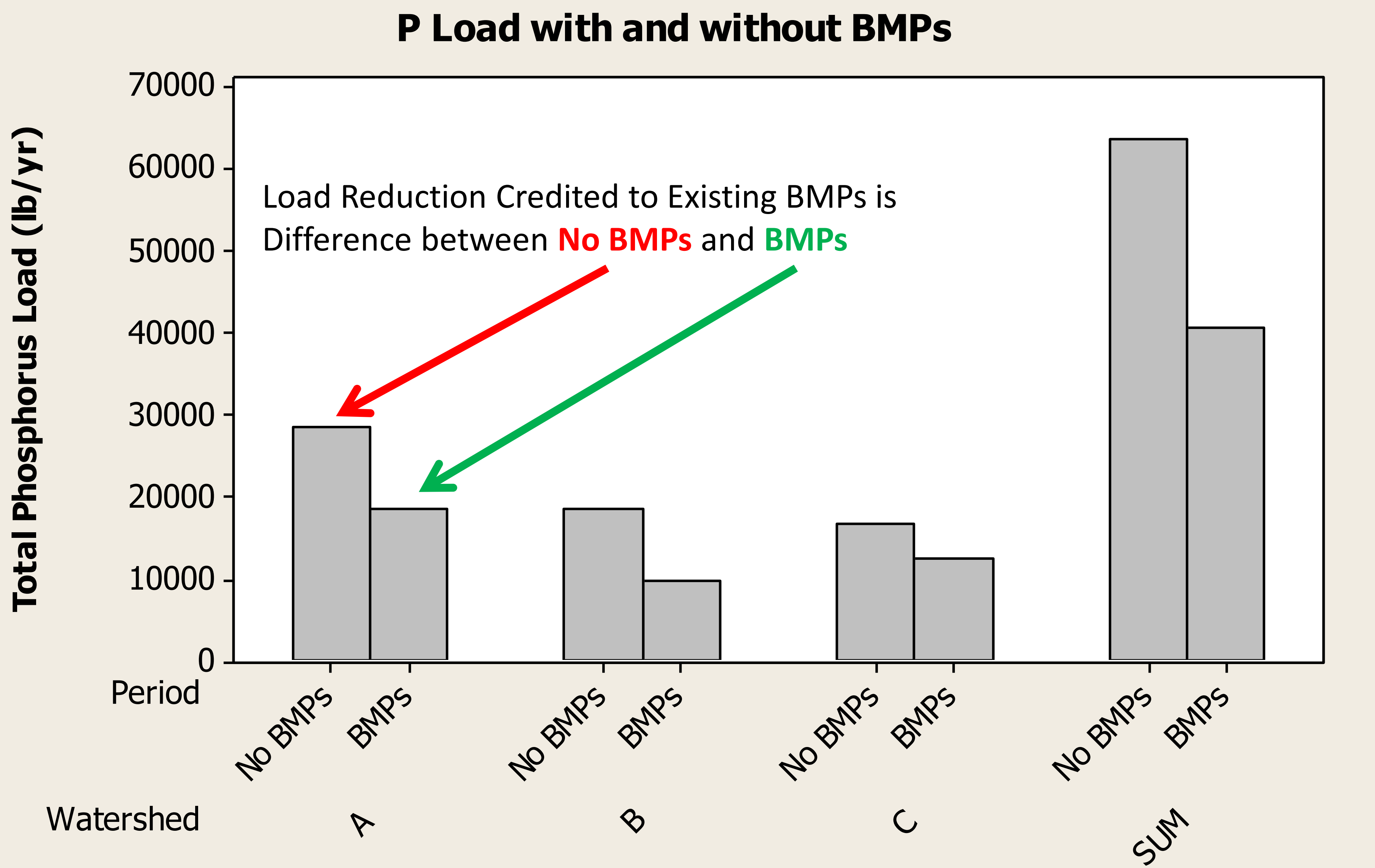
- Factors to consider in setting priorities (cont.):
  - Risky practices: focus on practices with a documented history of failure over time, more demanding operation and maintenance requirements, or a tendency to be abandoned
  - Practice age (more later)
  - Cost: focus on practices for which replacement costs (absolute or per unit load reduction) may be greatest if found later to not be performing as expected

3.a. Assessment for Project Planning

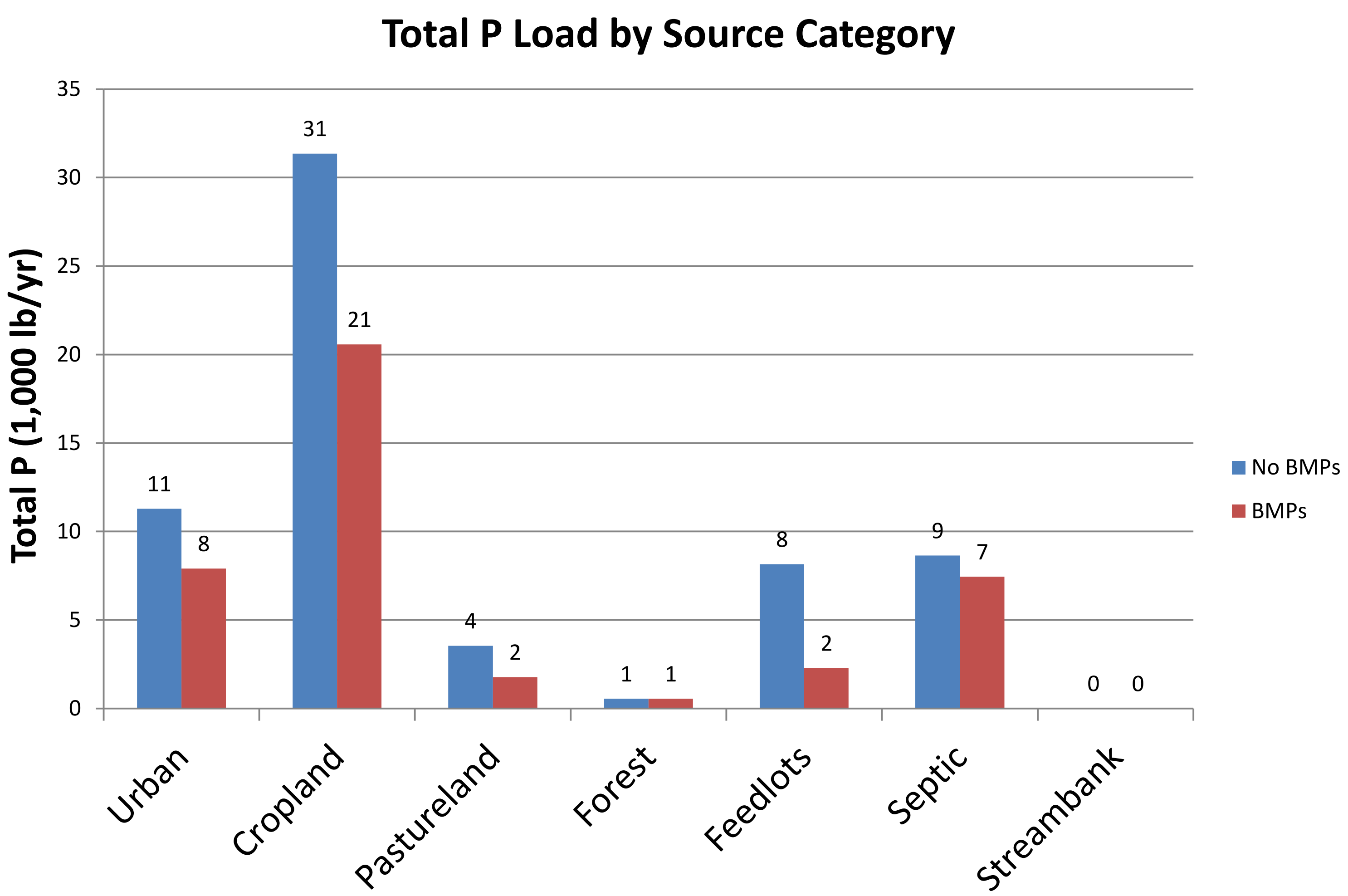
Selecting Priority BMPs for Planning-Phase Verification

- One method[1] to assess the relative importance of existing BMPs is based on the absolute or relative pollutant load reduction assumed to be achieved by these BMPs
  - Use models and spreadsheet tools to perform with and without BMP scenarios and tally load reductions by BMP and subwatershed
  - Where modeling is not performed to establish baseline conditions, estimate pollutant reductions by BMP and subwatershed using BMP records and literature values for pollutant reductions

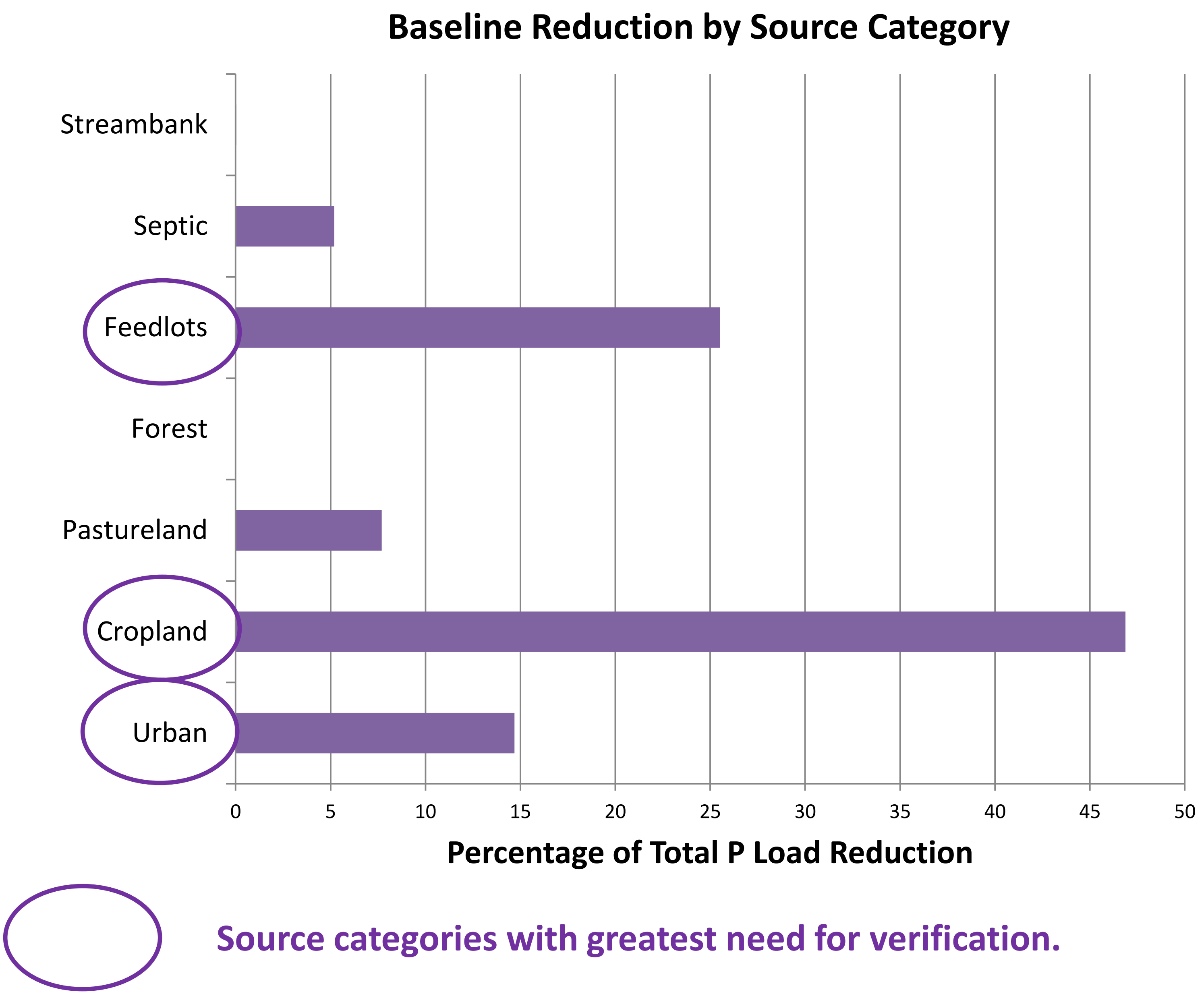
[1]Other methods may be based on the relationship of existing to planned additional BMPs (e.g., treatment trains), BMP location, or other project-specific factors.



STEPL Example: 3 Subwatersheds (A, B, and C)



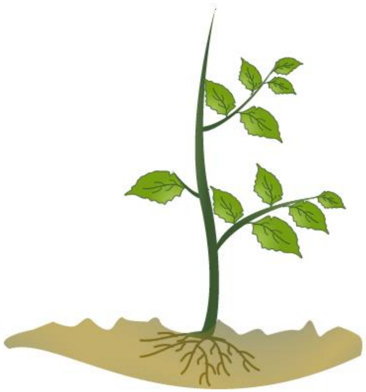
STEPL Example: Load reductions broken down by source category



Source categories with greatest need for verification.

3.a. Assessment for Project Planning

Age of BMP



- Cost-share, regulatory, and technical assistance databases typically include both implementation date and practice/contract/permit) lifespan
  - Need access to database, either direct or indirect (e.g., USDA 1619 agreements)
- Can select subset of practices to verify based on age or percentage of lifespan expired (e.g., 50%)
  - Census or random sample
- Alternatively, can verify all practices and summarize results by age
  - Patterns in BMP performance vs. age could be explored if verification continues after planning phase

3.a. Assessment for Project Planning

BMP Lifespans

Animal Waste Management Systems	15
Waste Storage Facility	15
Barnyard Runoff Controls	10
Nutrient Management Plans, Conservation Tillage, Cover Crops	1
Conservation Plans	10
Ag Land Retirement	10
Exclusion Fence with Buffer	5
Grass or Forest Buffer	10
Prescribed Grazing	10
Wetland Enhancement or Restoration	15
Bioretention/Rain Gardens	10
Septic Denitrification	10
Dry Extended Detention Ponds	10
Permeable Pavement	10

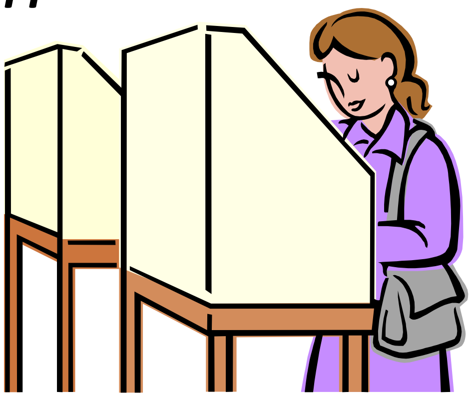
3.a. Assessment for Project Planning

Selecting Individual Practices to Verify

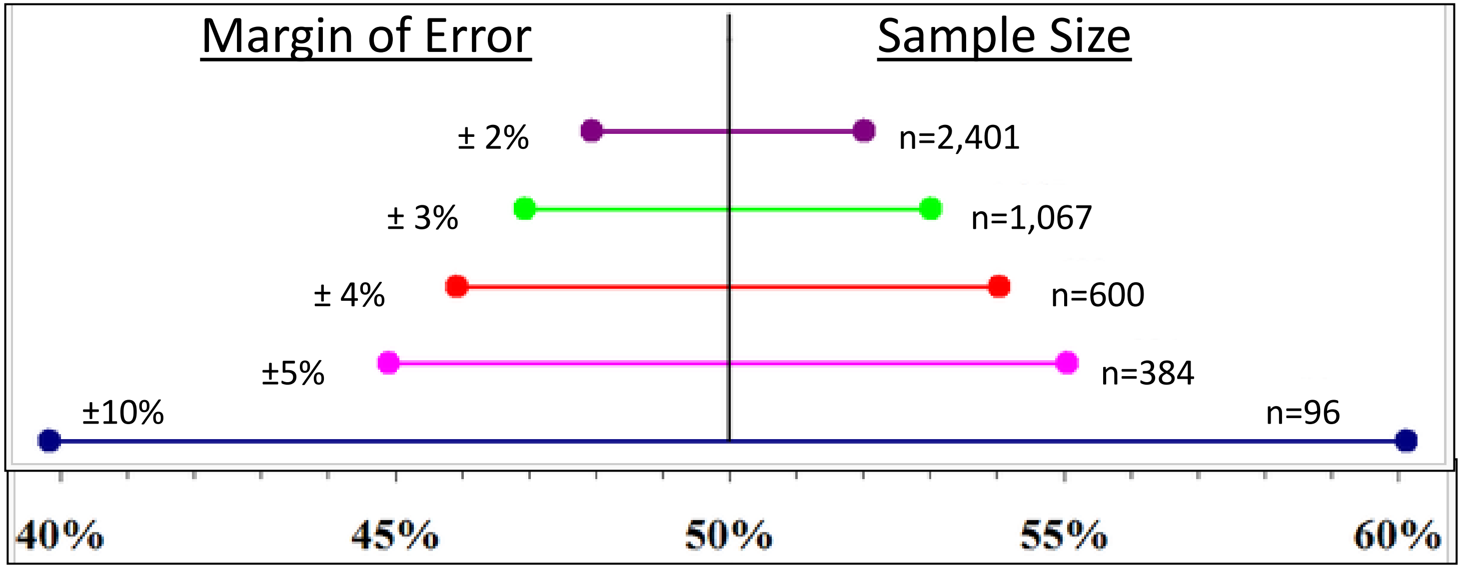
- Wherever feasible, all BMPs (or priority BMPs) should be evaluated during the planning phase
- Where a census approach is not feasible, use a sampling approach:
  - Binomial
  - Multinomial
  - Fixed percentage

3.a. Assessment for Project Planning

Binomial Sampling Approach



- Binomial Distribution (**two options**)
  - Are the BMPs still there?
    - Yes/No
  - Are the BMPs still functioning properly?
    - Yes/No
- Sample Size—just like political polls



Source: http://en.wikipedia.org/wiki/Margin_of_error#Calculations_assuming_random_sampling

Binomial Distribution

Standard Sample Size Equation

$$n_o = \frac{\left(Z_{1-\alpha/2}\right)^2 pq}{d^2}$$

Political Poll Example

$$96 = \frac{(1.96)^2(0.5)(0.5)}{(0.10)^2}$$

Finite Population Correction

$$n = \frac{n_o}{(1+\varphi)}$$

N = total number of population units in sample population

n_o = preliminary estimate of sample size (sample size for large N)

$Z_{1-\alpha/2}$ = value corresponding to cumulative area of 1-α/2 using the normal distribution

p = proportion of “yes” responses

q = proportion of “no” responses (i.e., 1-p)

d = allowable error (margin of error)

ϕ = n_0/N unless otherwise stated

n = number of samples (adjusted for finite population)

Observations

- Improved precision
  - More sampling
- Reduce sampling costs
  - Lower confidence level (e.g., 95% CI → 90% CI)
  - Increased allowable error, d, (e.g., ±10% → ±15%)
- Less sampling is needed to maintain precision if the percentage of BMPs maintained is closer to 100%
  - A priori knowledge is important
  - 50% BMP maintenance is a conservative assumption
  - But don’t overestimate
- Finite Populations
  - Sampling from small populations can result in large errors.

Potential Application

- Precision Statement
  - Estimate the percentage of BMPs maintained, **p**, to within **±d%** using a **X%** confidence level.
- Example:
  - The percentage of BMPs maintained is 85% ±10% with a 95% confidence level, or
  - The range of maintained BMPs is 75-95% with a 95% confidence interval.

► Worked Example

► **p**: No information (50%), Good (70%), Excellent (85%)

► **±d**: 5%, 10%, and 15%

► **X%**: 90% and 95%

Work Example—Sample Size (n)

95% Confidence Level

p		±d	Large N	100	200	600	1000	1,500	2,000
No Information	50%	5%	385	80	132	235	278	307	323
	50%	10%	97	50	66	84	89	92	93
	50%	15%	43	31	36	41	42	42	43
Good Maintenance	70%	5%	323	77	124	210	245	266	279
	70%	10%	81	45	58	72	75	77	78
	70%	15%	36	27	31	34	35	36	36
Excellent	85%	5%	196	67	99	148	164	174	179
	85%	10%	49	33	40	46	47	48	48
	85%	15%	22	19	20	22	22	22	22

90% Confidence Level

p		±d	Large N	100	200	600	1000	1,500	2,000
No Information	50%	5%	271	74	116	187	214	230	239
	50%	10%	68	41	51	62	64	66	66
	50%	15%	31	24	27	30	31	31	31
Good Maintenance	70%	5%	228	70	107	166	186	198	205
	70%	10%	57	37	45	53	54	55	56
	70%	15%	26	21	24	25	26	26	26
Excellent	85%	5%	138	58	82	113	122	127	130
	85%	10%	35	26	30	34	34	35	35
	85%	15%	16	14	15	16	16	16	16

3.a. Assessment for Project Planning

Multinomial Sampling Approach

- In a multinomial distribution there are ***more than two mutually exclusive options***
- For example, a multinomial distribution may include the following three options:
  - BMP is there and performing as expected
  - BMP is there but not performing as expected
  - BMP is not there
- Basis for CTIC Cropland Transect Survey Method sample size determination (Hill 1996, Tortora 1978)

Multinomial Distribution

<u>Sample Size Equation</u>

$$n = X^2_{(1,1-(\frac{a}{k}))} \times q(1-q)/d^2$$

n = sample size

$X^2_{(1,1-(\frac{a}{k}))}$ = Chi-square value for one d.f. and the value (1-(a/k)) substituted for (1-α)

a = 1-p

p = confidence level for each category (equivalent to 1- α for binomial)

k = number of categories

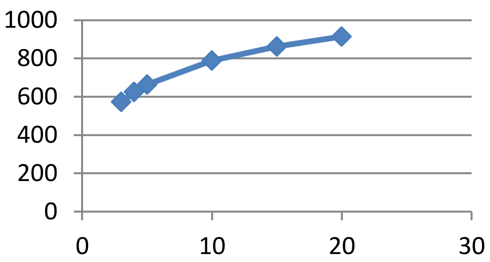
p = proportion of "yes" responses

q = *a priori* estimate of the proportion for each category (as a decimal). Use the q value for the category closest to 0.50 to ensure that sample size is sufficient for all categories. Use 0.50 when unknown. (q is the same as p for the binomial calculation).

d = allowable error in the proportions (e.g., +/- 10%), expressed as a decimal (same as d for binomial calculation)

Observations

- Sample size increases as number of categories increases (not linear)



- Sample size decreases as error margin increases
- Less sampling is needed to maintain precision if the percentage of BMPs maintained is closer to 100%
  - A priori knowledge is important
  - 50% BMP maintenance is a conservative assumption
  - But don’t overestimate

Potential Application

- Precision statement for each factor
- Can address multiple questions or variables (i.e., factors) when assessing existing BMPs
  - Is the BMP there?
  - Does the BMP still meet design standards and specifications?
  - Is the BMP designed for the water quality/quantity objectives of the project?

Example Sample Size Calculations

As a function of number of categories, confidence level (α), and margin of error (d).

α	d	Binomial Distribution (large N)	k Value for Multinomial Distribution					
			3	4	5	10	15	20
0.05	0.05	385	573	624	663	788	862	914
0.05	0.10	97	143	**156**	166	197	215	229
0.10	0.05	271	453	502	541	663	736	788
0.10	0.10	68	113	126	135	166	184	197

e.g., k =4 for four residue levels: 0-15%, 15-30%, 30-50%, and >50%
In a CTIC survey this would require 156 stopping points for observations at 95% confidence level with an error margin of ±10%

3.a. Assessment for Project Planning

Fixed Percentage Sampling

- USDA-NRCS verifies 100 percent of practices at installation and an annual minimum of 5 percent of total practices installed or reported in each State
  - NRCS has a rigorous protocol for verifying practices
  - Statistical significance and error margins of the 5 percent sampling are not advertised

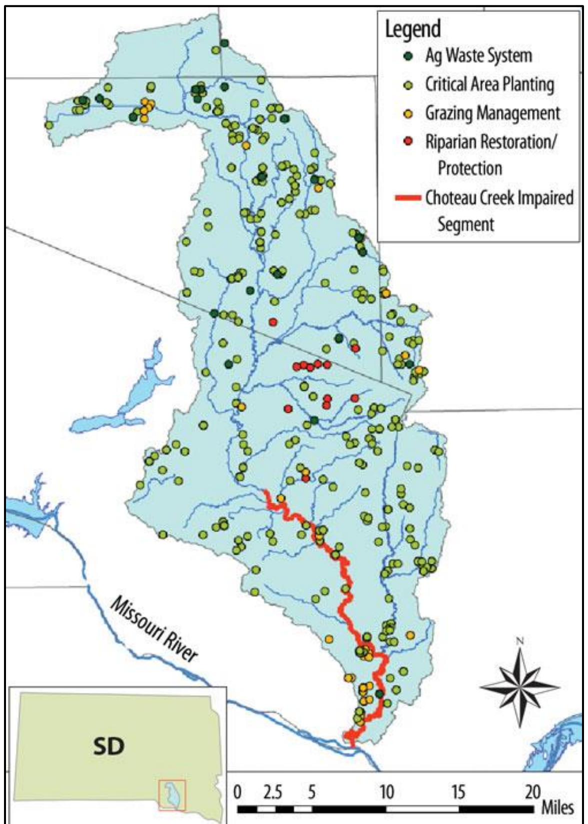
Confidence Intervals for Various Sampling Strategies and Confidence Levels

Sample Lev.	Number of non-CAFOs Implementing Practices	Minimum Selection Target	Half-width Confidence Interval (+/-d, %)							
			95% Conf. Level (w/ p=0.50)	95% Conf. Level (w/ p=0.80)	90% Conf. Level (w/ p=0.50)	90% Conf. Level (w/ p=0.80)	80% Conf. Level (w/ p=0.50)	80% Conf. Level (w/ p=0.80)	70% Conf. Level (w/ p=0.50)	70% Conf. Level (w/ p=0.80)
5% Sample	50	3	55%	44%	46%	37%	36%	29%	29%	23%
	100	5	43%	34%	36%	29%	28%	22%	23%	18%
	200	10	30%	24%	25%	20%	20%	16%	16%	13%
	300	15	25%	20%	21%	17%	16%	13%	13%	10%
	400	20	21%	17%	18%	14%	14%	11%	11%	9%
	500	25	19%	15%	16%	13%	12%	10%	10%	8%
10% Sample	50	5	42%	33%	35%	28%	27%	22%	22%	18%
	100	10	29%	24%	[illegible]	20%	19%	15%	16%	12%
	200	20	21%	17%	17%	14%	14%	11%	11%	9%
	300	30	17%	14%	14%	11%	11%	9%	9%	7%
	400	40	15%	12%	12%	10%	10%	8%	8%	6%
	500	50	13%	11%	11%	9%	9%	7%	7%	6%
20% Sample	50	10	28%	22%	23%	19%	18%	14%	15%	12%
	100	20	20%	16%	16%	13%	13%	10%	10%	8%
	200	40	14%	11%	12%	9%	9%	7%	7%	6%
	300	60	11%	9%	9%	8%	7%	6%	6%	5%
	400	80	10%	8%	8%	7%	6%	5%	5%	4%
	500	100	9%	7%	7%	6%	6%	5%	5%	4%

A 10% sampling strategy for a practice that has 200 operations implementing the practice would result in a confidence interval of ±17% at 90% confidence assuming 50% compliance (p=0.50)

3.b. Methods for Assessing BMP Presence and Performance

- Presence of BMP



US EPA South Dakota Choteau Creek watershed

- Pollutant reduction efficiency

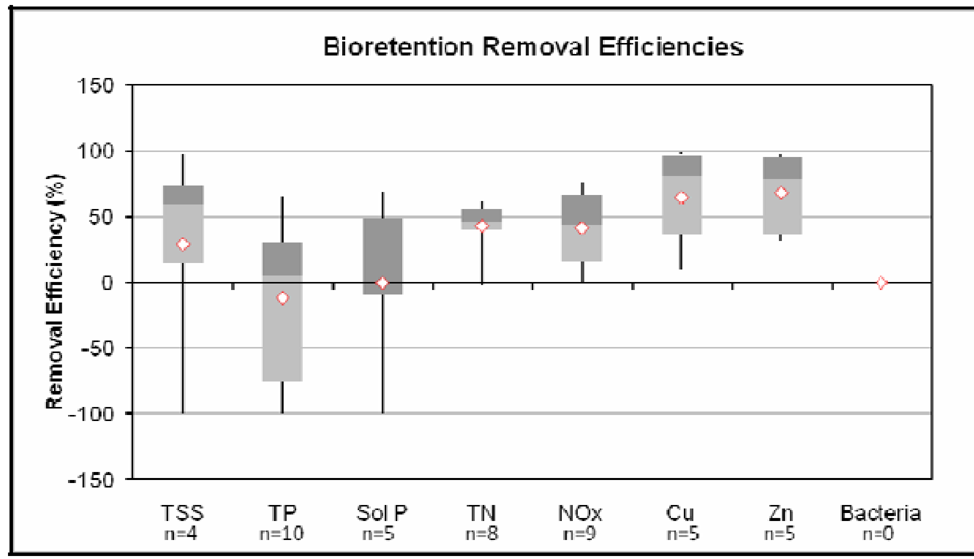


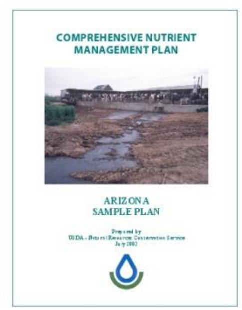
Figure 5. Bioretention Removal Efficiencies

CWP 2007 National Pollutant Removal Performance Database

3.b. Methods for Assessing BMP Presence and Performance

- Direct measurements
  - Soil tests
  - On-site inspection
  - Remote sensing
- Indirect methods
  - Landowner self-reporting
  - Third-party surveys

Different types of BMPs require different verification methods



No single approach is likely to provide all the information needed

3.b. Methods for Assessing BMP Presence and Performance

Need to search BMP information sources for complete record of BMPs already on the ground during the project planning phase

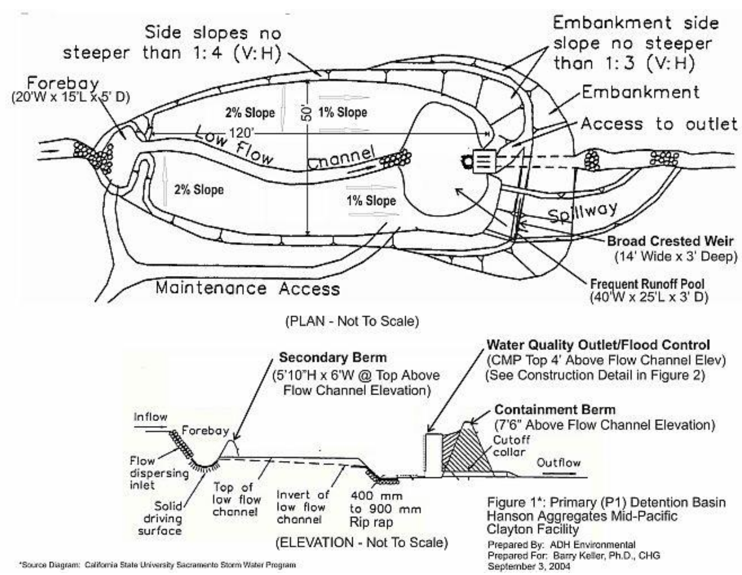
- Permit records
- Agency programs; cost-share records
- Voluntary implementation

3.b. Methods for Assessing BMP Presence and Performance

Certification

- Assurance that a BMP meets applicable design standards and is fully functional for its setting at a particular time
  - Detention pond properly designed and sized
  - NM plan considers all nutrient sources, soil testing, yield goals; meets applicable regulatory requirements
  - Cover crop planted within specified time window

- Supports assumption that BMP performs to efficiency standard
- Provides baseline against which depreciation can be measured
- May discount performance of BMPs not meeting standards



3.b. Methods for Assessing BMP Presence and Performance

Certification

3.b. Methods for Assessing BMP Presence and Performance

Depreciation Assessment Indicators

Nonvegetative structural practices (animal waste ponds, stormwater detention ponds, pervious pavement)

- ✓ Measured on-site performance data (e.g., infiltration capacity of pervious pavement),
- ✓ Structural integrity (e.g., condition of berms or other containment structures), and
- ✓ Water volume capacity/sediment removed at cleanout

- Identify indicators from practice standards
- Select indicators from required maintenance checklists, e.g., sediment accumulation, clogging of outlets, berm integrity

3.b. Methods for Assessing BMP Presence and Performance

Depreciation Assessment Indicators

Vegetative structural practices (constructed wetlands, swales, rain gardens, riparian buffers, and filter strips)

- ✓ Extent and health of vegetation (e.g., measurements of soil cover or plant density),
- ✓ Quality of overland flow filtering (e.g., evidence of short-circuiting by concentrated flow or gullies through buffers or filter strips),
- ✓ On-site capacity testing of rain gardens using infiltrometers or similar devices,
- ✓ Visual observations (e.g., presence of water in swales and rain gardens).

3.b. Methods for Assessing BMP Presence and Performance

Depreciation Assessment Indicators

<u>Nonstructural vegetative practices </u>(e.g., cover crops, reforestation)

- ✓ Density of cover crop planting (e.g., plant count),
- ✓ Percent of area covered by cover crop,
- ✓ Extent and vitality of tree seedlings.

3.b. Methods for Assessing BMP Presence and Performance

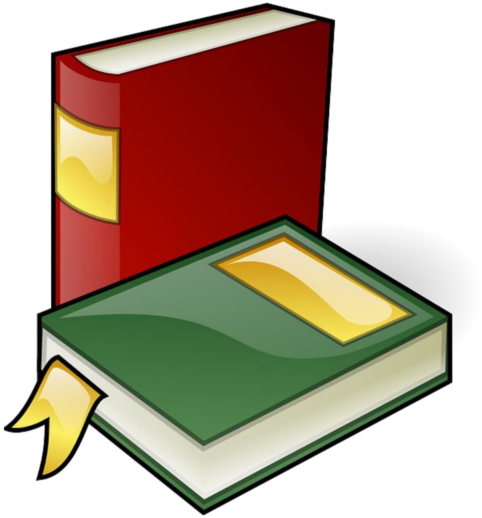
Depreciation Assessment Indicators

Management practices (e.g., nutrient management, conservation tillage, street sweeping)

- ✓ Records of street sweeping frequency and mass of material collected,
- ✓ Area or percent of cropland under conservation tillage,
- ✓ Extent of crop residue coverage on conservation tillage cropland, and
- ✓ Fertilizer and/or manure application rates and schedules, crop yields, soil test data, plant tissue test results, and fall residual nitrate tests.

Others Sources of Assessment Methods

- Gulliver, J.S., A.J. Erickson, and P.T. Weiss (editors). 2010. *"Stormwater Treatment: Assessment and Maintenance."* University of Minnesota, St. Anthony Falls Laboratory. Minneapolis, MN. http://stormwaterbook.safl.umn.edu/
- Chesapeake Bay Verification Resources



3.c. Data Analysis and Presentation

- Data on indicators can be expressed and analyzed in several ways, depending on the nature of the indicators used
- For ***continuous numerical data***, report either in raw form (e.g., acres with 30% or more residue cover) or as a percentage (e.g., percent of crop acres with 30% or more residue cover)
  - cover crop or conservation tillage acreage
  - manure application rates
  - miles of street sweeping
  - mass of material removed from catch basins or detention ponds
  - acres of logging roads/landings

3.c. Data Analysis and Presentation

- ***Categorical data*** are more difficult to express quantitatively.
  - Maintenance of detention basin ridge height and outlet elevations
  - Condition of berms or terraces
  - Observations of water accumulation and flow
- It might be necessary to establish an ordinal scale (e.g., condition rated on a scale of 1–10) or a binary yes/no condition, then use best professional judgment to assess influence on BMP performance

3.c. Data Analysis and Presentation

Pennsylvania Crop Residue Survey

2013 Tillage Survey - Summary of Observations (sample)						
		Proportion of Cropland[1]				
County	**Number of Obs.**	**< 30% residue**	**>30% residue**	**No-Till[2]**	**Conventional Tillage[2]**	**Total Planted Crop Acreage[1]**
Bradford	484	80%	20%	28%	72%	47,690
Centre	483	63%	37%	66%	34%	97,170
Clinton	548	35%	65%	84%	16%	42,477
Columbia	508	31%	69%	76%	24%	39,782
Dauphin	472	56%	44%	75%	25%	79,549
Franklin	475	60%	40%	82%	18%	206,539

[1]Crops: corn, soybeans, spring grain, newly established forage crops

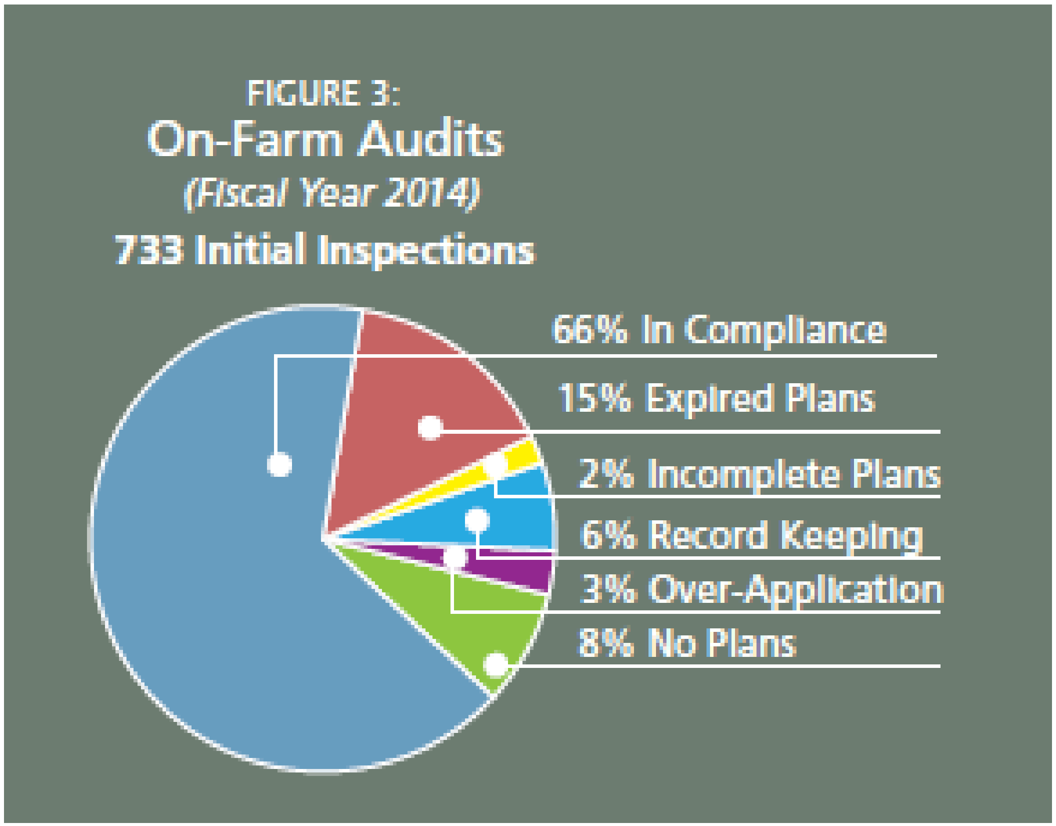
[2]All residue levels

Source: **Capital RC&D Area Council, Carlisle, PA** **www.capitalrcd.org**

3.c. Data Analysis and Presentation

Maryland Nutrient Management Program

2014 Annual Report



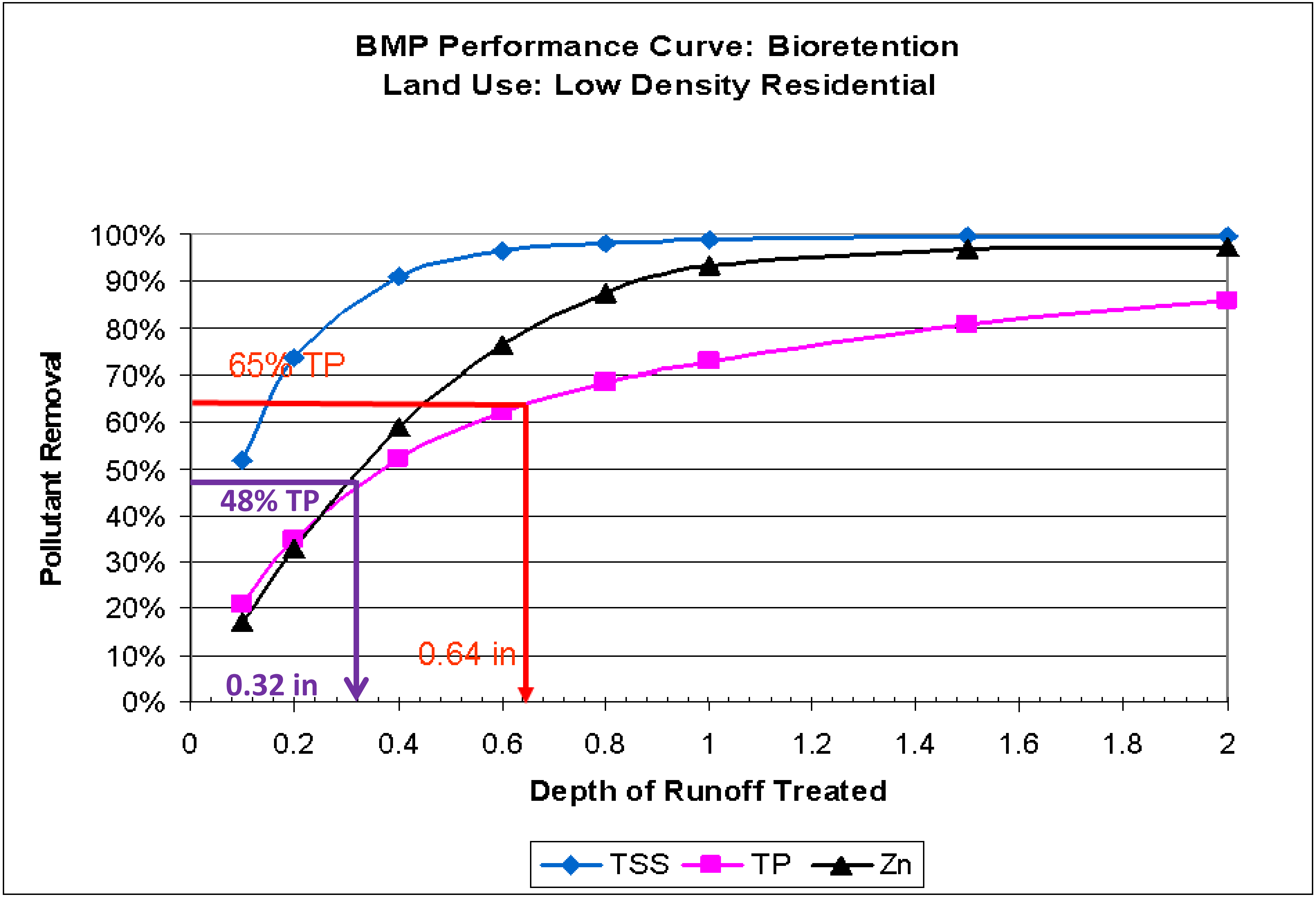
- 733 on-farm audits (14% of regulated farms)
- Verify NMP is current, examine records for consistency with plan
- Follow-up visits showed 66% compliance
- Enforcement actions for others

Source: **Maryland Department of Agriculture**
http://mda.maryland.gov/resource_conservation/counties/MDANMPAnnual2014.pdf

3.c. Data Analysis and Presentation

BMP Performance Curves

- In some cases, it might be possible to use modeling or other quantitative analysis to estimate individual or watershed-level BMP performance levels based on verification data.
  - E.g., Tetra Tech (2010) presented a series of BMP performance curves based on monitoring and modeling data that relate pollutant removal efficiency to depth of runoff treated (next slide). Where depreciation indicators track changes in depth of runoff treated as the capacity of a BMP decreases (e.g., from sedimentation), resulting changes in pollutant removal could be estimated from a performance curve.


BMP Performance Curve: Bioretention
Land Use: Low Density Residential
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Pollutant Removal
65% TP
48% TP
0.64 in
0.32 in
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
Depth of Runoff Treated
TSS
TP
Zn

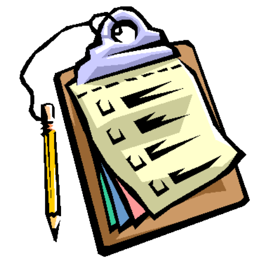
4. Adjusting for Depreciation

- Information on BMP depreciation can be used to improve both project management and project evaluation

4.a. Project Planning & Management

- Establish baseline conditions using adjustments based on knowledge of BMP depreciation or growth stage of vegetative practices.
- Adjust treatment plan to reflect current condition of existing BMPs.
  - Alternative BMPs or different level of treatment
  - Incorporate repair or enhanced maintenance and operation of existing BMPs

4.a. Project Planning & Management



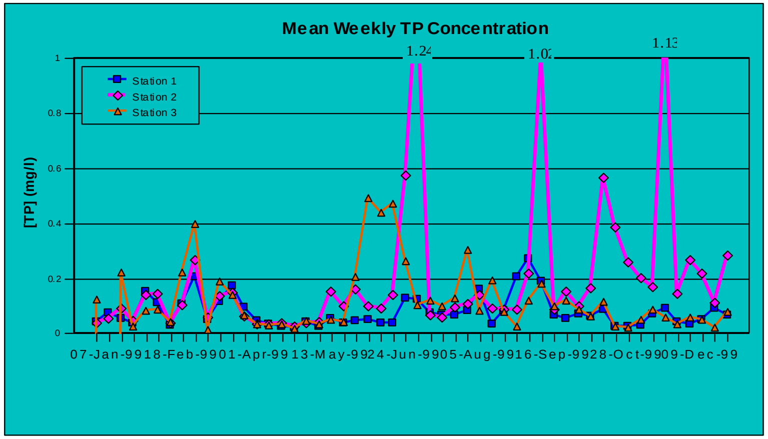
- Track both traditional measures of BMP implementation and indicators of BMP depreciation to provide holistic progress assessments that measure implementation as well as maintenance, and operation of BMPs.
- Examine patterns in BMP depreciation for information on systematic failures in BMP design or management that can be addressed through changes to standards and specifications, contract terms, or permit requirements.

4.b. Project Evaluation

Monitoring

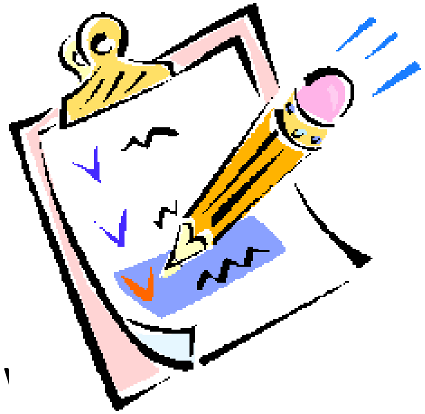
Short-term (3-5 year) NPS watershed projects:

- Database too short to evaluate incremental project effects
- Time too short for gradual BMP depreciation to be broadly significant
- Data on BMP depreciation might still improve interpretation of collected water quality data in cases of catastrophic failure or abrupt abandonment of BMP



4.b. Project Evaluation

Monitoring



Long-term NPS watershed projects (e.g., TMDL):

- Well-designed, sustained monitoring may allow detection of
  quality response to treatment
- BMP depreciation becomes more important over longer time periods
- Knowledge of BMP depreciation may be necessary for understanding watershed response

4.b. Project Evaluation

Monitoring

Suspension of a ban on winter manure application 3 years into monitoring in a NY dairy watershed led to dramatic increases in stream N and P

- Knowledge of that change in BMP explained observed increase in nutrient levels
- Data used to determine that the winter spreading ban had yielded 60-75% reductions in mean stream nutrient levels

(Lewis and Makarewicz 2009)

4.b. Project Evaluation

Monitoring

Conversion of row crop land to native prairie in Walnut Creek, Iowa

- Tracked both conversion of cropland to prairie and later reversion back to cropland
- Data showed not only that converting crop land to prairie reduced stream NO_3-N but also that increasing row crop land led to increased NO_3-N levels.

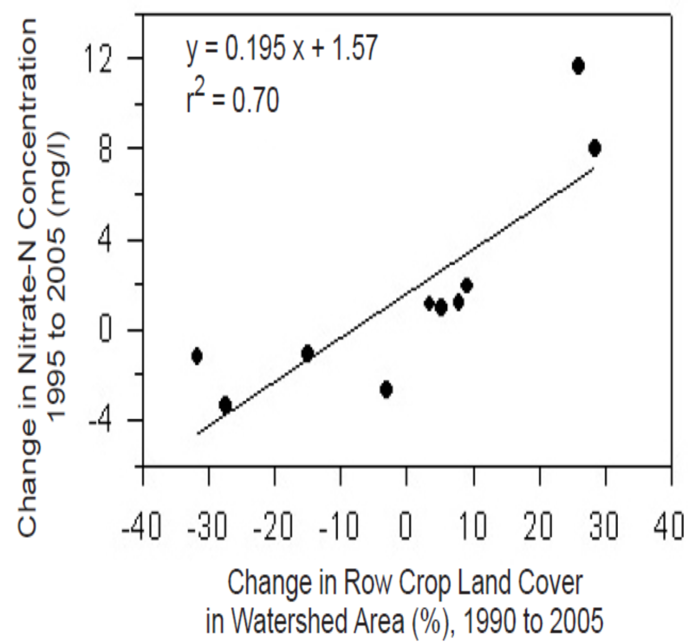


Figure 2. Relating Changes in Stream Nitrate Concentrations to Changes in Row Crop Land Cover in Walnut Creek, Iowa

(Schilling and Spooner 2006)

4.b. Project Evaluation

Modeling

Knowledge of BMP depreciation should be part of model inputs and parameterization.

- The magnitude of implementation (e.g., acres of treatment) and the spatial distribution of both annual and structural BMPs should be part of model input and should not be static parameters.
  - Adjust BMP pollutant reduction efficiencies based on verification of land treatment performance levels in the watershed
  - Perhaps set up a tiered approach for BMP efficiencies (e.g., different efficiency values for BMPs determined to be in fair, good, or excellent condition)
- In the planning phase of a watershed project, multiple scenarios could be modeled to reflect the potential range of performance levels for BMPs already in place.

Adjusting BMP Efficiencies

STEPL					
Landuse	BMP & Efficiency	N	P	BOD	Sediment
Cropland	Contour Farming	0.485	0.55	ND	0.405
Cropland	Filter strip	0.7	0.75	ND	0.65
Urban	Dry Detention	0.3	0.26	0.27	0.575
Urban	Extended Wet Detention	0.55	0.685	0.72	0.86

More complex models also offer options for user tweaking:

E.g., **SWAT** allows users to enter values for sediment, organic N, organic P, soluble N, and soluble P concentration in runoff after urban BMPs are applied.

http://swat.tamu.edu/documentation/2012-io/

5. Recommendations

The importance of accurate knowledge of BMP depreciation varies across projects and during the lifetime of a single project.

- During the planning phase, when planning for the achievement of pollutant reduction targets relies heavily on existing BMPs, good information on performance of existing BMPs is essential.

- If existing BMPs are a trivial part of the overall watershed plan, knowledge of BMP depreciation might not be critical during planning.

- As projects move forward, depreciation of existing and new BMPs becomes important; the types of BMPs implemented, their relative costs and contributions to achievement of project pollutant reduction goals, and the likelihood that BMP depreciation will occur will largely determine the type and extent of BMP verification required over time.

5. Recommendations

- During project planning, collect accurate and complete information about:
  - Land use,
  - Land management, and
  - The implementation and operation of existing BMPs for characterization of overall baseline NPS loads, better identification of critical source areas, and effective prioritization of new land treatment. This information should include:
    - Original BMP installation dates,
    - Design specifications of individual BMPs,
    - Data on BMP performance levels if available, and
    - The spatial distribution of BMPs across the watershed.

5. Recommendations

- Track the factors that influence BMP depreciation in the watershed, including:
  - Variations in weather that influence BMP performance,
  - Changes in land use, land ownership, and land management,
  - Inspection and enforcement activities on permitted practices, and
  - Operation, maintenance, and management of implemented practices.

5. Recommendations

- Develop and use observable indicators of BMP status/performance that:
  - Are tailored to the set of BMPs implemented in the watershed and practical within the scope of the watershed project's resources,
  - Can be quantified or scaled to document the extent and magnitude of treatment depreciation, and
  - Are able to be paired with water quality monitoring data.

5. Recommendations

- After the implementation phase of the NPS project, conduct verification activities to document the continued existence and function of implemented practices to assess the magnitude of depreciation and provide a basis for corrective action. The verification program should:
  - Identify and locate all BMPs of interest, including cost-shared, non cost-shared, required, and voluntary practices,
  - Capture information on structural, annual, and management BMPs,
  - Obtain data on BMP operation and maintenance activities, and
  - Include assessment of data accuracy and confidence.

5. Recommendations

- To adjust for depreciation of land treatment, apply verification data to watershed project management and evaluation by:
  - Applying results directly to permit compliance programs,
  - Relating documented changes in land treatment performance levels to observed water quality,
  - Incorporating measures of depreciated BMP effectiveness into modeling efforts, and
  - Using knowledge of treatment depreciation to correct problems and target additional practices as necessary to meet project goals in an adaptive watershed management approach.

References

Baker, D.B. 2010. *Trends in Bioavailable Phosphorus Loading to Lake Erie*. Final Report. LEPF Grant 315-07. Prepared for the Ohio Lake Erie Commission by the National Center for Water Quality Research, Heidelberg University, Tiffin, OH. http://141.139.110.110/sites/default/files/jfuller/images/13%20Final%20Report,%20LEPF%20Bioavailability%20Study.pdf.

Dosskey, M.G., M. J. Helmers, D.E. Eisenhauer, T.G. Franti, and K.D. Hoagland. 2002. Assessment of concentrated flow through riparian buffers. *Journal of Soil and Water Conservation* 57(6):336–343.

Hill, R.P. 1996. *Procedures for cropland transect surveys for obtaining reliable county- and watershed-level tillage, crop residue, and soil loss data*. Core4: Conservation for Agriculture's Future, Conservation Technology Information Center, West Lafayette, IN. http://www2.ctic.purdue.edu/Core4/CT/transect/Transect.html (Accessed October 13, 2015).

Jackson-Smith, D.B., M. Halling, E. de la Hoz, J.P. McEvoy, and J.S. Horsburgh. 2010. Measuring conservation program best management practice implementation and maintenance at the watershed scale. *Journal of Soil and Water Conservation* 65(6):413–423.

Joosse, P. J., and D.B. Baker. 2011. Context for re-evaluating agricultural source phosphorus loadings to the Great Lakes. *Canadian Journal of Soil Science* 91:317–327.

Lewis, T.W., and J.C. Makarewicz. 2009. Winter application of manure on an agricultural watershed and its impact on downstream nutrient fluxes. *Journal of Great Lakes Research* 35(sp1):43–49.

Lindsey, G., L. Roberts, and W. Page. 1992. Maintenance of stormwater BMPs in four Maryland counties: A status report. *Journal of Soil and Water Conservation* 47(5):417–422.

Schilling, K.E., and J. Spooner. 2006. Effects of watershed-scale land use change on stream nitrate concentrations. *Journal of Environmental Quality* 35:2132–2145.

Tetra Tech, Inc. 2010. *Stormwater Best Management Practices (BMP) Performance Analysis*. Prepared for U.S. Environmental Protection Agency Region 1 by Tetra Tech, Inc., Fairfax, VA. Revised March2010; accessed April 24, 2015. *http://www.epa.gov/region1/npdes/stormwater/assets/pdfs/BMP-Performance-Analysis-Report.pdf*.

Tortora, R.D. 1978. A note on sample size estimation for multinomial populations. *The American Statistician*, 32(3):100-102.

Urbonas, B., and J. Wulliman. 2007. Stormwater Runoff Control Using Full Spectrum Detention. In *Proceedings of World Environmental and Water Resources Congress 2007: Restoring Our Natural Habitat*, American Society of Civil Engineers. http://cedb.asce.org/cgi/WWWdisplay.cgi?159418.

USEPA. 2008. *Handbook for Developing Watershed Plans to Restore and Protect Our Waters*. EPA 841-B-08-002. http://water.epa.gov/polwaste/nps/upload/2008_04_18_NPS_watershed_handbook_handbook-2.pdf.

USEPA. 2013. *Nonpoint Source Program and Grants Guidelines for States and Territories*. http://water.epa.gov/polwaste/nps/upload/319-guidelines-fy14.pdf.

Virginia Department of Conservation and Recreation. 1999. Virginia Stormwater Management Handbook. Division of Soil and Water Conservation, Richmond, VA . http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/Publications.aspx.