Introducing the Phase 6 Scenario Builder

Presentation to the Chesapeake Bay Program Partnership's Water Quality GIT and interested parties

Curtis Dell, USDA-ARS and AMS Chair

Matt Johnston, UMD-CBPO and AMS Coordinator

1/14/2016

Phase 6 Model Structure

Average Load + ΔInputs * Sensitivity

*

Land Use Acres

*

BMPs

*

Direct Loads

Land to Water

*

Stream Delivery

*

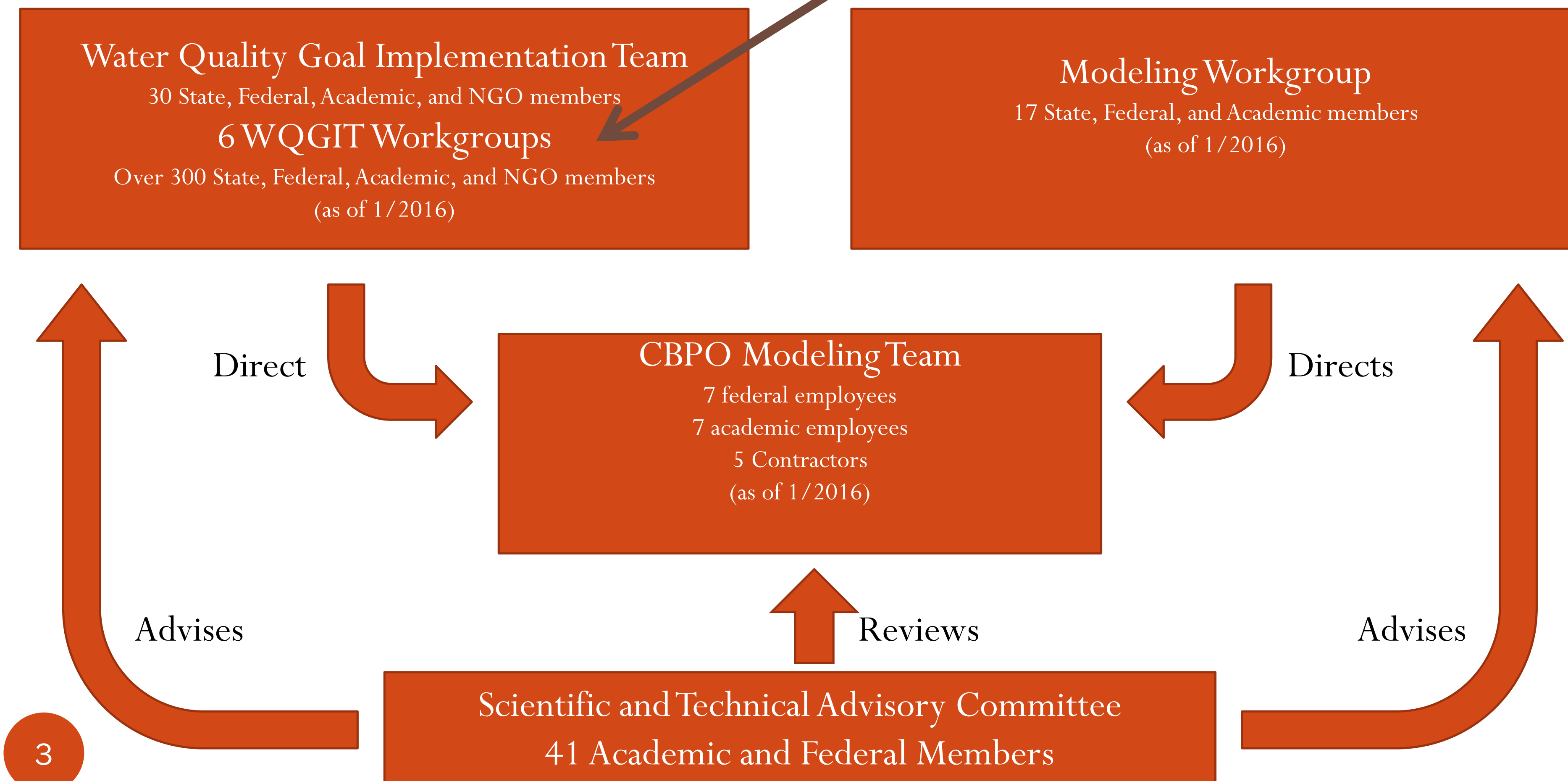
River Delivery

“Scenario Builder”

“Watershed Model”

Who advises, and directs?

- AMS fits in here under Ag Workgroup
- Ag Workgroup is responsible for agricultural portion of Scenario Builder



Agricultural Modeling Subcommittee Members and Scenario Builder Team

- Curtis Dell – USDA-ARS, AMS Chair
- Matt Johnston – UMD – CBPO, AMS Coordinator
- Mark Dubin – UMD – CBPO, Ag Workgroup Coordinator
- Lindsey Gordon – CRC, Staff
- Emma Giese – CRC, Staff (previously)
- Dave Montali – WV DEP
- Alisha Mulkey – MDA
- Chris Brosch – DDA, VA DCR (previously)
- Dana York – Green Earth Connection
- Don Weller – Smithsonian, STAC (previously)
- Gary Shenk – USGS-CBPO, EPA-CBPO (previously)
- Greg Albrecht – NYS Department of Agriculture and Markets,
- Jack Meisinger – USDA – ARS
- Jason Keppler – MDA
- Jenn Volk – UD
- Lauren Torres – DDA
- Bill Keeling – VA DEQ
- Ken Staver – UMD Rye Research
- Doug Goodlander – PA DEP
- Jeff Sweeney – EPA-CBPO, SB Team
- Olivia Devereux – Devereux Environmental Consulting, SB Team
- Jessica Rigelman – J7 LLC, SB Team
- Sucharith Ravi – UMCES-CBPO, SB Team
- Peter Claggett – USGS – CBPO, Land Use Team

Thank You!

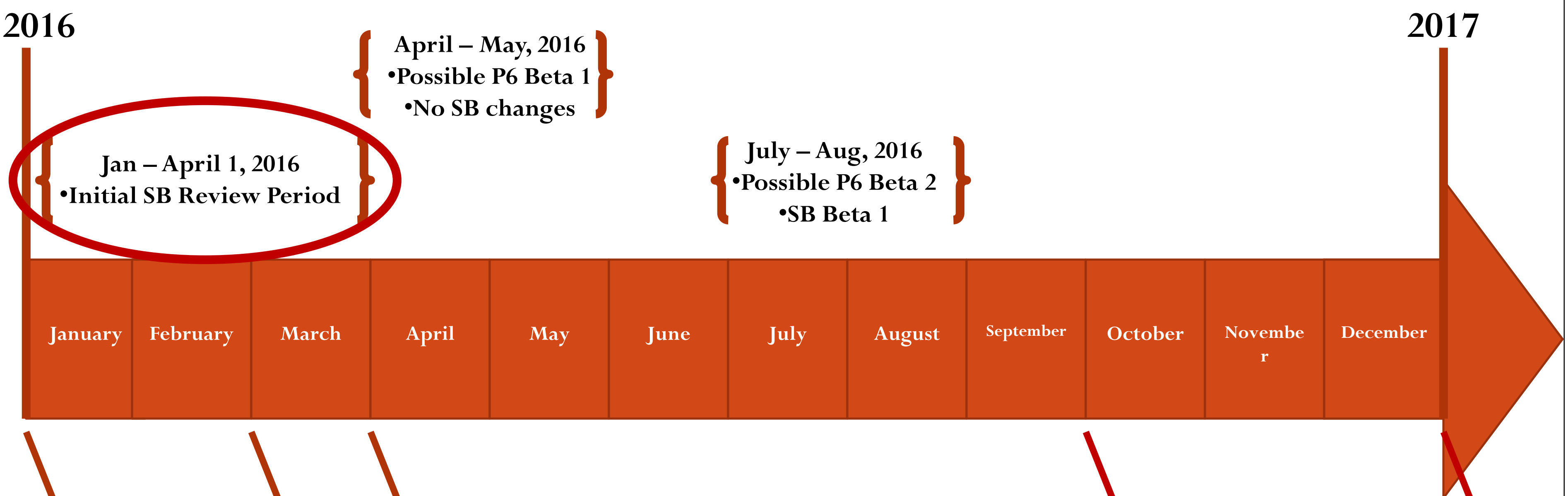
2016 Phase 6 Model and SB Review Timeline

April – September, 2016
•AMS continues to review comments as requested

April – May, 2016
•Possible P6 Beta 1
•No SB changes

Jan – April 1, 2016
•Initial SB Review Period

July – Aug, 2016
•Possible P6 Beta 2
•SB Beta 1



January, 2016
•P6 Beta 0
•SB Beta 0
•Documentation
•AMS review begins
(Jan. 28 full day meeting)

March 1, 2016
•SB comments due to AMS

April 1, 2016
•AMS SB changes for AgWG

September 30, 2016
•All changes to tools approved by Partnership

January 1, 2017
•P6 and SB complete

What the AMS Plans to Review by April, 2016

- **Nutrient Application Rates**
  - Assess if nutrient application rates on various crops/land uses are appropriate.
- **Manure Eligible Acres**
  - Determine if additional data exists to inform the number of acres receiving manure.
- **Documentation**
  - Review Scenario Builder documentation in full to ensure new methods reflect committee's intent.
- **Partnership Comments**
  - Review comments from AgWG, WQGIT, and other partners, and consider method changes if appropriate. **Comments received after March 1 will only be addressed if time allows.**

Start at the End…and Work Back

- Apply manure first
- Apply direct deposition manure to pasture, but assume it does not impact other applications of manure and fertilizer to pasture
- Prioritize fertilizer for applications that are specified as fertilizer-only over additional fertilizer applications elsewhere
- Use state-supplied application rates, acres of crops, and estimated yield application goals to determine application need
- Spread all estimated manure and fertilizer in each county regardless of amounts available

It's all about Application Rates

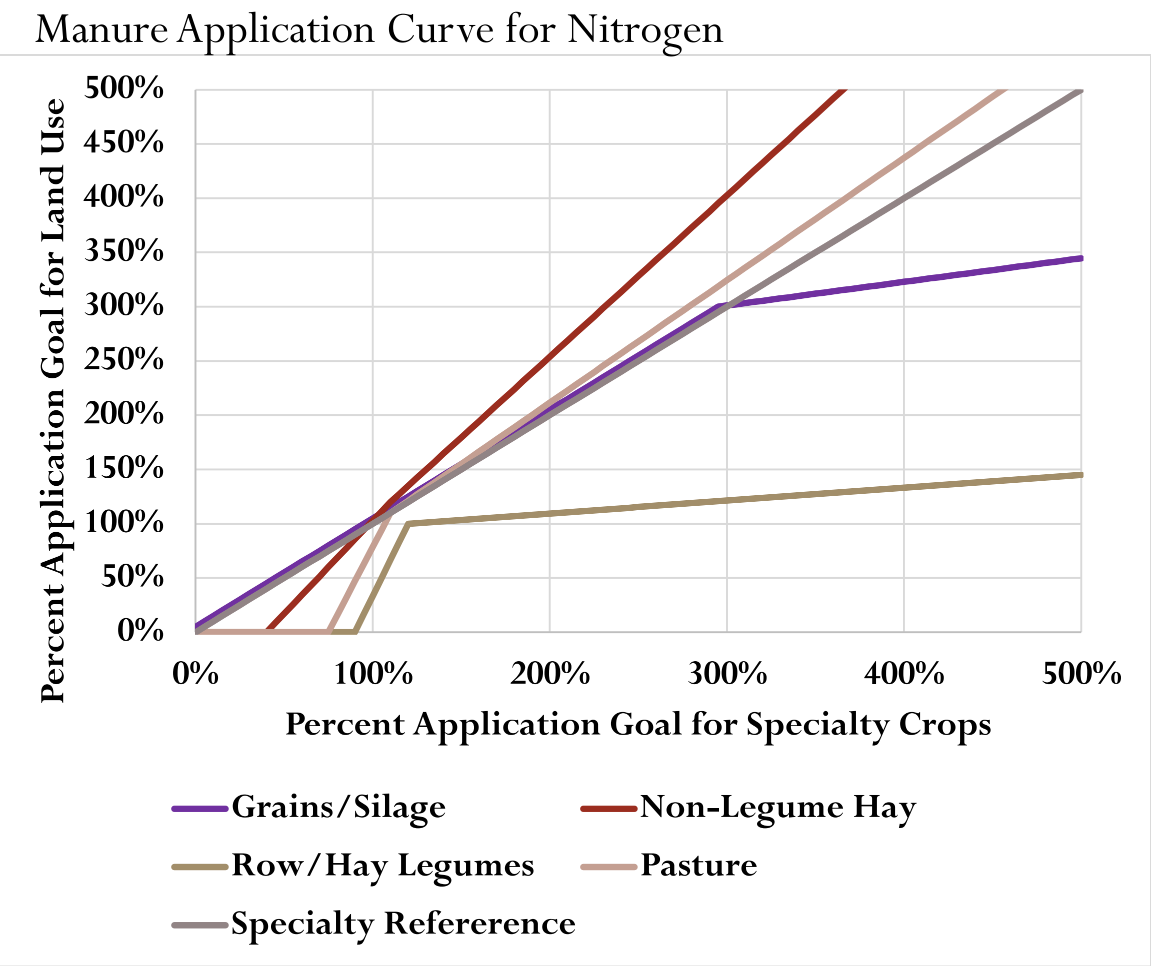
- Commercial fertilizers
  - Mean of AAPFCO and USDA-NASS fertilizer sales data per county
- Manure production (Simple Version)

  = Animal population x manure/animal x N or P recovery factor

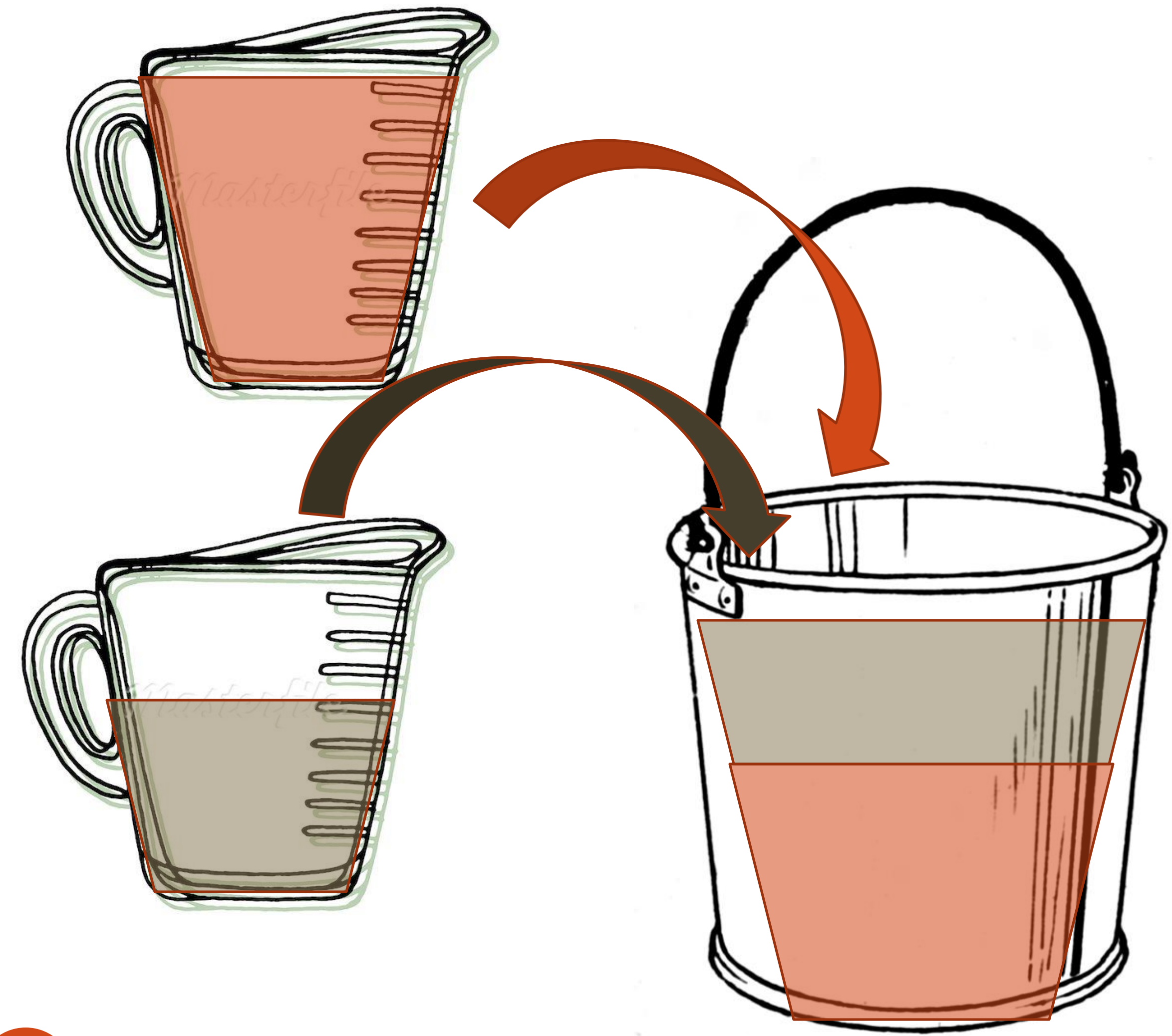
  - Animal population: Ag Census, annual NASS data, or state supplied data depending on availability by animal type
  - Manure/animal: ASABE methodology or supplied by states when available
  - N or P recovery: USDA-NRCS methodology

Application by Curves

- Manure application rates in the field
  - Crop N (or P) requirement/expected yield as estimated by each state's LGU
  - Prioritize manure nutrient applications relative to row crop requirement



Is my bucket (of crop application need) full?



- If my bucket is full or just below full, I don't have much concern about excessive nutrient runoff (above average for my crop or land use).

- If my bucket is overflowing, I have concern about excessive nutrient runoff.

Files Produced by Scenario Builder

Input	Spatial Scale	Temporal Scale
Septic Nutrient Loads	Land Segment	Daily
Land Use Acres	Land-River-Segment	Yearly
Manure Nutrient Applications	Land Segment/Land Use	Monthly
Inorganic Fertilizer Nutrient Applications	Land Segment/Land Use	Monthly
Legume Nitrogen Fixation	Land Segment/Land Use	Monthly
Nutrient Uptake	Land Segment/Land Use	Yearly
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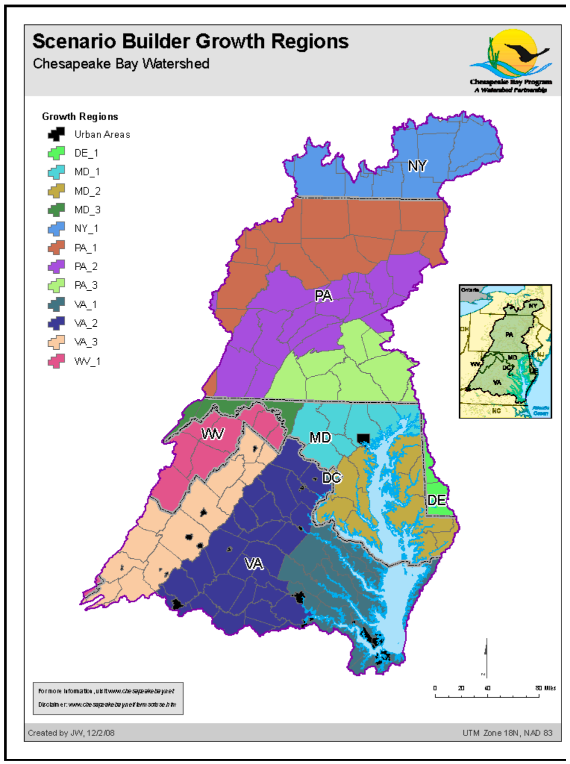
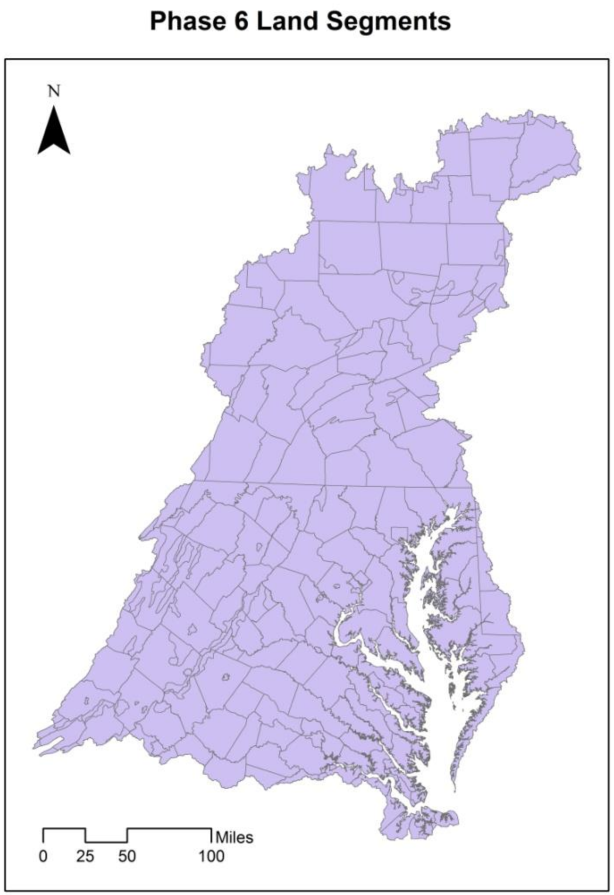
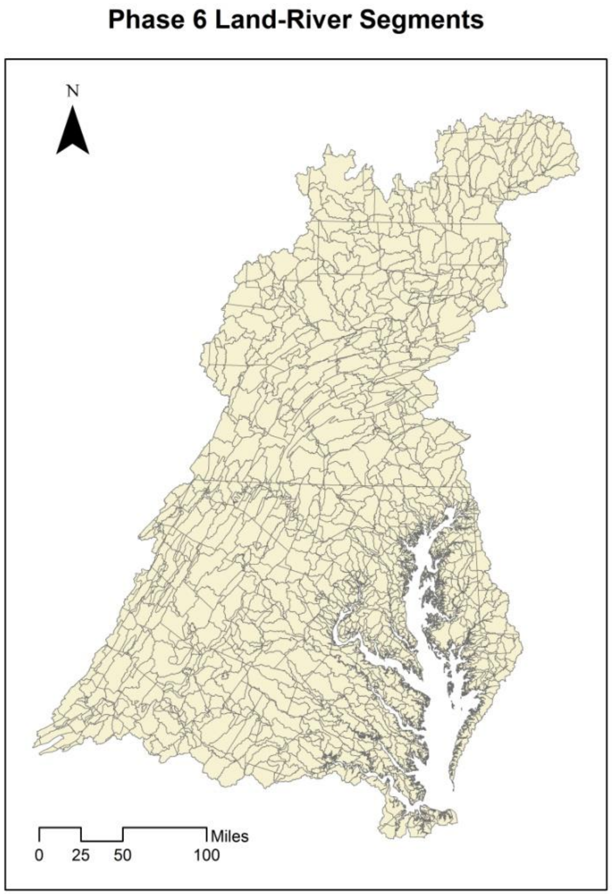
Crop Soil Cover Fractions	Land Segment/Land Use	Monthly
Detached Soil Fractions	Land Segment/Land Use	Monthly
Riparian Pasture Access Area Nutrient Loads	Land-River-Segment/Land Use	Monthly
Animal Feeding Area Nutrient Loads	Land-River-Segment/Land Use	Yearly
BMP Nutrient "Pass-through" Fractions	Land-River-Segment/Land Use	Yearly
[illegible]P Pounds Reduced	Land-River-Segment/Land Use	Yearly

Spatial Scales







12 Growth Regions, 235 Land Segments, 1,916 Land-River Segments

Septic Nutrient Loads

Equation:

(Persons on Septic in 1990/ Persons in 1990) X Persons for given year X 8.92 Lbs of N/Person X 0.4

Details:

- 1990 U.S. Census asked if each household was on septic. From this, the ratio of septic systems to number of people can be calculated.
- The ratio is then multiplied by the county population to estimate total people on septic.
- This number is then multiplied by an average load of 8.92 lbs of nitrogen per person.
- Finally, a 60% attenuation factor is applied to the load.
- Updated septics information is occasionally provided by states that can change the CBPO's total septic estimates.
- Wastewater Workgroup may revise the attenuation factor for Phase 6.

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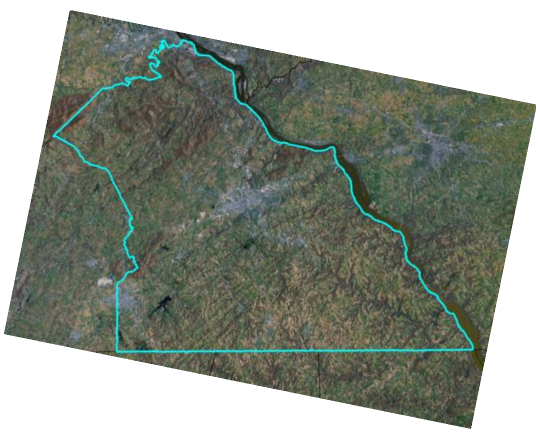
Land Use Acres: Land Uses

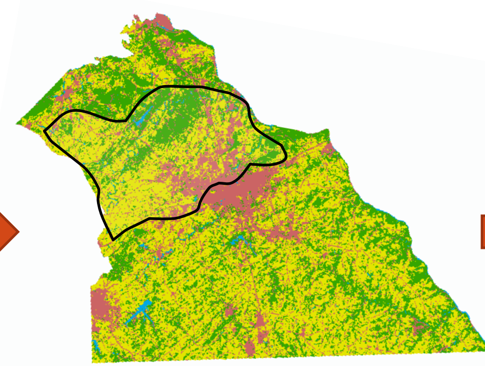
Agriculture	Developed			Natural
	Non-Regulated	MS4	CSS	
Ag Open Space	Non-Regulated Roads	MS4 Roads	CSS Roads	Disturbed Forest
Full Season Soybeans	Non-Regulated Buildings and Other	MS4 Buildings and Other	CSS Buildings and Other	Harvested Forest
Grain with Manure	Non-Regulated Tree Canopy over Impervious	MS4 Tree Canopy over Impervious	CSS Tree Canopy over Impervious	Forest
Grain without Manure	Non-Regulated Tree Canopy over Scrub Shrub	MS4 Tree Canopy over Scrub Shrub	CSS Tree Canopy over Scrub Shrub	Palustrine Forested Wetland
Legume Hay	Non-Regulated Tree Canopy over Herbaceous	MS4 Tree Canopy over Herbaceous	CSS Tree Canopy over Herbaceous	Palustrine Scrub-Shrub Wetland
Silage with Manure	Non-Regulated Turf Grass	MS4 Turf Grass	CSS Turf Grass	Palustrine Emergent Wetland
Silage without Manure		MS4 Construction	CSS Construction	Open Space
Small Grains and Grains				Water
Small Grains and Soybeans				
Specialty Crop High				
Specialty Crop Low				
Other Agronomic Crops				
Other Hay				
Pasture				
Farmstead				
Permitted Feeding Space				
Non-Permitted Feeding Space				

Land Use Acres: Digital Landscape

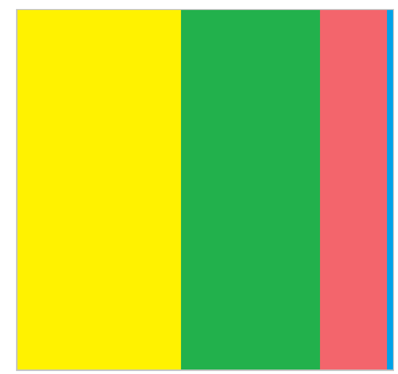
- Scenario Builder creates a "digital landscape" of land uses bases upon data from the Land Change Model and the USDA's Census of Agriculture.
- The new "digital landscape" is an aggregated representation of the county's land uses.



Satellite Imagery



Land Cover for each County (Land) and River Segment



Digital Landscape for each Land-River Segment

Land Uses: Developed and Natural

- USGS's Chesapeake Bay Land Change Model estimates these acres. Sources of data include or will include:
  - National Land Cover Dataset
  - Local Land Cover
  - Population Projections
  - Wetlands Inventory
  - High Resolution Satellite Imagery, including Leaf on/off
- Detailed documentation on the CBLCM will be available later this year.
- The CBLCM also estimates the total number of acres of agricultural land, but this is not used directly by Scenario Builder.

Land Uses: Agricultural

- Over 100 crops are listed in Census of Agriculture, and each crop fits into a specific land use.
- Double-cropped acres must be estimated.
- Manure-eligible land use acres must be estimated.
- Final crop acres are converted to land uses and combined with CBLCM developed and natural.

Land Uses: Agricultural

Crop Name	Land Use(s)	Eligible for Double Crops
Cropland idle or used for cover crops or soil improvement but not harvested and not pastured or grazed Area	Ag Open Space	N
Cropland in cultivated summer fallow Area	Ag Open Space	N
Wild hay Harvested Area	Ag Open Space	N
Corn for Grain Harvested Area	Grain with Manure/Grain without Manure	Y
Sorghum for Grain Harvested Area	Grain with Manure/Grain without Manure	Y
Corn for silage or greenchop Harvested Area	Silage with Manure/Silage without Manure	Y
Sorghum for silage or greenchop Area	Silage with Manure/Silage without Manure	Y
Soybeans for beans Harvested Area	Full Season Soybeans	Y

Land Uses: Agricultural Double-Cropped Acres

Year 1				Year 2				
winter	spring	summer	fall	winter	spring	summer	fall	winter

- The Small Grains/Soybeans land use is created using the double-cropping procedure to reflect the typical corn/soybean/wheat rotation.

Land Uses: Agricultural Double-Cropped Acres

- The following "major field crops" can be double-cropped with one another:
  - Barley; Buckwheat; Canola; Corn for Grain; Corn for Silage; Emmer and Spelt; Oats for Grain; Rye for Grain; Sorghum for Grain; Sorghum for Silage; Soybeans for Beans; Triticale; and Wheat for Grain
- Harvested acres of these crops are then compared to the total harvested cropland area reported by Census of Agriculture AFTER removing all other crop types. This represents the "major field cropland harvested area."
- If acres of "major field crops > "major field cropland harvested area," then acres of Small Grains and Soybeans are created.

Land Uses: Agricultural Grains with Manure Acres and Silage with Manure

- Many land uses can receive manure because the individual crops within the land uses can receive manure.
- AMS wanted to separate those acres of corn (and sorghum) that received manure.
- Very limited data available to separate these acres.
- Census of Agriculture does report the total agricultural acres receiving manure.

Land Uses: Agricultural Grains with Manure Acres and Silage with Manure

- Fraction of Acres Receiving Manure Equation:
  - Acres Receiving Manure/ (Acres of Harvested Cropland + Acres of Pasture – Acres of Soybeans)

Comparing Census of Agriculture to MD AIR Percent of Corn Need Met with Manure

Region	MD AIR Percentage (2011, 2012, 2013 combined)	Census of Agriculture Percentage (2012)
Statewide	17	21
Lower Eastern Shore	28	32
Western	24	20
Central	2	6
Northwestern	14	26
Northern	5	11
Southern	8	7
Upper Eastern Shore	17	20

Land Uses: Agricultural Feeding Operation Acres

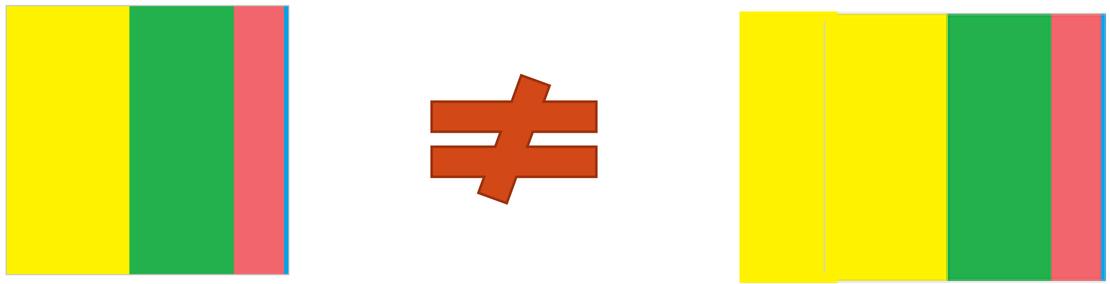
Source Name	Open-Air Barnyard (sq feet)			Roofed Structures (sq feet)			All Area (sq feet)	Cycles (NRCS)	Adjusted All Area (sq ft)	All Area (acres/animal)
	MAX	MIN	MED	MAX	MIN	MED	Total	Total	Total	Total
Pullets*						1.0	1.0	2.25	0.44	**0.000010**
Turkeys				2.0	2.0	2.0	2.0	2.00	1.02	**0.000023**
Broilers*						0.85	0.85	6.00	0.14	**0.000003**
Layers				1.7	1.7	1.7	1.7	1.00	1.72	**0.000040**
Hogs for Slaughter				9.7	9.7	9.7	9.7	2.00	4.84	**0.000111**
Hogs and Pigs for Breeding				13.6	13.6	13.6	13.6	1.00	13.56	**0.000311**
Beef (Beef Heifers)	60.3	50.6	55.4	35.5	18.3	26.9	82.3	1.00	82.31	**0.001890**
Dairy (Dairy heifers)	96.8	96.8	96.8	28.6	28.6	28.6	125.5	1.00	125.46	**0.002881**
Other Cattle	50.6	39.8	45.2	24.7	11.8	18.3	63.5	1.00	63.48	**0.001458**
Horses	147.3	147.4	147.4	147.3	147.3	147.3	294.7	1.00	294.66	**0.006765**
Sheep and Lambs*						25.0	25.0	1.00	25.02	**0.000574**
Goats*						15.0	15.0	1.00	15.00	**0.000344**

*Maximum, minimum and median values provided by Maryland Department of Agriculture, 2015.
All other maximum, minimum and median values provided by FASS, 2010.

Land Uses: Agricultural Farmstead Acres

- Simply: there are none…
- AMS and CBPO Land Use Team were unable to develop a method to separate farmstead areas from rural lots characterized as "developed."

Land Uses: Combining Acres



CBLCM   Scenario Builder

- Currently, land uses are reduced in sequence beginning with Open Space and Tree Canopy, and followed by Urban and finally Agriculture until land uses "fit" into domain.
- CBPO's Land Use Team is working on a revision to this procedure that will allow all land uses to be adjusted based upon percent confidence for each land use.
- For example, we may have less confidence in pasture acres than hay acres, so pasture may be more likely than hay to be reduced.

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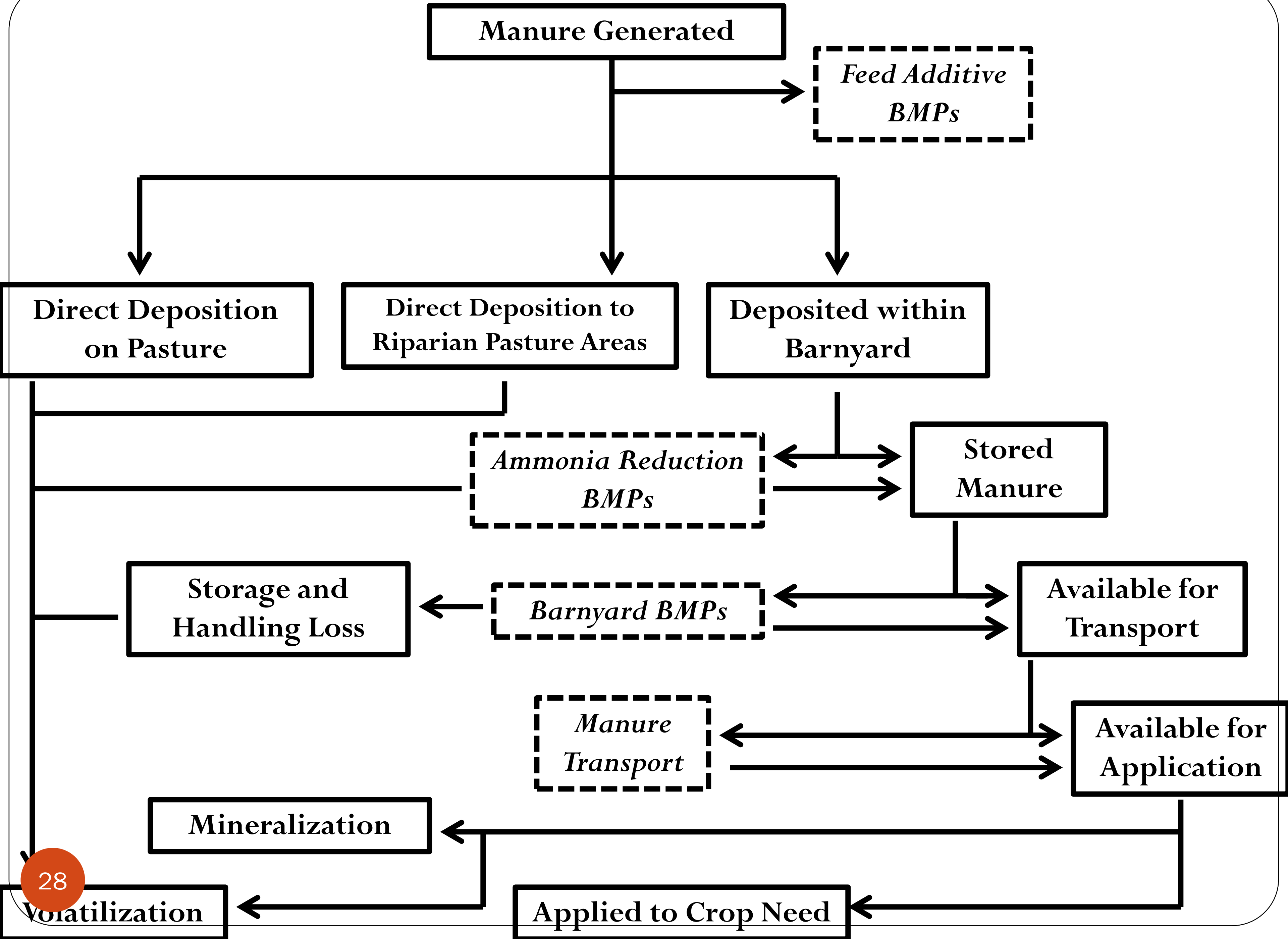

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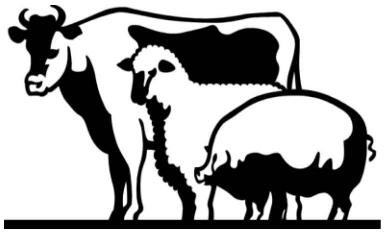
Mineralization
Volatilization
Applied to Crop Need

Manure: Manure Generation

Livestock Manure



Data Needed:

- Populations
- Estimates of Manure Produced per Animal
- Estimates of Manure Concentrations
- Estimates of Mineralization of Organic Nutrients

Equation to Estimate Manure per Animal Type

Animal Population
X
Lbs of Manure Produced/Animal
X
Lbs of nutrient species/Lb Manure

Once initial estimates of nutrients are made, then Organic Nitrogen is multiplied by a mineralization factor to estimate the amount of manure available from animals.

Manure: Livestock Populations

Data Needed:

- USDA-NASS 5-Yr Ag Census Inventory – All Livestock (helps inform distribution of turkeys and broilers to county)
- USDA-NASS 5-Yr Sales Numbers – For Hogs for Slaughter and Pullets
- NASS Annual Poultry Production – For Broilers and Turkeys

Population for Hogs for Slaughter and Pullets

(Ag Census County Inventory X 1/Production Cycles) + ((Ag Census County Animals Sold/Production Cycles) X (Production Cycles – 1/Production Cycles)

Hogs for Slaughter Cycle = 2; Pullets Cycle = 2.25

Population for Livestock and Layers =
Ag Census County Inventory

Population for Broilers and Turkeys =
(Statewide Birds Produced) X (Countywide Ag Census Inventory/Statewide Ag Census Inventory)

Manure: Estimating Manure Generation

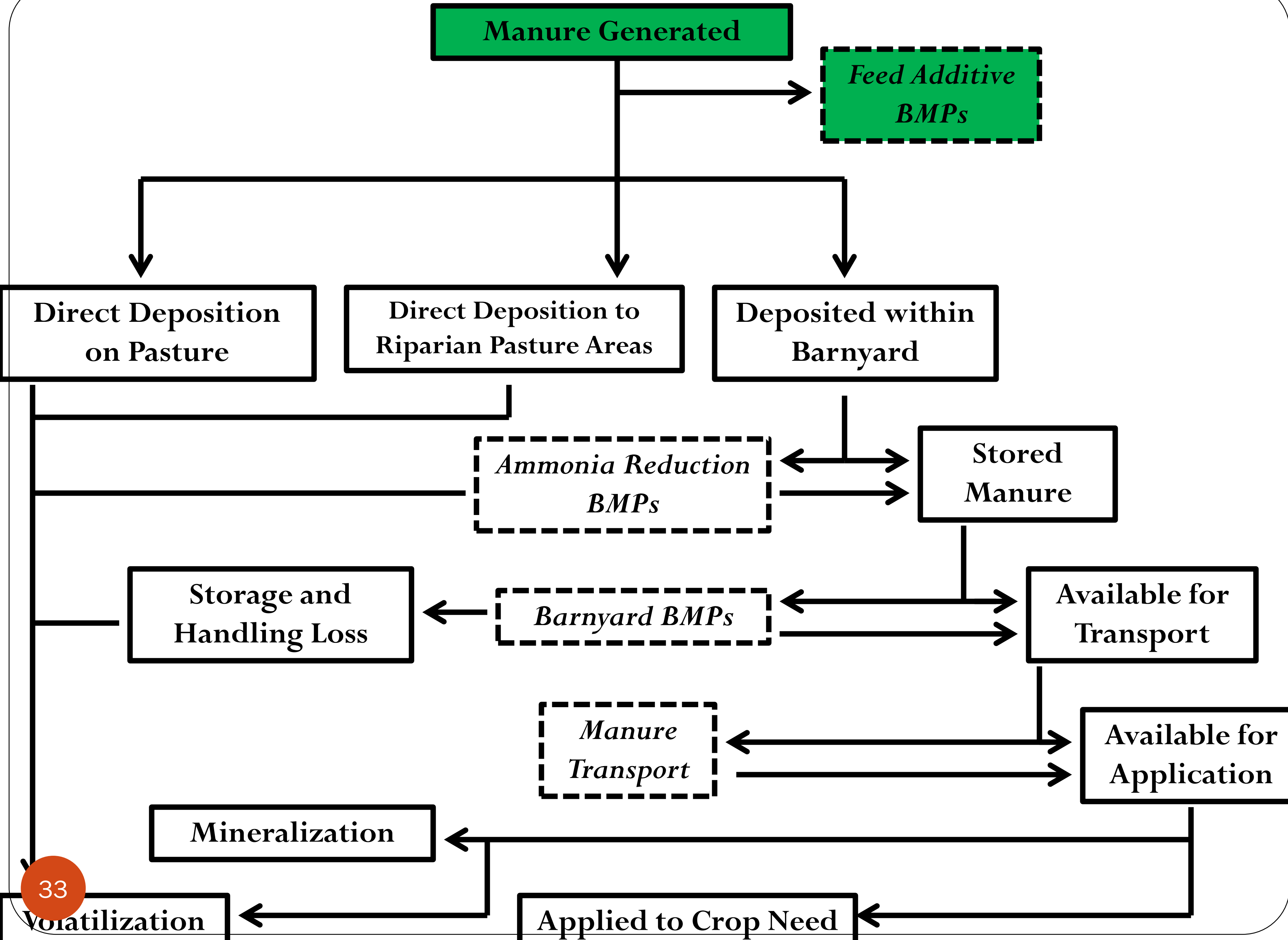
Animal Type	Manure Source	Lbs Dry Manure/Animal/Yr	Lbs TN/Lb Dry Manure	LbsTP/Lb Dry Manure
Beef	Use Beef - Cow (confinement) from ASAE 2005 for manure values	5,475.00	0.028788	0.006467
Dairy	Use Lactating Cow, Dry Cow and Heifer from ASAE 2005 for manure values	4,404.33	0.042221	0.006764
Other Cattle	Use average of Beef and Dairy from above to estimate manure values	4,939.67	0.035504	0.006616
Horses	Use average of Horse- Sedentary and Horse - Intense Exercise from ASAE 2005 for manure values	3,102.50	0.031672	0.005941
Hogs for Breeding	Use Gestating Sow and Lactating Sow ASAE 2005 for manure values	657	0.070273	0.019417
Hogs for Slaughter	Use Grow-Finish from ASAE 2005 for manure values	120	0.083333	0.014167
Sheep and Lambs	Use ASAE 2003 for manure values	240.9	0.038182	0.007909
Goats	Use ASAE 2003 for manure values	680.91	0.034615	0.008462

•Poultry litter estimates vary by year and are explained in detail in the PLS report.

Manure: Nutrient Concentrations

Livestock Type	Mineralized Nitrogen	Nitrate Nitrogen	Organic Nitrogen	Ammonia Nitrogen	Mineralized Phosphorus	Organic Phosphorus	Phosphate
Beef	0.007527	0.000000	0.013979	0.007282	0.004359	0.000000	0.002108
Dairy	0.012185	0.000000	0.022628	0.007408	0.000217	0.000000	0.006547
Other Cattle	0.009765	0.000000	0.018135	0.007605	0.004458	0.000000	0.002158
Horses	0.011831	0.000000	0.011831	0.008010	0.004350	0.000000	0.001591
Hogs for Breeding	0.015538	0.000000	0.015538	0.039196	0.006469	0.000000	0.012948
Hogs for Slaughter	0.018430	0.000000	0.018430	0.046473	0.004720	0.000000	0.009447
Sheep and Lambs	0.009984	0.000000	0.018541	0.009657	0.003955	0.000000	0.003955
Goats	0.009051	0.000000	0.016809	0.008755	0.005349	0.000000	0.003112

- Mineralization Factors for Swine and horses are 0.5 and other livestock are 0.35.
- Only mineralized nitrogen, nitrate nitrogen, ammonia nitrogen, mineralized phosphorus and phosphate are available for plant uptake.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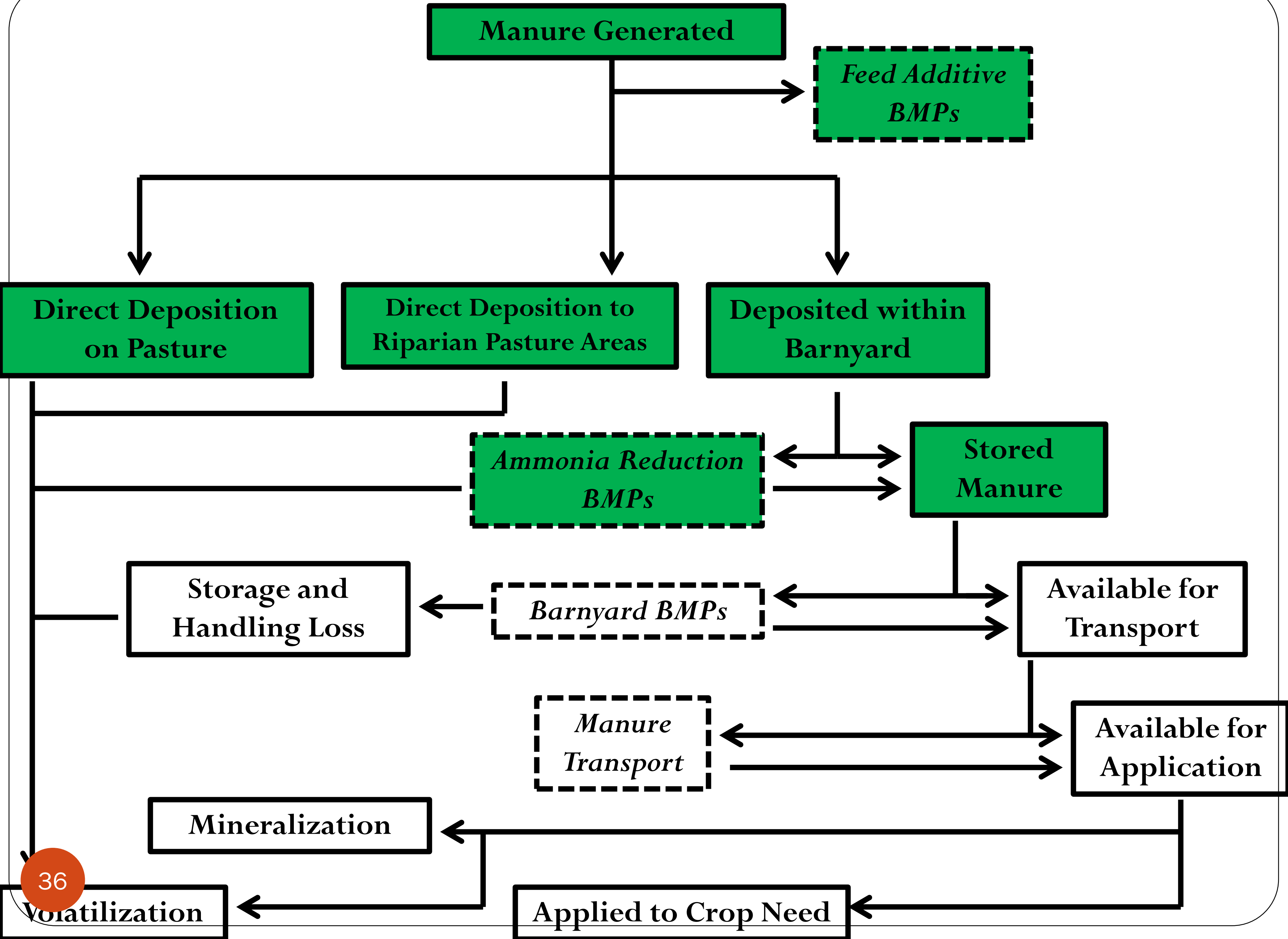
Manure: Separating Manure into Piles

- States were asked to estimate how much time each animal type would spend in the barnyard, in pasture and in the access area.
- These percentages separate the generated manure.

Growth Region	Animal Type	Month	Barnyard %	Pasture %	Access Area %
WV_1	beef	1	6	91	3
WV_1	beef	2	6	91	3
WV_1	beef	3	0	96	4
WV_1	beef	4	0	94	6
WV_1	beef	5	0	94	6
WV_1	beef	6	0	90	10
WV_1	beef	7	0	90	10
WV_1	beef	8	0	90	10
WV_1	beef	9	0	94	6
WV_1	beef	10	0	96	4
WV_1	beef	11	0	96	4
WV_1	beef	12	6	91	3

Manure: Direct Deposit, Access Area and Barnyard Manure

- Manure that is directly deposited on pasture can be taken up by pasture, but does not impact the estimated application goal for pasture.
- A fraction of the directly deposited manure is volatilized.
- Manure that is deposited in the access area becomes a direct load to nearby streams.
- A portion of access area manure is also volatilized.
- A portion of barnyard manure is also available to be volatilized.
  - Ammonia emission BMPs can reduce the volatilization, making more nutrients available to crops. Ag Wokgroup agreed not to credit these BMPs until the Watershed Model can account for the reduced air emissions.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Manure: Recoverability from NRCS

- 1- Fraction Recoverable = Storage and Handling Loss

Animal Type	Fraction of Manure Recoverable	Fraction N Retained in Recovered Manure	Fraction P Retained in Recovered Manure
Beef	0.600000	0.700000	0.850000
Dairy	0.553000	0.670500	0.871000
Other Cattle	0.576500	0.685250	0.860500
Horses	0.635000	0.685000	0.835000
Hogs for Breeding	0.798000	0.731000	0.881000
Hogs for Slaughter	0.775000	0.733000	0.870000
Sheep and Lambs	0.635000	0.685000	0.835000
Angora Goats	0.635000	0.685000	0.835000
Pullets*	0.850000	0.700000	0.900000
Layers*	0.850000	0.737000	0.950000
Turkeys*	0.765000	0.600000	0.930000
Broilers*	0.750000	0.700000	0.950000

*As described in the Poultry Litter Subcommittee report, it is already assumed that poultry litter nutrient concentrations reflect post-recoverable values. Thus, poultry litter nutrients were retroactively increased to calculate nutrients for storage and handling losses.

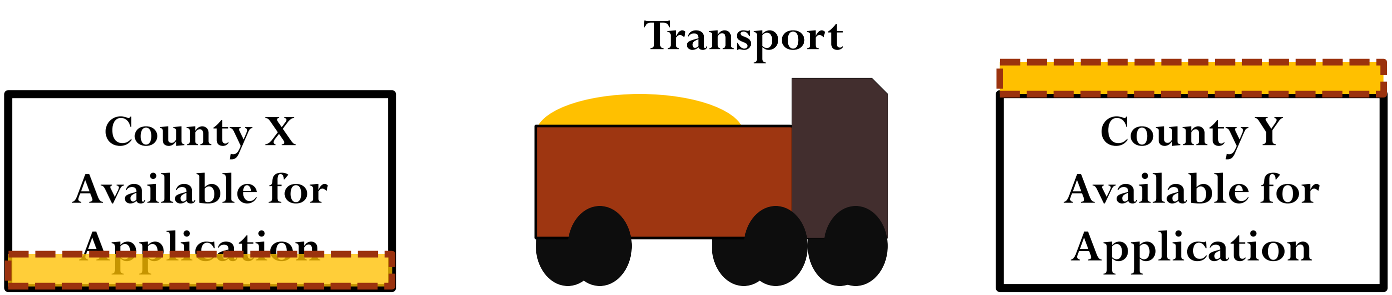
Source: USDA-NRCS, 2003. Costs Associated with Development and Implementation of Comprehensive Nutrient Management Plans. June, 2003.

Manure: Storage and Handling Loss and Animal Waste Management Systems

- Storage and Handling Loss value becomes the application to feeding operation land uses.
- 30% of nitrogen and 10% of phosphorus is assumed to be attenuated within the environment by the Watershed Model.
- Animal Waste Management Systems can reduce Storage and Handling Loss, making more nutrients available to crops and Manure Transport.

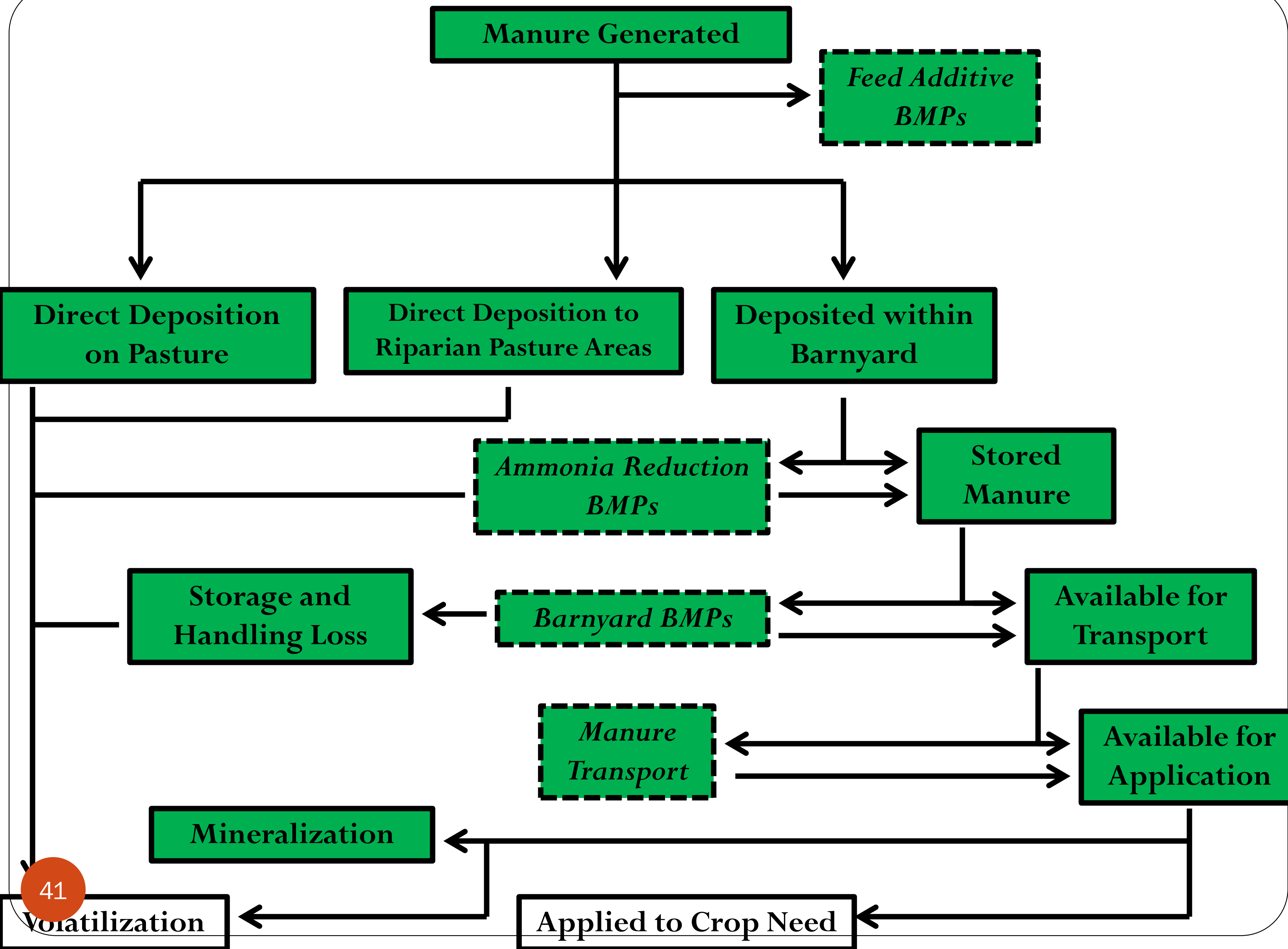
Manure: Manure Transport

- CBP does not estimate manure transport. States must provide the tons of manure transported from County X to County Y.
- Any manure remaining after manure transport is assumed to be available to crops.



Manure: Example for Beef

Calculation Step	Mineralized Nitrogen	Nitrate Nitrogen	Organic Nitrogen	Ammonia Nitrogen	Mineralized Phosphorus	Organic Phosphorus	Phosphate
Original Concentration	0.007527	0.000000	0.013979	0.007282	0.004359	0.000000	0.002108
Ammonia Volatilization Loss	0.000000	0.000000	0.000000	0.004733	0.000000	0.000000	0.000000
Post-Volatilization Concentration	0.007527	0.000000	0.013979	0.002549	0.004359	0.000000	0.002108
Storage and Handling Loss	0.003011	0.000000	0.005592	0.001019	0.001744	0.000000	0.000843
Post-Storage and Handling Loss Concentration	0.004516	0.000000	0.008387	0.001529	0.002615	0.000000	0.001265
Loss of Non-Ammonia Nutrients	0.000820	0.000000	0.001522	0.000000	0.000392	0.000000	0.000190
Final Manure Available for Transport Concentration	0.003697	0.000000	0.006865	0.001529	0.002223	0.000000	0.001075


Manure Generated
Feed Additive BMPs
Direct Deposition on Pasture
Direct Deposition to Riparian Pasture Areas
Deposited within Barnyard
Ammonia Reduction BMPs
Stored Manure
Storage and Handling Loss
Barnyard BMPs
Available for Transport
Manure Transport
Available for Application
Mineralization
Volatilization
Applied to Crop Need

Manure: Volatilization within Fields

Animal Type	Fraction Ammonia Volatilized
beef	0.65
dairy	0.65
other cattle	0.65
horses	0.65
hogs and pigs for breeding	0.55
hogs for slaughter	0.55
sheep and lambs	0.65
goats	0.65
pullets	0.28
turkeys	0.28
layers	0.28
broilers	0.28

Source: Maryland Nutrient Management Manual and Penn State Nutrient Management Guide

- Applications are made based upon only plant-available nutrients.
- A portion of ammonia in manure is assumed to be volatilized in the field, and not available to plants.

Manure: Calculating Manure Application-Eligible Goals

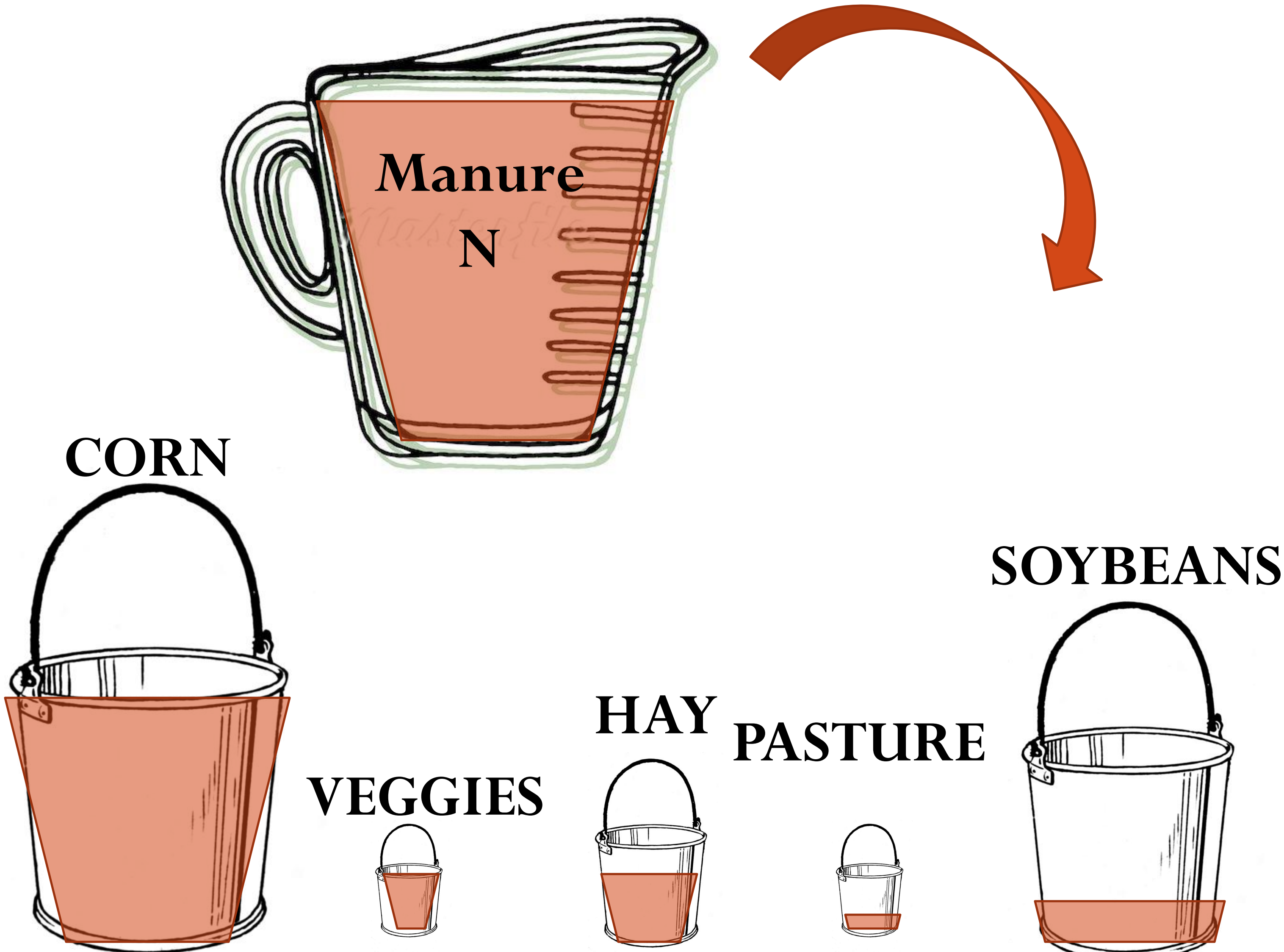
- States provided the following for each crop:
  - Total N and P application goals per acre or yield unit (varied by decade as nutrient management guidelines changed)
    - Example: 1 lb of N/bushel of corn for grain yield
  - Fraction of total application goal which should be met by applications in each month
    - Example: 0.4 of yearly total N on corn for grain should be applied in April
  - Indication of which applications are eligible to be met by manure nutrients in each month
    - Example: April applications are eligible to be met by manure nutrients

Manure: Incorporating Yields into Manure Application Goals

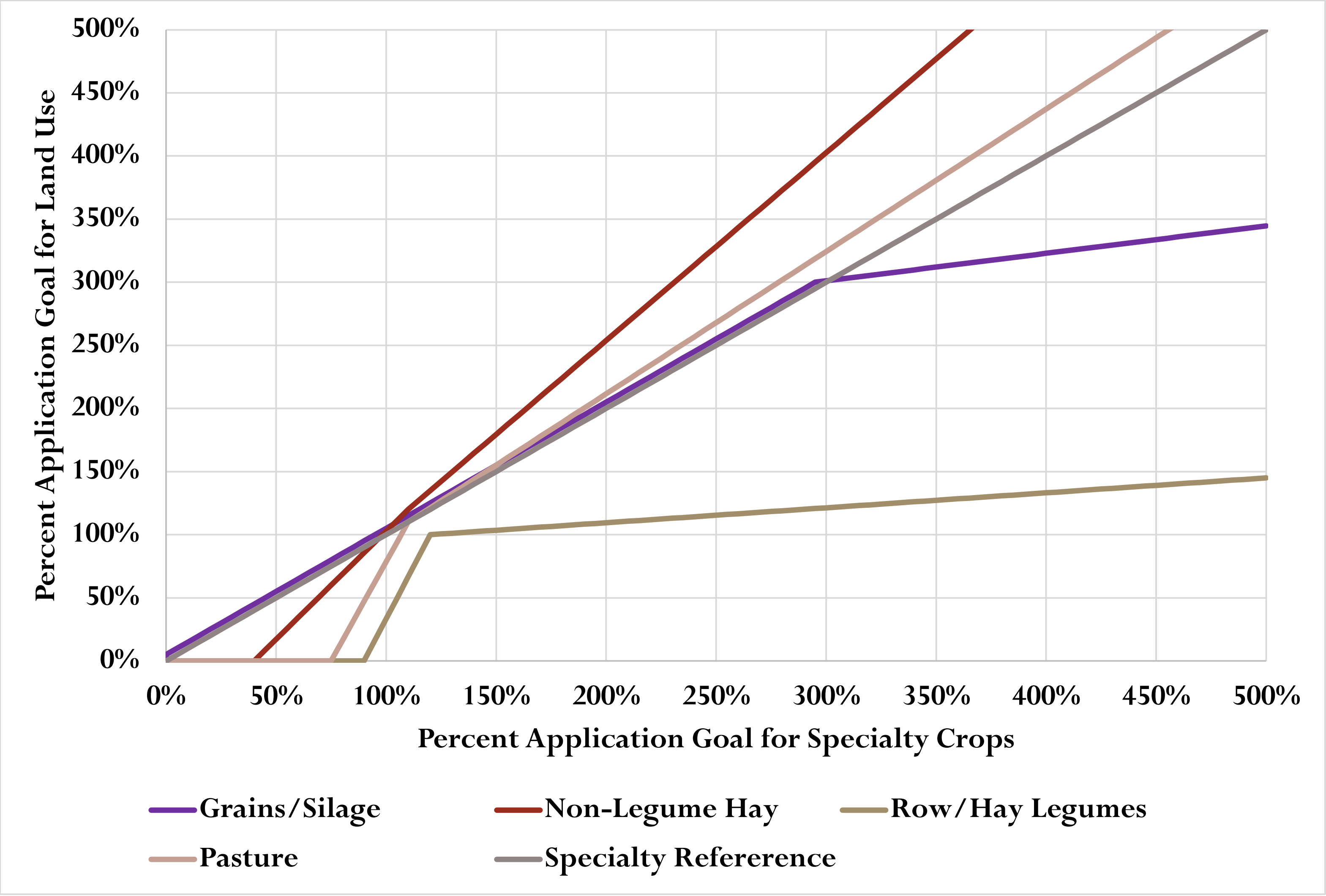
- Crop Application Goal Equation:
  - *Lbs of N/Year = State-Supplied Lbs of N/Application GoalYield Unit/Year XYield/Year X 1.25*

- Application goals are yield-based for the following major crops:
  - Alfalfa Hay; Barley; Buckwheat; Corn for Grain; Corn for Silage; Emmer and Spelt; Oats for Grain; Rye for Grain; Sorghum for Grain; Sorghum for Silage; Soybeans for Beans; Triticale; and Wheat for Grain
- Application goals are per acre for all other crops, and do not vary across the years.
- Yearly yields provided by NASS for major crops.
- AMS elected to multiply yearly yield by 1.25 assuming farmers are optimistic, and average yields are often under-estimated.

Filling the Buckets of Application Goal



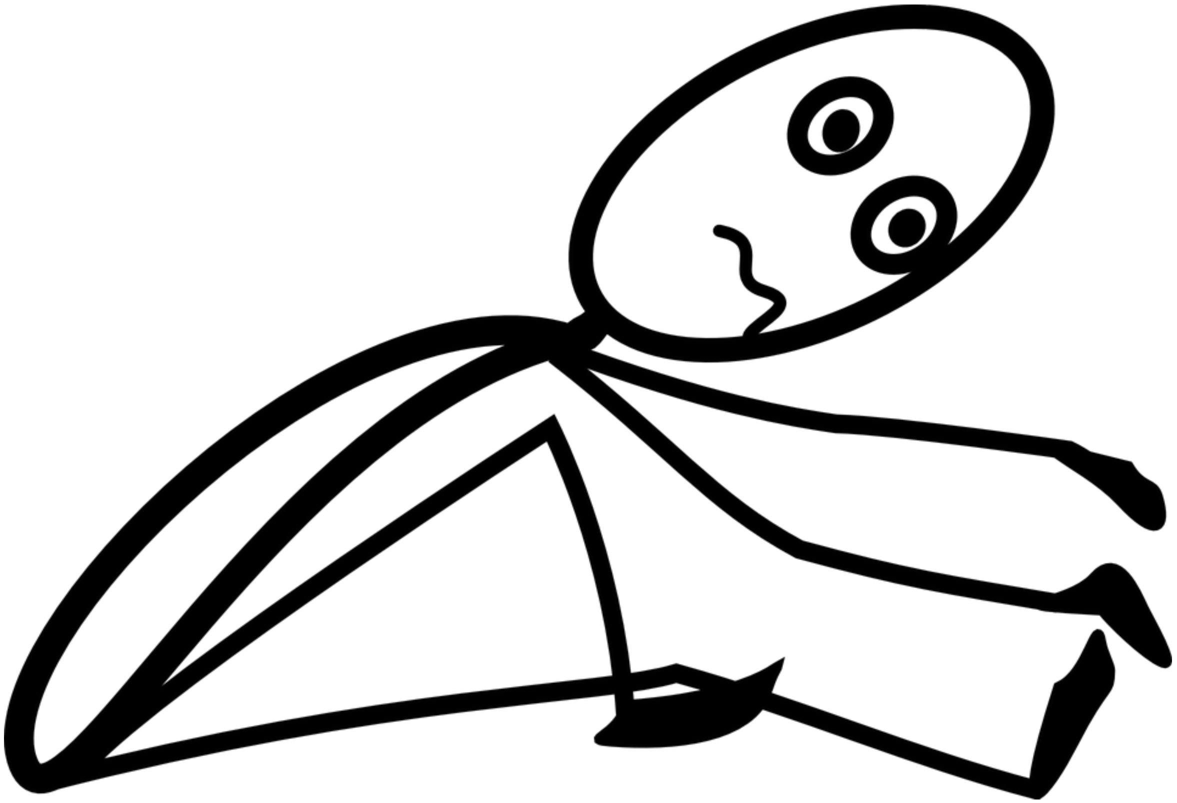
Manure: Prioritizing Manure Nitrogen Applications (and Biosolids)



Manure: Where to find the Data

- All model files can be found at:
  - https://archive.chesapeakebay.net/Modeling/Phase6.
- Save "Ph6CalibrationFiles_20151109.zip."
- Once unzipped, locate the following files:
  - SB_Applications_to_Crops_January2016Calib.xlsx
  - SB_Applications_to_LandUses_January2016Calib.xlsx

STRETCH!



Files Produced by Scenario Builder

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BMP Pounds Reduced	Land-River-Segment/Land Use	Yearly

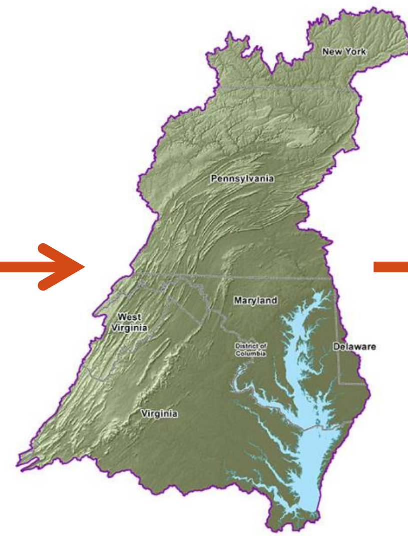
Inorganic: Urban Fertilizer Rates

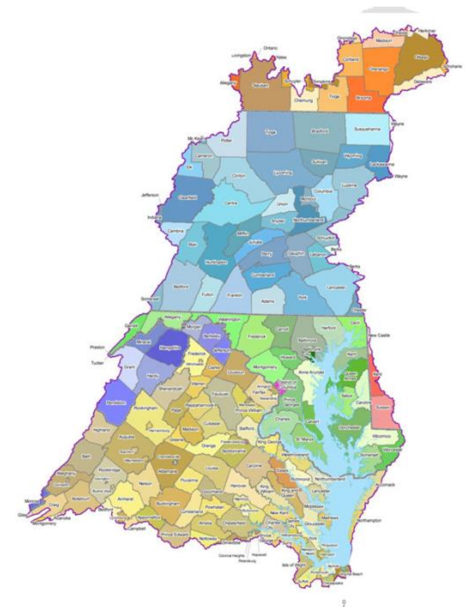
- These do not vary over time, and are based on analysis conducted in Phase 5.
- Analysis of AAPFCO non-farm fertilizer sales of N between 1985 and 2010 revealed that an average of 130 million lbs of N was sold per year. Dividing that up by an average of 3 million acres of Pervious Urban lands in the Phase 5 Model resulted in an estimated 42 lbs of N/Acre.
- Analysis of application rate information provided by Scotts, TruGreen and other producers and lawn care companies suggested a similar rate.
- Scotts and TruGreen N:P ratios were used to estimate phosphorus application of 1.3 lbs/Acre.
- Urban Stormwater Workgroup is responsible for recommending changes to these applications if appropriate.

Inorganic: Starting with AAPFCO

- Association of American Plant Food Control Officials (AAPFCO) collect the following from each state chemists office:
  - County of Fertilizer Sale
  - Tons of Fertilizer Sold
  - Designated Use of Fertilizer (Farm, Non-Farm, Unknown)
  - Concentration of Nutrients (Total N and P)
- AAPFCO Data CANNOT be used directly to estimate fertilizer use!
- USGS SPARROW and INPNI NuGIS both estimate fertilizer use starting with the AAPFCO data as a guide.

Inorganic: Going from Sales to Use





- Begin with regional-level sales, break those down to watershed-level sales, and break those down to county-level use.

Inorganic: Regional Farm Sales

Data Needed:

•AAPFCO Farm/Non-Farm/Unknown Lbs of Fertilizer Sold by County

Steps:

•Sum fertilizer sold across all six states.
•Sum "farm" fertilizer sold across all six states.
•Determine rolling 3-year average of the fraction farm-to-total fertilizer sold across all six states.
•Multiply total fertilizer sold across all six states by rolling 3-year average to determine 6 Statewide (REGIONAL) farm fertilizer sales.

Inorganic: Watershed-wide Farm Sales

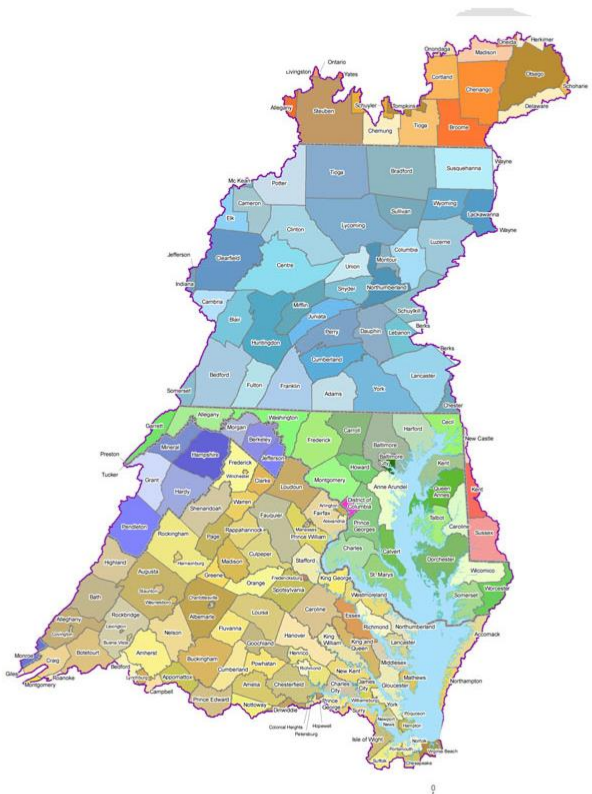
Data Needed:

•6 Statewide (REGIONAL) Farm Fertilizer Sales
•Ag Census county expenditures on fertilizer

Steps:

•Add up Ag Census county expenditures across all 6 states, and across just those counties in the watershed.
•Determine the fraction of expenditures that occurred just within the watershed.
•Multiply the 6 Statewide (REGIONAL) farm fertilizer sales by this fraction to determine watershed-wide farm fertilizer sales.

Inorganic: County Farm Use



Data Needed:

•Watershed-wide farm fertilizer sales
•Ag Census county expenditures on fertilizer
•SB county estimate of fertilizer crop need NOT met with manure

Steps:

•Determine fertilizer crop application goal for each county and manure available for each county
•Subtract manure available from fertilizer application goal to determine remaining fertilizer crop need
•Determine fraction of county's remaining fertilizer application goal out of ENTIRE watershed's remaining fertilizer application goal
  •Multiply by 0.5
•Determine fraction of county Ag Census expenditures on fertilizer out of ENTIRE watershed's Ag Census expenditures on fertilizer.
  •Multiply by 0.5
•Add together the two weighting factors for the county
•Multiply Watershed-wide farm fertilizer sales by the sum of the weighting factors for each county.

Inorganic: Projecting Future Use

- Future fertilizer use is assumed to be related to past fertilizer use, future crop application goals and future manure available.
- Example:
  - Ratio of Total Application to Crop Application Goal from 1985 through 2012 for county was 0.9, or 90%.
  - If future Manure estimates can only account for 50% of future Crop Application Goal, then the remaining 40% is assumed to be fertilizer.

Inorganic: Nutrient Concentrations

- Phase 5 inorganic nutrient concentrations were used.
- For every 1 lb of N, 0.75 lbs is ammonia nitrogen and 0.25 lbs is nitrate nitrogen.
- For every 1 lb of P, 1 lb is phosphate.

Inorganic: Inorganic Crop Application Goal

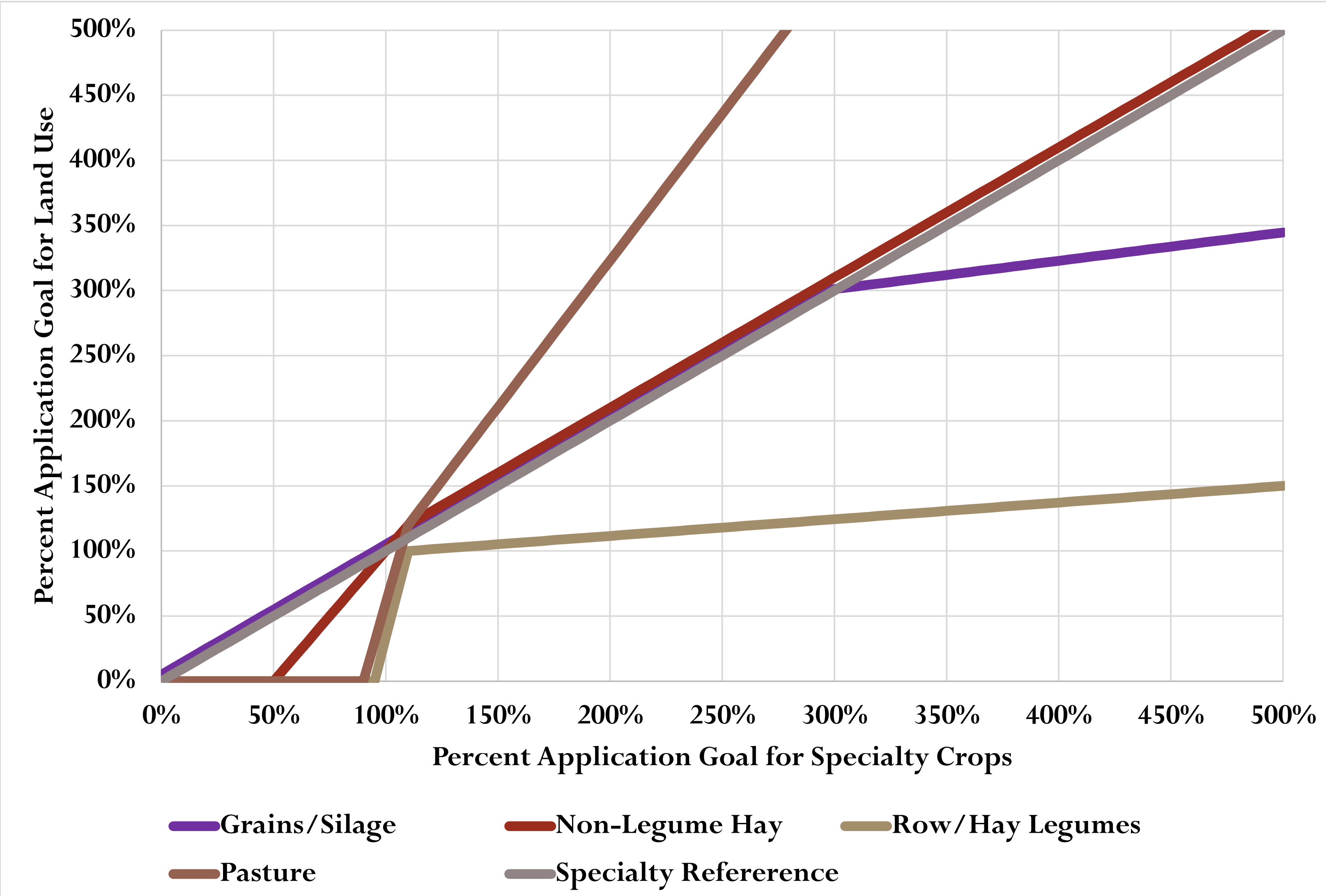
- States provided the following for each crop:
  - Total N and P application goals per acre or yield unit (varied by decade as nutrient management guidelines changed)
    - Example: 1 lb of N/bushel of corn for grain yield
  - Fraction of total application goal which should be met by applications in each month
    - Example: 0.4 of yearly total N on corn for grain should be applied in April
  - Indication of which applications are eligible to be met by only inorganic fertilizer, or by any kind of nutrient in each month
    - Example: April applications are eligible to be met by inorganic and organic fertilizer. June applications are eligible to be met by only inorganic fertilizer.

Inorganic: Incorporating Yields into Inorganic Application Goals

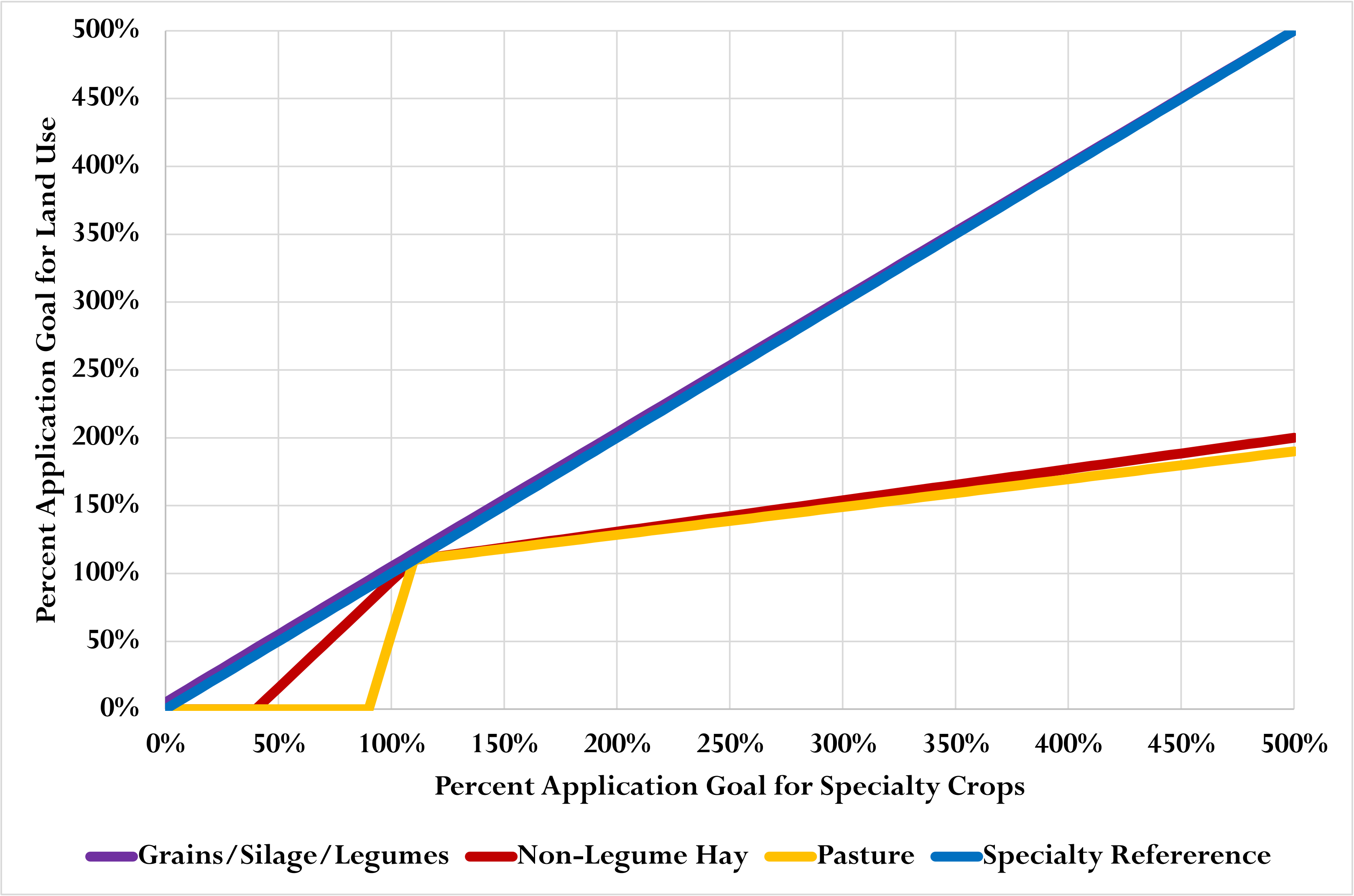
- Crop Application Goal Equation:
  - *Lbs of N/Year = State-Supplied Lbs of N/Application GoalYield Unit/Year XYield/Year X 1.25*

- Application goals are yield-based for the following major crops:
  - Alfalfa Hay; Barley; Buckwheat; Corn for Grain; Corn for Silage; Emmer and Spelt; Oats for Grain; Rye for Grain; Sorghum for Grain; Sorghum for Silage; Soybeans for Beans; Triticale; and Wheat for Grain
- Application goals are per acre for all other crops, and do not vary across the years.
- Yearly yields provided by NASS for major crops.
- AMS elected to multiply yearly yield by 1.25 assuming farmers are optimistic, and average yields are often under-estimated.

Inorganic: Prioritizing Inorganic Nitrogen Applications



Inorganic: Prioritizing Inorganic Phosphorus Applications



Fertilizer: Where to find the Data

- All model files can be found at:
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- Save "Ph6CalibrationFiles_20151109.zip."
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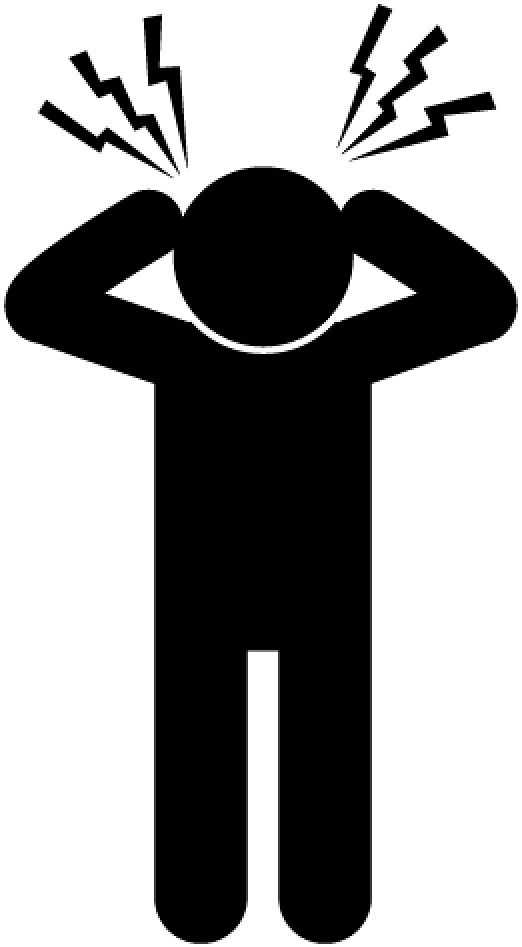
RELAX!



Files Produced by Scenario Builder

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BMP Pounds Reduced	Land-River-Segment/Land Use	Yearly

Legumes: Maximum Lbs N Fixation/Acre

Crop Name	DE_1	MD_1	MD_2	MD_3	NY_1	PA_1	PA_2	PA_3	VA_1	VA_2	VA_3	WV_1
Alfalfa Hay Harvested Area	180	300	300	300	120	240	240	240	180	180	180	180
Alfalfa seed Harvested Area	180	300	300	300	120	240	240	240	180	180	180	180
Birdsfoot trefoil seed Harvested Area	120	80	80	80	180	180	180	180	160	160	160	160
Dry edible beans, excluding limas Harvested Area	300	300	300	300	300	300	300	300	300	300	300	300
Green Lima Beans Harvested Area	300	300	300	300	300	300	300	300	300	300	300	300
Haylage or greenchop from alfalfa or alfalfa mixtures Harvested Area	180	300	300	300	120	240	240	240	180	180	180	180
Peanuts for nuts Harvested Area	90	90	90	90	90	90	90	90	90	90	90	90
Peas, Chinese (sugar and Snow) Harvested Area	300	300	300	300	300	300	300	300	300	300	300	300
Peas, Green (excluding southern) Harvested Area	300	300	300	300	300	300	300	300	300	300	300	300
Peas, Green Southern (cowpeas) – Black-eyed, Crowder, etc. Harvested Area	300	300	300	300	300	300	300	300	300	300	300	300
Red clover seed Harvested Area	120	80	80	80	180	360	360	360	160	160	160	160
Snap Beans Harvested Area	300	300	300	300	300	300	300	300	300	300	300	300
Soybeans for beans Harvested Area	30	40	40	40	130	130	130	130	40	40	40	40
Vetch seed Harvested Area	300	300	300	300	300	300	300	300	200	200	200	200

Source: States during Phase 5 development

Legumes: Accounting for Impact of Other N Applications

- Equation:
  - Lbs N Fixed/Acre/Year = Maximum Lbs N Fixed/Acre/Year – (Lbs Plant-Available N from Manure and Fertilizer/Acre/Year X 0.2021)

- Phase 6 Beta did not have legume values for pasture or urban turf grass. This will need to be adjusted prior to next Phase 6 release.

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BMP Nutrient "Pass-through" Fractions	Land-River-Segment/Land Use	Yearly
[illegible]P Pounds Reduced	Land-River-Segment/Land Use	Yearly

Nutrient Uptake: Yearly Uptake

- Theoretical uptake was collected from literature for Phase 5.
- Theoretical uptake = Total lbs of Uptake/Yield Unit
  - It is not clear if theoretical uptake is appropriate. For example, theoretical uptake for Corn for Grain is listed as 0.97 lbs N/bushel. Since applications are based upon a goal of 1 lb N/bushel, this suggests the best nutrient use efficiency ever seen!

- Equation for Major Crop Final Uptake
  - Lbs of Final Uptake = Lbs of Theoretical Uptake/Yield Unit X Yield

- Equation for Non-Major Crop Final Uptake
  - Lbs of Final Uptake = Lbs of Theoretical Uptake/Yield Unit X 0.61 X Phase 5 Maximum Yield

- Non-Major Crops do not have yields that vary by year. To determine how to adjust theoretical uptake based upon yields, the ratio of Phase 5 Maximum Yields for all Major Crops was compared to the Actual Yields from NASS for all Major Crops.

Nutrient Uptake: Monthly Uptake

- Monthly uptake is related to heat units received by crops during each day of the growing season.
- Monthly uptake can vary by county.
  - Heat Units Equation:
    - Daily Heat Unit = (Mean Daily Temperature Minimum + Mean Daily Temperature Maximum/2) – Crop Basal Temperature
  - Monthly Fraction Uptake Equation:
    - Sum of Daily Heat Units for Month/Sum of Heat Units for Growing Season

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BMP Pounds Reduced	Land-River-Segment/Land Use	Yearly

Soil Cover

- Soil cover by crops is the same as the fraction of soil surface that is not considered available for erosion by interception.
- RUSLE2 data for both canopy cover and residue cover were gathered for each crop for each month (even months outside the growing season). Whichever value was greater became the soil cover fraction.
- BMPs were left out of the RUSLE2 analysis.
- RUSLE2 scenarios were designed using existing Scenario Builder crop data (such as planting and harvesting dates), and in coordination with NRCS personnel across the watershed.

Photo courtesy USDA-NRCS

Detached Sediment

- Detached sediment is the difference in tons of sediment eroded due to plowing.
- Calculated for all row crops as the difference between RUSLE2 scenarios for plowing and no plowing other than planting.
- Not calculated for pasture or hay
- RUSLE2 scenarios were designed using existing Scenario Builder crop data (such as planting and harvesting dates), and in coordination with NRCS personnel across the watershed.

Photo courtesy USDA-NRCS

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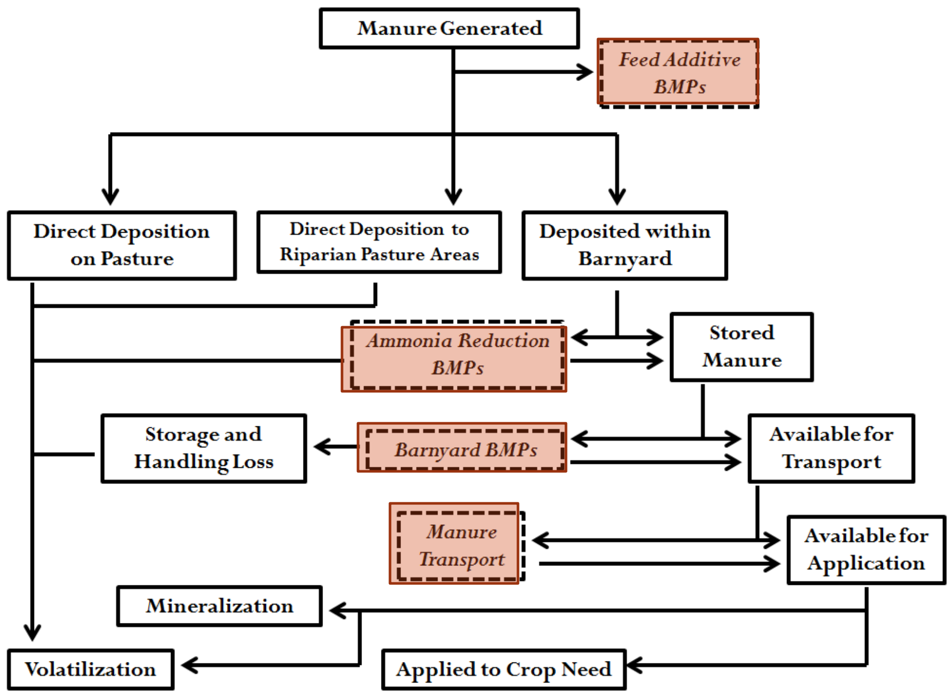
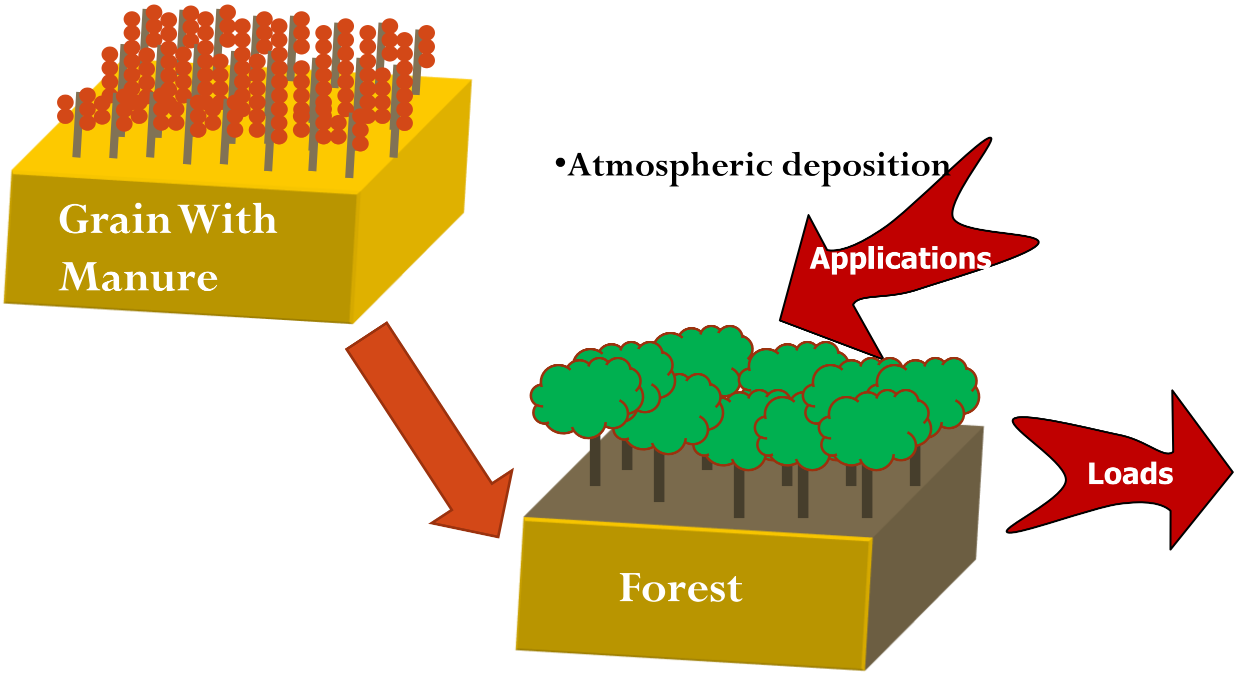
BMPs: Land Input Load Reduction Practices

- Some BMPs, such as Dairy Precision Feeding, can change the amount of nutrients available for land application.
- These BMPs are captured in the crop application sequence, not in the BMP files sent to the Watershed Model.



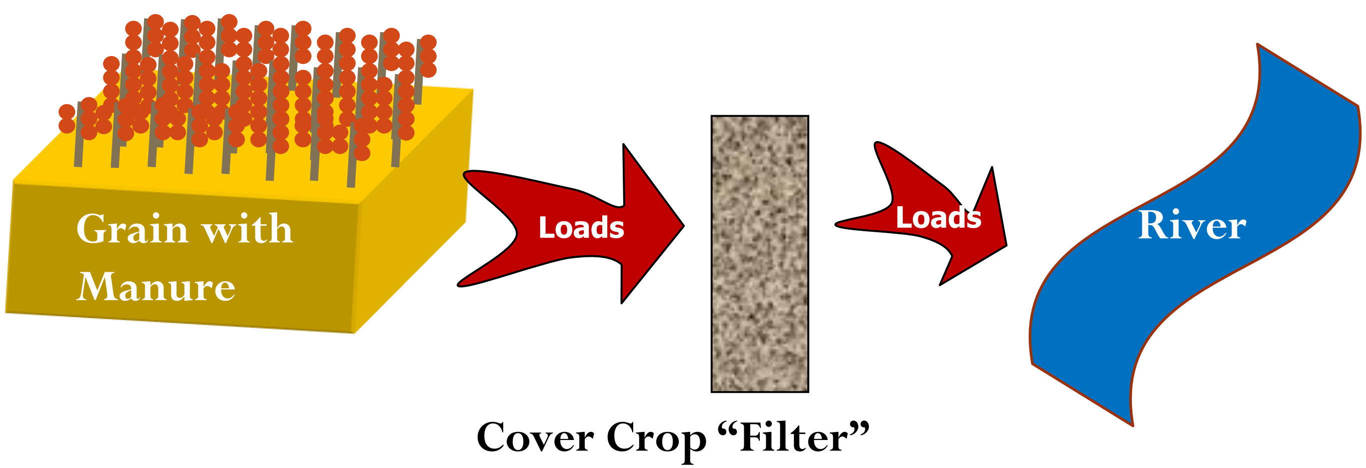
BMPs: Land Use Change Example: Tree Planting



- Some practices simply convert one acre of higher loading land use to another acre of a lower loading land use.
- This conversion is simulated before applications are made to crops.

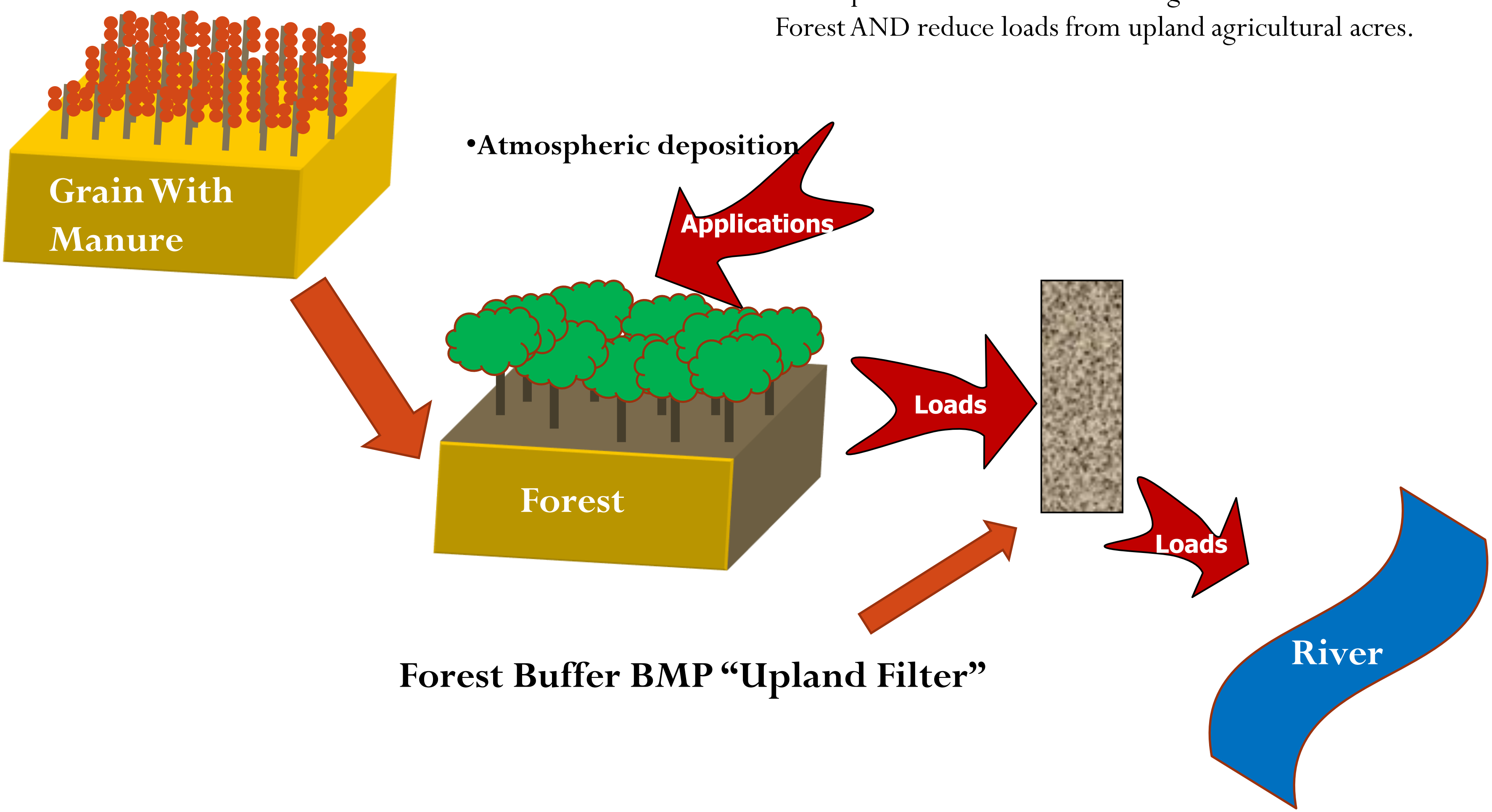
BMPs: Effectiveness Value Example: Cover Crops

- Most BMPs reduce the load simulated from the land by a percentage.
- For example, a Late Other Wheat Cover Crop planting can reduce the nitrogen load from Grain with Manure by about 10.15%.



BMPs: Land Use Change and Upland Reduction Example: Forest Buffers

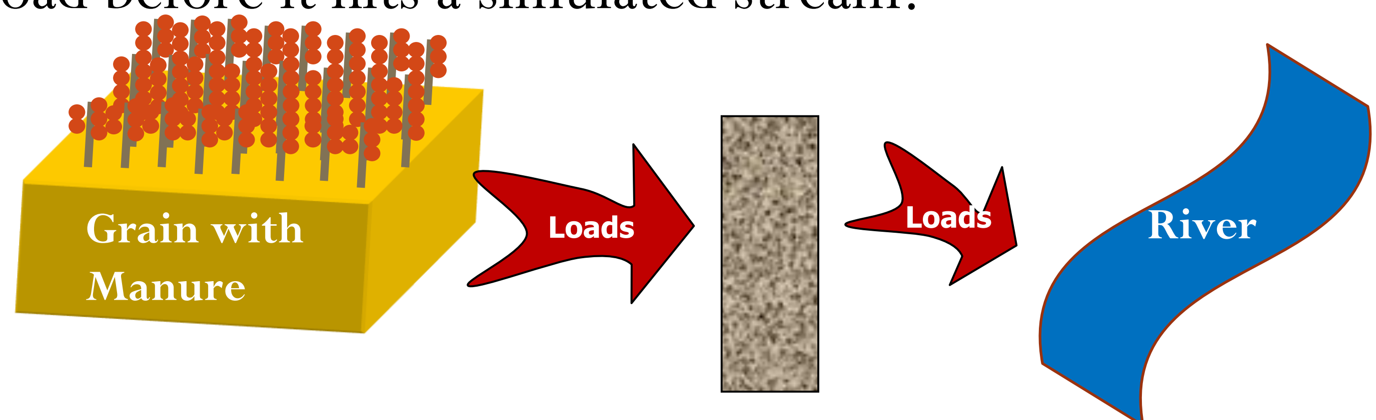
- Some land use change BMPs alter the land uses before any applications are calculated, AND reduce the loads from additional upland acres.
- Example: Forest Buffers will change Grain with Manure to Forest AND reduce loads from upland agricultural acres.



Forest Buffer BMP "Upland Filter"

BMP Pass-Throughs

- BMPs with effectiveness values reduce nutrient loads in the Watershed Model.
- Scenario Builder provides the Watershed Model with nutrient pass-through fractions for each land use.
- The Watershed Model applies these pass-through fractions to the originally calculated load for the land use, reducing the load before it hits a simulated stream.



BMP Pass-Through "Filter"

BMPs: Group Pass-Through Calculations

- BMPs are arranged into groups of similar practices that cannot be placed upon the same acre (e.g., cover crops).
- An aggregate pass-through fraction is calculated for each group and each land use.
- Group Pass-Through Fraction Equation:

$$F_g = 1 - \sum_{BMP=1}^{n} \left(\frac{i}{t} * E_{BMP} \right)$$

Where:
F = Pass-Through Fraction
g = BMP group
n = total number of BMPs in the group
BMP = specific BMP
i = Acres of specific BMP implementation
t=Acres of specific land use available for specific BMP implementation
E = BMP effectiveness fraction

Example Group Pass-Through Calculation for Nitrogen on Grain with Manure

0.8729 = 1 – ((100 acres/2000 acres X 0.1015) + (400 acres/2000 acres X 0.2603) + (500 acres/2000 acres X 0.2803)

Where:
100 acres = acres of grain with manure with late, other wheat cover crop
400 acres = acres of grain with manure with standard, drilled barley cover crop
500 acres = acres of grain with manure with early, drilled wheat cover crop
2,000 acres = acres of grain with manure
0.1015 = nutrient reduction efficiency of late, other wheat cover crop
0.2603 = nutrient reduction efficiency of late, other barley cover crop
0.2803 = nutrient reduction efficiency of early, drilled wheat cover crop

BMPs: Overall Pass-Through Fractions

- While two cover crops cannot receive credit on the same acre of land, an acre can have both a cover crop and continuous high residue tillage, as an example.
- To simulate these overlapping BMPs, an overall pass-through fraction is calculated for each land use.
- Overall Pass-Through Fraction Equation:

$$F_O = \prod_{g=1}^{G} F_g \leq 1$$

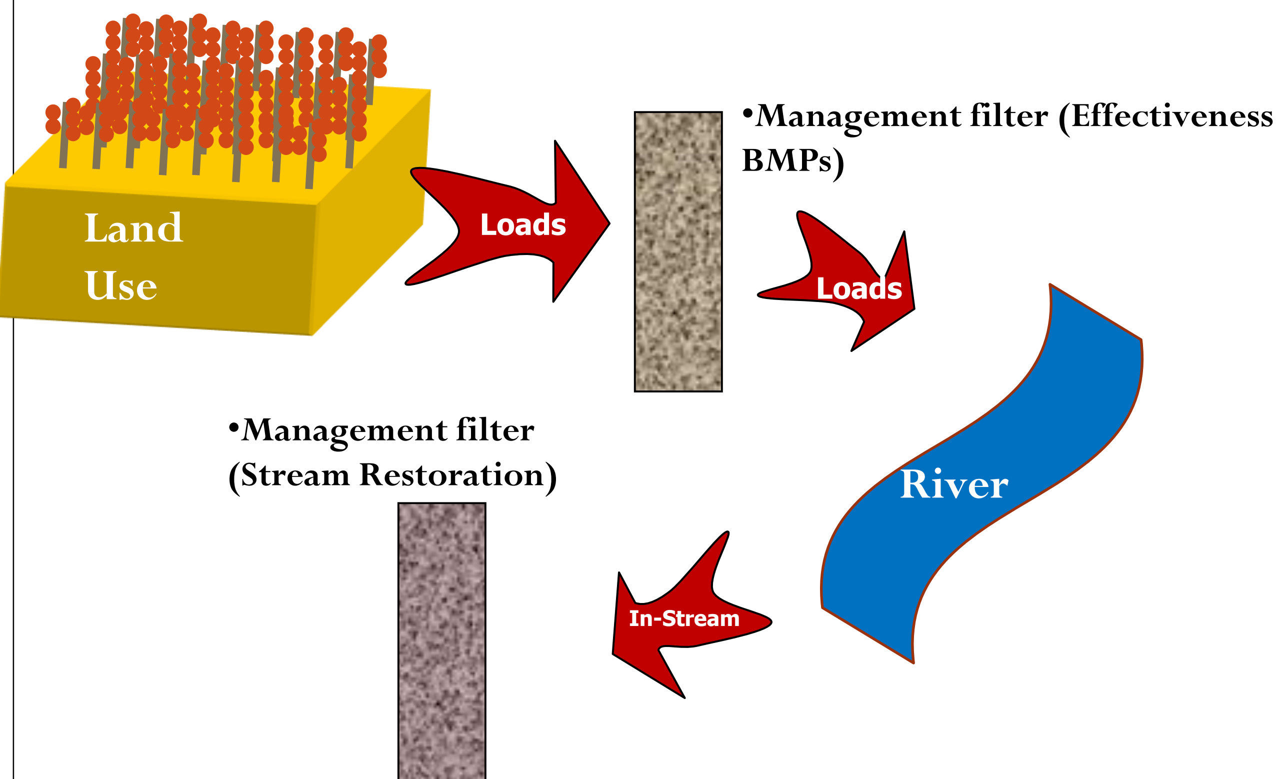
Where:
F = Overall Pass-Through Fraction
g = specific BMP group
G = Total number of BMP groups

Example Overall Pass-Through Calculation for Nitrogen on Grain With Manure:

0.8463 = 1 – (0.8728 X 0.9696)

Where:
0.8728 = group pass-through for cover crops
0.9696 = group pass-through for high residue tillage

BMPs: Land Output Load Reduction Example: Stream Restoration



- Some BMPs reduce loads which have already made it to a simulated river in the Watershed Model.
- For example, stream restoration may reduce the total sediment load coming from all agricultural lands in a land-river segment by 1,000 lbs (reductions vary by project).
- These are simulated after all upland land use change and effectiveness value BMPs has been simulated.

Files Produced by Scenario Builder

Input	Spatial Scale	Temporal Scale
Septic Nutrient Loads	Land Segment	Daily
Land Use Acres	Land-River-Segment	Yearly
Manure Nutrient Applications	Land Segment/Land Use	Monthly
Inorganic Fertilizer Nutrient Applications	Land Segment/Land Use	Monthly
Legume Nitrogen Fixation	Land Segment/Land Use	Monthly
Nutrient Uptake	Land Segment/Land Use	Yearly
Nutrient Uptake Monthly Fractions	Land Segment/Land Use	Monthly
Crop Soil Cover Fractions	Land Segment/Land Use	Monthly
Detached Soil Fractions	Land Segment/Land Use	Monthly
Riparian Pasture Access Area Nutrient Loads	Land-River-Segment/Land Use	Monthly
Animal Feeding Area Nutrient Loads	Land-River-Segment/Land Use	Yearly
BMP Nutrient "Pass-through" Fractions	Land-River-Segment/Land Use	Yearly
BMP Pounds Reduced	Land-River-Segment/Land Use	Yearly

Questions…