Disclaimer: This document is not a comprehensive draft of the AWMS BMP expert panel's full report. It excludes information that is currently under development or deliberation by the panel; text in this document may be revised or removed entirely for purposes of the panel's forthcoming full report, but much of the information below is expected to appear in the final report. Thus, **this document should not be cited nor used for review purposes beyond the preliminary recommendations for the fourth-beta version of the Phase 6 Watershed Model**. Furthermore, **the reader should be aware that figures, references, and other text below may exhibit inconsistent formatting or gaps at this time**. Effort has been made to ensure that Tables 1-20 are continuously numbered and referenced in the text, but other Figures or citations have not been edited for consistency across chapters for this document. **The reader is asked to ignore inconsistencies or gaps in flow, formatting or editing as this document is only intended to supplement the information presented for decision on 9/22/16.**

Contents

Background: charge and membership of the expert panel

In late 2014 through early 2015 the Agriculture Workgroup (AgWG) worked to form an ad hoc Expert Panel Establishment Group (EPEG) for Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads. The ad hoc group was asked to:

- Identify priority tasks for the first Phase 6.0 (P6.0) Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads Expert Panel (EP),
- Recommend areas of expertise that should be included on the Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads EP, and
- Draft the Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads EP's charge (the assigned tasks) for the review process.

From February 13, 2015 through March 5, 2015 the EPEG worked collaboratively to complete the above charge. Their report was approved by the AgWG in March 2015.

Virginia Tech, through its Expert Panel Management Cooperative Agreement with the Chesapeake Bay Program, subsequently worked to convene this expert panel to evaluate these AWMS BMPs as directed in the Charge and Scope of Work described in the EPEG's approved report. A group of experts that conformed to the EPEG's recommended needs for expertise. Following the BMP Protocol, the partnership was asked to review the proposed panel membership, which was approved by the AgWG in October 2015. The panel membership is included in Table 1 below.

Table 1 - Expert panel membership and support

Name	Affiliation	Role
Shawn Hawkins	University of Tennessee	Chair
Doug Hamilton	Oklahoma State University	Member
Jonathan Moyle	University of Maryland Extension	Member
Pete Vanderstappen	USDA-NRCS-Pennsylvania	Member
Mark Risse	University of Georgia	Member
Bridgett McIntosh	Virginia Tech	Member
Support:		
Jeremy Hanson	Virginia Tech, CBPO	Coordinator
Ashley Toy	EPA Region 3	Regulatory Point of Contact
Matt Johnston	University of Maryland, CBPO	CBP modeling team rep
Greg Albrecht	NYS Dept. of Ag and Markets	WTWG rep

The panel was asked to review the Phase 5.3.2 definition and loading or effectiveness estimates for AWMS practices and make adjustments or modifications as needed for Phase 6.0. In addition, the panel was asked to review and provide recommendations on the current standard baseline estimates of environmental nutrient losses associated with storage of various types of livestock and poultry manures for the Phase 6 modeling tools. The Panel was instructed to consider the results of a recent survey of CBW jurisdictions on animal waste management systems that they track and report (see Attachment 1 of Appendix B) as they determined which waste storage system types to include in their deliberations. Further, the Panel was asked to consider different loss and recoverability factors for specific animal species, livestock manure types, and manure storage and handling systems. They were instructed to consult regionally-appropriate published data sources in developing recommendations, including both of the following two USDA-NRCS reference sources:

- Table 11-5 of the USDA-NRCS *Agricultural Waste Management Field Handbook Chapter 11, Waste Utilization*, and;
- Table B-3 of USDA-NRCS *Costs Associated With Development and Implementation of Comprehensive Nutrient Management Plans. Part I—Nutrient Management, Land Treatment, Manure and Wastewater Handling and Storage, and Recordkeeping*[1]

As a part of their charge, the Panel was also directed to develop a recommendation on the partnership's request for a definition and loading or effectiveness estimates for Poultry Heavy Use Area Concrete Pads. The Panel was instructed to address only issues related to waste storage, while any effects of treatment will be covered by the Manure Treatment Technologies Expert Panel. Collaboration between the two panels was encouraged to ensure that recommendations are complimentary as well as to avoid double-counting and ensure effective reporting of practices. This collaboration was ensured by including Doug Hamilton (Chair of the Manure Treatment Expert Panel) as a member for this AWMS panel.

Finally, the panel was instructed to develop a report that includes information as described in the Water Quality Goal Implementation Team's *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model*, referred to as the BMP Protocol.[2] Throughout their deliberations the panel conformed to the expectations described in the BMP Protocol.

This preliminary report is provided to allow the Agriculture Workgroup to approve incorporation of the panel's current best professional judgment in the fourth beta version of the Phase 6 Watershed Model. The panel's estimates may be slightly revised in their final report based on new information or in response to feedback received from the partnership as the final report undergoes the BMP Protocol process.

[1] http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_012131.pdf
[2] http://www.chesapeakebay.net/publications/title/bmp_review_protocol

Background: livestock manure handling and the Chesapeake Bay Watershed Model

In the current version of the Chesapeake Bay Program (CBP) partnership's Watershed Model (version 5.3.2), Animal Waste Management Systems (AWMS) are defined as "practices designed for proper handling, storage, and utilization of wastes generated from confined animal operations. Reduced storage and handling loss is conserved in the manure and available for land application." In the current Chesapeake Bay Watershed Model (CBWM), an AWMS reduces the environmental loss of nitrogen and phosphorus from stored livestock manures through surface runoff, by the implementation of federal or state recognized engineered storage and handling systems.

The Phase 5.3.2 modeling tools incorporate a standard estimate of baseline environmental nutrient losses from improper storage and handling based on the consistency of the livestock manure; e.g. solid or liquid. For solid and semi-solid manure types, the baseline loss assumption is 15% of the manure whereas for liquid or slurry types of manure the baseline loss is 20%. Nutrient losses are applied as a base environmental load irrespective of the potential impacts of the livestock housing facility, from which the AWMS BMP effectiveness values are applied, i.e. the current 75% effectiveness value is applied to the baseline loss of either 15% or 20%, reducing the environmental load accordingly and making that portion of manure for field application or other manure processes. Atmospheric ammonia losses are not directly affected by AWMS BMPs, but managed through a separate atmospheric management BMP.

Poultry Heavy Use Area Concrete Pads represent the current industry standard of placing concrete pads at the primary doors of poultry housing facilities to reduce environmental litter handling losses during crust out and total house cleanup operations. These structures are not currently recognized as an existing or interim BMP by the Phase 5.3.2 models, and thus are not simulated in the Watershed Model for either implementation credit or for planning purposes until recommendations from an expert panel are adopted by the CBP partnership.

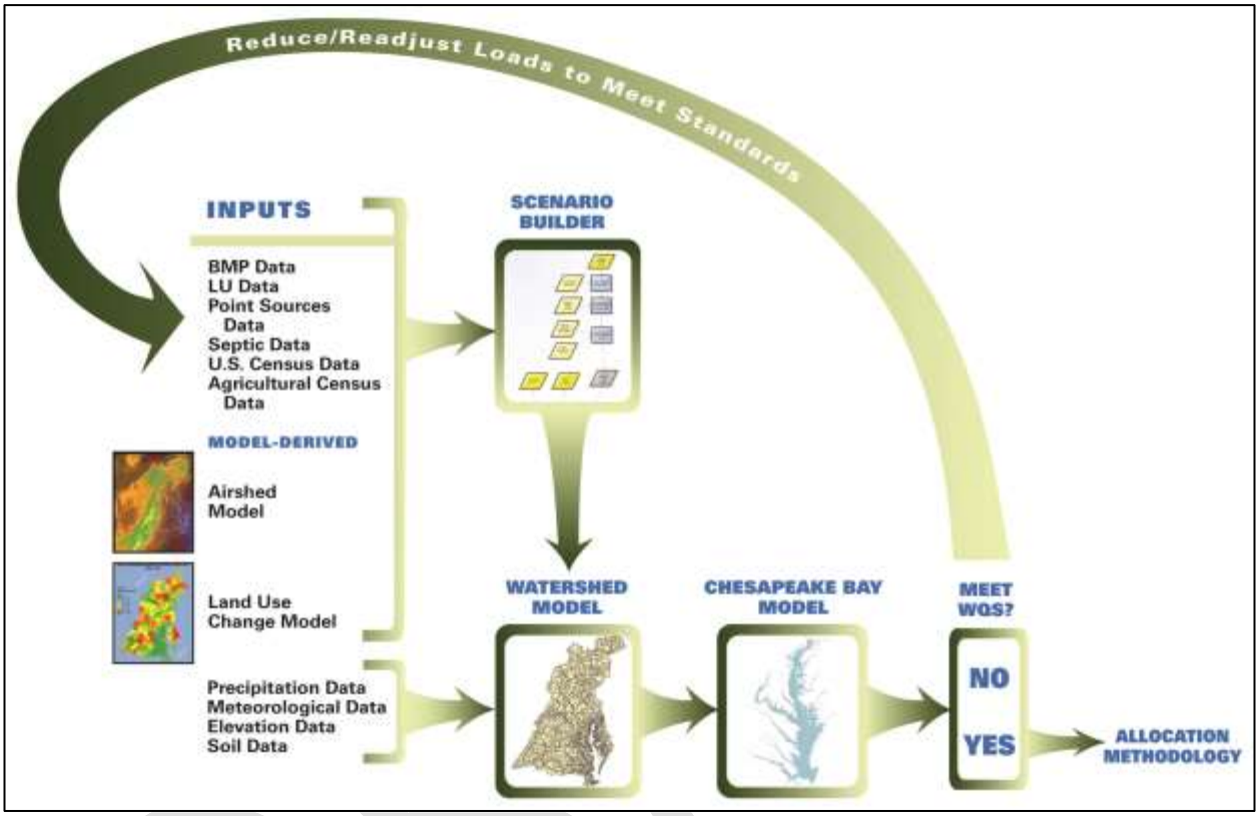
How animal manure and animal waste management systems are simulated in the modeling tools

Manure from animal agriculture is the largest source of phosphorus loads to the Chesapeake Bay and the second largest source of nitrogen. Traditionally, the manure from livestock and poultry has been a valuable resource for farmers as a cost-effective fertilizer. When used appropriately, manure adds nutrients and organic matter that improves soil quality. However, manure's ratio of phosphorus to nitrogen is higher than a crop's need, so over-application contributes to excess phosphorus in the soil. Manure is also a bulky material that is costly or difficult to transport long distances to areas where it is needed. Excess nutrients in some areas of watershed make nutrients in the soil more susceptible to runoff.

How nutrient loads from livestock manure will be simulated in the Phase 6 Chesapeake Bay Watershed Model

The Chesapeake Bay Watershed Model (CBWM) is one part of a larger suite of tools used by Chesapeake Bay Program partners, as illustrated in Figure 1. The Watershed Model combines all BMP, land use and nutrient input data to estimate delivered loads of nitrogen, phosphorus and sediment to the Chesapeake Bay. The Estuarine Model then uses these delivered loads to assess attainment of water quality standards. The Phase 6 Model will be calibrated to water quality monitoring data over the period of 1985 to 2013.

Figure 1. Chesapeake Bay Program partnership modeling tools (Phase 5.3.2)



Scenario Builder

Scenario Builder is a database management tool that combines a wide array of inputs for a given year and processes them into a single, comprehensive scenario for the Watershed Model to run, as illustrated in Figure 1 above. Scenario Builder is the tool where manure and nutrient inputs are combined with BMP implementation data reported annually by the states through the National Environmental Information Exchange Network (NEIEN).

How Scenario Builder simulates agricultural nutrient inputs from animal manure

Scenario Builder estimates nutrient applications to crops on a monthly basis. Monthly nutrient needs for each crop in each county are estimated based upon acres of crops reported by the USDA NASS Census of Agriculture (Ag Census) and yield and application rate/timing data provided by the Ag Census, literature sources and state agricultural agencies. The monthly nutrient need of each crop can be met by organic nutrients (manure and biosolids) and/or by inorganic nutrients (fertilizer).

The Phase 6 Scenario Builder first generates estimates of manure and fertilizer available to crops in a county based upon animal populations, manure nutrient concentration assumptions and fertilizer sales data. These nutrients are then spread across all acres of crops in a county to fulfill crop need using an optimization routine which prioritizes high-value crops such as corn, wheat, soybeans and vegetables. Hay, pasture and other crops are considered to be of lesser priority, and only receive nutrients in counties which have nutrients to spare after the majority of high-value crops' need is accounted for. Regardless of how few or how many nutrients are available in a county, they are all distributed to the land by Scenario Builder. As discussed previously, AWMS practices can increase the amount of nutrients available to be land-applied.

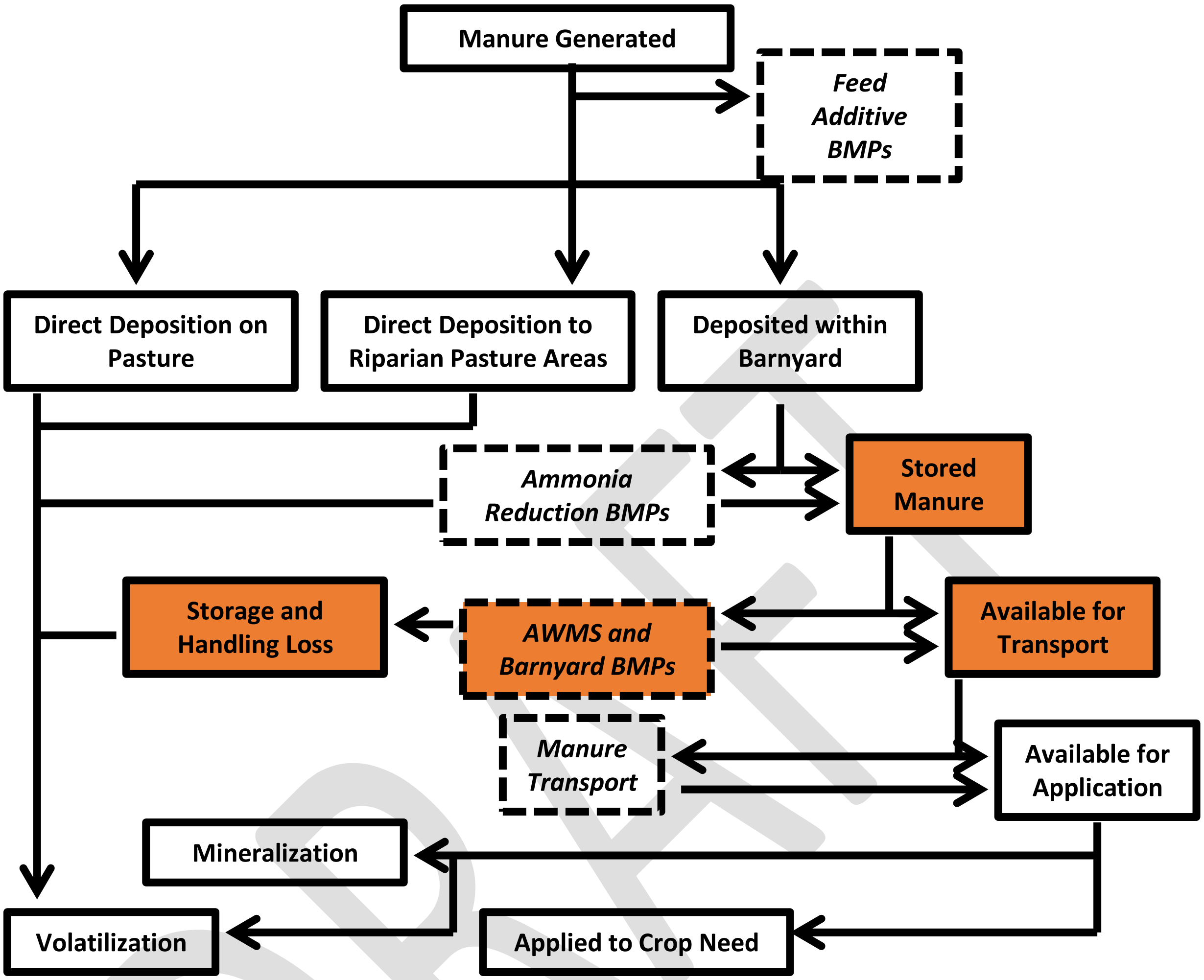
How AWMS fits in the modeling tools

This section describes how AWMS practices conceptually relate to the Phase 6 Watershed Model in relation to other process steps in the CBWM. Basically, the nutrients associated with manure go through five simple steps in the modeling tools:

1. Manure is produced/excreted
2. Manure is placed in storage
3. A portion of nitrogen from the manure is volatilized
4. Manure is lost through storage and transport
5. Manure is applied to crops

The panel did not need to be concerned with manure treatment or field application questions. This panel was asked to focus on the nutrient loss or recoverability associated with baseline manure storage and handling, and consider how storage BMPs reduce that nutrient loss (i.e. improve manure recoverability). The full range of steps and processes for manure in the Phase 6 CBWM are illustrated in Figure 2 below. The orange boxes represent the points where the panel's recommendations have a direct role, meaning their assessment of the baseline and BMP conditions for AWMS are a factor that determines how much of the stored manure is either directly lost or remains available for subsequent Manure Transport or field application.

Figure 2. Manure Application Processes in the Phase 6 Watershed Model



The current version of Scenario Builder contains 13 types of animals, listed below. Scenario Builder makes assumptions for animal weight, manure generation, and nutrient content based on the best available sources. Whereas this AWMS expert panel's purview is limited to the baseline and BMP conditions assigned in its charge, other CBP groups such as the Agriculture Workgroup and Modeling Workgroup oversee and make partnership decisions related to the processes and assumptions used to simulate animal manure in the modeling tools. Though there are 13 animal types, the vast majority of nutrients from manure in the watershed are generated by poultry, dairy, beef, and swine.

Animal types in the CBWM		
beef	pullets	angora goats
dairy	turkeys	milk goats
other cattle	hogs and pigs for breeding	sheep and lambs
broilers	hogs and pigs for slaughter	
layers	horses	

Overview of animal waste management as a system

Primary Reference Document

The primary reference document utilized by the AWMS Expert Panel was "Costs Associated With Development and Implementation of Comprehensive Nutrient Management Plans Part I – Nutrient Management, Land Treatment, Manure and Wastewater Handling and Storage, and Recordkeeping" (USDA Natural Resources Conservation Service, 2003). This document, through a process of best professional judgement by a team of 10 experts, assigned manure recoverability factors for model farms defined with a size category and AWMS (**Table 2)**. The principal technique used to estimate manure recoverability relied on an earlier publication by Robert L. Kellogg, Charles H. Lander, et al. (2000), which defined total manure recoverability (% of voided manure) for different animal types (**Table 2**). Robert L. Kellogg, Charles H. Lander, et al. (2000) defined manure recoverability for confined animals, and provided head counts below which all animals were unconfined (with no recoverable manure) and above which animals were continuously confined.

The values in **Table 2** by Robert L. Kellogg, Charles H. Lander, et al. (2000) are slightly modified from an earlier concept paper by Charles H. Lander, David C. Moffitt, et al. (1998). Only one difference exists between the manure recoverability factors of Charles H. Lander, David C. Moffitt, et al. (1998) and **Table 2**: for Virginia and West Virginia, manure recoverability for all poultry types was assumed to be 100% (versus 90-98% in **Table 2**). There is no documentation to explain this difference, but as far back as the mid-late 1970s it was asserted that manure from poultry farms was 100% recoverable (Donald L. Van Dyne and Gilbertson, 1978, Gilbertson, Dyne, et al., 1979).

Ultimately, the information in the most important concept paper (Charles H. Lander, David C. Moffitt, et al., 1998) and **Table 2,** was developed using a survey and phone questionnaires of NRCS State Agronomist and State Engineers in the mid-1990s. The concept paper utilized early work estimating manure recoverability in the mid- to late-1970s (Donald L. Van Dyne and Gilbertson, 1978). However, only aggregate manure recoverability factors are presented by Donald L. Van Dyne and Gilbertson (1978); no detail is provided describing the computation of losses associated with recoverable manure, particularly for "losses from storage and waste handling system" or computing manure that is "economically recoverable." This suggests that the concept paper, and ultimately the primary reference document used by this Expert Panel, mimics only the technique of dividing manure between a recoverable and unrecoverable fraction in the earlier work on manure recoverability. A source of details is available for the earlier work (Gilbertson, Dyne, et al., 1979) which estimated the distribution of manure into a "barn", "paved lot" and "unpaved lot." Unpaved lots were only assumed to be used in hot-arid climate conditions. Gilbertson, Dyne, et al. (1979) did estimate losses of manure solids and nutrients for those "paved lots", but the authors noted "runoff-transported constituents represent a relatively small portion of the total manure residue." Manure voided into the "unpaved lot" within regions with other climates, including the CBW, were assumed to be unrecoverable.

Table 2. Confinement manure recoverability factors (Robert L. Kellogg, Charles H. Lander, et al., 2000).

Animal Type	Robert L. Kellogg, Charles H. Lander, et al. (2000)									USDA Natural Resources Conservation Service (2003)[a]		RECOMMENDED RECOVERABILITY FACTORS	
	Small Farm Head Count	Large Farm Head Count	Confined Manure % Recoverability	Overall manure Recoverability									
				DE	MD	NY	PA	VA	WV	Before CNMP	After CNMP	Before AWMS BMP	After AWMS BMP
Beef cows	20	None	98	10	10	10	5	10	0	-	-	-	-
Confined Heifers	20	None	98	70	70	70	65	70	70	60-65	80-85	60	99
Fattened cattle	15	200	90	85	85	85	85	85	98	60	75	60	99
Milk cows & calves	20	None	98	80	80	80	80	60	80	45-60	50-75	75	95
Hogs, breeding	10	50	95	80	80	80	80	80	75	80	97	90	99
Hogs, slaughter	50	450	95	80	80	80	80	80	75	80	97	90	99
Chickens, layers	50	400	98	90	90	90	95	98	98	85	95	90	99
Chickens, pullets	25	400	98	90	90	90	95	98	98	85	95	90	99
Chickens, broilers	100	400	98	95	95	95	95	98	98	85	98	90	99
Turkeys, breeding	50	2,000	98	95	95	95	95	98	98	80	98	90	99
Turkeys, slaughter	50	5,000	98	95	95	95	95	98	98				

[a] Continuous loafing / grazing (0% recoverable).
[b] Continuous confinement with confined manure recoverability.
[c] **Confined Heifers** – Northeast (RF#1 - RF#2); **Fattened Cattle** – PA, NY, NJ, > 35 AU/farm (AF#1: feedlot scrape, stack); **Milk cows** –Northeast, > 35 AU/farm (RF#1-RF#4); **Breeding Hogs** – Northcentral, Northeast > 35 AU/farm (RF#2: confinement, liquid, no lagoon); **Hogs for Slaughter** – Northcentral, Northeast, > 35 AU/farm (RF#2: confinement, liquid, no lagoon); **Layers** – North Central & Northeast, > 35 AU/farm (RF#1 and RF#3); **Pullets** – North Central & Northeast, (RF#1 layer type confinement house); **Broilers** – Southeast, (RF#1: confinement, standard broiler house); **Turkeys** – East, <35 AU/farm (RF#1: confinement house).

Milk Cows

Summary of recoverability factors and key conclusions

- Of the animal types considered by the AWMS Expert Panel, dairy farms were the most difficult to characterize using the model farm concept. Dairy farms are highly diverse within the CBW, both in terms of the herd size and how the farms are managed, particularly with respect to waste management systems. Most dairy farms have both solid and liquid waste management streams that are managed.

Definitions

Milk Cows. Milk cows are mature dairy cows that are being actively milked and typically confined continuously in a structure like a free stall barn that facilitates daily milking by providing direct access to the farm parlor.

Animal Unit. 1,000 lbs of live animal weight. To convert between a given number of dairy cows and AUs, a dairy cow is assumed to average 1,350 lbs.

Watershed Population

According to the 2012 USDA Agricultural Census, there are approximately 1.3 million dairy cows within the six states that contain the CBW (**Table 3**). A large percentage of these milk cows are located in counties outside of the CBW (39%) or in counties with less than 50% of the county area within the CBW (19%) (**Table 3**). Although New York contains substantial numbers of dairy farms, less than 1% of the state milking herd is located in counties that contain some portion of the CBW. The vast majority of milk cows within counties that are wholly with the CBW (481,594) are found in Pennsylvania (363,663) (**Figure 3**).

The 2012 USDA Agricultural Census contains county level data on dairy farm size (number of dairy cows/farm). In this section of the Census, 342,736 dairy cows were reported on Pennsylvania farms in counties contained entirely within the CBW. The most important counties are Lancaster and Franklin counties which together house nearly half (46%) of the Pennsylvania dairy herd (**Table 4**).

The Ag Census partitions milk cow operations across 7 size categories (**Table 4**). The majority (57%) of these dairy cattle (190,720) are on farms with 20-99 head. Lancaster county farms that house between 20 and 99 milk cows (77,385) account for approximately one fourth (23%) of the state dairy herd; clearly substantial portion of Pennsylvania dairy cattle are located on small, plain sect farms. The vast majority of the remaining Pennsylvania farms house 100-199 (67,676; 20%) and 200+ dairy cows (81,569; 24%) (**Table 4**). Very small dairy farms, those with less than 20 milk cows, are insignificant (**Table 4**). Since the "before" condition of the CBW model (simulated with Ag Census year 1987), the Pennsylvania dairy cow herd has decreased ≈ 50% while a dramatic increase (8x) has occurred in the number of large farms (500+ head) (**Table 4**).

Table 3. A summary of the milk cow population in states that contain the CBW. The total dairy cow numbers and the percentage of the 6-state grand total are presented for counties that are: outside the CBW, with < 50% or > 50% of the county area within the CBW, and for those counties entirely within the CBW.

State	Outside CBW		<50% Inside CBW		>50% Inside CBW		Inside CBW		Total	
	#	%	#	%	#	%	#	%	#	%
Delaware	0	0	2,712	0	1,800	0	0	0	4,512	0
Maryland	0	0	3,088	0	2,142	0	45,225	3	50,455	4
New York	405,753	31	163,474	13	22,767	2	18,591	1	610,585	47
Pennsylvania	58,859	5	76,330	6	33,339	3	363,663	28	532,191	41
Virginia	30,850	3	4,606	0	3,091	0	50,521	4	89,068	7
West Virginia	4,725	0	1,056	0	0	0	3,594	0	9,375	1
Grand Total	500,187	39	251,266	19	63,139	5	481,594	37	1,296,186	100

Figure 3. A stacked bar chart illustrating the total number of dairy cows located in states that contain the CBW.

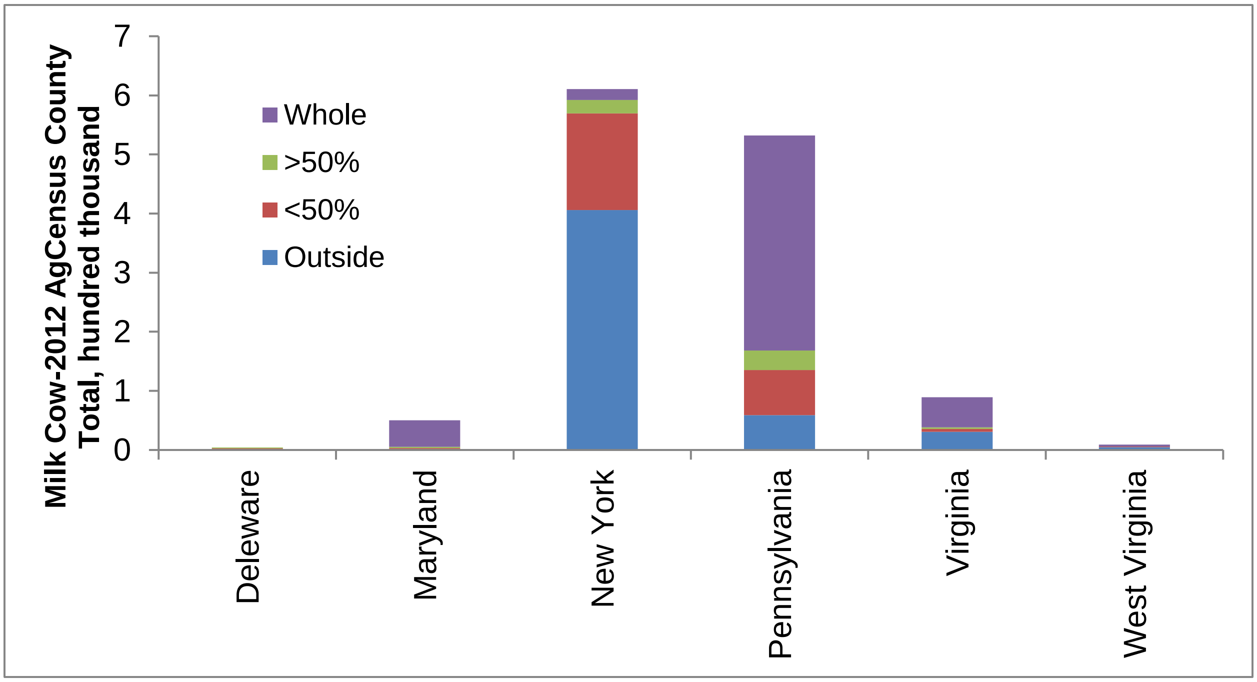


Table 5. An estimate of dairy cows within Pennsylvania counties that lie entirely within the CBW. Results are categorized by farm size.

Farm Size (# of dairy cows)	2012 Ag Census Data						1987 Ag Census Data	
	Lancaster		Franklin		Statewide		Statewide	
	#	%	#	%	#	%	#	%
1-9	377	0	62	0	1,177	0	5,680	1
10-19	205	0	132	0	1,594	0	15,733	2
20-49	33,936	10	2,217	1	65,701	19	235,735	35
50-99	43,449	13	12,279	4	125,019	36	266,083	40
100-199	11,784	3	16,067	5	67,676	20	116,793	17
200-499	5,474	2	10,158	3	43,804	13	28,844	4
500+	15,580	5	5,489	2	37,765	11	4,686	1
Grand Total	110,805	32	46,404	14	342,736	100	673,054	100

Table 4 Dairy AWMS descriptions included in a 1995 survey of 2,542 farms (United States Department of Agriculture, 1996).

AWMS		% of operations			
		Farm size, dairy cows			Total
		< 100	100-199	200+	
Cow Housing Removal System	Gutter cleaner	74	35	9	63
	Alley scraper (mechanical or tractor)	50	82	85	60
	Alley flushed with water	<1	4	27	3
	Other	1	<1	<1	1
Storage System	Below floor slurry or pit	5	20	17	8
	Slurry storage in tanks	3	11	18	5
	Slurry storage in earth-basin	14	25	28	16
	Anaerobic lagoon with cover	<1	<1	1	<1
	Anaerobic lagoon without cover	6	18	47	11
	Aerated lagoon	<1	3	8	2
	Manure pack	22	20	14	21
	Outside storage for solids (not in dry lot or pen)	38	33	30	37
	Outside storage within dry lots or pens	15	12	22	15
	Solids in a building with cattle access	3	4	2	3
	Other	2	2	2	2

Table 6. A summary of BMP placement and % recovery of manure (M before and after implementation of a CNMP (excluding dairies with < 35 AU).

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Model Farm. The primary reference document contains four model dairy farms for the "Northeast Region" that includes southern Pennsylvania. (USDA Natural Resources Conservation Service, 2003): #1 - no storage, #2 - solids storage, #3 - liquid storage in a deep pit or slurry, and #4 - liquid storage in a basin, pond, "lagoon."

These model dairy farms were formulated using best professional judgement and the information contained in a 1995 survey of 2,542 dairies (United States Department of Agriculture, 1996) containing simple AWMS descriptions (**Table 5**). At the time of the survey, smaller dairy farms tended to remove manure from cow housing using both gutter cleaners and alley scraping to an outside solids storage structure; larger dairies also scraped alleys, but more frequently using flushing systems with storage in pits, earthen-basins, and "lagoons" (assumed to be simply holding ponds). Small dairies (<100) tended to apply manure with a broadcast/solid spreader (91%) and less often as a slurry (surface application) (18%). A much larger percentage of larger dairies (200+) tended to irrigate waste water (41%). In short, smaller dairies tended to manage manure more often as a solid or slurry, while large dairies tended to manage manure more as a liquid waste.

According to the 1995 survey, a large percentage of farms, 30 and 47% of farms in summer and winter, respectively, spread manure daily (likely small farms managing manure as a solid or slurry with little or no manure storage). However, many of the farms, 33 and 31% for summer and winter, respectively, spread manure less often than monthly (likely larger farms managing manure as a liquid with significant manure storage capacity). For the Northeast Region, much of the manure was unrecoverable because 70 of dairies pastured lactating cows for at least 3 months, with 27% of those cow receiving 90% of roughage while on pasture (United States Department of Agriculture, 1996).

Mr. Vanderstappen summarized common AWMSs found in Pennsylvania based on his many years of service with the USDA NRCS in Pennsylvania:

- Tiestall barn with gutter cleaner directly loaded to a manure spreader or into short-term (< 30 days), mid-length (30-90 days) or long term storage (90-180 days). (slurry system)
- Tiestall barn with gravity flow directly loaded into a mid-length (30 to 90 days) or long-term storage (150 to 180 days). (Slurry system)
- Freestall barn using manual scrape or flush into short-term (< 30 days), mid-length (30-90 days), or long term (90-180 days) storage. (liquid system)
- Composted bedded pack with 25% liquids on feed alley to mid-length (30-90 days) or long-term (90-180 days) storage. (solid and liquid manure systems)
- Manure collection under barn. (slurry system)

These model dairy farm size categories are similar to the Census dairy farm size categories (**Table 4)**: < 35 AU, 35-135 135-270, and > 270 correspond to < 26, 26-100, 100-200, and > 200 dairy cows, respectively (assuming the average dairy cow is 1,350 lbs).

The majority (57%) of Pennsylvania dairy cattle (190,720) are on farms with 20-99 head, which corresponds to the reference North Central and Northeast farm size of 35-135 AU (**Table 4;**). Fewer dairy cows are on farms with the reference 135-270 AU (67,676; 20%) or > 270 AU farm sizes (81,569; 24%). These farms are assumed in the primary reference document to possess four different AWMS types: #1-no storage, #2-solids storage, #3-liquid storage (deep pit or slurry), #4-liquid storage (basin, pond, lagoon) with 45-60% of the manure recovered before adoption of a CNMP and 50-75% after adoption of the CNMP.

Using the reference document model farm concept, the 1985 model farm would:

- Be located in Lancaster County, Pennsylvania.
- Would utilize a mixture of solid manure and slurry and/or liquid manure AWMSs.

Current census data clearly indicate that the < 35 AU model farm dairy size should be eliminated from consideration because such farms are increasingly uncommon (**Table 4**). The current model farm is more difficult to describe than the model farm for other animal types in this report, but in general the following characteristics will be the most common:

- Be located in Lancaster County, Pennsylvania.
- The more common AWMS is movement by gutter cleaner to storage or scraping to the outside and then into the storage. Some of these areas may have wastes overtopping curbs (estimated as less than .5% of the volume).
- Many of the smaller operations are open concrete lots that also must be scraped into the storage. The opportunity for minor losses at the entrances or over the curbing also exist. Also, these open lots experience heavy snow that must be removed. The process may end up having some material inadvertently removed during the cleaning process. They also experience direct rainfall that the systems are designed to handle up to the 25 yr 24 hour event, however, screen plugging and other situations may result in some discharges prior to getting to the storage. These situations occur on even the best operations that are not totally confined and yet conform to CNMP regulations.

Manure recoverability factors

Mr. Vanderstappen, EP member assigned to the dairy AWMS, made contact with Mr. Moffitt, a primary reference document author, to express concern that the model dairy farm manure recoverability factors seemed too low. Mr. Moffitt confirmed that "if dairy systems involve grazing and loafing on pasture, manure deposited on these areas would be considered non-recovered". Thus, the dairy AWMS mass recoverability factors would clearly be higher than reported in the reference document.

Unfortunately, no data exist which describe the AWMS types in use on Pennsylvania dairy farms (or for other states within the CBW). There is certainly no method or data available to the EP to estimate manure practices in Pennsylvania or the broader CBW near the beginning of the modeling CBW modeling period (1983-19850. As others as noted, “little is known about the types and amounts of manure actually collected on typical dairy farms” (Powell, McCrory, et al., 2005).

What is clear from this limited study of Wisconsin dairies is that the “**apparent** manure collection” (AMC) as a fraction of the manure generated varies regionally and is correlated positively with the number of lactating animals (Powell, McCrory, et al., 2005). Importantly, of the dairies surveyed in this study, none reported the complete absence of manure collection/storage (the “no storage” model farms in the primary reference document). Also, the AMC for the lactating cows was very high for the 100-199 (95% ± 5.1 %) and the 200+ (100%) herd class size. AMC for the 50-99 herd size, likely representative of the majority of Lacaster County, Pennsylvania farms, was 76%, even though this recoverability estimate included time spent in non-confinement (for example vegetated loafing lots).

For dairy farms with good access to animal housing, limited use of pasture and unpaved lot areas were assumed and 90% of the manure was considered recoverable; dairy farms providing only limited access to a barn were assumed to recover only 10% of voided manure (Gilbertson, Dyne, et al., 1979).

In addition, based on best professional judgement of Mr. Vanderstappen, the model farm dairy size 25-135 AU with no storage is now rare and should be eliminated from consideration.

Dairy farms with > 200 AUs, according to Mr. Vanderstappen’s professional judgement (upon review of NRCS CPS 313 installations), can safely be assumed to have implemented a NMP and to possess waste management systems in which virtually all of the manure can be considered recoverable.

In the panel’s collective best professional judgment it makes sense for the other confined swine and poultry that have direct loading and no outside weather issues to consider 0.98 or higher recovery, as discussed in the following chapters. Based on the relatively greater – but still limited – opportunity for minor spillage, the panel recommend 95% recovery to allow for possible incidences and limited risk of loss. Some would argue this could be higher for current dairy operations and the 95% recoverability for post-CNMP conditions can be considered a conservative estimate.

Poultry

Summary of recoverability factors and key conclusions for poultry

- Virtually all poultry, including broilers, pullets, layers, and turkeys, are grown in total confinement. Animal housing serves as a component of the AWMS that stores manure during intermittent production cycles (flocks). This prevents manure from entering the environment during rearing and promotes efficient manure collection and storage between flock cycles. The current CBWM has the entire life cycle of all poultry types under roof (no open barnyard time). These production characteristics are true now and were true at the time the CBWM begins (≈ 1985).
- Heavy use areas (HUAs) are farm locations that are protected from rutting with concrete. HUAs primarily promote safety and prevent erosion but also facilitate recovery of the very small amount of waste (<0.1%) that is inadvertently lost during bird harvest and waste removal.
- Physical losses of poultry manure occur during waste transportation and storage, for example during: manure washed of HUAs during rain events, litter or manure blown out of trucks during transportation, and manure that adheres to equipment used to place or remove the birds from the production facilities. Such physical losses of the poultry manure are likely negligible.
- Poultry litter, after it is removed from production facilities, is now typically stored under roof prior to use as a fertilizer. Litter is less often applied immediately to crops with brief field storage. In some cases, litter is field stored for several weeks or months in anticipation of high crop nutrient demand. University Extension research and guidance for proper litter stockpiling (Gregory D. Binford, 2008) helps prevent any significant loss of manure and/or manure nutrients during precipitation events (Doody, Foy, et al., 2012, Liu, Kleinman, et al., 2015). Current manure handling and storage losses following waste removal from animal housing is minimal and a recommended recoverability factor of 99% is recommended. Such a small loss of manure is certainly within the margin of error for the CBW modeling team to both quantify the poultry waste generation rate.
- Poultry manure, after it was removed from production facilities in the mid-1980s, was typically piled outside and observation by professionals working in manure management at the time suggest losses to the environment were present (Moffitt, 2016). This was primarily due to improper stockpiling technique and neglect. Thus, the recommended poultry manure recoverability during this time is 90%.
- Litter storage structures improve manure recoverability efficiency. This is principally because litter storages prevent improper field storage of litter. The most important impact of litter storage structure is that it makes possible to more efficiently use manure nutrients – storing litter makes it possible to land apply waste during high crop nutrient demand.

Definitions descriptions of typical AWMS practices

Litter. A mixture of poultry manure, spilled feed and water, feathers, and soiled bedding with a total mass that is larger than voided manure.

Cake. Litter that is hard and forms large chunks and that typically results from excess wetting. Preferentially removing this portion of the litter between flocks is often referred to as "crushing out" or "de-caking." Caked litter is removed from the house between flocks and ether applied to a field as fertilizer, sold off farm, or placed in manure sheds to be stored for future use. Typically once a year, a cleanout will occur which will remove both "cake" litter and drier more finely divided waste. This is referred to as a "whole house cleanout."

Confinement House. A broiler (meat) chicken production house used to protect the birds and their manure from the environment **(Figure 4**). By design, they are long (400-600 ft) and narrow (40-60 ft). Typically, they are "tunnel ventilated" for summertime cooling: fresh air is pulled into one end of the houses through evaporative coolers, it then flows in a laminar fashion to the opposite end of the building where it is exhausted using large fans. In the mid-1980s broiler houses were more commonly curtain sided and bird cooling occurred by lower the curtains to allow air to flow across the width of what were then more narrow houses. Broiler production houses contain the equipment to distribute feed and water to the birds. Typically, the birds are introduced as day old chicks and grow within the houses for several weeks. Confinement houses for turkeys and young pullets are similar to broiler houses. Layers are typically produced in very large houses that contain cages – waste falls to a pit or a conveyor and there is no addition of bedding to the waste.

Figure 4. Broiler production houses.

Heavy Use Area (HUA) - (NRCS code 561). A hard pad typically at the entrance/exit of a broiler production house. HUAs are usually made with concrete and are designed to protect the ground from rutting as equipment enters and exists the production houses. HUAs also facilitate the recovery of manure and bedding that is inadvertently removed from the house by the equipment used to harvest the birds for transport to a processing plant, or by the equipment used to manage or recover excess litter from the production houses.

Figure 5. HUA outside a broiler house.

Manure Shed - (NRCS code 313). Roofed structures that are used to temporarily store poultry manure/litter after it has been removed from production houses. Manure sheds provide a storage space that protects manure from losses to the environment. Temporary storage significantly improves efficient management of poultry manure nutrients by promoting land application when crop nutrient demand is high, lowering nutrient losses to the environment.

Figure 6. Poultry manure shed.

Broilers

Watershed Population. According to the 2012 USDA Agricultural Census, there are 188,650,054 broiler chickens within the six states that contain the CBW (**Table 7**). Most of these birds are located in the CBW and are mainly found in Delaware, Maryland, Pennsylvania, and Virginia (**Figure 7**). The most important broiler production counties known to be entirely within the CBW are: Maryland-Somerset (14,935,325), Maryland-Caroline (12,558,685), Virginia-Rockingham (12,879,848), and Maryland-Wicomico (11,051,592). The 2012 USDA Agricultural Census does not contain county level data on broiler farm size. However, the size of the broiler farm (both in terms of the total number of birds confined, and the size of the broiler production houses) does not affect the type of AWMS used. All broiler farms within the CBW are well characterized by the reference document as a "standard broiler house" (USDA Natural Resources Conservation Service, 2003).

Model Farm. Dr. Moyle interviewed retired Extension agents to set the 1985 CBW model farm, and the panel concurred with the following general description:

- Located on the lower shore of Maryland in Somerset County.
- The poultry would be maintained indoors at all times but houses would lack HUAs.
- There would be no manure shed in which to store litter.
- Caked litter would be removed between flocks and typically stacked near the houses and not protected from the environment.
- Litter would be removed annually from the houses and used as fertilizer on fields located near the barns or piled next to the production site to be used as needed.

The panel set the 2016 model farm as follows:

- Located on the lower shore of Maryland in Somerset County.
- The poultry would be maintained indoors at all times and houses would have HUAs.
- Current farms have storage structures for litter that are maintained on the farm to hold litter (≈ 2 flocks, 4 months) until it is land applied or shipped off farm. Field storage is much less common, and done properly to prevent losses to the environment.
- New broiler farms now being constructed (MD, DE) are graded to collect storm water and divert it through grass swales to a wetland (**Figure 8**). This reduces the stormwater

nutrients from the small amounts of dust lost exhausted from poultry houses (note: this diversion and wetland type of practice may be covered under the future agriculture stormwater runoff BMP expert panel).

Table 7. A summary of the broiler chickens in states that contain the CBW. The total broiler numbers and the percentage of the 6-state grand total are presented for counties that are: outside the CBW, with < 50% or > 50% of the county area within the CBW, and for those counties entirely within the CBW.

State	Outside CBW		<50% Inside CBW		>50% Inside CBW		Inside CBW		Total	
	#	%	#	%	#	%	#	%	#	%
Delaware	0	0	7,708,825	4%	35,497,689	19	0	0	43,206,514	23
Maryland	0	0	13,248,270	7%	203	0	50,839,407	27	64,087,880	34
New York	179,282	0	18,270	0%	4,422	0	3241	0	205,215	0
Pennsylvania	15,762	0	3,437,586	2%	3,733,265	2	21,667,573	11	28,854,186	15
Virginia	20,8651	0	6,930,800	4%	1,097,093	1	29,284,272	16	37,520,816	20
West Virginia	13,427	0	594	0%	0	0	1,4761,422	8	1,4775,443	8

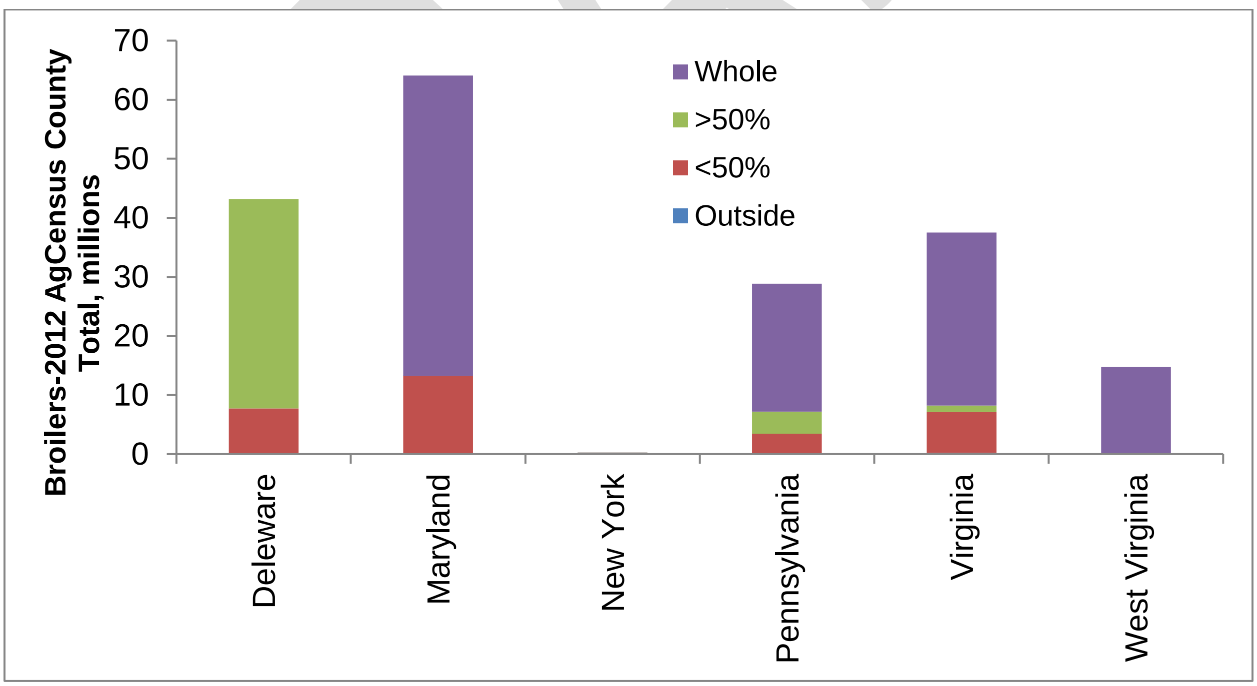

Figure 7. A stacked bar chart illustrating the total number of broiler chickens located in states that contain the CBW.

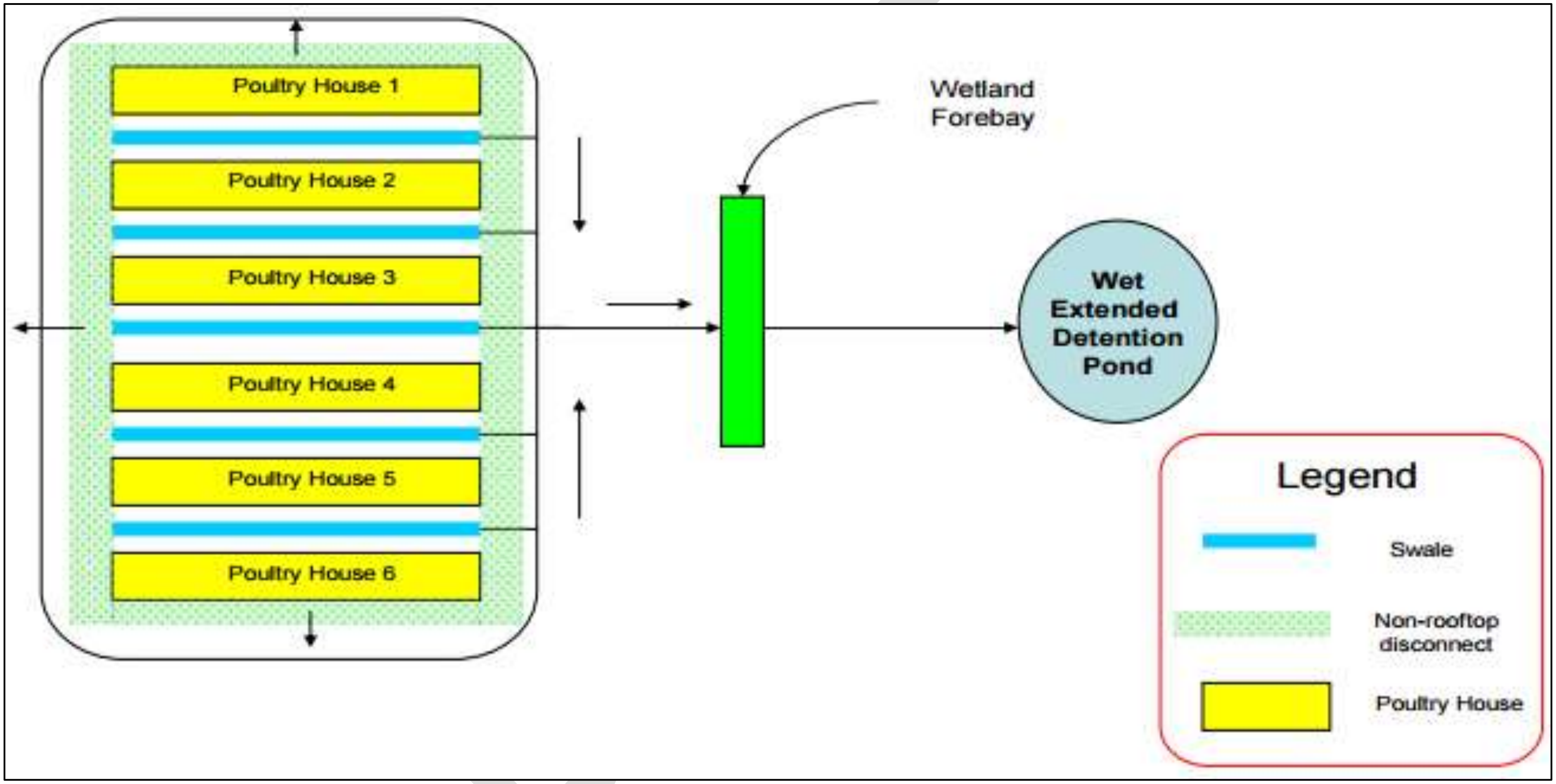

Figure 8. Current day model broiler farm wetland treatment system.

Manure recoverability factors. Broiler farm manure recoverability has not been systematically studied, but it has been estimated in several publications. The primary reference document contains only one model AWMS farm (a standard broiler confinement house), but for unknown reason provides different manure recoverability estimates for "Northeast" and "Southeast" farms (**Table 8**) (USDA Natural Resources Conservation Service, 2003). The "Northeast" model farm, which would include Pennsylvania, is estimated to have 75% and 98% manure recoverability before and after CNMP implementation, respectively (**Table 8**). The "Southeast" model broiler farm, which would include the important states of Delaware, Maryland, Virginia, and West Virginia (**Figure 7**), is estimated to have 85% and 98% manure recoverability before and after adoption of the CNMP, respectively (**Table 8**). The improvement in manure recoverability was attributed to structures that enabled manure storage and better mortality management **Table 8**.

Other estimates of the manure recoverability for broiler farms are higher than the values presented in **Table 8**, particularly for the "Northeast" model farm "before" condition. Robert L. Kellogg, Charles H. Lander, et al. (2000) estimated broiler farm manure recoverability in the mid-1990s to be 90% in Maryland, Delaware, and New York, 95 % in Pennsylvania, and 98% in Virginia and West Virginia (**Table 2**). As early as the mid- to late-1970s, broilers were noted to be in complete confinement with no losses during manure handling and storage (Donald L. Van Dyne and Gilbertson, 1978, Gilbertson, Dyne, et al., 1979). The consensus expert panel opinion was that the recoverability values presented in **Table 8** were too low**.**

Table 8. BMP placement and % recovery of manure (M), manure nitrogen (N), and manure phosphorus (P) before and after CNMP implementation on north east (PA, NY) and southeast (DE, MD, VA, WV) broiler farms.

Model Farm			CNMP Need & percentage of model farm type and size with need		% manure recovered before CNMP	% manure recovered after CNMP
Size (AU)	AWMS	%				
<220	NE Broiler House	100	316: Mortality Management	45	75	98
			634: Solids Collection	2		
			313: Solids Storage	30		
220-400		100	316: Mortality Management	15		
			634: Solids Collection	2		
			313: Solids Storage	30		
>400		100	316: Mortality Management	15		
			634: Solids Collection	2		
			313: Solids Storage	25		
<220	SE Broiler House	100	316: Mortality Management	45	85	98
			634: Solids Collection	2		
			313: Solids Storage	30		
220-400		100	316: Mortality Management	15		
			634: Solids Collection	2		
			313: Solids Storage	30		
>400		100	316: Mortality Management	15		
			634: Solids Collection	2		
			313: Solids Storage	25		

Several professionals active in the area of broiler litter management were contacted concerning recoverability of broiler litter (Brown, 2016, Malone, 2016, Rhodes, 2016). In addition, an author and/or contributor to key references used herein (Charles H. Lander, David C. Moffitt, et al., 1998, Robert L. Kellogg, Charles H. Lander, et al., 2000, USDA Natural Resources Conservation Service, 2003) was contacted about broiler litter recoverability in the md-1980s (Moffitt, 2016). The consensus was that poultry manure, after it was removed from production facilities in the mid 1980s, was typically piled outside and observation by professionals working in manure management at the time suggest losses to the environment were present (Moffitt, 2016). This was likely primarily due to improper stockpiling technique and potentially neglect. **Thus, the Expert Panel recommends that the recoverability factor of broiler litter near the beginning of the CBW model time period should be 90%.**

Current broiler litter management practices in the CBW are well known. Poultry litter, after it is removed from production facilities, is now typically stored under roof prior to use as a fertilizer. Litter is less often applied immediately to crops with brief field storage. In some cases, litter is field stored for several weeks or months in anticipation of high crop nutrient demand. University Extension research and guidance for proper litter stockpiling (Gregory D. Binford, 2008) now helps prevent any significant loss of manure and/or manure nutrients during precipitation events (Doody, Foy, et al., 2012, Liu, Kleinman, et al., 2015). While there is very little scientific data that looks at current loses of poultry manure/litter due to handling and transportation, Moyle and Rhodes (2015) did examine how much litter was on heavy use areas after birds and litter was removed from production houses. This research documented very small losses of manure/litter (0.33 kg/m^2) equating to ≈ 46 kg per pad or 93 kg per barn. The amount of litter lost (and recovered by the HUAs) was approximately 0.095% of the total amount of litter typically removed from a broiler house. Based on this study, and lacking any other scientific research, it would appear that a recovery factor of even 98% would be low assuming storages and HUAs are properly used and maintained. **The Expert Panel recommends that the current recoverability factor of broiler litter should be 99%**.

Turkeys

Watershed Population. According to the 2012 USDA Agricultural Census, there are 8,662,765 turkeys within the six states that contain the CBW (**Table 9**). Virtually all of these birds are located within the CBW and are primarily found in Virginia, Pennsylvania, and West Virginia (**Figure 9**). Over half of the turkeys within the CBW are found in only three Virginia Counties: Rockingham (2,198,758), Augusta (1,508,473), and Page (12,558,685). The 2012 USDA Agricultural Census does not contain county level data on turkey farm size.

Model Farm. The reference document identifies four sizes (< 35, 35-220, 220-440, and >440 AUs) of two AWMS model turkey farms (turkey ranches, in which the birds are reared outside, and confinement houses similar to broiler houses) (**Table 10)**. The consensus of the expert panel, after consulting with professionals active in 1985 (Malone, 2016), is that the turkey ranch style of production, and farms with fewer than 35 animal units, are not pertinent within the CBW modelling timeframe (≈ 1985-present). Thus, the only model farm that the Expert Panel recommends for consideration are confinement houses.

Table 9. A summary of the turkey population in states that contain the CBW. The total turkey numbers and the percentage of the 6-state grand total are presented for counties that are: outside the CBW, with < 50% or > 50% of the county area within the CBW, and for those counties entirely within the CBW.

State	Outside CBW		<50% Inside CBW		>50% Inside CBW		Inside CBW		Total	
	#	%	#	%	#	%	#	%	#	%
Delaware	0	0%	502	0%	0	0%	0	0%	502	0%
Maryland	0	0%	77	0%	0	0%	3,831	0%	3,908	0%
New York	5,943	0%	2,482	0%	346	0%	426	0%	3,254	0%
Pennsylvania	2,880	0%	56,089	1%	37	0%	1,663,413	19%	1,722,419	20%
Virginia	955	0%	1,508	0%	161	0%	5,113,047	59%	5,115,671	59%
West Virginia	446,706	5%	229	0%	0	0%	1,370,076	16%	1,817,011	21%
Grand Total	456,484	5%	60,887	1%	544	0%	8,150,793	94%	8,662,765	100%

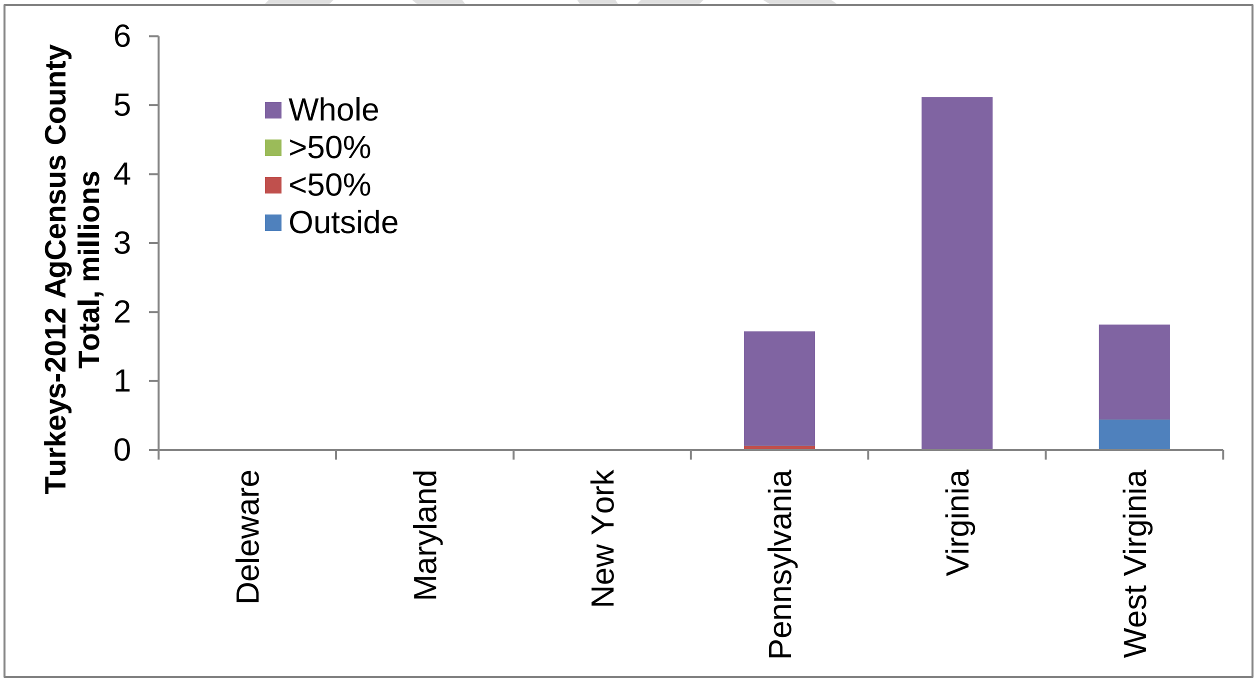

Figure 9. A stacked bar chart illustrating the total number of turkeys located in states that contain the CBW.

Table 10. BMP placement and % recovery of manure (M), manure nitrogen (N), and manure phosphorus (P) before and after CNMP implementation on model turkey farms (USDA Natural Resources Conservation Service, 2003).

Model Farm			CNMP Need & percentage of model farm type and size with need		% manure recovered before CNMP	% manure recovered after CNMP
AWMS	%	Size				
Turkey Ranch	10	35-220	316: Mortality Management	60	45	50
			634: Solids Collection	15		
			313: Solids Storage	50		
			362: Earth berm, surface outlet	40		
			558: Roof runoff management	90		
			634: Contaminated runoff collection	90		
			634: Runoff Storage Pond	90		
			533: Liquid transfer	90		
			Settling Basin	90		
		220-440	316: Mortality Management	60		
			634: Solids Collection	15		
			313: Solids Storage	50		
			362: Earth berm, surface outlet	40		
			558: Roof runoff management	90		
			634: Contaminated runoff collection	90		
			634: Runoff Storage Pond	90		
			533: Liquid transfer	90		
			Settling Basin	90		
		>440	316: Mortality Management	60		
			634: Solids Collection	15		
			313: Solids Storage	2		
			362: Earth berm, surface outlet	40		
			558: Roof runoff management	90		
			634: Contaminated runoff collection	90		
			634: Runoff Storage Pond	90		
			533: Liquid transfer	90		
			Settling Basin	90		
Turkey House	90	<220	316: Mortality Management	60	80	98
			634: Solids Collection	15		
			313: Solids Storage	50		
		220-440	316: Mortality Management	30		
			634: Solids Collection	15		
			313: Solids Storage	50		
		>440	316: Mortality Management	30		
			634: Solids Collection	15		
			313: Solids Storage	25		

The 1985 model farm would generally be described as:

- Located in Rockingham County, Virginia.
- The birds would be reared indoors in confinement houses that lack HUAs.
- There would be no manure shed in which to store litter. Litter would be removed between flocks and typically stacked near the houses and not protected from the environment.

The current model farm would:

- Located in Rockingham County, Virginia.
- The birds would be reared indoors in confinement houses that lack HUAs.
- There would be a manure shed in which to store litter.

Manure recoverability factors. Turkey farm manure recoverability has not been systematically studied. The primary reference document contains an estimated manure recoverability factor before CNMP implementation of 80% (USDA Natural Resources Conservation Service, 2003) (**Table 10**). An improvement to 98% manure recoverability was estimated upon implementation of a CNMP and the addition of manure storage structure and better mortality management **(Table 10).**

Other estimates of the manure recoverability for turkey farms are higher than the values presented in **Table 10**. Robert L. Kellogg, Charles H. Lander, et al. (2000) estimated turkey farm manure recoverability in the mid-1990s to be 95% in Maryland, Delaware New York, and Pennsylvania, and 98% in Virginia and West Virginia (**Table 2**). The consensus expert panel opinion was that the "before" recoverability values presented in **Table 10** were low**.** However, turkey litter, after it was removed from production facilities in the mid-1980s, was typically piled outside and observation by professionals working in manure management at the time suggest losses to the environment were present (Moffitt, 2016). **Thus, the Expert Panel recommends that the recoverability factor of turkey waste should be 90% for the "before" condition.**

Current turkey litter management practices in the CBW are well known. After turkey litter is removed from production facilities, is now typically stored under roof prior to use as a fertilizer. While there is very little scientific data that looks at current loses of turkey manure/litter due to handling and transportation, the work of Moyle and Rhodes (2015) indicates that the losses will be minimal. **The Expert Panel recommends that the current recoverability factor of turkey waste should be 99%**.

Layers

Watershed Population. According to the 2012 USDA Agricultural Census, there are 28,167,041 layer type chickens within the six states that contain the CBW. The vast majority of layers are found in Pennsylvania counties containing some part of the CBW (23,925,741) (**Table 11**). The 2012 USDA Agricultural Census indicates that 73% of all Pennsylvania layers are concentrated in counties that lie entirely within the CBW (17,444,480) (**Table 11**). Lancaster County contains the majority of these birds (61% of all Pennsylvania layers) (**Table 12**). The majority of Pennsylvania layers are located on very large farms (>50,000) (**Table 12**).

Table 11. A summary of layer chicken population in states that contain the CBW. The total bird numbers and the percentage of the 6-state grand total are presented for counties that are: outside the CBW, with < 50% or > 50% of the county area within the CBW, and for those counties entirely within the CBW.

State	Outside CBW		<50% Inside CBW		>50% Inside CBW		Inside CBW		Total	
	#	%	#	%	#	%	#	%	#	%
Delaware	0	0	3,133	0	0	0	0	0	3,133	0
Maryland	0	0	4,965	0	0	0	172,525	1	177,490	1
New York	691,152	3	501,712	2	7,713	0	12,453	0	1,213,030	4
Pennsylvania	103,916	0	4,222,586	15	2,258,675	8	17,444,480	62	24,029,657	85
Virginia	97,495	0	17,573	0	326,501	1	1,189,002	4	163,0571	6
West Virginia	51,646	3	4,439	0	0	0	1,057,075	4	1,113,160	4
Grand Total	944,209	3	4,754,408	17	2,592,889	9	19,875,535	71	28,167,041	100

Table 12. An estimate of layer chicken numbers within Pennsylvania counties that lie entirely within the CBW. Results are categorized by farm size.

Farm Size (# of layers)	Lancaster		Franklin		All Others	
	#	%	#	%	#	%
1-49	22,150	0%	5,250	0%	69,450	0%
50-99	6,975	0%	1,500	0%	16,725	0%
100-399	22,000	0%	5,750	0%	25,000	0%
400-3199	75,600	0%	14,400	0%	54,000	0%
3,200-9,999	151,800	1%	6,600	0%	310,200	2%
10,000-19,999	420,000	2%	0	0%	615,000	4%
20,000-49,999	945,000	5%	350,000	2%	595,000	3%
50,000-99,999	1,275,000	7%	525,000	3%	1,575,000	9%
100,000+	7,732,844	44%	971,210	6%	2,399,234	9%
Grand Total	10,651,369	61%	1,879,710	11%	5,659,609	28%

Model Farm. The average confinement house capacity for layer chickens has increased over the past several decades (Animal and Plant Health Inspection Service, 1999, Animal and Plant Health Inspection Service, 2013). In 1999, 40% of layer houses held less than 30,000 birds; this declined to 18% by 2013. Layers held in large confinement houses holding 30,000-199,999 birds increased from 59% in 1999 to 74% in 2013. Very large confinement houses holding > 200,000 birds represented only 1% of barns in use in 1999; the proportion increased to 10% by 2013. The 1987 and 1982 Ag Census Going (back to the beginning time period for the CBW model) indicate that large layer farms were dominant even then, with 73% and 60% of Pennsylvania farms confining flocks of more than 50,000, respectively. In conclusion, the model farm concept should be focused only the AWMSs common on large layer farms with continuous confinement.

The types of AWMSs in use on layer farms were reported in 1999 and 2013 studies conducted by USDA APHIS (Animal and Plant Health Inspection Service, 1999, Animal and Plant Health Inspection Service, 2013) (**Table 13**). In both 1999 and in 2013, production was dominated by high rise confinement houses built directly on top of ground level manure storage pits (≈60% of production houses). Prior to 1999, shallow pits and manure belts were in less common. Between 1999 and 2013 shallow pit and manure belt systems were replaced with raised that accommodated the change to cage free table egg production. The primary reference document contains “North Central and Northeast” model layers farms with 35-400 animal units (≈ 8,750-99,999 layers as well as large farms with > 100,000 layers with reference AWMSs being high rise houses with ground level pits, houses with shallow in-ground pits, or manure belts system (USDA Natural Resources Conservation Service, 2003) (**Table 14)**. In any case, layers have been maintained in complete confinement with manure collection occurring under roof.

Table 13. Layer farm AWMSs.

AWMS	1999 (%)	2013 (%)
High Rise	63	61
Deep Pit	0	0
Shallow Pit	23	9
Flush-Lagoon	0	-
Slats – no belt	-	22
Manure Belt	14	5
Scraper	0	3

Manure recoverability factors. Layer farm manure recoverability has not been quantified. The primary reference document estimates that all AWMS in common use provide 85% and 95% manure recoverability before and after CNMP implementation (**Table 14**). BMPs forecast to bring about this improved manure recoverability were primarily the construction of manure storages and mortality management facilities (**Table 14**). Other estimates of the manure recoverability for layer farms are higher than the values presented in **Table 14**. Robert L. Kellogg, Charles H. Lander, et al. (2000) estimated layer farm manure recoverability in the mid-1990s to be 95% in Maryland, Delaware New York, and Pennsylvania, and 98% in Virginia and West Virginia (**Table 2**). The consensus expert panel opinion was that the before recoverability values in **Table 14** were low, though production facilities in the mid 1980s, may have been more likely to store layer waste outside (Moffitt, 2016). **Thus, the Expert Panel recommends that the recoverability factor of layer waste should be 90% for the “before” condition.** Current turkey layer management practices in the CBW are well known. Waste is typically stored in the production house and following removal it is stored in manure storage structures. **The Expert Panel recommends that the current recoverability factor of layer waste should be 99%**.

Table 14. BMP placement and % recovery of manure (M), manure nitrogen (N), and manure phosphorus (P) before and after CNMP implementation on layer farms.

Model Farm			CNMP Need & percentage of model farm type and size with need		% manure recovered before CNMP	% manure recovered after CNMP
Size (AU)	AWMS	%				
35-400	High Rise Ground Level Pit	40	316: Mortality Management	45	85	95
			634: Solids Collection	10		
			313: Solids Storage	40		
	Shallow Ground Level Pit	40	316: Mortality Management	45		
			634: Solids Collection	10		
			313: Solids Storage	40		
	Manure Belt or Scraper	20	316: Mortality Management	15		
			634: Solids Collection	10		
			313: Solids Storage	40		
>400	High Rise Ground Level Pit	81	316: Mortality Management	45	85	95
			634: Solids Collection	10		
			313: Solids Storage	20		
	Manure Belt or Scraper	19	316: Mortality Management	15		
			634: Solids Collection	10		
			313: Solids Storage	20		

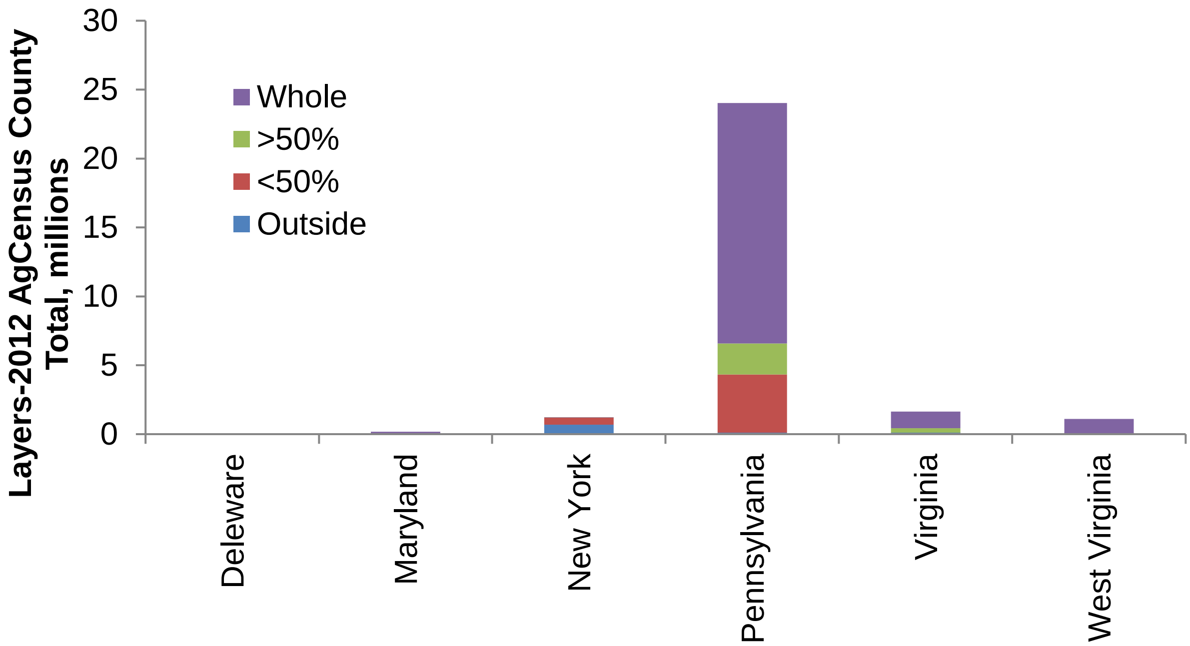

Figure 10. A stacked bar chart illustrating the total number of layer chickens located in states that contain the CBW.

Beef (fattened cattle)

Summary of Recoverability Factors and Key Conclusions for Fattened Cattle

Prior to 1997, before Comprehensive Nutrient Management Plans (CNMP) went into effect, Edmonds et al. (2003) estimated that cattle feeding fattening operations feeding more than 35 animal units (AU) per year in the Chesapeake Bay Watershed used feedlots to house animals and handle manure. Today this is no longer the case. Facilities feeding more than 100 AU per year feed animals under roof, with bedded pack barns being the predominant animal waste management system (AWMS). Those operations feeding less than 100 AU per year rely primarily on pasture finishing with little or no manure collection. Estimations of recoverable manure and manure nutrients based on review of literature for the pre and post CNMP implementation systems are given in Table 15.

Editor's note: Edmonds et al (2003) is the same key source reference document referred to in other chapters, i.e. "Costs Associated with Development and Implementations of CNMPs…"

Table 15. Estimations of Recoverable Manure and Recoverable Manure Nutrients from Beef Fattening AWMS before and after implementation of CNMP.

	Proportion of Excreted Manure Recovered	Proportion of Excreted Manure Nutrients Retained in Recovered Manure	
		N	P
Before CNMP Implementation Open Lot Scraped and Stockpiled >35 AU	60	`	70
Model Farm Bedded Pack Barn SE Pennsylvania >100 AU	99	80	84

Estimating the proportion of excreted manure that is recoverable for land application from both feedlot and bedded pack systems is difficult. The difficulty arises in feedlot systems because of shrinkage due to weathering and decomposition of manure. The difficulty in bedded packs systems arises from the practice of adding bedding on a weekly basis. The 60% recoverable estimation given in Table 15 for pre-CNMP conditions agrees with values for scraped and stockpiled systems in New York, Pennsylvania, and New Jersey by Edmonds et al. (2003). One hundred percent of excreted manure is assumed to be collectible for bedded pack systems after implementation of CNMP. Excreted feces are contained for the duration of time cattle are housed inside the barn. Urine is absorbed by bedding material. The total mass of manure dry matter collected may be overestimated in Table 15 due to shrinkage that occurs when manure is stacked before land application.

A better estimation of excreted nutrients available for land application can be made based on the literature review. Values in Table 15 for the feedlot AWMS are lower than those given in

Edmonds et al. (2003). Table 15 also shows that more nutrients are available for land application from the model farm bedded pack AWMS compared to pre-CNMP, feedlot based AWMS.

Definitions of terms used

Fattening Cattle: steers or heifers, generally 1 to 1 1/2 years of age, fed on feedlots or roofed confinement for the express purpose of being prepared for slaughter. These cattle are also called **Finishers.** Fattening cattle are housed for approximately 6 months before slaughter.

Steer: male cattle of any age that have been castrated.

Heifer: Young female cattle, either dairy or beef breed, before their first calf.

Stocker: Weaned steers and heifers being prepared to be placed on feedlots.

Backgrounding: A beef production system maximizing the use of pasture and forages for placing stocker cattle on feedlot.

Pasture Finishing: A beef fattening operation in which pasture is relied upon to supply roughage. Cattle are fed supplemental grain using feeders (Figure 1.).

Figure 1. Pasture Finishing of Beef Cattle Using A Mobile Feeder with Shade (Beefproducer.com).

Feedlot: Open area with a paved or compacted soil surface in which cattle are confined open to the elements (Figure 2). Feedlots are also called **Feedyards.** Feeding is done in bunks, which may be open to the atmosphere or under a shade or shed. For feedlots with a CNMP, water is kept from running onto the feedlot and runoff is diverted into a liquid storage structure (USDA NRCS Code 362).

Feedlot Pack: An AWMS in which manure is allowed to accumulate on the feedlot. Manure is cleaned and land applied once or twice per year – usually in spring or fall.

Stockpiling: An AWMS in which manure is heaped into stockpiles or uncontained stacks, either inside or outside feedlot pens (Figure 3), to await reloading, hauling and spreading (Sweeten, 1996). Stockpiling permits regular pen cleaning, even when spreader trucks or cropland are not available for spreading (Larney et al, 2006). Stockpiled manure is spread on a frequency of six months to one year.

Figure 2. Small Midwestern Feedlot (Americancattlemen.com)

Figure 3. Manure Stockpile on Beef Feedlot (feedlyardfoodie.files.woodpress.com).

Stack: An open, covered, or roofed storage structure used for solid manure (Figure 4.) Leaching is prevented by constructing the walls and floor of the stack to be essentially watertight. Seepage from uncovered stacks is collected and sent to a liquid storage structure (USDA Code 313). Storage period of stacks is 6 months to 1 year.

Figure 4. Stacked Beef Manure Storage (Farmprogress.com)

Dry Stack: A stack covered by a roof (Figure 5). Leachate is prevented by constructing walls and floors of the stack to be essentially watertight. The roofed stack precludes the need for seepage control (USDA Code 313).

Figure 5. Empty Dry Stack Manure Storage (CrawfordSWCD)

Bedded Pack Barn: An AWMS in which cattle are fed under roof (Figure 6). In larger barns, the feeding floor is broken into a number of pens with fencing running perpendicular to the long wall of the building. Pens are broken into two sections: an alley close to the feed bunk in which cattle stand as they eat, and a packed bed behind the alley (Figure 7). Bedding is blown into the barn from the open sides of the barn at least weekly – more frequently as cattle become larger. The bedding absorbs urine, and solidifies the semi solid manure. Bedding is compacted by hooves as the cattle stand and move around in the pens. Alleys are usually scraped before each new layer of bedding is added to the barn. Alley manure may be stored for later spreading in an in-barn stack (Figure 7). Manure in the packed bed portion of the pens is removed after each herd of cattle is fed out. If not immediately land applied, packed manure is stored in open or dry stack storage areas (Figures 4 and 5). Alley and packed bed manure is sometimes composted before land application.

Figure 6. Bedded Pack Beef Production (asicoveredbuildings.com).

Figure 7. Interior of a Bedded Pack Beef Barn (the Feed Bunk and Alley are Located Nearest the Building Opening. The Packed Bed is behind the Alley towards the Rear of the Barn). In-barn Storage of Manure Scraped from the Alley (Livingthecountrylife.com, South Dakota NRCS).

The bedded pack AWMS can be used in any type of barn, but often hoop (Figure 8) or monoslope (Figure 9) structures are built specifically for use with a bedded pack AWMS.

Figure 8. Hoop Cattle Feeding Barn Showing Feeding Bunk and Gate for Cattle Removal via the Alley (asicoverbuildings.com)

Figure 9. Monoslope Cattle Feeding Barn. Cattle are Fed in Bunks Placed in front of the High Side of the Monoslope. In This Photo Cattle are Eating and Standing in the Alley Section of the Pen. (titanoutletstore.com)

Deep Pit Barn: An AWMS in which cattle are housed on a slatted floor over a concrete manure storage pit (Figure 9). Hooves move manure through grooves into the deep pit. Barn layout is similar to bedded pack barns with a feed bunk located adjacent to a feed lane running down the center of an enclosed barn or the along long side of an open barn. Deep pit barns usually do not have a separate alley in front of feed bunks, and the entire floor of the barn is slatted. Slurry is removed from deep pitted barns usually every six months to a year.

Figure 9. Monoslope Cattle Feeding Barn with Deep Pit Manure Handling Systems (High Plains Journal).

Review of Available Data for Beef Cattle in the Chesapeake Bay Watershed

Beef fattening operations exist in the Chesapeake Bay Watershed in two distinct types: small operations feeding less than 100 AU per year for custom slaughter, and large operations feeding more than 100 AU per year for large slaughter facilities in South Eastern Pennsylvania.

There are virtually no feedlots in most of Pennsylvania. Smaller, custom finishing operations in Pennsylvania use pasture finishing and do not have a distinct AWMS. The larger operations are concentrated in York County, PA and Lancaster County, PA. Many of these farms finish more than 1,000 AU of cattle each year. Heifers and steers finished in these large units are backgrounded in Pennsylvania as well as New York, Maryland, Virginia, and West Virginia. The larger farms primarily use some form of bedded pack AWMS in a variety of barn structures. Some cattle are housed in old deep pit dairy barns converted to cattle feeding (Tara Felix, Penn State University Extension Beef Specialist, personal communication August 29, 2016).

Smaller feedlots with runoff collection may exist along the eastern slope of the Appalachians and the Shenandoah Valley in Virginia, but these are minor contributors to the Chesapeake Bay Watershed.

Description and summary of model farms applicable to Beef Cattle in the Chesapeake Bay watershed

The model farm used for Beef Fattening in the Chesapeake Bay Watershed is a 500 AU capacity (1,000 AU finished per year) located in York or Lancaster County, Pennsylvania. This operation produces cattle for slaughter in a large packing plant in southeastern Pennsylvania. It has hoop or monoslope barns specifically constructed to house finisher cattle. The bedded pack AWMS is used on this farm. Barns are bedded with oat or wheat straw once or twice per week. Bedded alley manure is scraped weekly and stored in a dry stack manure storage structure. Packed bed manure is removed after each herd turn – twice each year. If fields are not available for immediate land application, packed bed manure is stored in a dry stack manure storage structure. All manure is handled as a solid. Solid manure is stored in dry stacks in order to avoid construction of runoff control diversions and liquid storage structures. Roofs are guttered. Clean roof runoff is diverted away from cattle handling areas and manure storage. Solid manure is land applied to cropland using manure and soil testing to maximize efficient use of nutrients.

Review/Discussion of Recoverability Factors

<u>Manure Nutrients Recovered in Beef AWMS</u>. A literature review did not uncover any data on nutrient recovery from AWMS systems located in the Chesapeake Bay Watershed. Euken (2009) determined average mass of nutrients captured from three types of beef AWMS in Iowa. The numbers in Table 16 were calculated by sampling beef feeding operations (Euken, 2010), determining the mass of nutrients leaving the system in land applied manure, and comparing to estimated mass of manure excreted by the animals housed (ASABE standard D384.2, March

2005). Although the climate in Iowa is slightly colder and drier than that in the Chesapeake Bay Watershed, the numbers in Table 16 are good approximations of nutrients recovered from beef finishing operations in Pennsylvania.

Table 16. Proportion of Excreted Nutrients Captured for Land Application from Three Types of Beef Confinement Systems in Iowa (Euken, 2009).

AWMS	Proportion of Excreted Nutrients Captured		
	N	P_2O_5	K_2O
Open Lot	54	71	54
Bedded Confinement	80	84	58
Deep Pit	77	87	88

Manure Nutrients and Dry Matter Losses from Stockpiled Manure. Several studies conducted in climates similar to the Chesapeake Bay Watershed (Table 17) provide data on the loss of manure dry matter, carbon, and nutrients after storage in stockpiles. Beef or Dairy Manure was mixed with straw in all of the studies given in Table 17. Larney et al. (2006) collected manure from open feedlots. The other studies removed manure from roofed confinement systems. Manure was stockpiled for approximately 6 months in all studies. Manure stacked and left open to the environment lost 20 to 50% of its dry matter mass, 20 to 30% of Total Nitrogen (TN), and 2 to 20% of Total Phosphorus (TP) when stored for 6 months. Compacting and covering piles reduced losses of dry matter and nutrients. Chadwick (2005) determined that leaching accounted for 7.4% TN losses, and Vadas et al. (2015) calculated that 3% of open feedlot TP was lost through leaching. Therefore, dry stack storage of beef manure should be expected to recover approximately 7.4% more TN and 3% more TP that open stack and stockpiled manure. Bedded pack manure is expected to undergo similar conditions as compacted and covered stockpiled manure. Sommers (2001) measured considerably less dry matter and TN losses when bedded manure was compacted and covered. Chadwick (2005) found similar reductions in dry matter loss, but very little difference in TN losses between stockpiled and compacted and covered manure.

Table 17. Dry Matter, Total Carbon, Total Nitrogen, and Total Phosphorus Losses of Stockpiled Cattle Feedlot Waste.

Study	Location	Handling/Storage System	Mass loss (%)			
			DM	TC	TN	TP
Sommers, 2001	Denmark	Stacked	45	49	28	1.7
		Stacked and Compacted	38	40	18	2.8
		Cut and Mixed with Manure Spreader, Stacked	41	44	12	1.8
		Stacked and Covered with Porous Tauplin	34	40	15	1.8
Parkinson,et al 2004	UK	Stacked			25	12
Chadwick, 2005	UK	Stacked	29	41	31	22
		Stacked, Compacted, and Covered with Plastic	11	30	30	14
Larney et al., 2006	Alberta and Manitoba	Stacked	22.5	38	22.5	6.7

Recoverable Manure From Feedlot Systems   It is difficult to account for manure deposited and collected from open lot systems. The Midwest Plan Service (MWPS, 1985) estimates that 70% of manure excreted by beef cattle is retained on feedlots although data substantiating this value is not given. Edmonds et al. (2003) gave a value for recoverability for scraped and stockpiled manure of 60% before implementation of CNMP, and 75% after CNMP implementation. The increase in recoverability is assumed to be the result of better run-on and runoff controls. Based on the results of studies of stockpiled manure it is likely that the 60% recoverable value is closer to correct given losses of dry matter on the feedlot surface as well as those in the stockpile.

Recoverable Manure from Bedded Pack Systems   It is also difficult to account for all the manure recovered from bedded pack AWMS. It is assumed that all of the feces excreted by fattening cattle will be collected in the bedded pack system. Cattle never leave the facility, and bedding is added to solidify excreted manure. Urine is absorbed in bedding. Up to 40% of manure dry matter may be lost from the pen floor and during storage (Table 17). But, given the fact that the mass of excreted manure is doubled with bedding, the mass of collected manure may be greater than the mass of excreted manure and urine.

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Swine

Summary of recoverability factors and key conclusions for swine

- The panel reached similar conclusions for swine as for poultry since the manure for both has very limited opportunities for loss in current operations. Swine are confined 100% of the time, and manure losses are limited to stocking/load out, which are unimportant simply because of they are short duration events, and manure pit overflows, which are very rare (and illegal) events, the recommended manure recoverability factors for swine manure is 99%.
- The 1% loss is certainly within our ability to quantify the true number of animals present, as well as their manure generation rate.
- Swine production in the CBW is localized to the southeast corner of Pennsylvania (SE PA) and focuses almost entirely on “finishing” as opposed to “breeding” facilities. The distinction between “finishing” and “breeding” facilities is irrelevant because the waste collection efficiency in a similar at both types of facilities. Production is dominated by large farms that house in excess of 1,000 animals in total confinement, both now and at the time the reference document was generated. Only one model farm/AWMS type should be considered (swine confinement houses).
- No data is available for the AWMSs in use on swine farms in SE PA, but because of loading factor considerations it is likely dominated by slurry collection systems and not lagoons. There are no literature sources for manure recoverability for swine confinement houses, likely because it is understood that all waste is easily collected from animals confined 100% of the time.

Definitions of terms used in this chapter and short descriptions of typical storage practices

Anaerobic Lagoon

A lagoon is an agricultural waste management system in which an impoundment is created by excavating an earthen pit. The impoundment is typically lined with clay or a flexible membrane to reduce seepage (USDA NRCS Conservation Practice Standard 359). In the case of anaerobic lagoons, the excavation is deep (8-12 feet) and the waste residence time is long (≥ 60 days). Anaerobic lagoons do not simply provide waste storage, rather they are designed and operated to biologically treat wastes by providing solids settling for phosphorus removal (although accumulated sludge must be removed every 5-10 years) along with significant reductions of waste organic nitrogen and ammonia concentrations and odor. Anaerobic lagoons are not designed to receive contaminated runoff from exposed animal confinement lots and are never fully emptied. A “treatment volume” is continuously maintained at a depth of ≥ 6 feet. Anaerobic lagoons are designed with an organic or volatile solids loading factor that reflects local climate, in effect the average daily temperature (see Chapter 10, Figure 10-27 of the USDA NRCS Agricultural Waste Management Field Handbook). Loading factors affect the size and thus the economics of anaerobic lagoons as a waste treatment option. It is impractical to use of anaerobic lagoons for animal waste storage in colder regions of the country, for example where most of the dairy and swine farms are located in southeastern Pennsylvania. Swine and dairy waste holding ponds here, and in other parts of the country, are often referred to incorrectly as “lagoons.” As one Pennsylvania State university Extension publication notes, “lagoons are not popular in Pennsylvania, partially because they required a large land area and treatment is seasonal” (Leggett and Graves, 1995).

Waste Storage Facility

A waste storage facility is an agricultural waste management system in which an impoundment is created by excavating an earthen pit that is lined with clay or a flexible membrane to reduce seepage, or by fabricating a structure to protect groundwater quality in sensitive areas (USDA NRCS Conservation Practice Standard 313). Waste Storage Facilities typically store contaminated rainfall runoff from exposed animal confinement lots and are emptied two or more times yearly. These facilities provide no active waste treatment, rather they simple store waste between critical times of the year when the waste can be removed and used as a nutrient source for crop production. The design criteria is based on an estimate of the waste generation volume, accounting for rainfall runoff and expected evaporation, and must include allowances for freeboard and storm events such that overflow events are prevented.

Review of available data for swine in the Chesapeake Bay watershed

According to the 2012 USDA Agricultural Census, there are 1,260,865 swine identified as "other hogs and pigs" (non-breeding swine) in the six states that contain the CBW (Table **15** 18). The majority of these animals (72%) are located in counties contained entirely inside the CBW (Table 18). Pennsylvania clearly dominants finishing swine production within the six states that contain the CBW, housing 94% of all swine located in counties contained entirely inside the CBW (**Error! Reference source not found.**; **Figure 11**).

A much smaller number of swine (88,225) were identified in the 2012 USDA Agricultural Census as "hogs and pigs used or to be used for breeding" (**Figure 11**). Thus, swine production within the CBW is primarily associated with swine finishing rather than gestation farms. For the project at hand, the model farm developed for swine should reflect this fact, although it should be noted that there is no difference between manure and manure nutrient recoverability factors for breeding vs finishing swine farms in the main reference document (USDA Natural Resources Conservation Service, 2003).

The 2012 USDA Agricultural Census contains county level data on swine farm size; a summary of county level Pennsylvania non-breeding swine numbers, organized by farm inventory size, is presented in Table 19. Approximately half (49%) of non-breeding swine are produced in Lancaster and Lebanon counties. Production is clearly dominated by large scale (presumably integrated) production, because 90% swine are present on farms that confine 1,000 or more animals.

Table 158. A summary of the swine population in states that contain the CBW. The swine numbers and the percentage of the 6-state grand total are presented for counties that are: outside the CBW, with < 50% or > 50% of the county area within the CBW, and for those counties entirely within the CBW.

State	Outside CBW		<50% Inside CBW		>50% Inside CBW		Inside CBW		Total	
	#	%	#	%	#	%	#	%	#	%
Delaware	0	0%	31	0%	0	0%	0	0%	31	0%
Maryland	0	0%	349	0%	0	0%	11,764	1%	12,113	1%
New York	54,978	4%	6,771	1%	1,360	0%	2,330	0%	65,439	5%
Pennsylvania	15,977	1%	121,182	10%	102,886	8%	849,651	67%	1,089,696	86%
Virginia	45,823	4%	4,686	0%	910	0%	36,380	3%	87,799	7%
West Virginia	3,399	0%	477	0%	0	0%	1,911	0%	5,787	0%
Grand Total	120,177	10%	133,496	11%	105,156	8%	902,036	72%	1,260,865	100%

The 2012 USDA Agricultural Census contains county level data on swine farm size; a summary of county level Pennsylvania non-breeding swine numbers, organized by farm inventory size, is

presented in **Table 19**. Approximately half of non-breeding swine are produced in Lancaster and Lebanon counties. Production is clearly dominated by large scale (presumably integrated) production, because 90% of swine are present on farms that confine 1,000 or more animals. Thus, the model farm developed for swine should reflect modern, large scale production facilities found within southeastern Pennsylvania.

Table 19. Numbers of Pennsylvania non-breeding hog and pigs organized by farm size; information for two counties (Lancaster and Lebanon) are presented, along with the category totals for all other Pennsylvania counties. Only counties that were entirely within or with > 50% of the county area within the CBW were considered.

Farm Size (non-breeding swine)	Lancaster		Lebanon		All Others	
	#	%	#	%	#	%
1-24	623	0%	122	0%	4666	0%
25-49	520	0%	250	0%	2541	0%
50-99	261	0%	342	0%	1208	0%
100-199	1534	0%	0	0%	3887	0%
200-499	9437	1%	1249	0%	8625	1%
500-999	25913	3%	8515	1%	1810	0%
1,000+	321217	34%	91446	10%	437818	46%
Grand Total	359505	38%	101924	11%	460555	48%

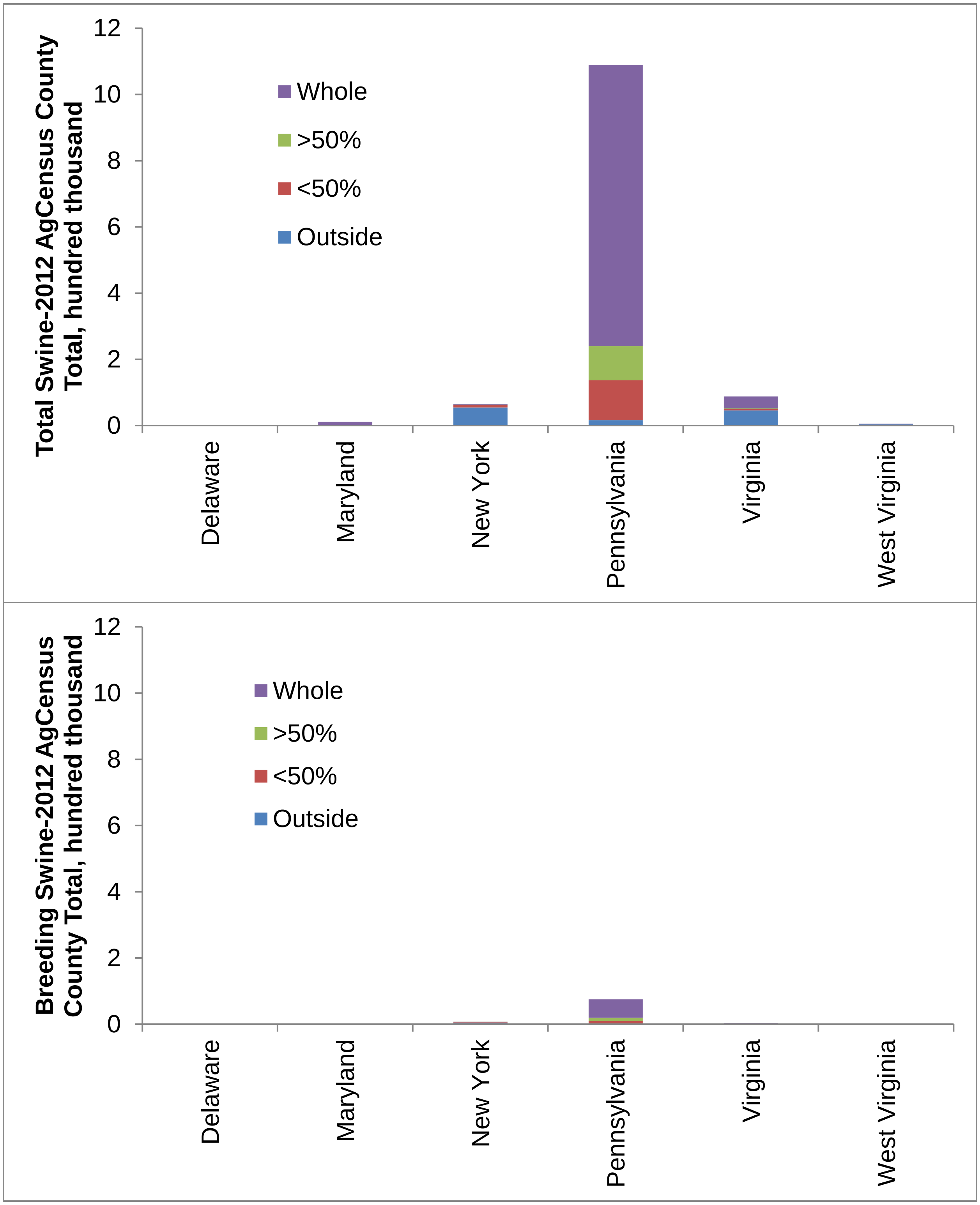

Figure 11. Stacked bar charts illustrating (A) total number of hogs and pigs, (B) breeding hogs and pigs (at the same vertical scale) in states that contain the CBW.

Description and summary of model farms applicable to swine in the Chesapeake Bay watershed

The document "Costs Associated With Development and Implementation of Comprehensive Nutrient Management Plans" provides an estimate of manure and manure nutrient recoverability from swine farms. Manure and nutrient recoverability are based on best professional judgment both before and after implementation of a CNMP with concomitant BMPs placement. Estimates for swine farms located in the northeast, which includes Pennsylvania, is provided in Table .

There are only two model farm sizes that are present in the reference NRCS document (Table **)**. Based on the 2012 USDA census (Table), the 35-500 model farm size should be dismissed from consideration as a model farm because the vast majority of swine are found on farms that confined more than 500 swine animal units.

Table 20. BMP placement and % recovery of manure (M), manure nitrogen (N), and manure phosphorus (P) before and after CNMP implementation on northeast swine farm housing hogs for slaughter (GF=Grower-Feeder; FF=Farrow-Finish).

<table>
<tr><th colspan="3" rowspan="2">Model Farm</th><th colspan="2" rowspan="2">Farm Upgrades</th><th colspan="6">% recovered</th></tr>
<tr><th colspan="3">Before</th><th colspan="3">After</th></tr>
<tr><th>Size</th><th>Region-AWMS</th><th>%</th><th>Conservation Practice Standard</th><th>%</th><th>M</th><th>N</th><th>P</th><th>M</th><th>N</th><th>P</th></tr>
<tr><td rowspan="20">35-500</td><td rowspan="4">GF, Confined, Lagoon</td><td rowspan="4">6</td><td>316: Mortality Management</td><td>70</td><td rowspan="4">85</td><td rowspan="4">25</td><td rowspan="4">85</td><td rowspan="4">97</td><td rowspan="4">25</td><td rowspan="4">85</td></tr>
<tr><td>634: Solids Collection</td><td>10</td></tr>
<tr><td>313: Solids Storage</td><td>20</td></tr>
<tr><td>533: Liquid Transfer</td><td>20</td></tr>
<tr><td rowspan="3">GF, Confined, Slurry</td><td rowspan="3">53</td><td>316: Mortality Management</td><td>70</td><td rowspan="3">80</td><td rowspan="3">80</td><td rowspan="3">90</td><td rowspan="3">97</td><td rowspan="3">80</td><td rowspan="3">90</td></tr>
<tr><td>313: Slurry Storage</td><td>60</td></tr>
<tr><td>533: Liquid Transfer</td><td>60</td></tr>
<tr><td rowspan="5">GF, Un-confined, Liquid</td><td rowspan="5">14</td><td>316: Mortality Management</td><td>70</td><td rowspan="5">70</td><td rowspan="5">75</td><td rowspan="5">90</td><td rowspan="5">95</td><td rowspan="5">75</td><td rowspan="5">90</td></tr>
<tr><td>362: Earth berm, surface outlet</td><td>20</td></tr>
<tr><td>558: Roof runoff management</td><td>30</td></tr>
<tr><td>313: Slurry Storage</td><td>50</td></tr>
<tr><td>533: Liquid Transfer</td><td>50</td></tr>
<tr><td rowspan="8">GF, Un-confined, Solid</td><td rowspan="8">27</td><td>316: Mortality Management</td><td>70</td><td rowspan="8">75</td><td rowspan="8">70</td><td rowspan="8">80</td><td rowspan="8">90</td><td rowspan="8">70</td><td rowspan="8">80</td></tr>
<tr><td>362: Earth berm, surface outlet</td><td>20</td></tr>
<tr><td>558: Roof runoff management</td><td>30</td></tr>
<tr><td>634: Solids Collection</td><td>10</td></tr>
<tr><td>313: Solids Storage</td><td>60</td></tr>
<tr><td>313: Runoff Storage Pond</td><td>50</td></tr>
<tr><td>533: Liquid Transfer</td><td>50</td></tr>
<tr><td>350: Settling Basin</td><td>50</td></tr>
<tr><td rowspan="7">>500</td><td rowspan="4">FF, Confined, Lagoon</td><td rowspan="4">27</td><td>316: Mortality Management</td><td>70</td><td rowspan="4">85</td><td rowspan="4">25</td><td rowspan="4">85</td><td rowspan="4">97</td><td rowspan="4">25</td><td rowspan="4">85</td></tr>
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<tr><td rowspan="3">FF, Confined, Slurry</td><td rowspan="3">73</td><td>316: Mortality Management</td><td>70</td><td rowspan="3">80</td><td rowspan="3">80</td><td rowspan="3">90</td><td rowspan="3">97</td><td rowspan="3">80</td><td rowspan="3">90</td></tr>
<tr><td>313: Slurry Storage</td><td>60</td></tr>
<tr><td>533: Liquid Transfer</td><td>60</td></tr>
</table>

Only two AWMS model farms types are present for farms confining greater than 500 animal units (Table). These are “farrow to finish” farms that are complete confinement with either a lagoon or slurry waste handling system. Based on professional judgment, it would appear that the “lagoon” treatment option is vastly overestimated at 27% of northeast swine farms. True lagoon waste treatment facilities are impractical in the model region because of low design waste loading criteria; the census survey respondents more likely have a Waste Holding Facility that is referred to as a Lagoon (see definitions). Thus, the model swine farm for the Northeast Region should be a complete confinement system with a slurry AWMS system.

Review/discussion of recoverability factors

No measurements of manure recoverability were found in the primary literature for 100% confinement swine housing. Thus, best professional judge is used to set the recommended manure recoverability factor.

In considering the swine manure recoverability from 100% confinement housing, past experience and farm visits were used to evaluate losses. Because the animals are confined 100% of the time, manure collection into storage pits, particularly for farms housing over 1,000 swine, will be virtually 100% efficient. The only conceivable opportunities for losses are during transfer events, which are very few and short lived, usually to a finishing facility and during loadout for processing. Losses during these time periods is well less than 1% of the manure generated. The only other losses will be from overflow events which are extremely rare and illegal.

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Equine and small ruminants

Forthcoming.

BMP tracking, reporting and verification

Chapter to be included in forthcoming full report.

Future research and management needs

Chapter to be included in forthcoming full report.

Appendix A: Technical Appendix for Scenario Builder

To be included in full report.

Appendix B: Charge from Agriculture Workgroup's Expert Panel Establishment Group for Animal Waste Management Systems

Charge and Scope of Work

Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads Phase 6.0 Expert Panel

Prepared for the Chesapeake Bay Program Partnership's Agriculture Workgroup by the Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads Expert Panel Establishment Group

Approved by AgWG March 19, 2015

Background

In the current version of the Chesapeake Bay Program (CBP) partnership's Watershed Model (version 5.3.2), Animal Waste Management Systems (AWMS) are defined as "practices designed for proper handling, storage, and utilization of wastes generated from confined animal operations. Reduced storage and handling loss is conserved in the manure and available for land application." In the current Watershed Model, an AWMS reduces the environmental loss of nitrogen and phosphorus from improperly stored livestock manures through surface runoff, by the implementation of federal and state recognized engineered storage and handling systems.

The Phase 5.3.2 modeling tools incorporate a standard estimate of baseline environmental nutrient losses from improper storage and handling based on the consistency of the livestock manure; e.g. solid or liquid. Nutrient losses are applied as a base environmental load irrespective of the potential impacts of the livestock housing facility, from which the AWMS BMP effectiveness values are applied. Atmospheric ammonia losses are not directly affected by AWMS BMPs, but managed through a separate atmospheric management BMP.

Poultry Heavy Use Area Concrete Pads represent the current industry standard of placing concrete pads at the primary doors of poultry housing facilities to reduce environmental litter handling losses during crust out and total house cleanup operations. These structures are not currently recognized as an existing or interim BMP by the Phase 5.3.2 models, and thus are not simulated in the Watershed Model for either implementation credit or for planning purposes until recommendations from an expert panel are adopted by the CBP partnership.

Virginia Tech, through its Expert Panel Management Cooperative Agreement with the CBP, will issue a Request for Proposals to convene an expert panel for these BMPs following adoption of this Charge and Scope of Work by the Agriculture Workgroup (AgWG).

The Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads Expert Panel Establishment Group (EPEG) was formed to:

- Identify priority tasks for the first Phase 6.0 (P6.0) Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads Expert Panel (EP),
- Recommend areas of expertise that should be included on the Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads EP, and
- Draft the Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads EP's charge (the assigned tasks) for the review process.

From February 13, 2015 through March 5, 2015 the EPEG met 4 times by conference call and worked collaboratively to complete this charge for presentation to the Agriculture Workgroup (AgWG) on March 18-19, 2015. Members of the EPEG are listed in Table 1.

Table 16. Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads Expert Panel Establishment Group membership and affiliations.

Member	Affiliation
Peter Hughes	Red Barn Consulting, Lancaster, PA
Robb Meinen	Pennsylvania State University
Jeff Porter	USDA NRCS
Lauren Torres	Delaware Department of Agriculture
EPEG support staff	
Jeremy Hanson	Virginia Tech
Mark Dubin	University of Maryland
Emma Giese	Chesapeake Research Consortium
Don Meals	Tetra Tech, Inc.

Method

The Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads EPEG developed its recommendations in accordance with the process specified by the AgWG (AgWG 2014). This process is informed by the strawman proposal presented at the December 11, 2014 AgWG meeting, the Water Quality Goal Implementation Team (WQGIT) Best Management Practice (BMP) protocol, input from existing panelists and chairs, and the process recently undertaken by the AgWG to develop the charge for the Manure Treatment Technologies EP.

The collective knowledge and expertise of EPEG members formed the basis for the recommendations contained herein. A number of EPEG members have had experience on BMP expert panels, including the P5.3.2 AWMS EP. Other EPEG members have knowledge and/or expertise in state and federal programs, the Chesapeake Bay model, and animal waste management practices within the Chesapeake Bay watershed.

Communication among EPEG members was by conference call and email. All decisions were consensus-based.

Recommendations for Expert Panel Member Expertise

The AgWG expert panel organization process directs that each expert panel is to include eight members, including one non-voting representative each from the Watershed Technical Workgroup (WTWG) and Chesapeake Bay Program modeling team. Panels are also expected to include three recognized topic experts and three individuals with expertise in environmental and water quality-related issues. A representative of USDA who is familiar with the USDA-Natural Resources Conservation Service (NRCS) conservation practice standards should be included as one of the six individuals who have topic- or other expertise. Panelists' areas of expertise may overlap.

In accordance with the WQGIT BMP protocol, panel members should not represent entities with potential conflicts of interest, such as entities that could receive a financial benefit from Panel recommendations or where there is a conflict between the private interests and the official responsibilities of those entities. All Panelists are required to identify any potential financial or other conflicts of interest prior to serving on the Panel. These conditions will minimize the risk that Expert Panels are biased toward particular interests or regions.

The Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads EPEG recommends that the P6.0 Animal Waste Management Systems and Poultry Heavy Use Area Concrete Pads EP should include members with the following areas of expertise:

- Biological/bio-systems engineering
- Livestock production and manure management systems typical in the Chesapeake Bay region.
    - Knowledge of dairy and poultry practices required
    - Knowledge of swine, beef, and equine practices preferred
- Knowledge of how BMPs are tracked and reported, and the Chesapeake Bay Program partnership's modeling tools.
- Knowledge of relevant NRCS practice codes or standards.

Expert Panel Scope of Work

The panel will review the Phase 5.3.2 definition and loading or effectiveness estimates for the AWMS practices listed above and make adjustments or modifications as needed for Phase 6.0. In addition, the panel will review and provide recommendations on the current standard baseline estimates of environmental nutrient losses associated with storage of various types of livestock manures for the Phase 6 modeling tools. The Panel will consider the results of a recent survey of CBW jurisdictions on animal waste management systems that they track and report (see Attachment 1) as they choose which waste storage system types to include in their deliberations. The Panel will consider different loss and recoverability factors for specific animal species, livestock manure types, and manure storage and handling systems. The panel will consult regionally-appropriate published data sources in developing recommendations, including both of the following two USDA-NRCS reference sources:

- Table 11-5 of the USDA-NRCS *Agricultural Waste Management Field Handbook Chapter 11, Waste Utilization* (see Attachment 2), and
- Table B-3 of USDA-NRCS *Costs Associated With Development and Implementation of Comprehensive Nutrient Management Plans. Part I—Nutrient Management, Land Treatment, Manure and Wastewater Handling and Storage, and Recordkeeping*[3]

The Panel will also develop a recommendation on the partnership request for a definition and loading or effectiveness estimates for Poultry Heavy Use Area Concrete Pads. The Panel will address only issues related to waste storage, while any effects of treatment will be covered by the Manure Treatment Technologies Expert Panel. Collaboration between the two panels will be critical to ensure that recommendations are complimentary as well as to avoid double-counting and ensure effective reporting of practices.

The Expert Panel will be provided a project timeline for the development of the panel recommendations based on the Phase 6 development schedule. Due to additional VT technical assistance considerations for this panel, this timeline will not include the development of a provisional recommendation for this BMP prior to the finalization of a fully documented recommendation report with effectiveness values. Instead, the EPEG panel charge document may be considered by the partnership in replacement of the provisional panel recommendations, and potentially used only for initial Phase 6 Beta model development and calibration. The EPEG document however cannot be used for the final version of Phase 6.0 for future implementation progress reporting by the jurisdictions.

The panel will develop a report that includes information as described in the Water Quality Goal Implementation Team's *Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model*, hereafter referred to as the BMP Protocol[4] (see Attachment 3 for an outline of the final report).

Timeline/Deliverables
May/June 2015 - Panel stakeholder kickoff meeting

Spring 2015 – The panel's proposed scope of work will be based on the written EPEG charge and the Virginia Tech RFP, which will include BMP structure and type, draft BMP definition(s), and

[3] http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_012131.pdf

[4] http://www.chesapeakebay.net/documents/Nutrient-Sediment_Control_Review_Protocol_v7.14.2014.pdf

initial elements of the BMP such as associated components and conservation practices, and USDA-NRCS associated CP codes. Initially identified literature citations will be included to provide a range of potential effectiveness values that the panel will consider and supplement with further evaluation. The technical assistance coordinator for Virginia Tech will jointly present the panel's EPEG report and proposed scope of work to the AgWG, WTWG, and WQGIT for informational purposes, and for initial partnership comments on the proposed direction of the panel's evaluation. The paper will not represent a full recommendation report, and the partnership will not be asked for formal approval at this time.

Prior to October 1, 2015 – **Target date** for partnership approval of full panel recommendations. If approved by the partnership, the CBPO modeling team will build the recommendations in to the Phase 6 Beta Scenario Builder tool to meet an early October deadline. If a partnership approved panel report will not be available at this time, the CBPO modeling team will request a decision by the partnership of whether the BMP will be represented using the Phase 5.3.2 information, or if the panel's EPEG charge and proposed scope of work will be the interim representation of the BMP.

Early October 2015 – All inputs are final and delivered to the WSM by the Scenario Builder team for the final calibration run. Final targets are based on this information.

April 2016 – **Final date** for panel to release full recommendations for approval by the AgWG, WTWG, and WQGIT.

July 2016 – If approved by the partnership, panel recommendations are final and will replace the interim representation of the BMP in the final version of the Phase 6 modeling tools.

Phase 6.0 BMP Verification Recommendations

The panel will utilize the Partnership approved *Agricultural BMP Verification Guidance*[1] as the basis for developing BMP verification guidance recommendations that are specific to the BMP(s) being evaluated. The panel's verification guidance will provide relevant supplemental details and specific examples to provide the Partnership with recommended potential options for how jurisdictions and partners can verify recommended animal waste management systems and poultry heavy use area concrete pads practices in accordance with the Partnership's approved guidance.

[1] http://www.chesapeakebay.net/documents/Appendix%20B%20-Ag%20BMP%20Verification%20Guidance%20Final.pdf

References

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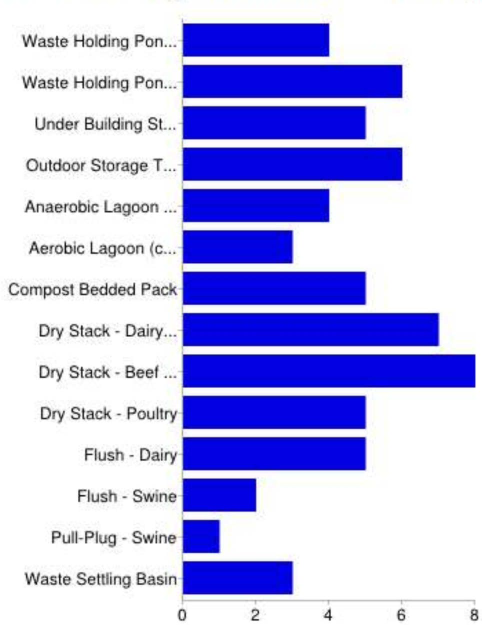
Attachment 1: Agriculture Workgroup feedback on Animal Waste Management Systems

2/20/15

10 responses

Summary

Please select all systems that are tracked and reported in your jurisdiction



Waste Holding Pond - Compacted Earth Lined	4	40%
Waste Holding Pond - Geomembrane Lined	6	60%
Under Building Storage Tank	5	50%
Outdoor Storage Tank (Open Top)	6	60%
Anaerobic Lagoon (compacted earth or geomembrane lined)	4	40%
Aerobic Lagoon (compacted earth or geomembraned lined)	3	30%
Compost Bedded Pack	5	50%
Dry Stack - Dairy (Dry Stack/Bedded Pack)	7	70%
Dry Stack - Beef (Dry Stack/Bedded Pack)	8	80%
Dry Stack - Poultry	5	50%
Flush - Dairy	5	50%
Flush - Swine	2	20%
Pull-Plug - Swine	1	10%
Waste Settling Basin	3	30%

Please list below any systems not included in the list above that are tracked and reported in your jurisdiction

Dry Stack – Equine: 3 sided above ground waste storage structure designed to house a combination of equine solids and saturated bedding material.

Non of the above. This list is far too specific based on the data reported to Virginia. The main source for animal waste systesm is NRCS which does not report type of animal or system installed just a count by practice code aggregated based on 1619 confidentiality rules. Virginia cost share collects animal type and amount of manure stored but nothing from the list provided. Currently VA discards the VACS data and only reports NRCS because of NRCS engineering support and to eliminate potential double counting.

VA currently tracks the primary type and number of animals generating the waste being stored but only limited data on the exact type of waste storage facility.

PA comments: Waste Holding Pond: we have some of these as concrete lined, should that be added as a subset? Under Building: this should include poultry. Outdoor Storage Tank: We have some of these as "covered" – the Amish buried railcar comes to mind. Dry Stack- had a question whether these are all roof-covered systems, some of them are not and is that critical to the definition or a different type of system? Also: we have poultry rooftop and litter shed systems if those are not captured in the poultry dry stack definition.

Attachment 2: USDA NRCS Estimates of Nutrient Retention in Various Waste Management Systems

Table 11–5 Percent of original nutrient content of manure retained by various management systems

Management system	Beef N	Beef P	Beef K	Dairy N	Dairy P	Dairy K	Poultry N	Poultry P	Poultry K	Swine N	Swine P	Swine K
	Percent											
Manure stored in open lot, cool, humid region	55–70	70–85	55–70	70–85	85–95	85–95				55–70	65–80	55–70
Manure stored in open lot, hot, arid region	40–60	70–80	55–70	55–70	85–95	85–95						
Manure liquids and solids stored in a covered, essentially watertight structure	70–85	85–95	85–95	70–85	85–95	85–95				75–85	85–95	85–95
Manure liquids and solids stored in an uncovered, essentially watertight structure	60–75	80–90	80–90	65–75	80–90	80–90				70–75	80–90	80–90
Manure liquids and solids (diluted less than 50%) held in waste storage pond				65–80	80-95	80-95						
Manure and bedding held in roofed storage				65–80	80–95	80–95	55–70	80–95	80–95			
Manure and bedding held in unroofed storage, leachate lost	55–75	75–85	75–85									
Manure stored in pits beneath slatted floor	70–85	85–95	85–95	70–85	90–95	90–95	80–90	90–95	90–95	70–85	90–95	90–95
Manure treated in anaerobic lagoon or stored in waste storage pond after being diluted more than 50%	20–35	35–50	50–65	20–35	35–50	50–65	20–30	35–50	50–60	20–30	35–50	50–60

Source: U.S. Department of Agriculture, Natural Resources Conservation Service. 2013. Agricultural Waste Management Field Handbook, Chapter 11, Waste Utilization.. http://directives.sc.egov.usda.gov/viewerFS.aspx?hid=21430

Attachment 3: Outline for Final Expert Panel Reports

- Identity and expertise of Panel members.

- Detailed definition of the practice.
- Recommended N, P, and sediment loading or effectiveness estimates.
    - Discussion may include alternative modeling approaches if appropriate.
- Justification for the selected effectiveness estimates, including:
    - List of references used (peer-reviewed, grey literature, etc.).
    - Detailed discussion of how each reference was considered and, if applicable, which sources of potential relevance were not considered.
- Description of how best professional judgment was used, if applicable, to supplement available literature and data.
- Expected Phase 6 Watershed Model land uses to which the BMP will be applied.
- Load sources that the BMP will address and potential interactions with other practices.
- Description of pre-BMP and post-BMP circumstances, including the baseline conditions for practices.
- Conditions under which the BMP works:
    - Should include conditions where the BMP will not work, or will be less effective. An example is large storms that overwhelm the design.
    - Any variations in BMP effectiveness across the watershed due to climate, hydrogeomorphic region, or other measureable factors.
- Temporal performance of the BMP including lag times between establishment and full functioning (if applicable).
- Unit of measure for the BMP and its effectiveness estimate (e.g., feet, acres).
- Locations within the Chesapeake Bay watershed where this practice is applicable.
- Useful life; effectiveness of practice over time.
- Cumulative or annual practice.
- Description of how the BMP will be tracked, reported, and verified.
    - Include a clear indication that this BMP should be used and reported by jurisdictions;
- Suggestion for a review timeline; when will additional information be available that may warrant a re-evaluation of the estimate.
- Outstanding issues that need to be resolved in the future and a list of ongoing studies, if any, that may inform future reviews of the practice.
- Documentation of any dissenting opinion(s) if consensus cannot be reached.
- Operation and Maintenance requirements and how neglect alters performance.

Additional Guidelines

- Identify ancillary benefits and unintended consequences
- Include negative results
    - Where studies with negative pollution reduction data are found (i.e. the BMP acted as a source of pollutants), they should be considered the same as all other data.
- Include results where the practice relocated pollutants to a different location. An example is where a practice eliminates a pollutant from surface transport but moves the pollutant into groundwater.

In addition, the Expert Panel will follow the "data applicability" guidelines outlined in Table 1 of the Water Quality Goal Implementation Team's BMP Protocol.

Appendix C: Minutes from the expert panel

To be included in full report.

Appendix D: Conformity with the BMP Protocol

To be included in full report

Additional appendices as needed.