Animal Waste Management Systems

Recommendations from the BMP Expert Panel for Animal Waste Management Systems in the Phase 6 Watershed Model

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Approved by the Water Quality Goal Implementation Team: TBD

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Executive Summary

The Animal Waste Management System (AWMS) expert panel convened in March 2016 and deliberated over the following nine months to develop the recommendations described in this report in response to the Charge provided to the panel by the Agriculture Workgroup (Appendix B). Specifically, the panel was instructed to evaluate the existing assumptions of manure lost and manure recovered for each animal type in the Chesapeake Bay Watershed Model (CBWM) and the potential benefits of storage best management practices (BMPs) represented by the AWMS BMP that is reported annually by the jurisdictions.

The panel was provided an initial reference document (USDA Natural Resources Conservation Service, 2003) (Primary Reference Document – see Chapter 3) that described recoverability estimates for each animal type and was considered for early beta calibrations of the Phase 6 CBWM. The panel's efforts to understand and improve upon the NRCS estimates led the panel to the recommendations described in this report, which are built on the panel's best professional judgment and understanding of typical – or, "model" – operations for each animal type in the Chesapeake Bay Watershed. The panel's framework is very similar to the one used by NRCS, which considered model farms, by operation size, for various regions. The panel worked to improve the estimates based on its understanding of animal operations in the region and with intent for the recommendations to be consistent with the Phase 6 CBWM. **A point of emphasis to consider throughout this report is that the Primary Reference Document recoverability estimates apply to all manure excreted by the animal including time in confinement and in pasture; for the CBWM, the panel was asked to consider manure recoverability for only the confined portion of each animal type.**

The panel acknowledges that animal waste management is a general system that includes many different practices. Confusion about the Chesapeake Bay Program's definition of "AWMS" is thus possible, since some BMPs that practitioners would consider part of the wider "animal waste management system" are captured through other CBP practices (e.g. barnyard runoff controls, loafing lot management) while the AWMS BMP defined herein is more reflective of storage and the ability to effectively collect and store – or recover – manure for subsequent field application, transport, or use in association with other "barnyard" BMPs. This panel's recommendations for the AWMS BMP are for purposes of the Phase 6 CBWM and only apply to the confined portion of manure as described in the more detailed model documentation and summarized in this report.

This report documents the panel's recommendations in chapters for each respective animal type, with chapters for animal groups when recoverability estimates can be appropriately described in a consolidated fashion (i.e. poultry in Chapter 3; equine and small ruminants in Chapter 8). The panel's recommended recoverability estimates for each animal type are summarized in Table ES.1 below, with columns for the "before-AWMS" and "after-AWMS" recoverability factors.

The panel is not recommending changes to current Phase 5 reporting elements of the AWMS BMP as part of these Phase 6 recommendations (i.e. states report each AWMS system implemented, and animal type/group associated with it if known). The same data reported is applicable under these Phase 6 recommendations that improve the recoverability estimates used for the Phase 5 model.

Table ES.1 – Summary of recommended manure recoverability factors for Phase 6 CBWM, by animal type

	Recommended recoverability factors	
Animal type	**Before AWMS BMP**	**After AWMS BMP**
Beef cows	-	-
Confined Heifers	60	99
Fattened cattle	60	99
Milk cows & calves	75	95
Hogs, breeding	90	99
Hogs, slaughter	90	99
Chickens, layers	90	99
Chickens, pullets	90	99
Chickens, broilers	90	99
Turkeys, breeding	90	99
Turkeys, slaughter		
Equine and small ruminants	95	98

The panel is not recommending new BMP verification guidance, noting that the states' existing verification plans already treat AWMS as a priority practice. The panel provides its insights in each chapter as to important operation and maintenance considerations that may be useful for the states. Chapter 9 summarizes how the AWMS BMP relates to the Agriculture Workgroup's existing BMP verification guidance.

The statements and considerations outlined in this report are intended to supplement existing jurisdictional requirements, where established. Nothing in the expert panel report shall affect jurisdictional regulatory or legal requirements.

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Common acronyms used in this report:

AFO	Animal Feeding Operation
AgWG	Agriculture Workgroup
AU	Animal Unit
AWMS	Animal Waste Management System
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CBP	Chesapeake Bay Program
CBW	Chesapeake Bay Watershed
CBWM	Chesapeake Bay Watershed Model
CNMP	Comprehensive Nutrient Management Plan
HUA	Heavy Use Area
NRCS	Natural Resource Conservation Service
USDA	U.S. Department of Agriculture

1. 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 (the full report from the EPEG is provided as Appendix X of this report).

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, Ph.D., P.E.	University of Tennessee	Chair
Doug Hamilton, Ph.D., P.E.	Oklahoma State University	Member
Jonathan Moyle, Ph.D.	University of Maryland Extension	Member
Pete Vanderstappen, P.E.	USDA-NRCS-Pennsylvania	Member
Mark Risse, Ph.D.	University of Georgia	Member
Bridgett McIntosh, Ph.D.	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 convened for its first conference call in March 2016. The panel met a total of 10 times via conference call as well as one face-to-face meeting and public stakeholder session hosted on April 7, 2016 near Baltimore, Maryland.

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 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 X) 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.

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

2. 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

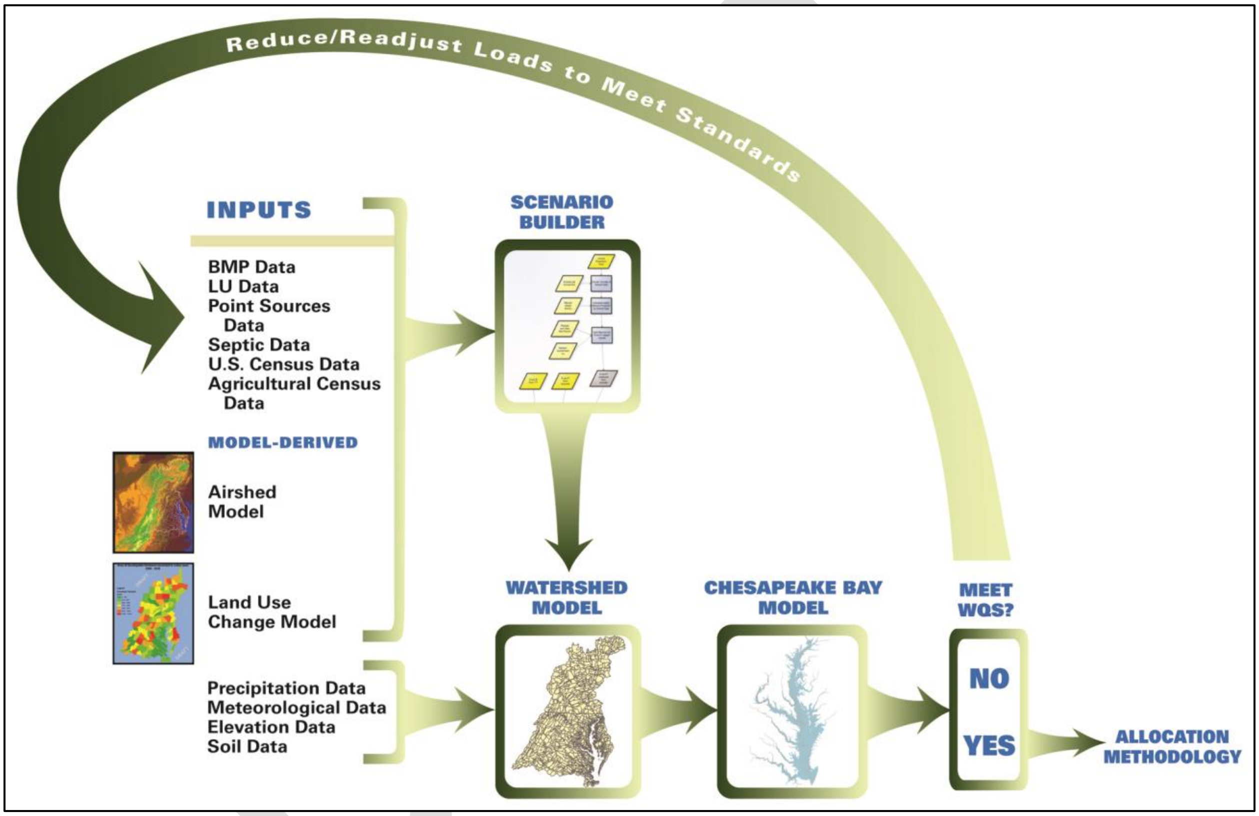
Manure from animal agriculture is the largest source of phosphorus loads to the Chesapeake Bay and the second largest source of nitrogen. Traditionally, the manure from livestock and poultry has been a valuable resource for farmers as a cost-effective fertilizer. When used appropriately, manure adds 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.

The need to rebalance the use of nutrients to protect water quality has generated interest and invest in manure treatment technologies and alternate uses of manure. Additionally, revisions to phosphorus management regulations (e.g., in Maryland) further increase the need for such manure technologies. Some technologies have been in use for decades (e.g., anaerobic digesters) while others are much newer and still in the pilot or research stage.

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



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.

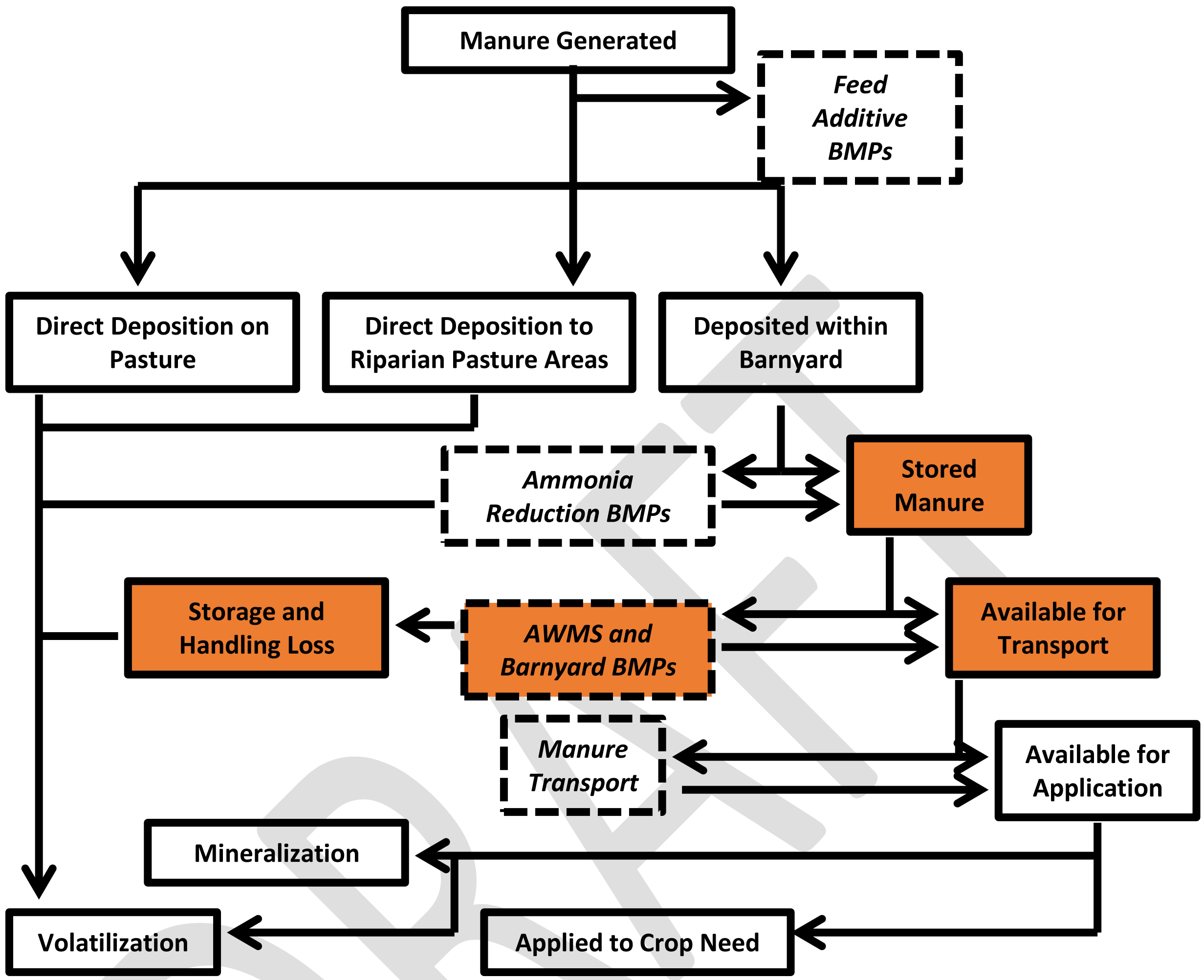
How AWMS fits in the modeling tools

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

This panel's two primary tasks correspond to Steps 2 and 4 in this process. In other words, 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 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 total animal types in the modeling tools (Box 1), the vast majority of nutrients from manure in the watershed are generated by poultry, dairy, beef, and swine.

Box 1. Animal types in the Chesapeake Bay Watershed Model

- beef
- dairy
- other cattle
- broilers
- layers
- pullets
- turkeys
- hogs and pigs for breeding
- hogs and pigs for slaughter
- horses
- angora goats
- milk goats
- sheep and lambs

3. Review of 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 by animal and AWMS type and farm size (**Table 2)**. The principal technique used to estimate manure recoverability relied on an earlier publication by Robert L. Kellogg *et al.* (2000), which defined total manure recoverability (% of voided manure) for different animal types (**Table 2**). Robert L. Kellogg *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 *et al.* (2000) are slightly modified from an earlier concept paper by Charles H. Lander *et al.* (1998). Only one difference exists between the manure recoverability factors of Charles H. Lander *et al.* (1998) and **Table 2**: for Virginia and West Virginal, 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 assumed that manure from poultry farms was 100% recoverable (Donald L. Van Dyne e Gilbertson, 1978; Gilbertson *et al.*, 1979).

Ultimately, the information in the most important concept paper (Charles H. Lander *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 e Gilbertson, 1978). However, only aggregate manure recoverability factors are presented by Donald L. Van Dyne e 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 recoverability." This fact 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 earliest work on manure recoverability. A source of details is available for the earliest work (Gilbertson *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 *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, was assumed to be unrecoverable.

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

Animal Type	Robert L. Kellogg *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				
Equine, small ruminants												95	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).

4. Milk Cows

Summary of recoverability factors and key conclusions for milk cows

- The majority (76%) of dairy cows within counties that are wholly within the CBW are found in Pennsylvania.
- Nearly half (46%) of the Pennsylvania milking herd is located in Lancaster and Franklin counties in south eastern part of the state.
- Dairy farms in Lancaster County with a milking herd size of 20-99 house 23% of the Pennsylvania milking herd. This indicates that a substantial number of dairy cattle are found on small, unregulated dairy farms owned by the plain sect community.
- Since the mid-1980s, the Pennsylvania dairy herd has decreased by 50%, while the proportion of cows on large (500+ head) farms has increased dramatically. Relatively large farms (200+ head) now constitute 24% of the state milking herd.
- 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, particularly with respect to waste management systems. Most all dairy farms have both solid and liquid waste management systems.
- At the time the CBW model begins (mid-1980s), one model dairy farm is recommended with the following characteristics: located in Lancaster County with 20-99 head herd size, manage manure as solid or slurry with little or no manure storage, possess open lots without proper curbing and drainage, and utilize pasturing between milking. For the current time period, this size model farm is modified to reflect implementation of a federal and state CAFO rules and a CNMP, concomitant with significant manure storage capacity, proper lot curbing and drainage, and clean water diversion.
- For the current time, a second model dairy farm AWMS is recommended as follows: located in Lancaster County with > 100 head herd size and continuous confinement, manage manure as a liquid with significant manure storage capacity, and possess open lots with proper curbing and drainage and clean water diversion.
- The recommended manure recoverability factors for the beginning (mid-1980s) and current modelling time period is 60% and 95%, respectively.

Definitions and descriptions of typical AWMS practices

Anaerobic Lagoon. A lagoon is an impoundment created by excavating an earthen pit that is deep (8-12 ft) with a long waste residence time (≥ 60 days). The impoundment is typically lined with clay or a flexible synthetic membrane to reduce seepage. Anaerobic lagoons 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 organic and ammonia nitrogen concentrations and odor. Anaerobic lagoons are generally not designed to receive contaminated runoff from exposed animal confinement lots and are never fully emptied. Lagoons are rarely used as an AWMS component at dairy farms. However, dairy waste holding ponds are often referred to incorrectly as “lagoons.” Anaerobic lagoon loading factors affect the size of impoundment required for proper treatment function, and dramatically increase the size of these structures in the cooler climate of the CBW region. This makes it impractical to use anaerobic lagoons for dairy waste treatment in the CBW.

Waste Storage Facility. A waste storage facility is an impoundment created by excavating an earthen pit that is lined with clay, concrete, or a flexible synthetic membrane to reduce or prevent seepage. Waste storage structures can also be above ground steel or concrete structures to protect groundwater quality in sensitive areas. In the case of dairy operations, Waste Storage Facilities are typically used to store contaminated rainfall runoff from exposed confinement lots because the animals are not confined continuously. Most dairy Waste Storage Facilities are open topped and collect direct rainfall, although there are some storages under dairy barns with slatted floors. Waste Storage Facilities provide no active waste treatment, they simply store waste.

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 parlor.

Animal Unit. 1,000 lbs of live animal weight. To convert between a given number of dairy cows and AUs, divide the average weight of the dairy cows by 1,000. In the primary reference document, the dairy cows are assumed to average 1,350 lbs (USDA Natural Resources Conservation Service, 2003).

Dairy cows in the Chesapeake Bay Watershed

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 are located in counties outside of the CBW (39%) or with less than half 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) (Table 3).

The 2012 USDA Agricultural Census contains county level data on dairy farm size (**Error! Reference source not found.**). In this section of the Census, 342,736 dairy cows were reported on Pennsylvania farms, with a majority (55%) on farms with a 20-99 head milking herd. The most important Pennsylvania dairy counties are Lancaster and Franklin, which contain nearly half (46%) of the state milking herd (**Error! Reference source not found.**). Lancaster county farms that house between 20 and 99 milk cows (77,385) account for approximately one fourth (23%) of the state dairy herd, indicating a substantial portion of Pennsylvania dairy cattle are located on small, plain sect farms. The majority of the remaining Pennsylvania farms house 100-199 (67,676; 20%) and 200+ dairy cows (81,569; 24%) (**Error! Reference source not found.**). Very small dairy farms, those with less than 20 milk cows, are insignificant (**Error! Reference source not found.**). Since the "before" condition of the CBW model (simulated with Ag Census year 1987), the Pennsylvania dairy cow herd has decreased ≈ 50%, concomitant with a dramatic increase (8x) in the number large farms (500+ head) (**Error! Reference source not found.**).

Model Farms. The primary reference document contains four general dairy farm AWMSs: #1 - no storage, #2 - solids storage, #3 - liquid storage in a deep pit or slurry, and #4 - liquid storage in a basin, pond, or “lagoon” (Table 5) (USDA Natural Resources Conservation Service, 2003). Model AWMSs are classified by herd size categories similar to the 2012 USDA Ag Census size categories (Table 5**)**: < 35 AU, 35-135 135-270, and > 270, equal to < 26, 26-100, 100-200, and > 200 dairy cows, respectively. Model AWMSs in the primary reference document were formulated using professional judgement and a 1995 survey of 2,542 dairies(United States Department of Agriculture, 1996a). At the time of this survey, small dairy farms tended to remove manure from housing using both gutter cleaners and alley scraping to an outside solids storage structure; larger dairies also scarped alleys, but more frequently use flushing systems with liquid storage in pits, earthen-basins, and “anaerobic lagoons” (United States Department of Agriculture, 1996b)). Small dairies (<100 head) tended to apply manure with a solid spreader (91%) and less often as a slurry (surface application) (18%). Larger dairies (200+ head) tended to irrigate waste water (41%).

In 1995 many farms, 30 and 47% in summer and winter, respectively, spread manure daily (United States Department of Agriculture, 1996b). These were likely small farms managing solid manure, with little or no manure storage. 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, 1996a). Other farms, 33 and 31% for summer and winter, respectively, spread manure less often than monthly. These were likely larger farms managing manure as a liquid with significant manure storage capacity. In short, when the CBW model begins (mid-1980s) small dairies tended to manage manure as a solid or slurry with little or no storage capacity, while the few large dairies managed manure as a liquid waste with significant storage capacity.

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

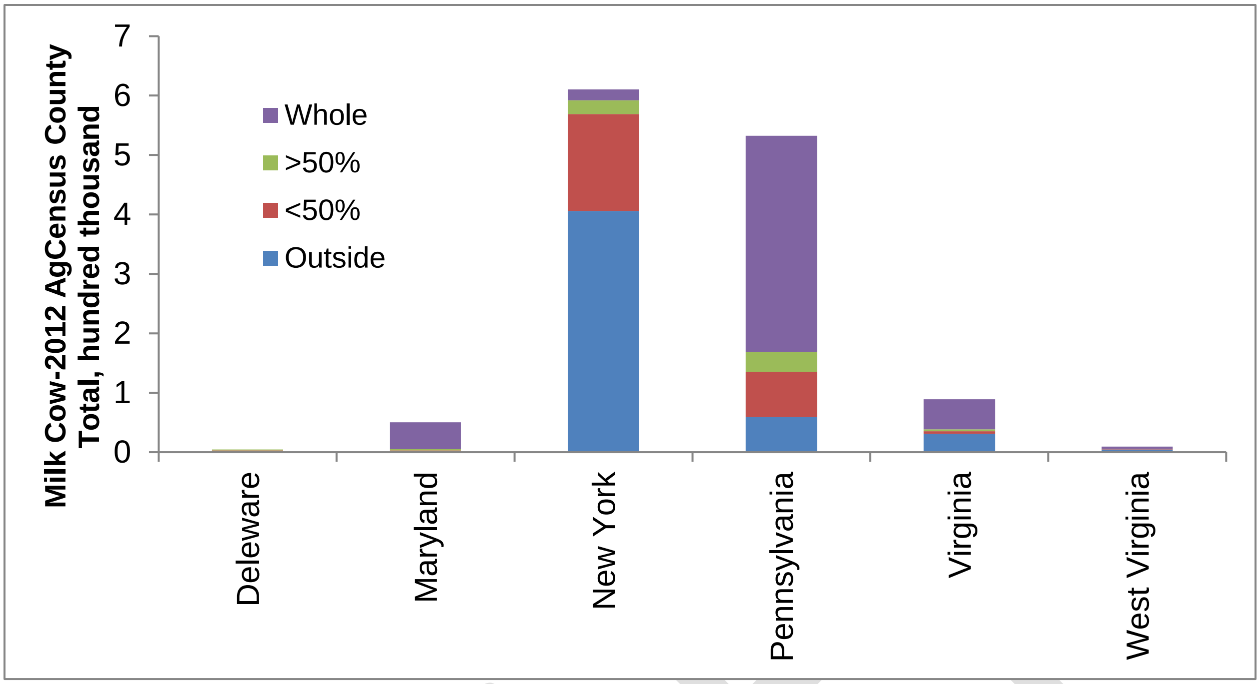


Figure 3. A stacked bar chart illustrating the total number of dairy cows located in states that contain the CBW.

Table 4. 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 5. BMP placement and % recovery of manure (M), manure nitrogen (N), and manure phosphorus (P) before and after CNMP implementation on model dairy farms (Usda Natural Resources Conservation Service, 2003).

Model Farm	Size (AU)	CNMP Need & percentage of model farm type and size with need		% manure recovered before CNMP	% manure recovered after CNMP
Dairy #1 no storage	35-135	Roof runoff management	80	45	50
		Earth berm, underground outlet	50		
		Solids Collection	10		
		Solids Storage	100		
		Liquid Treatment	65		
	135-270	Roof runoff management	80	50	
		Earth berm, underground outlet	50		
		Solids Collection	10		
		Solids Storage	100		
		Liquid Treatment	65		
		Runoff storage pond	80		
		Liquid transfer	80		
		Settling basin	80		
Dairy #2 solids storage	35-135	Roof runoff management	80	60	75
		Earth berm, underground outlet	50		
		Solids Collection	10		
		Solids Storage	20		
	135-270	Roof runoff management	80	55	
		Earth berm, underground outlet	50		
		Solids Collection	10		
		Solids Storage	40		
		Liquid Treatment	75		
		Runoff storage pond	80		
		Liquid transfer	80		
		Settling basin	80		
	>270	Roof runoff management	45	50	
		Earth berm, underground outlet	30		
		Liquid storage	100		
		Liquid collection	100		
		Liquid transfer	100		

Dairy #3 Liquid storage: deep pit or slurry	35-135	Roof runoff management	40	55	75
		Earth berm, underground outlet	30		
		Slurry storage	20		
		Liquid transfer	30		
	135-270	Roof runoff management	40		
		Earth berm, underground outlet	30		
		Slurry storage	20		
		Liquid transfer	30		
	>270	Roof runoff management	40		
		Earth berm, underground outlet	30		
		Slurry storage	20		
		Liquid transfer	20		
Dairy #4 Liquid storage: basin, pond, lagoon	35-135	Roof runoff management	40	60	75
		Earth berm, underground outlet	40		
		Liquid collection	30		
		Liquid storage	20		
		Liquid transfer	30		
	135-270	Roof runoff management	40		
		Earth berm, underground outlet	40		
		Slurry storage	30		
		Liquid storage	30		
		Liquid transfer	30		
	>270	Roof runoff management	40	55	
		Earth berm, underground outlet	40		
		Slurry storage	20		
		Liquid storage	40		
		Liquid transfer	20		

Table 6. Dairy AWMS descriptions included in a 1995 survey of 2,542 farms (United States Department of Agriculture, 1996b).

AWMS		% of operations: Farm size, dairy cows < 100	100-199	200+	Total
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

Unfortunately, no data exist which describes the current AWMS types in use on Pennsylvania dairy farms and which could be used to select model farms. Beyond the 1995 USDA survey (United States Department of Agriculture, 1996a), there are no data available to the Expert Panel to describe dairy farm manure practices near the beginning of the modeling period. As recently as 2005, it has been noted that "little is known about the types and amounts of manure actually collected on typical dairy farms" (Powell *et al.*, 2005). With this in mind, and using information from the 1987 USDA Ag Census (**Error! Reference source not found.**), the Expert Panel recommends one model CBW dairy farm for the beginning CBW modelling period (mid-1980s):

- Located in Lancaster County with a herd size between 20 and 99.
- Utilize a tiestall barn with gutter cleaner or freestall barn with alley scrapping directly loaded to a manure spreader or into short-term storage.
- Use open lots without proper curbing and drainage, significantly lowering manure recoverability.
- Manage the milking herd using pasturing between milking during permissible times of the year, with a significant portion of roughage coming from pasture forages.

For the current dairy farm AWMS model systems, the Expert Panel relies on Mr. Vanderstappen's professional judgement that it can now safely be assumed most smaller farms (20-199 head) now have implemented a CNMP and possess waste management systems in which virtually all of the manure is collected with proper curbing, drainage, clean water diversion, and storage. Mr. Vanderstappen also noted that there are now many larger farms (199+ head) within the CBW with liquid waste management systems; most are subject to regulatory oversight by

EPA as CAFOs and/or DEP as CAOs and by regulatory necessity collect virtually all manure voided in production areas. Thus, two model farms are now more appropriate.

- Located in Lancaster County with a herd size between 20 and 99.
- Utilize a tiestall barn with gutter cleaner or freestall with alley scrapping directly loaded to a manure spreader or into short-term storage.
- Use open lots with proper curbing and drainage, to recover virtually all voided manure.
- Manage the milking herd using pasturing between milking during permissible times of the year, with a significant portion of roughage coming from pasture forages.

A larger farm with liquid waste management as follows:

- Be located in Lancaster County with a herd size greater than 100.
- Utilize a freestall barn with manual or automatic scrape into long term storage and manure manage as a liquid.
- Practical continual confinement under roof with no pasturing.
- Open areas, for example between the free stall barn and parlor, if they exist, have proper curbing and drainage to recover virtually all voided manure.

Manure recoverability factors. It is clear from a study of Wisconsin dairies 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 *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) (Table 5). 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 Lancaster County, Pennsylvania farms, was 76%, even though this recoverability estimate included time spent in non-confinement (for example, vegetated loafing lots or pastures). 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 limited access to a barn were assumed to recover only 10% of voided manure (Gilbertson *et al.*, 1979).

Mr. Vanderstappen, EP member assigned to the dairy AWMS, as well as Dr. Hawkins, made contact with Mr. Moffitt, a primary reference document author (USDA Natural Resources Conservation Service, 2003), to express concern that the model dairy farm manure recoverability factors were 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, because the focus of recoverability herein excludes pastured deposited manure.

Based on these considerations, the Expert Panel recommends that the manure recoverability for the beginning time periods (mid-1980s) model farm with litter or not storage, should be increased from 50% in the primary reference document, to 60%. For both current model dairy farms, the small herd size farm with solid manure management, and the larger herd size farm with liquid manure management, the Expert Panel recommends a recoverability factor of 95%.

Dairy Farm AWMS Maintenance or Operational Needs

Dairy farm AWMSs require regular maintenance. Key maintenance items include:

- Confinement facility roof and gutters must be maintained to continually divert clean water and prevent intermingling with waste and/or entering the waste storage structure.
- Fencing, curbing, and berms-swales must be maintained to restrict confined animals and/or the waste they generate to an area which drains to the waste storage structure.
- Heavy use areas require regular (usually daily) scraping so that waste does not accumulate and overflow curbs and berms designed to contain and direct the waste to the waste storage structure.
- Waste storage structures should be inspected regularly for structure integrity and emptied in a timely manner to prevent waste from accumulating to the point that it overflows, for example during large rainfall events.
- The recoverably factor with an implemented CNMP assumes that all wastes from both the housing area and associated lot are collected into a storage with adequate capacity. The risk becomes higher for facilities with storage periods less than 120 days due to potential lack of storage capacity when no land is available for land application.

AWMS ancillary benefits and potential environmental hazards

There are no known environmental hazards associated with dairy farm AWMSs currently in use.

Future research or management needs

Further research must characterize AWMSs in use within the CBW, and particularly within Pennsylvania. Of particular interest is whether a CNMP or NMP has been implemented, and what the waste storage structure storage capacity is operating days.

There is a large variance associated with nutrient retention in dairy waste because of the variety in waste management system types and farm management practices. The average nutrient content of recovered waste could perhaps be better characterized using state manure testing laboratory values. It would be advisable to seek information on the manure analysis sheet that would characterize the dairy herd size, AWMS type in use, and the farm's county location?

Mr. Vanderstappen consulted with state conservationists in the region about Conservation Practice Standards that are implemented each year by NRCS. This data is reported to each state for subsequent reporting in annual progress runs. He asked whether or not NRCS can generate data that would better characterize the practice location, type of facility, the storage period and volume, etc. without infringing on Section 1619 regulations which protect individual landowner data. The software used by NRCS nationwide is specifically designed to track NRCS contracts with various customers; no input data is required to breakdown the operation by type, location (other than county), storage period etc., and thus the data is not extractable. This type of detailed reporting is not mandated by other agencies that have oversight on NRCS operations. At this time, there are no plans to add these requirements.

5. Poultry and Turkeys

Summary of Recoverability Factors and Key Conclusions for Poultry and Turkeys

- Virtually all poultry, including broilers, pullets, layers, and turkeys, are grown in total confinement. Animals 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 CBW model 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 CBW model 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 do occur during waste transportation and storage: manure can be washed off HUAs during rain events, litter can be blown out of trucks during transportation if the truck bed is not tarped, and manure does adhere to equipment used to place or remove the birds and/or litter 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 *et al.*, 2012; Liu *et al.*, 2015). Current manure handling and storage losses following waste removal from animal housing is minimal, therefore the recommended recoverability factor is 99%. Such a small loss of manure is certainly within the margin of error for the CBW modeling team, both in the ability quantify the number of poultry within the watershed, and their 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. Therefore, 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 it practical to more efficiently use manure nutrients. Storing litter makes it possible to land apply waste during high crop nutrient demand, which minimizes nutrient losses to the environment.

Definitions Related to Poultry and Turkey Housing and AWMSs

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 land applied as fertilizer, sold off farm, or placed in manure sheds for future use. Typically, once a year a full house cleanout will occur which will remove both the "cake" litter and the drier more finely divided litter. This is referred to as a "whole house cleanout."

Confinement House. A poultry or turkey production house used to protect the birds and their manure from the environment **(**Figure 4). For broilers (meat chickens), they are long (400-600 ft) and narrow (40-60 ft) and are now "tunnel ventilated" for summertime cooling: fresh air is pulled into one end of the house through evaporative coolers and flows in a laminar fashion to the opposite end of the building where it is exhausted using large fans. In the mid-1980s broiler confinement houses were more commonly curtain sided and bird cooling occurred by lowering the curtains to allow air to flow across the width of what were then more narrow (40 ft wide) houses. Typically, the birds are introduced as day old chicks and grow within the house for several weeks. Confinement houses for all poultry and turkey types contain the equipment to distribute feed and water to the birds. Confinement houses for turkeys and young pullets are similar to broiler houses. Mature layers are typically placed 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 confinement house. HUAs are usually made with concrete and are designed to protect the ground from rutting as equipment enters and exists the confinement 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 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 manure/litter after it has been removed from confinement 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, thereby lowering nutrient losses to the environment.

Figure 6. Poultry manure shed.

Broilers in the Chesapeake Bay Watershed

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 the these birds are 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, in terms of the total number of birds confined, the confinement house dimensions, and the number of confinement 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:

- Located on the lower shore of Maryland in Somerset County.
- Broilers would have been confined within the production houses continuously.
- Manure sheds and HUAs were not present.
- 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.
- Stockpiled litter would not be protected from the environment.

Dr. Moyle set the 2016 model farm as follows:

- Located on the lower shore of Maryland in Somerset County.
- Broilers are confined within the production houses continuously.
- HUAs are present at the entrance/exit of the confinement houses.
- Current farms have storage sheds for litter that will hold ≈ 2 flocks worth of litter until it can be land applied or shipped off farm. Field storage is much less common, and is 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 nutrients from the small amounts of dust exhausted from poultry houses and present in stormwater.

Table 7. A summary of the broiler chicken population in states that contain the CBW (2012 USDA Agricultural Census). 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

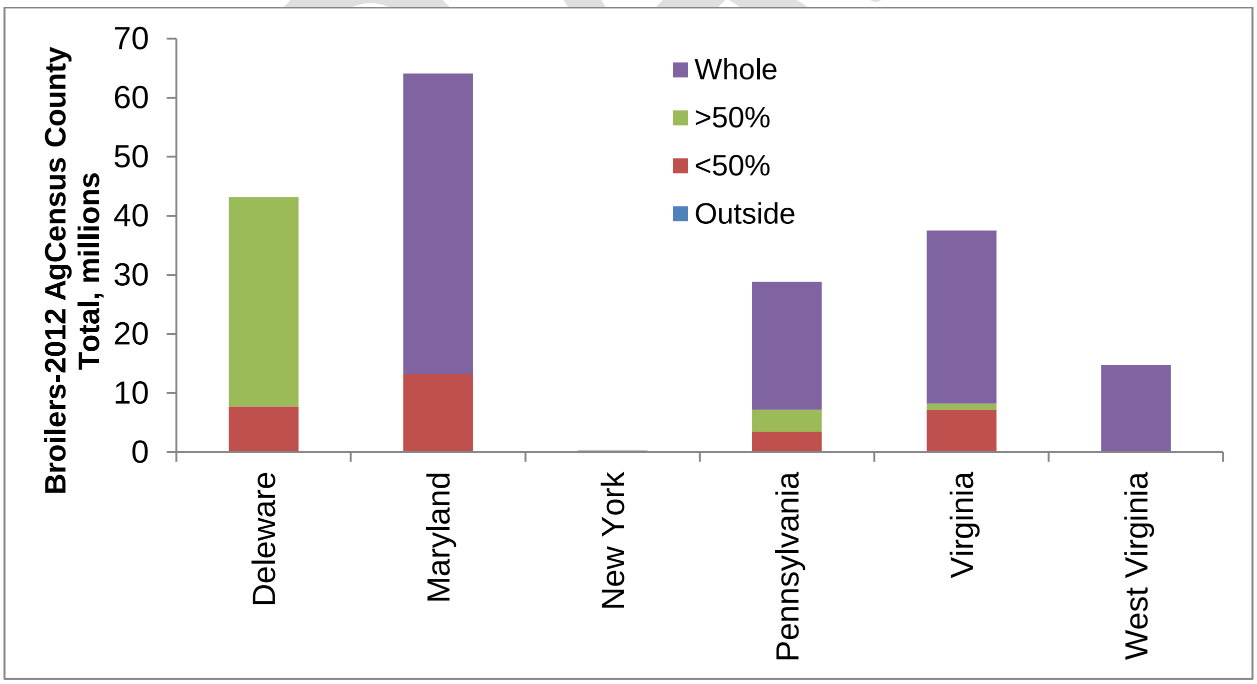


Figure 7. A stacked bar chart illustrating the total number of broiler chickens located in states that contain the CBW (2012 USDA Agricultural Census).

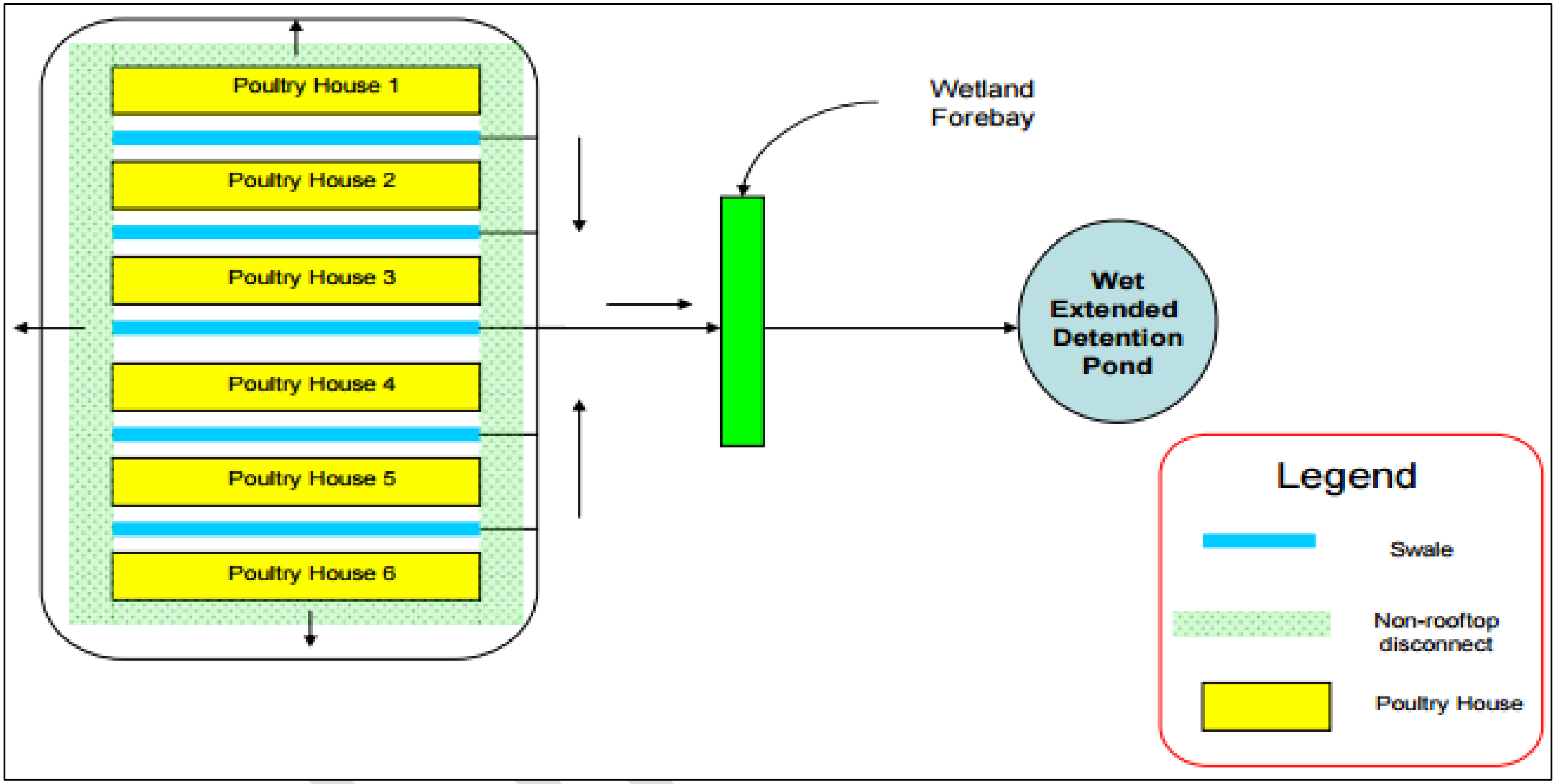


Figure 8. Current day model broiler farm with a wetland treatment system.

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 reasons 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 *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 e Gilbertson, 1978; Gilbertson *et al.*, 1979). The consensus expert panel opinion was that the recoverability values presented in Table 8 were low, particularly for the “before” condition**.**

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 *et al.*, 1998; Robert L. Kellogg *et al.*, 2000; USDA Natural Resources Conservation Service, 2003) was contacted about broiler litter recoverability in the md-1980s (Moffitt, 2016). Mr. Moffitt indicated that broiler 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 suggested losses to the environment were present (Moffitt, 2016). This was primarily due to improper stockpiling technique and potentially neglect. Based on this interview, and thorough review of the previously mentioned reference documents, the Expert Panel recommends a compromise "before" CNMP recoverability factor of 90%. This is higher than the low reference document recoverability (Table 8) but is lower than the assumption of no losses during a time when litter was likely stockpiled improperly.

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 *et al.*, 2012; Liu *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 e Rhodes (2015) did examine how much litter was on heavy use areas after birds and litter were 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, a recovery factor of even 98% would be low. The Expert Panel recommends that the current recoverability factor of broiler litter should be 99%.

Turkeys in the Chesapeake Bay Watershed

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 three Virginia Counties: Rockingham, Augusta, and Page.

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, were not pertinent within the CBW modelling timeframe (≈ 1985-present). The only model farm AWMS type that the Expert Panel recommends for consideration throughout the modeling time period 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%

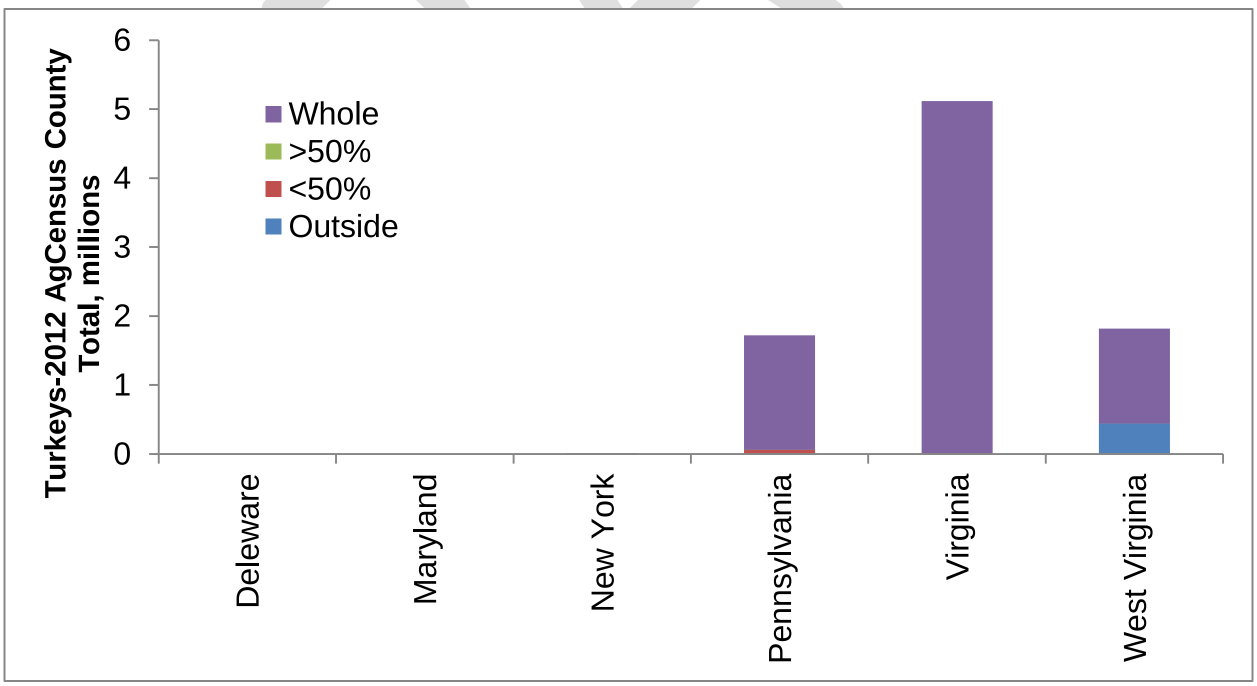


Figure 9. A stacked bar chart illustrating the total number of turkeys located in states that contain the CBW.

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 Expert Panel recommends a 1985 model farm with the following characteristics:

- 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 Expert Panel recommends a current model farm with the following characteristics:

- 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 with 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 *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 for turkey waste should be 90% at the time the CBW model begins.

Current turkey litter management practices in the CBW are well known. After turkey litter is removed from production facilities, it is typically stored under roof prior for later 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 are likely minimal. The Expert Panel recommends that the current recoverability factor for turkey waste should be 99%.

Layers in the Chesapeake Bay Watershed

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; 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 with 30,000-199,999 birds increased from 59% of all houses in 1999 to 74% in 2013. Very large confinement houses holding > 200,000 birds represented only 1% of barns in 1999; this increased to 10% by 2013. The 1987 and 1982 Ag Census Going (at 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 50,000+ birds, respectively. In conclusion, the model farm concept should be focused only the AWMSs common on large layer farms with continuous confinement.

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

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; 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 less common. Between 1999 and 2013, shallow pit and manure belt systems were replaced with raised slats 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 farms with > 100,000 layers, both with reference AWMSs being high rise houses with ground level pits or 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 for several decades.

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 *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 14). 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 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%.

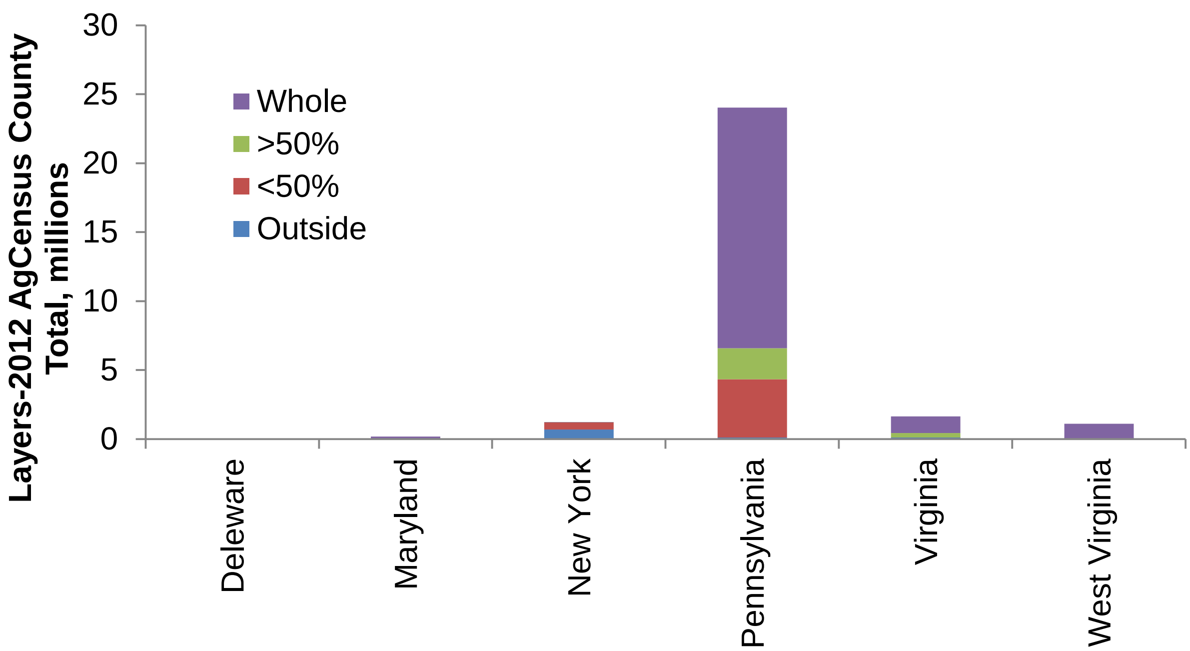


Figure 10. A stacked bar chart illustrating the total number of layer chickens located in states that contain the CBW.

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		

Poultry and Turkey AWMS Maintenance or Operational Needs

Poultry and turkey confinement houses are the primary storage structure for waste, therefore confinement house maintenance is a vital part of preventing manure losses. Maintenance should include:

- Maintain waterers to prevent leaks
- Maintain roof to prevent leaks.
- Make sure storm water runoff does not enter houses by proper grading and use of properly sized drainage systems.
- Keep all doors closed to prevent rainwater from entering houses.
- Check footers/stem walls for cracks.
- Ventilate house properly to maintain proper moisture levels.

Manure sheds operation and maintenance should include:

- Sufficient capacity to hold all litter/waste removed during times it cannot be land applied (usually 4 months).
- Manage manure to prevent overfilling the structure such that litter is exposed to blowing rain at the structure end walls-entrances/exits.
- Keep wet manure separate from dry manure.
- Keep composted material (e.g. mortalities) separate from manure and stored under roof.
- Avoid compaction of the manure and stacking manure against side walls.
- The maximum suggested stacking height is eight feet in the center of the pile.
- Schedule manure removal from the structure at proper times (usually fall and spring when it can be used for crop production) to allow for adequate storage during the winter and the growing season.
- Check backfill areas around structure often for excessive settlement. Make repairs as necessary.
- Check walls and floors often – at least after each flock – for broken or missing boards, rusted or damaged metal sheeting and/or low spots in the floor and along the walls. Make needed repairs immediately.
- Remove any woody vegetation and/ or noxious weeds growing around the structure.
- Check frequently for burrowing animals around buildings, structures, berms and backfill. Remove the animals and repair any damage.
- Inspect haul roads and approaches to and from the storage facility frequently to determine the need for stone, gravel or other stabilizing material.
- Do not allow runoff from loading areas or spills to flow into streams or drainage or road ditches.
- Mobile farm equipment may be temporarily stored within the structure as long as no manure is located outside the structure. No other equipment or items (hay, straw, boats, recreational vehicles, etc.) are permitted in the structure at any time.
- No composting of mortalities is permitted in the structure except for a catastrophic loss.

- No manure may be stockpiled outside of the structure.
- Manure added to or removed from the waste storage structure is required to be documented by origination, amount, date and destination
- Any modifications, changes or additions to the structure require prior approval of the local soil conservation district, the Natural Resources Conservation Service, and MDA if state cost-share funds were used in its construction.
- Landowners should notify the local soil conservation district of any major problems or repairs that are needed

HUA operation and maintenance should include:

- No manure may be stockpiled on the heavy use area at any time.
- Inspect the heavy use area after each live haul or manure removal event.
- Scrape or sweep the surface after each live haul or manure removal event to remove excess manure and/or sediment. Use of a power washer or blower is not permitted.
- Repair paved areas by patching holes and replacing paving materials.
- Replace loose surfacing material such as gravel, cinders, stone, clam shells, etc., as needed, around the area when removed by equipment traffic or by scraping.
- Maintain all vegetation that is established as part of the HUA by fertilizing and liming according to soil test recommendations and reseeding or replanting as necessary.
- Any modifications, changes or additions to the structure require prior approval of the local soil conservation district, the NRCS cost-share funds were used in its construction.
- Landowners should notify the local soil conservation district concerning major problems.

AWMS ancillary benefits and potential environmental hazards

The use of HUAs reduces erosion and thereby prevents sediment from entering waterways.

Future research or management needs

Further research needs to be done on how organic production of broilers, with its requirement to provide outdoor access, will affect the amount of manure recovered.

6. Beef (Fattened Cattle)

Summary of Recoverability Factors and Key Conclusions for Beef

- More than 90% of beef cattle on feed in the Chesapeake Bay region are found in Pennsylvania. The majority are found in southeast Pennsylvania in three counties (Lancaster, Cumberland, and York).
- Most of these animals are found on relatively large (> 100 head) farms.
- Prior to 1997, and before CNMPs were prepared, cattle fattening operations with more than 35 animal units (AU) in the CBW likely used feedlots and scraped and openly stockpiled manure (USDA Natural Resources Conservation Service, 2003). For this model farm, the Expert Panel recommends a recoverability factor published in the primary reference document (60%).
- Today, farms that finish more than 200 head per year do so under roof, mainly with bedded pack barns. Because the animals are continuously confined under roof, with waste being stored in a confinement structure, the Expert Panel recommends a current recoverability factor of 99%.
- Today, farms that feed less than 100 AU per year rely primarily on pasture finishing with no manure collection (0% recoverability). Open feedlots are very uncommon today in the CBW.

Definitions Related to Beef Housing and AWMSs

Fattened Cattle. Steers or heifers, generally 1 to 1 1/2 years of age, fed on feedlots or in roofed confinement for the express purpose of being prepared for slaughter. These cattle are also called Finishers. Fattening cattle are fed 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 that are generally purchased at about 450 lbs and placed for further weight gain on pasture forages for eventual sale as fattened cattle at about 750 lbs.

Backgrounding: A beef production system maximizing the use of pasture and forages to transition stocker cattle to fattened cattle.

Pasture Finishing: A beef fattening operation in which pasture is relied upon to supply roughage. Cattle are fed supplemental grain using feeders (Figure 11-A).

Feedlot: Open area with a paved or compacted soil surface in which cattle are confined open to the elements (Figure 11-B). 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 12-A), 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.

Stack: An open, covered, or roofed storage structure used for solid manure (Figure 12-B). 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.

Dry Stack: A stack covered by a roof (Figure 12-C). 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).

Bedded Pack Barn: an AWMS in which cattle are fed under roof (Figure 13-A). 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 13-B). 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 13-C). 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 (Figure 12-B and C, respectively). Alley and packed bed manure is sometimes composted before land application. The bedded pack AWMS can be used in any type of barn, but often hoop (Figure 14-A) or monoslope (Figure 14-B) structures are built specifically for use with a bedded pack AWMS.

Deep Pit Barn: An AWMS in which cattle are housed on a slatted floor over a concrete manure storage pit (Figure 14-C). 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 11. A. Pasture finishing beef cattle using a mobile feeder with shade (Beefproducer.com). B. Feedlot finishing beef cattle on a small mid-western feedlot (Americancattlemen.com).

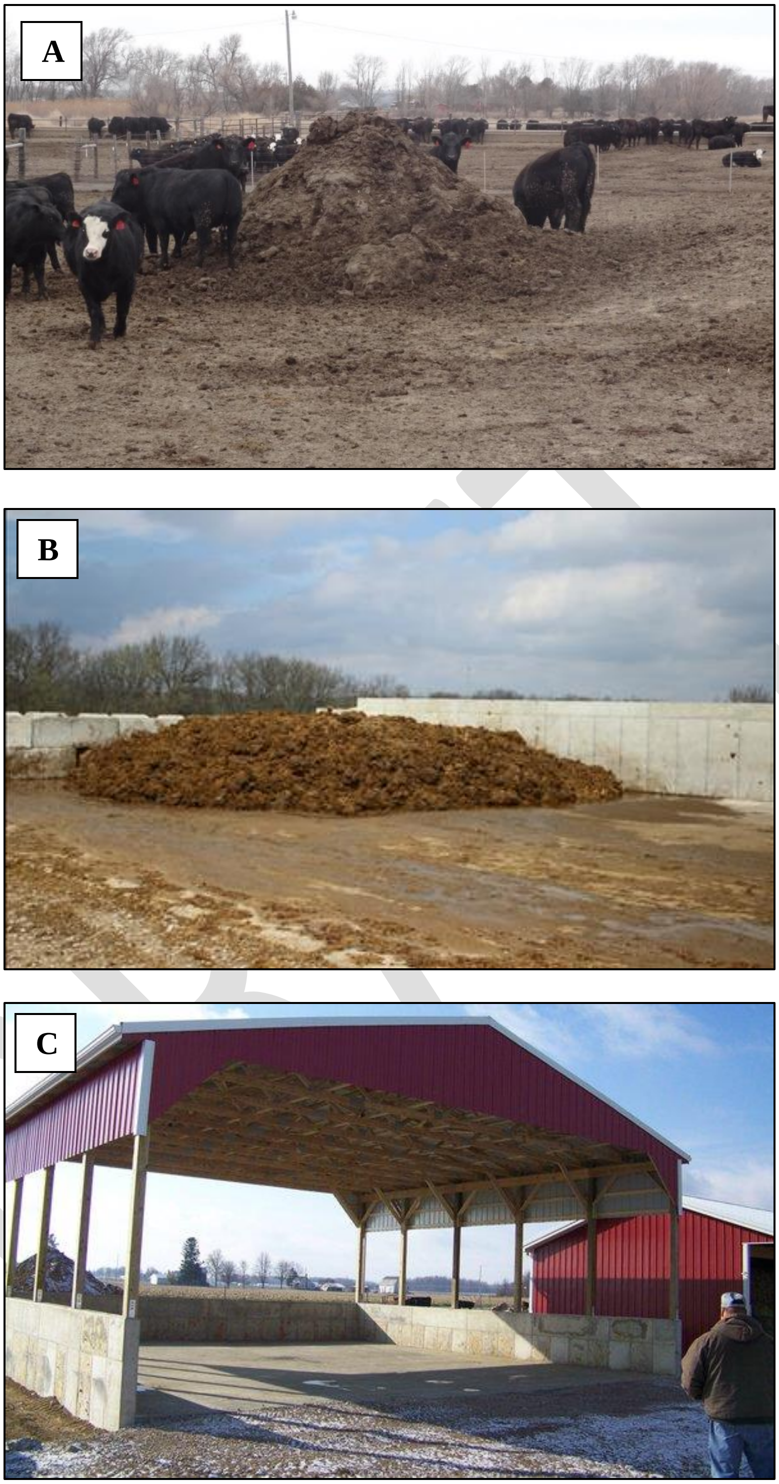


Figure 12. A. Manure stockpiled on a beef feedlot. B. Open stacked beef manure storage (Farmprogress.com). C. Empty Dry Stack Manure Storage (CrawfordSWCD).

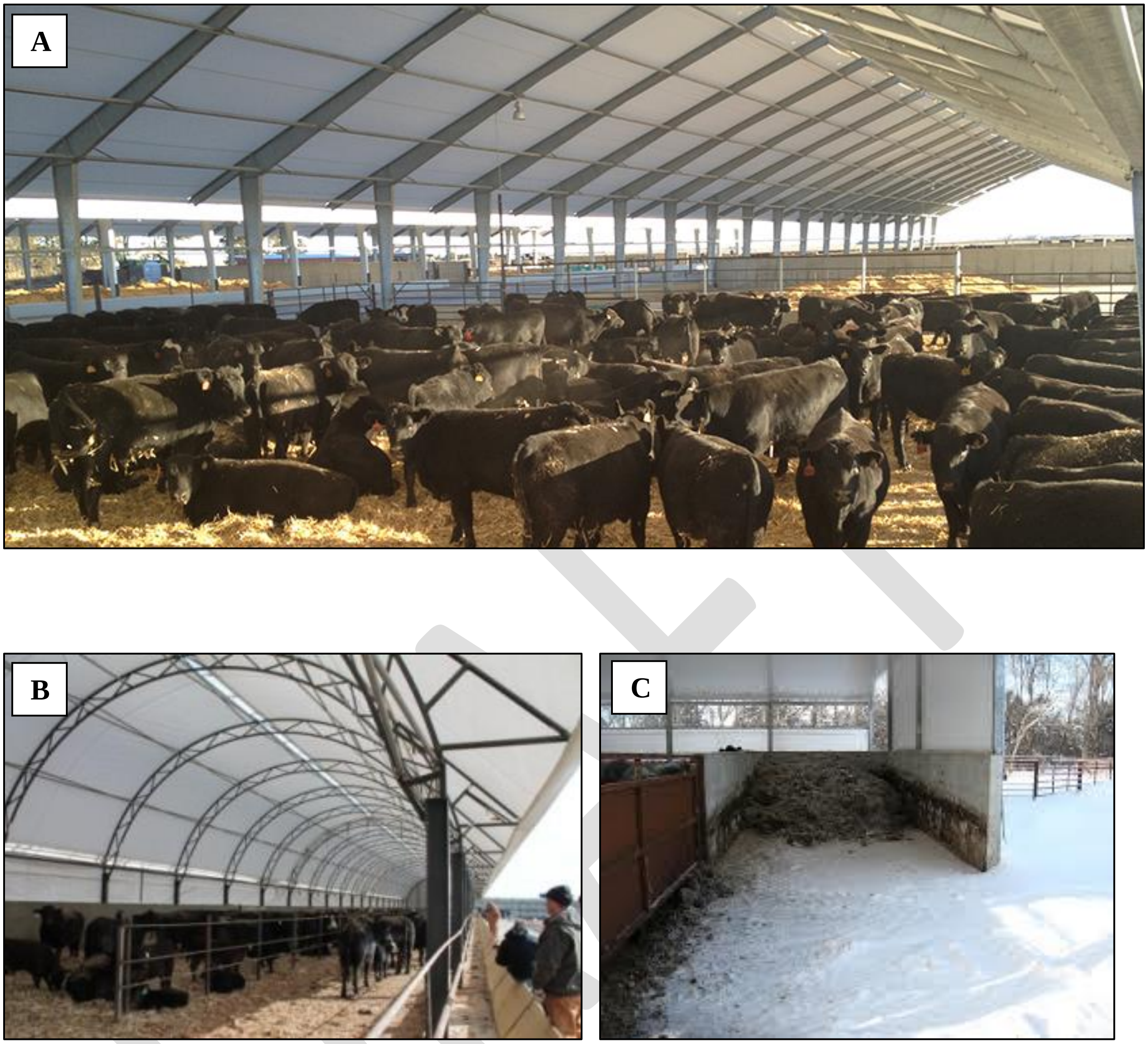


Figure 13. A. Bedded Pack Beef Production (asicoveredbuildings.com). B. Interior of a bedded pack beef barn (the feed bunk and alley are located nearest the building opening). The packed bed is behind the alley towards the rear of the barn). C. In-barn storage of manure scraped from the alley (Livingthecountrylife.com, South Dakota NRCS).

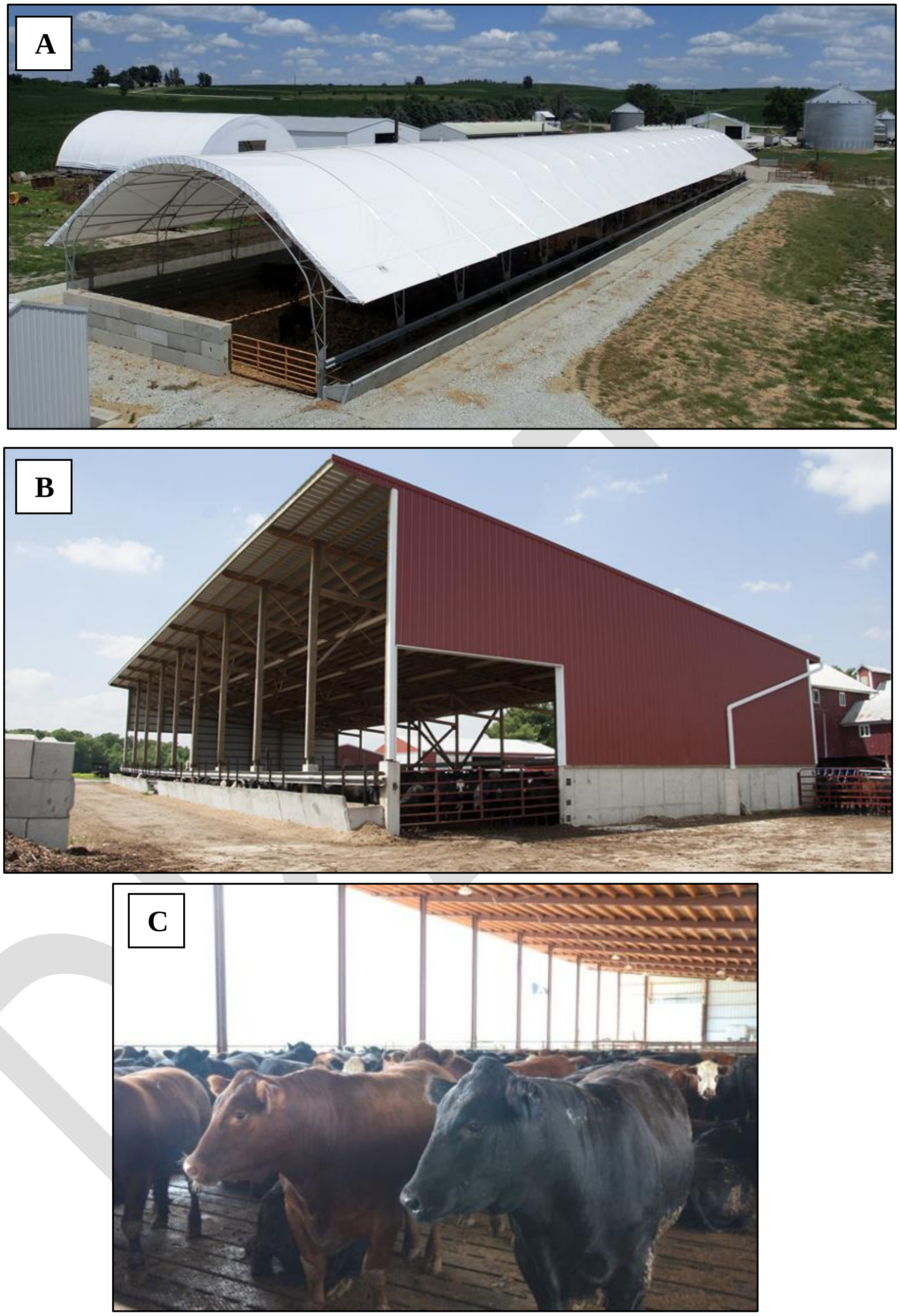


Figure 14. A. Hoop cattle feeding barn showing feeding bunk and gate for cattle removal via the alley (asicoverbuildings.com). B. Monoslope cattle feeding barn. cattle are fed in bunks placed in front of the high side of the Monoslope. In this photo cattle are eating and standing in the alley section of the pen (titanoutletstore.com). C. Monoslope Cattle Feeding Barn with Deep Pit Manure Handling Systems (High Plains Journal).

Beef Cattle in the Chesapeake Bay Watershed

Watershed Population. According to the 2012 USDA Agricultural Census, there are 171,159 cattle on feed in the six CBW; most (69%) are in Pennsylvania counties containing some portion of the CBW (Table 15; Figure 15). Most (54%) of the Pennsylvania herd are located in Lancaster County (Table 16**Error! Reference source not found.**); most (72%) are found on relatively large farms with over 100 head. The primary reference AWMS for Pennsylvania fattened cattle is a "feedlot scrape, stack" with manure recoverability before and after CNMP adoption of 60 and 75%, respectively (Table 17) (USDA Natural Resources Conservation Service, 2003).

Table 15. Cattle on feed in CBW states. The number and percentage of the 6-state grand total are presented for counties: outside the CBW, with < 50% or > 50% of the county area within the CBW, and entirely within the CBW.

State	Outside CBW		<50% Inside CBW		>50% Inside CBW		Inside CBW		Total	
	#	%	#	%	#	%	#	%	#	%
Delaware	0	0%	0	0%	0	0%	0	0%	0	0%
Maryland	0	0%	742	0%	0	0%	0	0%	742	0%
New York	21,845	13%	3,272	2%	0	0%	66	0%	3,338	2%
Pennsylvania	10,425	6%	18,336	11%	6,431	4%	93,217	54%	128,409	75%
Virginia	3,083	2%	934	1%	1,393	1%	8,785	5%	14,195	8%
West Virginia	1,600	1%	0	0%	0	0%	1,030	1%	2,630	2%
Grand Total	36,953	22%	23,284	14%	7,824	5%	103,098	60%	171,159	100%

Table 16. An estimate of cattle on feed within Pennsylvania counties that lie entirely within the CBW. Results are categorized by farm size.

Farm Size (# of cattle on feed)	Lancaster		Cumberland		York		All Others	
	#	%	#	%	#	%	#	%
1-19	391	0%	0	0%	0	0%	998	1%
20-49	2222	3%	319	0%	748	1%	3637	4%
50-99	7357	8%	1385	2%	313	0%	7191	8%
100-199	12187	14%	635	1%	528	1%	9736	11%
200-499	12221	14%	2795	3%	3397	4%	10393	12%
500+	10556	12%	0	0%	0	0%	0	0%
Grand Total	44934	52%	5134	6%	4986	6%	31955	37%

Table 17. BMP placement and % recovery of manure (M), manure nitrogen (N), and manure phosphorus (P) before and after CNMP implementation on northeast fattened cattle farms.

Model Farm			Farm Upgrades		% recovered					
					Before			After		
Region-AWMS	%	Size	Conservation Practice Standard	%	M	N	P	M	N	P
PA, NY, NJ; Scrape and Stack	100	>35	561: Lot upgrade	15	60	70	85	75	70	85
			412: Grassed Waterway Diversion	15						
			634: Solids Collection	10						
			313: Solids Storage	25						
			635: Contaminated Runoff Collection	40						
			313: Runoff Storage Pond	40						
			533: Liquid Transfer	40						
			350: Settling Basin	40						

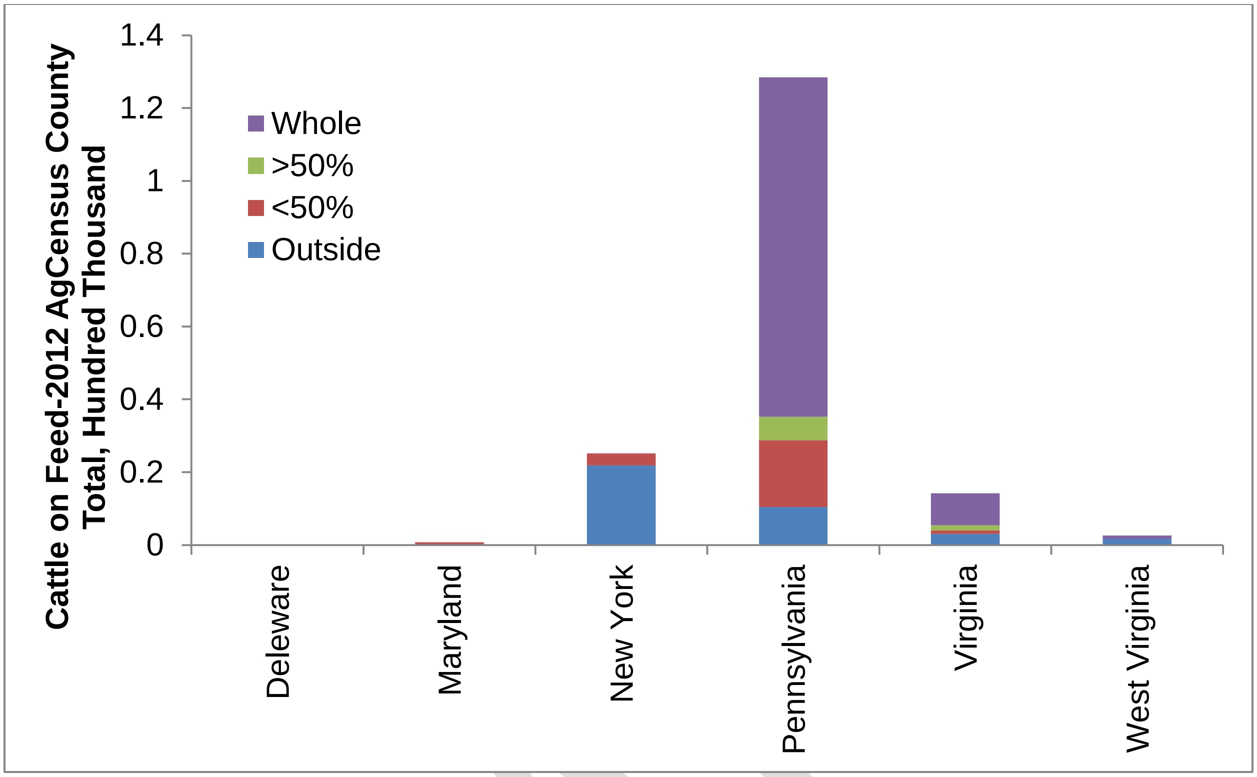


Figure 15. A stacked bar chart illustrating the total number of cattle on feed located in states that contain the CBW.

Model Farm. Tara Felix, Penn State University Extension Beef Specialist, was interviewed on August 29, 2016 to properly characterize a current fattened cattle model farm for southeastern Pennsylvania. Ms. Felix indicated that there currently very few, if any, open feedlots in Pennsylvania. Small (< 100 head) custom finishing operations in Pennsylvania now tend to use pasture finishing and do not collect manure. Ms. Felix confirmed that larger operations (200+ head) are concentrated in Lancaster and York County, PA (Table 16**Error! Reference source not found.**) and that many of these farms finish more than 1,000 AU/year (500 head capacity, two finished herds/year). Cattle finished on larger capacity farms (+200 head) are backgrounded in Pennsylvania as well as New York, Maryland, Virginia, and West Virginia. Ms. Felix indicated that the larger farms primarily use some form of bedded pack AWMS in a variety of barn structures **(**Figure 13) or are housed in old deep pit dairy barns converted to cattle feeding (Figure 14). In summary, the current model fattened cattle farm in the Chesapeake Bay Watershed is a 200+ head capacity operation located in Lancaster County. 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. Alley manure is scraped weekly and stored in a dry stack manure storage structure. Packed bed manure is removed after each herd is finished. 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 has 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.

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. Near the beginning of the CBW modeling period (mid-1980s) such open feedlots were much more common in Pennsylvania and would serve as an appropriate model farm for that time period.

Manure recoverability factors. It is difficult to account for manure deposited and collected from the beginning (mid-1980s) model cattle feedlot with scrap and manure handling. The primary reference document estimates recoverability for this AWMS before CNMP implementation at 60% (Table 17) (USDA Natural Resources Conservation Service, 2003). The Midwest Plan Service (Livestock Waste Facilities Handbook, 1998) estimated that 70% of manure excreted by beef cattle was retained on feedlots, but data substantiating this value were not provided. Several studies conducted in climates similar to the CBW do provide data on the loss of manure dry matter, carbon, and nutrients during cattle manure storage (≈ 6 months) in open stockpiles. Larney *et al.* (2006) collected manure from open feedlots in Alberta and Manitoba and estimated manure dry matter recoverability from manure stacks at 78%. This is similar to the 71% recoverability observed by Chadwick (2005) for open stockpiles of cattle manure collected from roofed structures; in their study when the manure was covered the dry matter recoverability increased to 89%. Similarly, Sommer (2001) observed an increase in manure dry matter recoverability when solid dairy barn manure was composted in covered (66% recoverability) versus uncovered (55% recoverability) stockpiles. Based on these literature values, the Expert Panel recommends adoption of the primary reference document manure recoverability for the beginning (mid-1980s) model cattle feedlot of 60% (Table 17) (USDA Natural Resources Conservation Service, 2003).

No data were discovered in a literature search to document manure recoverability from the current model fattened cattle farm, which utilizes a bedded pack confinement barn. Given that all feces and urine excreted by the cattle are collected by the bedded pack system on largely impermeable floors, and that cattle are confined and manure is stored continuously under roof, the Expert panel recommends a recoverability factor of 99%. Only small losses (minor spillage) are expected when the bedded pack is moved to dry stack storage between herds, and when the pack manure is land applied. Though physical losses of the bedded pack manure are expected to be very low, with a corresponding low loss to the environment, some reduction of bedded pack dry matter may occur due to natural biological degradation (Chadwick, 2005). However, these losses do not represent direct discharges to the environment. Similar to broilers and turkeys, the amount of “manure” recovered from bedded pack barns used to finish cattle is likely much more than the excreted feces and urine as a result of the bedding addition.

Fattened Cattle AWMS (Bedded Pack Barn) Maintenance or Operational Needs

- The most critical need for packed bed performance is the frequent placement of fresh bedding in the barn. Procurement or purchase of sufficient amount of bedding for the system to function can place a financial burden on the operation. Without addition of absorbent bedding; however, the manure pack moisture content can increase, leading not only to accidental spillage of manure, but degradation of the cattle's physical condition.
- Adequate diversion of rainwater and rainfall runoff must occur to avoid wetting the manure pack or manure stored in a dry stack. In the model farm, no storage is provided for contaminated runoff, making any contact of rainwater with manure a critical factor.
    - Maintain roof to prevent leaks.
    - Make sure storm water runoff does not enter houses by proper grading and use of properly sized drainage systems.
- Adequate storage for alley and bedded pack manure must be available to avoid spreading manure on saturated or frozen soil.
- Maintain waterers to prevent leaks inside the confinement structure.
- Check footers/stem walls for cracks.
- Ventilate confinement barn properly to maintain proper moisture levels.

AWMS ancillary benefits and potential environmental hazards

Adoption of bedded pack confinement systems should increase the amount of manure and manure nutrients collected on beef fattening farms in the Chesapeake Bay Watershed. Well managed systems encourage composting that will likely increase the stability of land applied organic matter and reduce nutrient and pathogen losses following land application.

Adoption of bedded pack housing poses few additional hazards to the environment provided adequate, protected storage is available to hold manure during periods of rain, frozen or snow covered soil, and when fields are not available for spreading. Unincorporated solid manure also has the ability to increase polluted runoff during prolonged periods of heavy precipitation.

Future research or management needs

Data from beef finishing operations within the Chesapeake Bay Watershed should be collected. Manure recoverability data requires many years of sampling of a large number of farms with similar AWMSs to obtain representative, repeatable results.

7. Swine

Summary of Recoverability Factors and Key Conclusions for Swine

- Swine production in the CBW predominantly occurs in the southeast corner of Pennsylvania (SE PA) on finishing farms.
- SE PA swine production is dominated by large herd size farms (500+ head), both now and at the time the CBW model begins. At this herd size, the Expert Panel assessment is that CBW swine have been mainly held in total confinement since the mid-1980s with relatively high manure collection efficiency.
- Lagoons and slurry system AWMSs are used as model large farms (500+ AU; 4,500 head) in the North Central and Northeast region in the reference document (USDA Natural Resources Conservation Service, 2003). No data is available for SE PA swine farm AWMSs, but because of loading factor considerations, the Expert Panel concluded that lagoons would be very rarely used.
- The recommended model farm for the current timeframe includes total confinement housing, is operated by a contract grower, and incorporates waste management using underfloor pits flushed to a Waste Storage Facility. In addition to this model farm type, an unconfined model farm was recommended for the beginning time period of the CBW model, including an open building with outside access and solid manure management.
- No studies of swine manure recoverability were found in the literature for the current model farm, likely because it is understood that all waste is easily collected from animals that are confined continuously. Manure losses do occur during stocking/load out, but such losses are very small simply because these are short duration events. Manure pit overflows are another source of losses but are rare (and illegal). Swine farm AWMS losses are minimal not only because the animals are confined continuously, but also because these farms are now regulated as CAFOs. The recommended recoverability factor for the current model farm is 99%.
- While most swine production (60%) in SE PA in the mid 1980s occurred on farms with a relatively large herd size (500+), more small, unconfined swine farms were likely present (19% of Pennsylvania swine were on farms with a herd size of less than 200 head). No measurements of swine manure collection efficiency are available for these farms, but recoverability was likely lower (USDA Natural Resources Conservation Service, 2003). The recommended swine AWMS manure recoverability factor for the mid-1980s was 90%.

Definitions Related to Swine housing and AWMSs

Anaerobic Lagoon. A lagoon is an impoundment created by excavating an earthen pit that is deep (8-12 ft) with a long waste residence time (≥ 60 days). The impoundment is typically lined with clay or a flexible synthetic membrane to reduce seepage. Anaerobic lagoons do not simply provide waste storage, but 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 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 and is mainly related to 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 swine farms are located in southeastern Pennsylvania. 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 e Graves, 1995). However, swine and dairy waste holding ponds here, and in other parts of the country, are often referred to incorrectly as "lagoons."

Waste Storage Facility. A waste storage facility is an impoundment created by excavating an earthen pit that is lined with clay, concrete, or a flexible synthetic membrane to reduce seepage, or by fabricating an above ground structure to protect groundwater quality in sensitive areas. In the case of swine operations, Waste Storage Facilities typically do not store contaminated rainfall runoff from exposed animal confinement lots because the animals are confined continuously. However, they do collect direct rainfall. These facilities provide no active waste treatment, rather they simply store waste often received from pits under a slotted floor in the hog confinement houses (the pits are pre-charged with water and flushed at regular intervals). This the more common type of swine AWMS in use in SE PA.

Swine in the Chesapeake Bay Watershed

Watershed Population. According to the 2012 USDA Agricultural Census, there are 1,260,865 hogs and pigs in the six states that contain the CBW (Table 18). The majority of these animals (72%) are located in counties contained entirely inside the CBW (Table 18) and are not breeding for breeding (Figure 16). Pennsylvania dominants swine production, housing 94% of the hogs and pigs located in counties contained entirely inside the CBW (Table 18; Figure 16**)**. Most (69%) swine are on some type of "finishing" farm as opposed to operations that involved farrowing or piglet production (PA Ag Census Table 25). The distinction between "finishing" and "farrowing" facilities is irrelevant because the waste collection efficiency is the similar (USDA Natural Resources Conservation Service, 2003).

The 2012 USDA Agricultural Census contains county level data on swine farm size (Figure 16**)**. Approximately half (49%) of hogs and pigs in Pennsylvania are produced in Lancaster and Lebanon counties (Table 19). Production is dominated by large farms, with 90% of swine farms confining 1,000+ animals, the largest farm size category included in the county level Census data (Table 19). In fact, according to state level Ag Census data most Pennsylvania swine are on very large (regulated) farms with more than 2,000 head (65% of all hogs and pigs). At greater than 1,000 head, almost all of the farms are produced by contract growers (2012 Ag Census Table 23) and therefore would be continuously confined in a building. The tendency for Pennsylvania swine to be present on large farms is long standing: the 1987 USDA Agricultural Census indicated that 60% were present on farms with 500+ animals (many of which would have be continuously confined and raised by contract growers).

Table 18. A summary of the non-breeding swine population in states that contain the CBW. 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%

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 in 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%

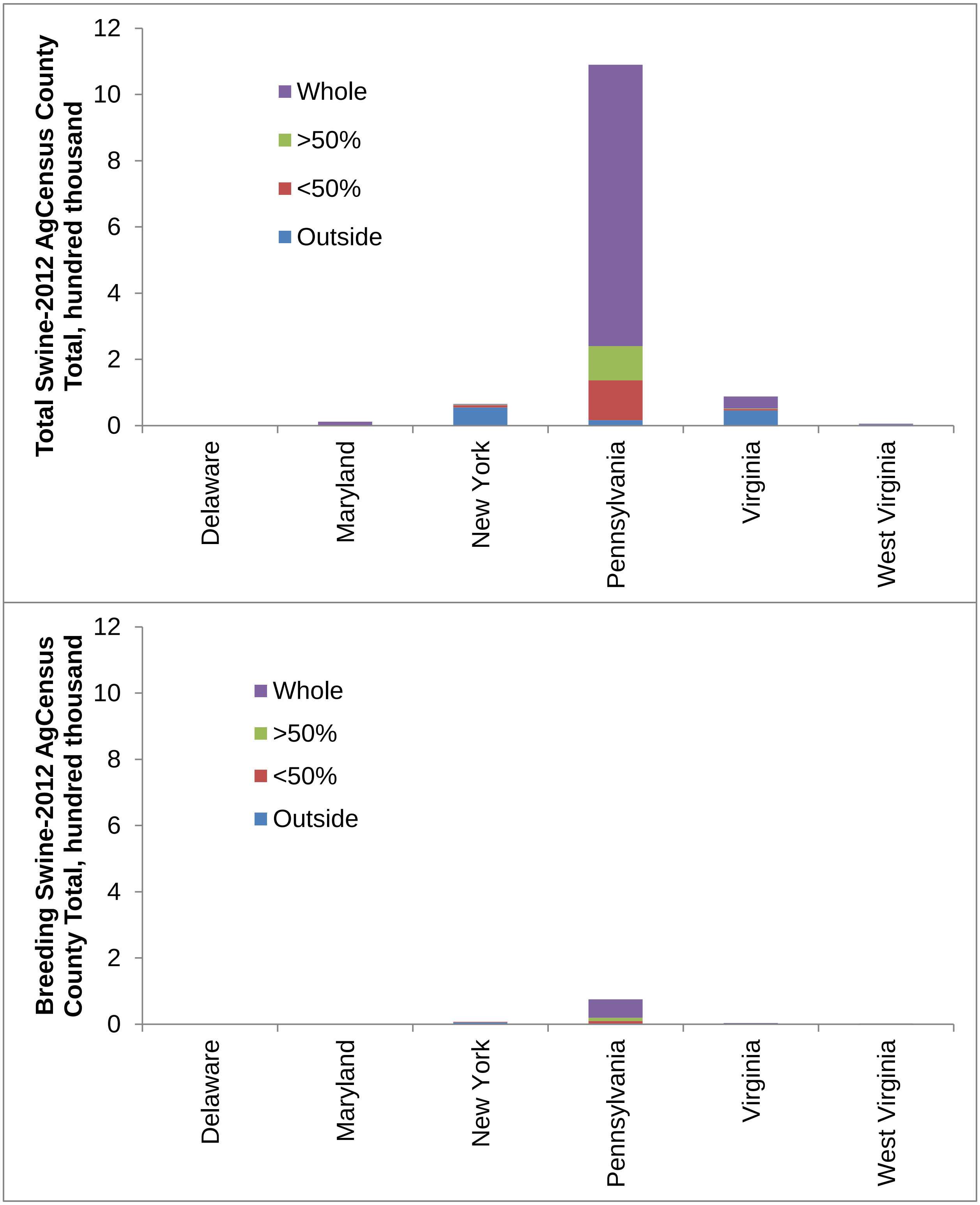


Figure 16. Stacked bar charts illustrating (top) total number of hogs and pigs, (bottom) breeding hogs and pigs (at the same vertical scale) in states that contain the CBW.

Model Farm. The CBW swine population analysis indicates that the current model farm should have the following characteristics:

- Large (>1,000 head) herd size finishing farm run by a contract grower.
- Located in SE PA in Lancaster or Lebanon county.
- Use total confinement production houses with slatted floors and underfloor manure pits.
- Waste from pits is transferred to outside waste storage facility (no lagoons in use).

The reference document identifies two model farm sizes for non-gestating swine farms in the Northeast Region: 35-500 and > 500 swine AUs, which correspond to approximate herd sizes of 320-4,500 and > 4,500 finishing animals, respectively (Table 20). The smaller herd size category includes large, regulated farms that are Medium (>750 head weighing 55+ lbs), or Large CAFOs (2,500+ head weighing 55+ pounds). At this herd sizes, the Expert Panel conclusion was that the reference document assumption that 41% of the smaller size farms (35-500 AU) hold swine in only partial confinement is inaccurate, primarily because at this herd size production is dominated by contract growers (2012 Ag Census Table 23).

Data from the 1987 Ag Census indicated that the model farm at the time of the initiation of the CBW model (mid-1980) would be similar to the current model farm (60% of hog farms in the 1987 Ag Census reported a herd size of greater than 500 head). However, 40% of swine where on farms with a herd size of less than 500 head, many of which would have not been continuously confined. Thus, the Expert Panel agreed that a second model farm type was necessary for the beginning model time period, and that model farm should be:

- Small (>500 head) finishing farm run by an independent grower.
- Located in SE PA in Lancaster or Lebanon County.
- Facility type is an open building with outdoor access.
- Solid waste is collected from the open building and land applied weekly.

Manure recoverability factors. Swine farm manure recoverability has not been quantified, but was estimated in the reference document to be 97% for large (>500 AU) total confinement farms that have implemented a CNMP (Table 20). The consensus of the Expert Panel was the 3% loss for modern, integrated swine finishing farms that are regulated as CAFOs was high, and that virtually all waste would be expected to be collected by the model AWMS. Therefore, as with the other animal types in total confinement (i.e. poultry and turkeys), the recommended AWMS manure recoverability factor is 99% for the current model farm.

In the mid-1980s, manure recoverability for the 60% of farms with a herd size larger than 500 head is recommended to be the same as for the current model farm (99%). The recommended recoverability factor for model partial confinement farm is taken from Table 20, 75% for the "before" condition, with solid waste management. The overall recoverability factor for swine in the mid-1980s was computed as follows: 0.60×0.99 (60% of swine in total confinement with 99% manure recoverability) plus 0.40×0.75 (40% of swine in partial confinement with solid waste management and 75% manure recoverability) = 90% manure recoverability overall.

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.

Model Farm			Farm Upgrades		% recovered					
					Before			After		
Size (AU)	AWMS	%	Conservation Practice Standard	%	M	N	P	M	N	P
35-500	Confined, Lagoon	6	316: Mortality Management	70	85	25	85	97	25	85
			634: Liquid Collection	10						
			313: Liquid Storage	20						
			533: Liquid Transfer	20						
	Confined, Slurry	53	316: Mortality Management	70	80	80	90	97	80	90
			313: Slurry Storage	60						
			533: Liquid Transfer	60						
	Un-confined, Liquid	14	316: Mortality Management	70	70	75	90	95	75	90
			362: Earth berm, surface outlet	20						
			558: Roof runoff management	30						
			313: Slurry Storage	50						
			533: Liquid Transfer	50						
	Un-confined, Solid	27	316: Mortality Management	70	75	70	80	90	70	80
			362: Earth berm, surface outlet	20						
			558: Roof runoff management	30						
			634: Solids Collection	10						
			313: Solids Storage	60						
			313: Runoff Storage Pond	50						
			533: Liquid Transfer	50						
			350: Settling Basin	50						
>500	Confined, Lagoon	27	316: Mortality Management	70	85	25	85	97	25	85
			634: Liquid Collection	10						
			313: Liquid Storage	20						
			533: Liquid Transfer	20						
	Confined, Slurry	73	316: Mortality Management	70	80	80	90	97	80	90
			313: Slurry Storage	60						
			533: Liquid Transfer	60						

Swine AWMS Maintenance or Operational Needs

Swine confinement houses typically are outfitted with slotted floors and waste collection in underfloor pits. Waste is typically transferred from the pit to a slurry Waste Storage Facility (not a Lagoon) where the waste is stored until it is land applied when crop nutrient demand is high. Maintenance should include:

- Maintain waterers to prevent leaks
- Maintain roof to prevent leaks.
- Make sure storm water runoff does not enter houses or manure pit by proper grading and use of properly sized drainage systems.
- Keep all doors closed to prevent rainwater from entering houses.
- Check footers/stem walls of the building and underfloor pit for cracks

Waste Storage Facility operation and maintenance should include:

- Sufficient capacity to hold all waste removed during times it cannot be land applied (usually 6 months).
- Manage manure to prevent overfilling the structure.
- Schedule manure removal from the structure at proper times (usually fall and spring when it can be used for crop production) to allow for adequate storage during the winter and the growing season.
- Remove any woody vegetation and/ or noxious weeds growing around or in the berm wall of the structure.
- Check frequently for burrowing animals. Remove the animals and repair any damage.
- repairs that are needed

AWMS ancillary benefits and potential environmental hazards

Overflow spills from large Waste Storage Facilities can erode the sidewalls of earthen pits and result in the catastrophic lass of most if not all of the stored waste.

Future research or management needs

Further research needs to be done on how the move to pastured pork production will impact manure recoverability.

8. Equine and small ruminants

Summary of Recoverability Factors and Key Conclusions for Equine

- Because very little data is available for small ruminant manure management systems, an analysis specific to small ruminants was not conducted. This chapter presents an analysis for equine; recoverability factors for equine should also be used for small ruminants (angora goats, milk goats, sheep and lambs).
- Unlike other animal types studied by the Expert Panel, horses and ponies were spread more evenly throughout the CBW. One area where equine are concentrated was Lancaster County, Pennsylvania.
- Horse are maintained in a wide variety of settings, with highly variable waste management systems. The horse population in southeastern Pennsylvania is likely managed very differently than equine in north central Virginia and western Maryland. Manure recoverability is also highly variable. Most horses are pastured the majority of time.
- The recommended model farm is a pasture with partial confinement in winter to either a hay ring or stall. A small amount of winter deposited manure (≈ 10% of the yearly total) is collected with relatively high efficiency (95%). Manure collection efficiency is slightly improved (98%) with installation of a HUA or solid manure storage structure.
- Overall manure recoverability is very low (≈ 10%) as the majority of the animals are pastured most (≈ 90%) of the time.

Definitions Related to Equine Housing and AWMSs

Pastured equine. Horses and/or ponies maintained in a vegetated lot that produces forage during the normal growing season (**Figure 17**). Pasture forage constitutes a substantial portion of sustenance. Equine pastures often have “run-in sheds”, which are open sided, roofed structures that horses shelter in by choice (**Figure 17**); they are not used to confine horses

Figure 17. Equine facilities with pasture in background, HUA and run-in shed in foreground.

Manure is not collected for pastured equine. However, there is some manure management for pastured horses because horses avoid eating where they have deposited manure. This creates pasture “roughs” where vegetation is not grazed and results in other areas of the pasture that are prone to overgrazing. Many horse owners, at least yearly, “drag” the pasture with an implement that removes the manure from “roughs” and spreads it over a larger area of the pasture where it decomposes quickly. Other equine owners that mostly pasture install heavy use areas (**Figure 17**) where horses can be confined in the open, and which allows manure to be collected.

Horse pastures are commonly overgrazed, typically due to a combination of high stocking rates (> 2 horses/acre) and poor pasture management. When overgrazed, and outside of the normal growing season, horses may remain on pasture where they are fed mostly hay.

Equine heavy use area (HUA). Areas often referred to as "sacrifice lots" where horses are confined outside in the open air but often close to a roofed structure (stall barn) or at least a run-in shelter (**Figure 17**). Topsoil is typically removed and the subsoil is armored with a layer of geotextile topped with course sand or stone. Equine HUAs are used to rest and restore pastures, or to protect pastures when they are wet or becoming overgrazed, and during winter when forages are dormant. Manure is collected efficiency from HUAs.

Stall. A small bedded (shavings, straw) enclosure, typically 12 x 12 ft, used to confine horses for a variety of reasons: pasture is not readily available or is wet or overgrazed, to protect less hardy breeds from adverse weather conditions, for example winter cold/snow, or to provide easy access for tack up and subsequent sport or work. Stalled horses are typically feed and watered daily, and all manure and soiled bedding is mucked (removed) from the stall daily. Manure collection efficiency for stalled horses is very high. This manure is typically stockpiled outside, or sometimes in roofed bins, and then land applied to pasture as weather conditions permit.

Stabled equine. Horses that are confined to a barn that typically has an array of stalls, which at some farms are rented by horse owners. This management system is used instead of pasturing for part of the day or during adverse weather (during rain or winter weather).

Equine in the Chesapeake Bay Watershed

Watershed Population. According to the 2012 USDA Agricultural Census, there are 358,035 equine within the six states that contain the CBW (**Table 21**). Over half of these animals are either outside of the watershed or in counties in which the majority of the county is not within the CBW (**Table 21**). Most of the remaining equine are in counties entirely within the CBW and are concentrated mainly in Pennsylvania, Virginia, and Maryland (**Table 21**). The EP recognizes that the USDA Ag Census does not accurately account for the equine population. The 2012 USDA Agricultural Census doesn't contain county level data on equine farm size, but does indicate that Lancaster County, Pennsylvania contains a large part of the equine population of those counties that lie entirely within the CBW.

Model Farm. CBW horse farms are diverse with respect to how the animals are maintained and what, if any, AWMS is used. In Maryland and Virginia, many horses are stabled in boarding facilities and released to pastures mainly for exercise; HUAs are more common and waste collection efficiency is relatively high. In the Pennsylvania plain sect community, horses are more traditional farm animals that are kept in confinement when worked, but with little or no use of HUAs; waste collection efficiency is relatively high when confined and nil when pastured. The majority of horse owners maintain equine exclusively on pasture. There is a continuum of pasture condition, from those that are well managed and protected with HUAs, to overgrazed pastures which require frequent need for feeding hay; some horse "pastures" could more aptly be described as confinement lots. Manure collection efficiency is poor for such confinement lots.

Table 21. A summary of the horse and pony population in states that contain the CBW. The total horse and pony 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%	4,654	1%	1,503	0%	0	0%	6,157	2%
Maryland	0	0%	1,268	0%	2,622	1%	24,772	7%	92,779	26%
New York	64,117	18%	19,398	5%	3,569	1%	2,974	1%	25,941	7%
Pennsylvania	35,427	10%	25,878	7%	4,802	1%	53,793	15%	119,900	33%
Virginia	21,856	6%	10,803	3%	3,586	1%	50,595	14%	86,840	24%
West Virginia	19,939	6%	1,192	0%	0	0%	5,287	1%	26,418	7%
Grand Total	141,339	39%	63,193	18%	16,082	4%	137,421	38%	358,035	100%

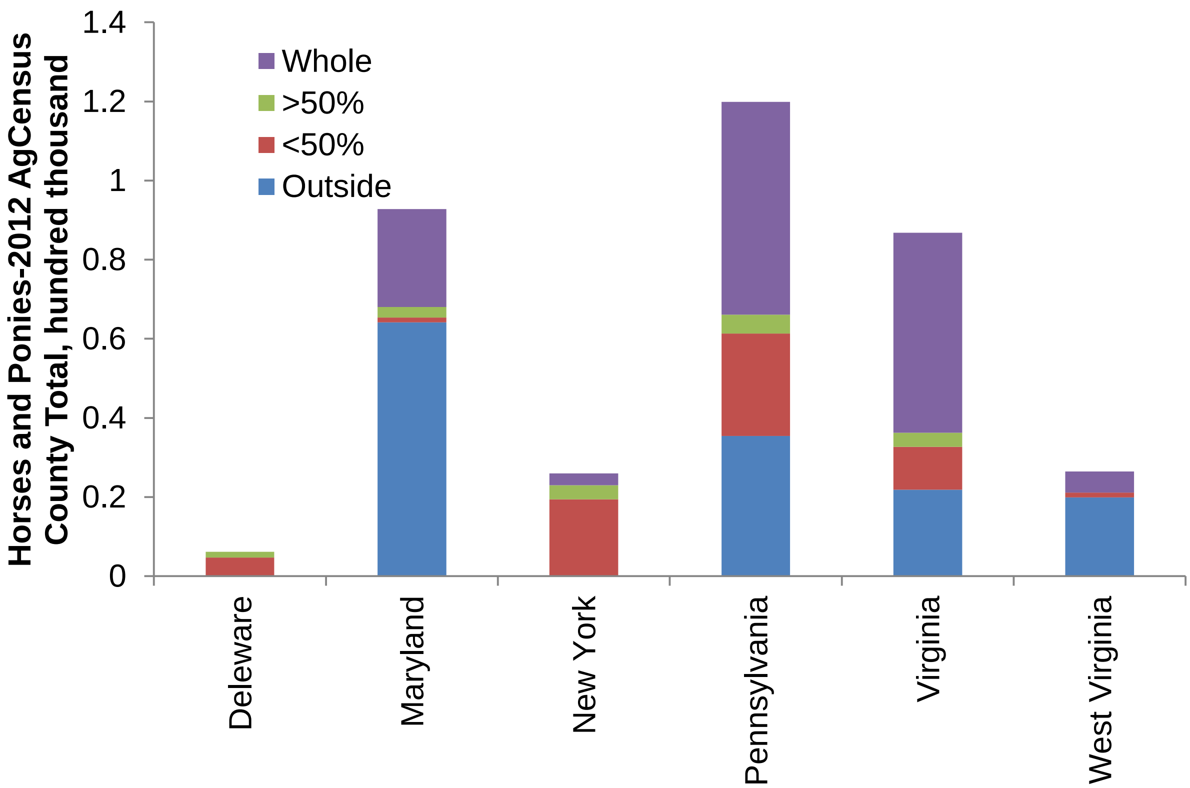


Figure 18. A stacked bar chart illustrating the total number of horses and ponies located in states that contain the CBW.

There are no model AWMSs in the primary reference document specific to equine or small ruminants (USDA Natural Resources Conservation Service, 2003). These animal types were instead lumped with beef cattle and modeled generically as a “pastured livestock.” Two representative pasturing situations were used for the Northeast region, which included the entire CBW (USDA Natural Resources Conservation Service, 2003):

- Pasture with heavy use area, applicable to farms with less than 70 animal units.
- Pasture with barn for shelter, applicable to farms with more than 70 animal units.

The recommendation of the Expert Panel is to utilize one model farm for both the beginning and current CBW modeling time periods and disregard the number of animal units. The model farm should be pasture based with partial confinement in winter to either a hay ring or stall/stable with mainly winter deposited manure collected with high efficiency. Manure collection efficiency should be slightly improved with installation of HUAs.

Manure recoverability factors. The primary reference document estimates BMPs required for grazing animal farms, including a HUA for pastured animals and solids storage for stabled horses (Table 22). However, explicit manure recoverability factors for grazing animals were not published (USDA Natural Resources Conservation Service, 2003). Instead, reference was made to a previous USDA publication that listed estimates of manure recoverability for confined grazing animals (beef cows, calves, heifers, stockers) to be 98% (Robert L. Kellogg *et al.*, 2000). The overall manure recoverability, considering an estimated division of time between pasturing and confinement varied from state to state: Delaware (10%), Maryland (10%), New York (10%), Pennsylvania (5%), Virginia (10%), and West Virginia (0%). Thus the estimate of time confined ranges from 0 to approximately 10%. The Expert Panel recommends a 95% recoverability factor for farms without HUAs/Solids Storage, and 98% after these BMPs are installed (Table 22).

Table 22. BMP placement and % recovery of manure (M), manure nitrogen (N), and manure phosphorus (P) before and after CNMP implementation.

Model Farm			Farm Upgrades		% recovered (when confined)					
					Before			After		
Size (AU)	AWMS	%	Conservation Practice Standard	%	M	N	P	M	N	P
< 70	Pasture with HUA	6	316: Fence	30	95	-	-	98	-	-
			634: Heavy Use Area Protection	50						
			313: Water Well	40						
			533: Watering Facility	40						
> 70	Pasture with Barn for Shelter	27	316: Fence	30	95	-	-	98	-	-
			634: Filter Strip	30						
			313: Solids Storage	50						

Equine AWMS Maintenance or Operational Needs

Equine are not normally confined continuously. When the animals are placed within a stable-stall, maintenance of the confinement area should include:

- Maintain waterers to prevent leaks.
- Maintain roof to prevent leaks.
- Make sure storm water runoff does not enter stalls or stable by proper grading and use of properly sized drainage systems.

Waste removed from stalls should be stored in a roofed Waste Storage Facility with the following characteristics:

- Sufficient capacity to hold all waste removed during times it cannot be land applied (usually 4 months).
- Schedule manure removal from the structure at proper times (typically in the CBW this will be fall and spring for pasture forage that cool season varieties).

AWMS ancillary benefits and potential environmental hazards

Ancillary benefits of proper management of recovered manure include lower parasite and disease pressure, better hoof health.

Future research or management needs

Further research needs to be done to characterize typical AWMS for CBW equine and small ruminants, particularly with respect to when, where, and how long animals are typically confined.

9. BMP tracking, reporting and verification

In Phase 6, states are responsible for reporting the number of eligible AWMS practices to the National Environmental Information Exchange Network (NEIEN) for all years. If a state does not currently have historic implementation information, they should consider obtaining historic BMP implementation information where possible, and tracking and reporting for future years. However, as with all BMPs reported to CBP in the future, the jurisdictions will document their verification protocols and procedures in their Quality Assurance Project Plan (QAPP) for AWMS practices that are reported in their annual progress runs. The jurisdictions existing BMP verification plans that were approved by the EPA earlier in 2016 describe their BMP priorities and procedures to verify practices – including AWMS – using the CBP partnership's BMP Verification Framework, which includes the Agriculture Workgroup's BMP Verification guidance. The full BMP Verification Framework and the jurisdictions' BMP verification plans are available online.[3] The full implementation of CBP BMP verification requirements in 2018 will necessitate the tracking and reporting of practice implementation data for future reduction credits.

The AgWG's verification guidance[4] breaks BMPs into three general categories: Visual Assessment BMPs (Single Year), Visual Assessment BMPs (Multi-Year), and Non-Visual Assessment BMPs. The complete AgWG guidance is quite extensive and is not restated in this section. The panel is not proposing any new or unique aspects of BMP verification for purposes of practices that are part of the AWMS BMP or any other BMPs approved, or under review, by the CBP that are associated with the storage and handling of manure. As the AgWG verification guidance states, Animal Waste Management Systems can be verified as Visual Assessment BMPs (Multi-Year); the panel's recommendations for the Phase 6 Watershed Model do not change this given the physical presence of manure storage structures as part of the larger manure management system.

The expert panel does not believe that new or additional guidance is needed for purposes of verifying AWMS practices as described in this report for the Phase 6 modeling tools. However, if a future expert panel provides enhanced recoverability factors based on availability of improved animal and BMP data then it may be necessary for the AgWG to consider updating its verification guidance at that time. The jurisdictions' current verification plans generally treat AWMS as a priority BMP and their documentation plus the existing AgWG guidance developed based on the Phase 5 BMP definition for AWMS remain sufficient for these Phase 6 recommendations.

As seen in this report, there are a wide range of practices that comprise an animal waste management system on a real-world poultry or livestock operation; only a subset of these practices are defined as an AWMS BMP for annual progress purposes while others such as roof gutters are counted as other BMPs by the CBP, e.g. as Barnyard Runoff Control or Loafing Lot

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[3] http://www.chesapeakebay.net/about/programs/bmp/additional_resources

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

Management. To avoid double-counting the AWMS practice has been more narrowly defined for CBP purposes consistent with the Phase 5 definition that focused on manure storage, though the conceptual shift from manure loss to terms of recoverability factors in Phase 6 required the panel to improve upon some of the Phase 5.3.2 assumptions using their best professional judgment, as described in this report.

For BMP verification purposes it is beneficial to remember that manure storage structures and heavy use area concrete pads are part of a larger manure management system that often involves multiple management and physical components (e.g., manure or nutrient management plans, conservation plans, manure treatment systems, manure transport) that can be assessed using a variety of methods available to partners at the state or county level.

Each state will determine the most appropriate methods for verifying AWMS BMP implementation given their specific priorities, programs, needs, and capacity. For example, one state may leverage existing farm site visits to also verify that the operation meets applicable AWMS BMP definitions as recommended by the Panel and that the manure is storage structure meets applicable standards. Another state may incorporate quality assurance and quality control (QA/QC) spot-checks to periodically verify a random selection of their documented AWMS practices. Ideally, states will leverage multiple existing and perhaps new avenues to verify that AWMS practices are sufficient to meet the BMP criteria as determined by a trained and/or certified independent third party, and that the data records are accurate and up-to-date. As noted in the AgWG guidance, a Visual Assessment (multi-year) practice such as AWMS "has a protracted physical presence on the landscape, i.e., of more than one year when properly maintained and operated. This type of BMP often requires increased technical and financial resources to implement compared with a single year practice." The AWMS BMP is reported as a cumulative practice, as opposed to an annually reported practice such as cover crops. This provides the jurisdictions increased flexibility and opportunities to verify AWMS practices over the course of their designed lifespan or credit duration in the modeling tools.

Given the close association between AWMS practices and other CBP-approved BMPs (e.g., manure treatment, manure transport, nutrient management, barnyard runoff control, etc.) the state agency can potentially use relevant data or associated verification methods for other reported BMPs to verify the presence and animal type for reported AWMS BMPs. Alternatively, verification methods such as spot checks or site visits associated with the installation or future verification of a manure storage and handling system provides an opportunity to identify other BMPs that were previously un-reported or to verify other Visual Single Year practices or Visual Multi-Year practices that have been reported.

The improved manure recoverability from AWMS BMPs are simulated differently in the modeling tools than other agricultural BMPs in the sense that AWMS practices reduce the simulated loss of manure to the stream, thus making more manure available for other BMPs in the barnyard and subsequently field application or transport (Figure 2).

References

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Appendix A: Technical Appendix for Scenario Builder

To be posted as a separate file as soon as it is available.

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 23. 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*[5]

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[6] (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 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.

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

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

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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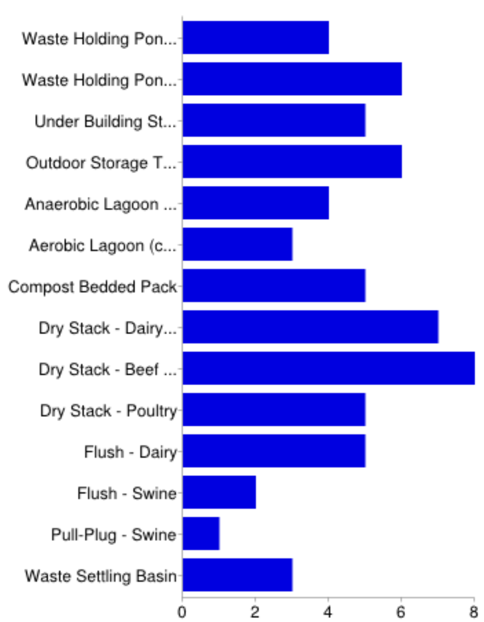
Attachment 1: Agriculture Workgroup feedback on Animal Waste Management Systems

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 posted as separate file as soon as it is available.

Appendix D: Conformity with the BMP Protocol

To be posted as separate document as soon as it is available.