Final Report for Turkey Litter Generation and Nutrient Content for use in Phase 6.0 Chesapeake Bay Program Watershed Model

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Table of Contents

List of Tables

List of Figures

Abbreviations and Acronyms

1SH	One stage hen
1SHT	One stage heavy tom
2SH	Two stage hen
2SHH	Two stage heavy hen
2SHT	Two stage heavy tom
B/P	Brooder/Poult/Brooder/Poult
Bay	Chesapeake Bay
BRE	Breeder
CBP	Chesapeake Bay Program
FHH	Finisher heavy hen
FHT	Finisher heavy tom
K	Potassium
K2O	Potassium oxide (potash)
lbs	Pounds
LGB	Litter generated per bird raised
LGP	Litter generated per pound of bird
MC	Moisture content
N	Nitrogen
P	Phosphorus
P2O5	Phosphorus pentoxide
TAN	Total ammonium nitrogen
TN	Total nitrogen
VADCR	Virginia Department of Conservation and Recreation

Units

- Concentrations: All nutrient concentrations are expressed as lbs/ton. Moisture content is reported as a percent (%). All concentrations are reported on "as-sampled" or wet basis.
- Phosphorus (P): All phosphorus concentrations values are reported as P2O5. To convert from P2O5 to elemental P, multiply P2O5 values by 0.4364.
- Total and Ammonia nitrogen are reported as N.
- Potassium (K): reported as K2O. To convert from K2O to elemental K, multiply K2O values by 0.8301.

1.0 Introduction

The Chesapeake Bay (Bay) is the largest estuary in the Americas and recognized by the United States as a national treasure. About one quarter of land in the Bay watershed is used for some form of agricultural production. While agriculture is important in the provision of food and fiber and supporting local economies, it has been identified as the single largest source of nutrient and sediment pollution entering the Bay. In fact, according to 2012 estimates by the Chesapeake Bay Program (CBP), agriculture contributes 42% of the nitrogen (N) and 58% phosphorous (P) entering the Bay.

The Chesapeake Bay Program is a unique regional partnership that has led and directed the restoration of the Chesapeake Bay since 1983. The restoration efforts have primarily focused on reducing contribution of N, P, and sediment pollution to the Bay watershed from different sources. The CBP partners include members from different agencies in the states of Maryland, Pennsylvania, Virginia, New York, West Virginia, Delaware, and the District of Columbia; the Chesapeake Bay Commission, a tristate legislative body; the Environmental Protection Agency (federal government representative); citizen advisory groups; local governments; non-profit organizations; and academic institutions. To determine the reductions of nutrients and sediment levels flowing into the Bay, stakeholders are using decision tool models to predict and track nutrients entering the Bay from the various land uses within Bay watershed. Model data inputs come from academic research, partner data collection efforts, and scientific based assumptions.

One important model input is the annual mass and concentrations of Brooder/Poultry and livestock manure nutrients generated within the Bay watershed. Currently, these inputs are estimated by multiplying a manure nutrient generation factor by the population of Brooder/Poultry and livestock maintained or raised in the watershed over a one-year period. The manure nutrient generation factor is developed from reported research data by national agricultural experts. This approach presents some inherent challenge, notably, over- or under-estimation of manure nutrients if the factors are not representative of the livestock production systems found in the Bay.

Currently, annual watershed Brooder/Poultry populations are based on the 5-year agricultural census data by the United States Department of Agriculture National Agriculture Statistics Service (USDA NASS). Typically, this census collects data at a county level, but not always with enough detail required to estimate the available mass of manure nutrients to be used as input to the Bay model. In years where USDA NASS does not collect census data, CBP's modeling tools estimate animal population using an algorithm developed by CBP modeling team and approved by the Program Partnership's Agriculture Workgroup. Briefly, the algorithm estimates watershed animal population at the county level from trends based on past USDA NASS censuses. Establishing annual trends over data collected every five years has called into question the accuracy of the population estimates developed by the modeling algorithms. This uncertainty was validated in a report developed by the Agriculture Workgroup's Brooder/Poultry Litter Subcommittee which compared the estimated Brooder/Poultry population numbers to annual Brooder/Poultry slaughter data collected by NASS. Consequently, the subcommittee concluded that new and more accurate sources of publically available production data are required to more accurately represent commercial Brooder/Poultry production in the CBP partnership's decision support tools for all areas of the Bay watershed. Subsequently, the Brooder/Poultry Litter Subcommittee made a recommendation to build a regional database that accurately characterizes Brooder/Poultry populations in the Chesapeake Bay watershed on an annual basis at the county or sub-basin scale.

2.0 Goal and scope

This report focuses on the mass generation rate and nutrient content of litter from turkey production systems in Virginia. The long term goal is to develop and maintain a database of turkey litter production and nutrient concentration information that can be develop and improve equations relating litter generation rates to bird market weight. Using equations derived from locally derived data would increase the accuracy and quality of annual mass of nutrients (nitrogen and phosphorus) estimates used as inputs in the Bay watershed modeling tools. As a first step to achieve the goal, kind of data to be collected was identified and collected from the Virginia region of the Bay watershed. The data collected, processed, and analyzed and the results presented in this report. It is anticipated that collection of data will continue into future years and expanded to all regions of the Bay watershed.

3.0 Materials and Methods

3.1 Description of Turkey Production Systems

Turkey production is a partnership between Brooder/Poultry companies (integrators) and private farmers. The company owns the birds while the farmers raise the birds and manage the litter that results from production. Once the birds reach maturity, they are collected by the Brooder/Poultry companies and processed at designated regional plants. After the mature birds are removed, the production houses on farms are cleaned and preparations are made to receive a new flock. Depending on consumer markets which often dictate the desired bird weight, the number of flocks a farmer raises may vary each year. Two products will result from a turkey farm, birds for meat and turkey litter.

Turkey production farms can be broadly classified into breeder, hatchery, and grow-out. Breeder farms raise bird stocks to produce fertile eggs that are hatched into meat birds. Typically, breeder hens and toms are raised separately. The hens will start laying eggs around 28-32 weeks of age and be in production for about 26 weeks. The eggs are collected from the breeder farms and sent to hatchery farms for incubation. The incubated eggs hatch into Brooder/Poults within a 28 days. The Brooder/Poults are then processed and sent to grow out farms. Typically, the grow out farms receive Brooder/Poults within 24 h of removal from incubators. At the grow out farms, birds are raised to different sizes depending on the desired market weight. The first stage in the grow out farms is called brooding and may last 5 to 7 weeks and the second stage of growth involves raising the birds to market weight. Once the birds attain market age, they are taken to regional plants for processing into meat products.

Two production (one and two Stage) and five (hen, heavy hen, heavy tom, breeders, Brooder/Poult/Brooder/Poult) bird types were identified to be operational in Virginia. A brief description of the general management bird houses in these production systems are described below.

3.1.1 One stage turkey house

In one stage production systems, the houses are either starter or finisher. Starter houses receive Brooder/Poults which are grown for 6 to 8 weeks and then moved to finishing houses where they continue to grow until ready for harvest. Birds may be kept in finisher houses for a period of 6 to 12 weeks depending on turkey gender and desired harvest weights.

3.1.2 Two stage turkey houses

Two stage turkey houses the growing and finishing phases of production are completed in the same house. Starters are placed in one end of the house (Brooder/Poult) as Brooder/Poults for the initial 6 to 8 weeks of their life then move to the other end of the house for finishing to harvest size. Once a batch of starters are moved, the brood area is prepared to receive another batch starter flock while the finishing end is occupied This results in two flocks of turkey birds (different ages) in opposite ends of a house at the same time.

3.1.3 All-in-all-out turkey houses

In these houses a single flock of turkeys are raised from brooding to harvest. These houses are different from two stage houses because only one flock is handled at a time and the house is not divided into stages of production. Brooder/Poults may be started in a section of the house with additional sections of the house made available to the flock as the birds grow bigger until the flock occupies the entire house.

3.1.4 Litter management and production

Turkey litter is a combination of bird droppings and bedding generated as a byproduct of raising meat birds. In general, turkey litter is a valuable organic fertilizer rich in nutrients (N, P, K) essential for crop and forage production. Typically, litter is generated when a batch is removed or cleaned out of a turkey house. It is normal practice to raise several flocks of birds on a batch of litter before it is removed from a house. In general, house management will affect the quantity, nutrient concentration, and moisture content of litter removed. Three practices, single use, partial reuse, and multiple use can be used to describe litter management in turkey production operations. Single use litter operations clean out all the litter in a house after each flock and replaces it with new bedding material (some Brooder/Poult/Brooder/Poult operations). Partial reuse entails removing litter from the brooding area and spreading it on the grower section of the house. The brooding area receives new bedding. Some of the crusted litter is removed from the grower section of the building between flocks and a total clean out occurs after raising several flocks on the litter. In multi-use litter operations, only caked litter is removed from the house with occasional topping up with fresh bedding. The litter characteristics presented in this report reflects the current industry litter cleanout and management practices.

3.2 Data Collection and Analysis

Both historical and current data was used for this report. Turkey litter nutrient concentration data was obtained from the VADCR nutrient database. The database stores samples collected from livestock and Brooder/Poultry operations in Virginia and sent to Clemson Agricultural Service Laboratory (ASL) for analysis. The data was used to see litter nutrient content changes over time. To discern nutrient concentrations for different production and bird types, only a subset of the data for the period 2012 to 2016 was used. This was because of the need to realistically, match and verify production and bird types associated with the litter analysis in the database. The team felt that going back to 2012 was reasonable. A combination of farmer and integrator surveys was conducted to identify bird and production type for the 2012 to 2016 data. Additional samples were collected during the summer of 2016 and sent to Clemson ASL for analysis to augment the VADCR database. Litter generation rate was determined using the 2016 data only, because of the challenges in getting reliable information for other years. The data collected included bird and production type, number of birds placed, number of birds harvested, average bird harvest or market weights, mass of litter removed from houses at total clean out, number of flocks per cleanout, and number of flocks raised per year.

The data was processed, analyzed, and used to estimated mass of litter produced by each bird and production type. Statistical analysis to detect any differences mass of litter generated and litter nutrient concentrations. Statistical analysis was performed using JMP® version 12 from SAS. One-way analysis of variance (ANOVA) was performed to test for significant differences group means and the Tukey's HSD test to identify which groups were different. Differences were considered significant at $p < 0.05$. After completing means comparisons, bird types were grouped and averages of litter generation nutrients for the groups calculated and proposed as factors to use in calculating annual nutrient loads.

3.3 Estimating Mass of Turkey Litter Generated

Turkey litter is considered generated when a batch is removed from a building at crust and/or total clean out. The mass of turkey litter generated was estimated by relating the estimated bird numbers, mass of litter removed from buildings, and average bird market weight (ABMW). This approach is currently used to estimate litter generation in broiler production, because of the very strong correlation ($r^2 = 0.922254$) that was observed between mass of litter produced by broilers and their average market weights (Figure 1)[1]. Briefly, the method entails dividing the mass of litter removed from an operation at clean out to the total number of birds grown on that batch of litter. The litter generated using this approach can be reported as mass per bird (lbs/bird) or mass of litter per pound of bird produced.

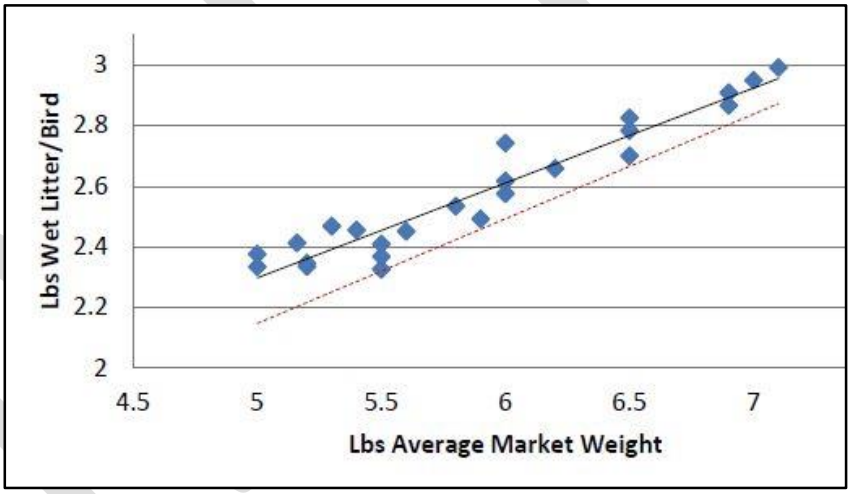

Figure 1. Boiler litter production and average market weight

Litter generated per bird (LGB) was estimated dividing total mass of litter removed from an operation at total clean out by the total number of birds raised on that batch of litter, as described in Equation (1).

Equation (1):

$$LGB\ (lbs/bird) = \frac{Mass\ of\ litter\ at\ total\ clean\ out\ (lbs)}{Number\ of\ birds\ raised\ on\ the\ litter}$$

Litter generated per pound of bird (LGP) raised was estimated by dividing the total mass of litter removed at total cleanout by the total mass of the birds raised on the batch of litter as expressed in Equation (2).

Equation (2):

$$LGP\ (lbs/lb\ bird) = \frac{Mass\ of\ litter\ at\ total\ clean\ out\ (lbs)}{Number\ of\ birds\ raised\ on\ the\ litter\ \times ABMW\ (lb\ bird)}$$

[1] In Recommendations to Estimate Poultry Nutrient Production in Phase 6 Watershed Model; Report for the Agricultural Modeling Subcommittee to the Poultry Litter Subcommittee and Agriculture Workgroup; March 2015

4.0 Results

4.1 Litter Generation Rates

4.1.1 Turkey litter generation rates in Virginia

A summary of LGB and LGP is presented in Table 1 and the corresponding data distributions by production and bird types in figures 1 and 2. A total of 117 verified data points from 1 Stage Hen (1SH), 2 Stage Hen (2SH), 2 Stage Heavy Hen (2SHH), Finisher Heavy Hen (FHH), 1Stage Hen (1SHT), 2 Stage Heavy Tom (2SHT), and Finisher Heavy Tom (FHT) operations for the year 2016 were used in the analysis. A wide range of LGB and LGP exists within each production and bird type (Figures 2 and 3). The overall mean for mass of LGB and LGP were 10.26 (±4.97) and 0.41 (±0.20), respectively. Breeders (BRE) and Brooder/Poults/Brooder/Poults (B/P) were not includes in LGB and LGP analysis because of inadequate information on market weights.

Table 1. Average mass of litter produced per bird (LGB) and per pound of bird (LGP)

Production System	Samples (N)	LGB (lbs/bird)	LGP (lbs/lb bird)	Flocks/cleanout	ASABE[2]
1SH	19	8.47 ± 3.85 ^{A,B}	0.52 ± 0.24 ^{A,B}	5.4 ± 1.4 ^{B,C}	20.95
2SH	20	10.99 ± 4.75 ^{A,B}	0.68 ± 0.30 ^{A}	6.9 ± 1.5 ^{A}	21.06
2SHH	16	7.39 ± 2.45 ^{B}	0.35 ± 0.14 ^{B,C}	7.1 ± 1.0 ^{A}	31.82
FHH	7	8.95 ± 3.31 ^{A,B}	0.38 ± 0.14 ^{B,C}	5.1 ± 0.6 ^{B,C}	28.75
1SHT	12	9.65 ± 2.16 ^{A,B}	0.24 ± 0.05 ^{C}	5.9 ± 0.9 ^{A,B,C}	32.21
2SHT	22	11.73 ± 7.46 ^{A,B}	0.29 ± 0.18 ^{C}	6.6 ± 1.6 ^{A,B}	32.81
FHT	20	12.83 ± 5.80 ^{A}	0.31 ± 0.14 ^{C}	4.9 ± 1.7 ^{C}	32.45

Numbers with the same letter superscript in the same column were not significantly different.

The following observations can be reported:

- The was no differences in LGB within hens and within toms. The only significant difference was observed between FHT and 2SHH systems. FHT had the highest (12.8 lbs/bird) LGB while 2SHH and lowest (7.4 lbs/bird).
- The LGP was highest in 2SH and lowest in 1SHT. LGP means comparisons showed no discernable differences within toms; between 1SH and 2SH; and in 1SH, 2SHH, and FHH.
- LGP was generally higher for hens compared to toms. LGP value for 2SH was highest and only similar to 1SH.
- The average flocks raised on a batch of litter was between 5 and 7.
- The litter generation rates per bird based on the data used for this report are smaller in magnitude compared to rates calculated from the ASABE Manure Production and Characteristics Standard D384.2 (2005)[1]. The ASABE standard lists a litter generation rate of 0.24 lbs/bird/day for all turkeys. Thus, using the ASABE as-removed turkey litter generation rate, hens raised for a period of 14 weeks will produce 23.77 lbs/bird (compared to 9.05 lbs/ bird found in this study) and toms raised for a period of 19 weeks would generate about 32.25 lbs/bird (compare to 11.67 lbs/bird found in this study).

[2] ASABE. Calculated from ASABE 2005. Manure production and characteristics. Amer. Soc. of Agric. Eng. D384.2. St. Joseph, MI. Values reported are corrected for moisture content (listed ASABE values are for 30% MC).

- While it is not easy to explain the large differences in litter generation rates found in this study and those calculated using the ASABE value, the following points should be noted: (1) the ASABE standard does not state litter management practices e.g. flocks grown on a batch of litter before cleanout, that may impact the values reported; (2) data used in developing the standard are dated (2003) may not reflect the changes the industry may have implemented in the last 13 years; (3) the ASABE standard notes that the variability of as-removed manure production and characteristics, are significantly high, and strongly correlated to the geographic location and the type of manure management system in use; and (4) the standard cautions use may be helpful for individual farm long-term planning where local data is not available and encourages use of location or site-specific in lieu of these national tabular estimates.

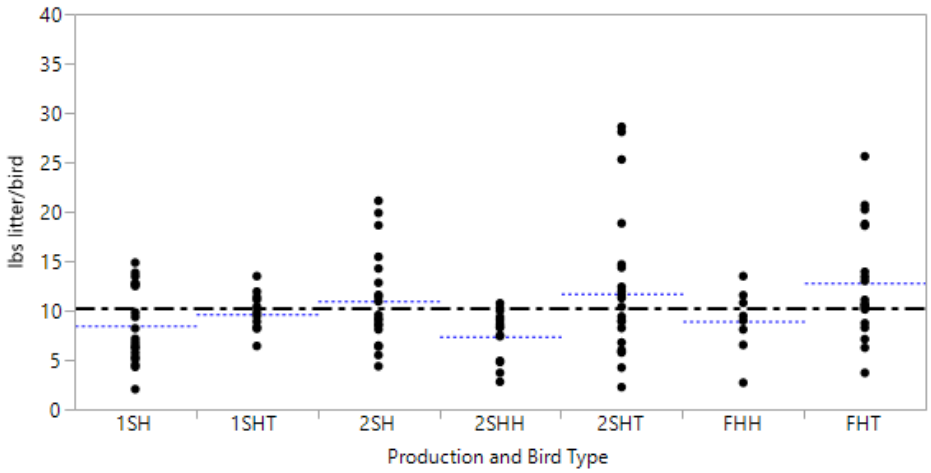

Figure 2. Litter generated per bird by production and bird type. The blue dotted lines are averages by type; long dashed line is the overall mean (10.26 ± 4.97) lbs/bird.

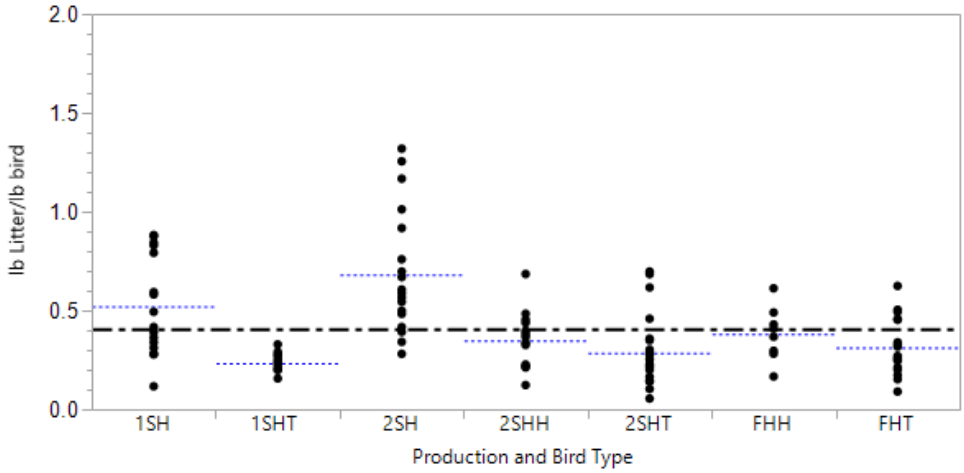

Figure 3. Litter generated per lb bird raised by production and bird type. The blue dotted lines are averages by type; long dashed line is the overall mean) (0.41 ± 0.20) lbs/ lb bird.

A linear regression analysis was conducted to describe to ascertain if there is a relationship between litter generation rates (LGB and LGP) and average bird market weights (Figures 5 and 6). The correlation

coefficients were 0.0542 and 0.2777, for LGB and LGP, respectively. The correlation coefficients are not strong and may be due to the constant nature of bird market weights clustered around 15.25, 22, and 41 lbs for hens, heavy hens, and heavy toms, respectively, with wide vertical spreads of mass of litter generated.

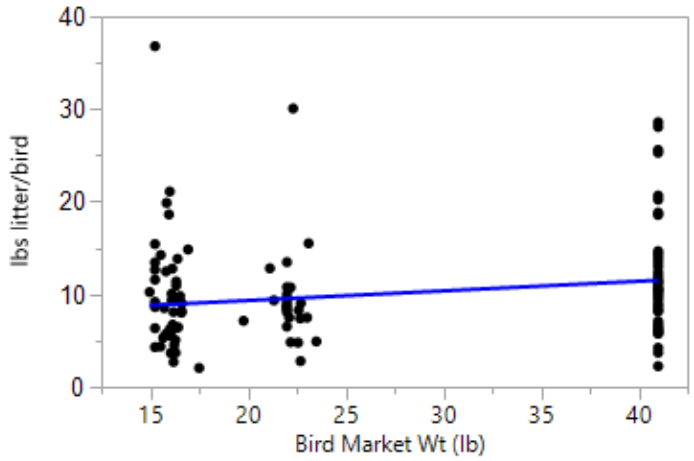

Figure 4. Correlation between litter generated per bird and average bird market weight for all production and bird types (r^2 = 0.0542)

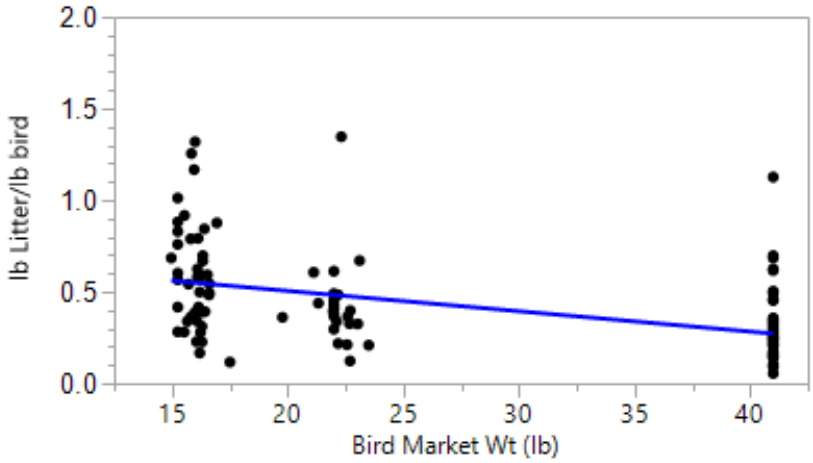

Figure 5. Correlation between litter generated per lb bird and average bird market weight for all production and bird types (r^2 = 0.2778)

The resulting linear regression equations for LGB and LGP are presented in Equations (3) and (4), respectively.

Equation (3):

$$LGB\ (lbs\ per\ bird) = 7.27 + 0.10 * Average\ Market\ weight\ (lbs\ per\ bird)$$

Equation (4):

$$LGP\ (lbs\ per\ lb\ bird) = 7.28 - 0.01 * Average\ Market\ weight\ (lbs\ per\ lb\ bird)$$

Using litter generation rates based on the data gathered from operations in the Bay watershed would improve the accuracy of the input data used in the Bay model by avoiding the current practice of applying as-excreted values or recovery factors from literature. Listed below are some potential grouping for assigning mass of litter generated per bird raised.

- All Hens (9.05 ± 3.99)
- All Toms (11.67 ±6.04)

Potential grouping for assigning mass of litter generated per pound of bird raised are:

- 1SH and 2SH (0.60 ± 0.28)
- 2SHH and FHH (0.36 ± 0.15)
- All toms (0.28 ± 0.14)

4.2 Litter Nutrient Concentrations

A summary of the nutrients concentrations and moisture content of turkey litter removed from turkey operations in Virginia during the period 2012 to 2016 is presented in Table 2. The data included in the analysis were for operations where bird and production types could be verified either through survey of farmers or information provided by the integrator. The nutrient concentrations and the moisture content summaries include breeders (BRE), Brooder/Poults/Brooder/Poults (B/P), 1SH, 2SH, 2SHH, FHH, 1SHT, 2SHT, and FHT. All nutrient concentrations and moisture content values are "as sampled".

4.2.1 Total Nitrogen (TN)

The TN concentrations by production and bird type are presented in Figure 6. The overall mean for all the TN concentrations was 79.55±18.08 lbs/ton. The highest average TN concentration was observed in 1SHT production systems while B/P had the lowest. Of the bird and production type considered in the mass of litter generation, significant difference in TN concentration was observed in litter from 1SH and 1SHT. There was no difference in TN concentration in litter from BRE and B/P. Potential grouping of bird types and mean values for assigning TN factors are:

- 1SHT (89.09 ± 13.17)
- 2SH, 2SHH, 2SHT and FHT (82.57 ± 19.77)
- 1SH and FHH (74.64 ± 16.44)
- BRE and B/P (63.91 ± 18.04)

Table 2. 2012 to 2016 Nutrient concentration summaries all bird and production types

Production and Bird Type	N	Nutrient, lbs/ton				Moisture content (%)
		Total Nitrogen	Ammonium N	Phosphorus (P2O5)	Potassium (K2O)	
1SH	46	74.33 ± 17.09 ^{B,C,D}	15.84 ± 4.83 ^{A,B}	59.54 ± 14.86 ^{D}	55.26 ± 14.17 ^{A,B}	26.26 ± 7.65 ^{A,B}
2SH	67	84.23 ± 19.07 ^{A,B}	15.67 ± 4.67 ^{A,B}	66.50 ± 16.07 ^{C,D}	59.59 ± 13.24 ^{A}	26.64 ± 7.81 ^{A,B}
2SHH	51	83.40 ± 21.92 ^{A,B}	17.29 ± 5.33 ^{A}	68.50 ± 13.99 ^{B,C,D}	58.35 ± 13.38 ^{A}	29.05 ± 7.52 ^{A}
FHH	7	76.69 ± 12.14 ^{A,B,C,D}	14.89 ± 4.88 ^{A,B}	64.23 ± 11.48 ^{A,B,C,D}	48.50 ± 7.21 ^{A,B,C}	21.48 ± 3.08 ^{A,B}
1SHT	65	89.09 ± 13.17 ^{A}	15.82 ± 3.77 ^{A,B}	79.83 ± 16.09 ^{A}	61.22 ± 11.10 ^{A}	26.21 ± 7.66 ^{A,B}
2SHT	58	80.65 ± 19.90 ^{A,B}	15.68 ± 5.64 ^{A,B}	70.12 ± 17.37 ^{B,C}	56.54 ± 13.06 ^{A,B}	27.56 ± 9.39 ^{A}
FHT	20	80.69 ± 15.80 ^{A,B,C}	15.56 ± 4.55 ^{A,B}	58.26 ± 10.72 ^{C,D}	46.56 ± 8.46 ^{B,C}	26.77 ± 8.02 ^{A,B}
BRE	30	66.33 ± 18.81 ^{C,D}	12.78 ± 5.30 ^{B}	78.03 ± 27.12 ^{A,B}	45.18 ± 9.20 ^{C}	26.38 ± 8.78 ^{A,B}
B/P	31	61.57 ± 17.22 ^{C,D}	8.42 ± 2.89 ^{C}	41.62 ± 16.77 ^{E}	37.68 ± 14.25 ^{C}	21.23 ± 6.91 ^{B}

Numbers with the same letter superscript in the same column were not significantly different

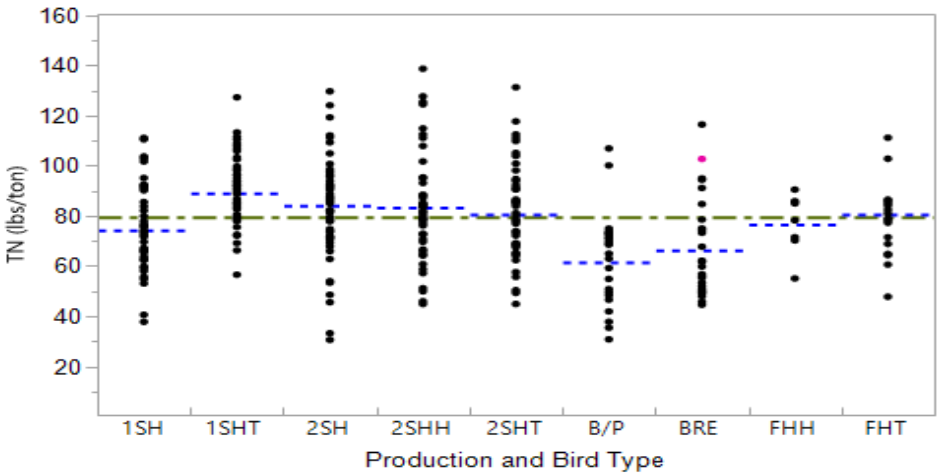

Figure 6. Total nitrogen (TN) concentrations (lbs/ton) in clean out litter for by bird and production type from 2012 to 2016 (blue dotted lines are means for each category; green dashed line is the overall mean for all categories).

4.2.2 Total ammonium nitrogen (TAN)

The TAN concentrations by production and bird type are presented in Figure 7. The overall mean for all the TAN concentrations was 15.09 ± 4.74 lbs/ton. Total ammonium nitrogen concentrations were similar in all hens and toms. The B/P had the lowest TAN concentration that was significantly different from all the others. Significant difference was also observed between the TAN concentrations of BRE and 2SHH. Potential grouping of bird types and mean values for assigning TAN factors are:

- All hens and toms (16.52 ± 6.75)
- BRE (12.78 ± 5.30)
- B/P (8.42 ± 2.89)

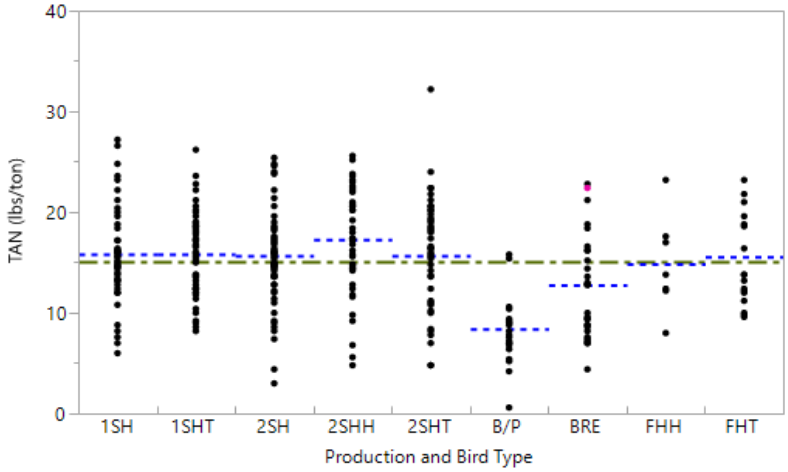

Figure 7. Total ammonium nitrogen (TAN) concentrations (lbs/ton) in clean out litter for by bird and production type from 2012 to 2016 (blue dotted lines are means for each category; green dashed line is the overall mean for all categories).

4.2.3 Total Phosphorus

The TP (as P2O5) concentrations by production and bird type are presented in Figure 8. The overall mean for all the TN concentrations was 67.18 ± 16.80 lbs/ton. The highest average TP concentration was observed in 1SHT production systems while B/P had the lowest. No significant differences were observed in the average TP concentrations in the litter from all hens. Potential grouping of bird types and mean values for assigning TP factors are:

- 1SHT and BRE (79.26 ± 20.09)
- 2SHT and 2SHH (69.36 ± 15.83)
- 2SH and FHH (66.29 ± 15.65)
- 1SH and FHT (59.19 ± 13.66)
- B/P (41.62 ± 16.77)

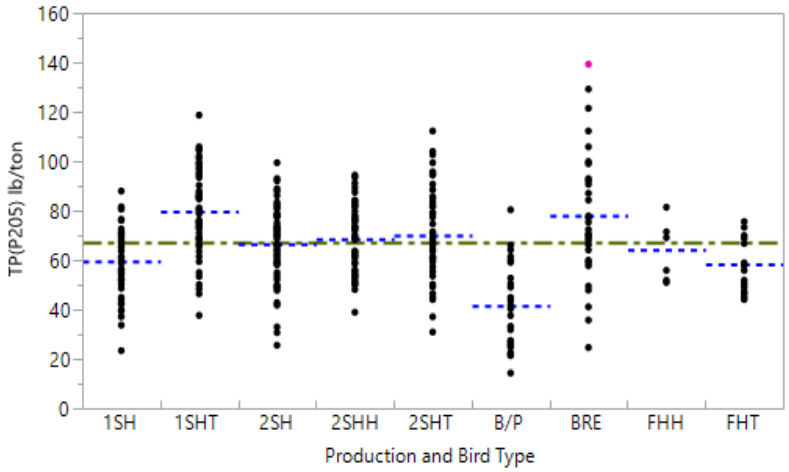

Figure 8. Total phosphorus (P2O5) concentrations (lbs/ton) in turkey litter clean out litter for by bird and production type from 2012 to 2016 (blue dotted lines are means for each category; green dashed line is the overall mean for all categories).

4.2.4 Potassium

The K (as K2O) concentrations by production and bird type are presented in Figure 9. The overall mean for all the TN concentrations was 54.83 ± 12.52 lbs/ton. The highest average TP concentration was observed in 1SHT production systems while B/P had the lowest. No significant differences were observed in the average K concentrations in the litter from all hens. Listed below are the potential grouping of bird types and mean values for assigning K factors.

- All hens (57.60 ± 13.50)
- 1SHT and 2SHT (59.05 ± 12.20)
- FHT and BRE (45.62 ± 8.92)
- B/P (37.68 ± 14.25)

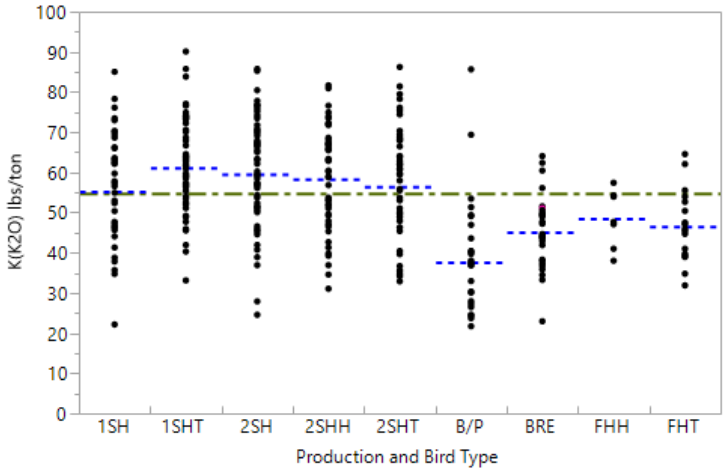

Figure 9. Potassium (K2O) concentrations (lbs/ton) in turkey litter clean out litter for by bird and production type from 2012 to 2016 (blue dotted lines are means for each category; green dashed line is the overall mean for all categories).

4.2.5 Moisture content

The MC of litter by production and bird type are presented in Figure 10. The overall mean for all the MC concentrations was 26.47 ± 7.99 lbs/ton. The highest average MC was observed in 2SHH production systems while B/P had the lowest. The Brooder/Poults had the driest litter with a moisture content of 21.23%. In general, there is no significant difference in litter moisture content except for between B/P and 2SHT and B/P and 2SHH. Potential grouping of bird types and mean values for assigning moisture content factors are:

- B/P (21.23 ± 6.91)
- All hens, all toms, and BRE (27.14 ± 8.32)

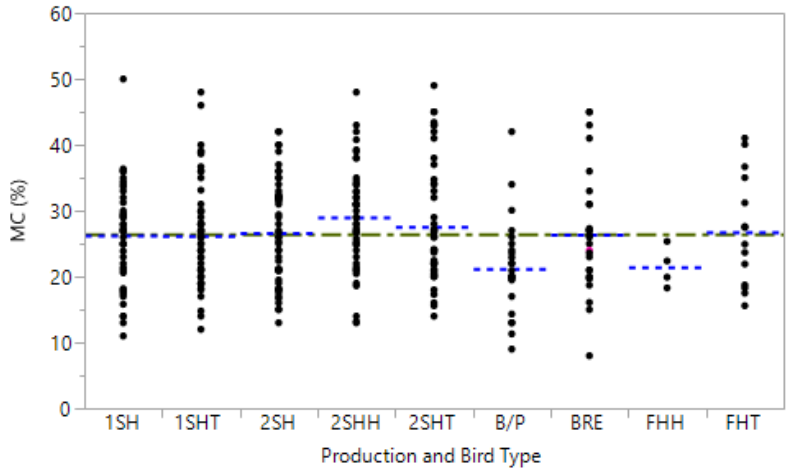

Figure 10. Turkey litter moisture content (%) clean out litter for by bird and production type from 2012 to 2016 (blue dotted lines are means for each category; green dashed line is the overall mean for all categories).

4.3 Litter nutrient concentration and moisture content trends: 1990 to 2016

The average nutrient concentrations and moisture content of turkey litter from 1990 to 2016 are presented in Figures 11 to 15. In general, all nutrient concentrations in the litter was stable from the early 1990's till 2010/2011 and remained high compared to values in the mid 2000's. when increases were observed the total nitrogen concentration was around 60 lbs/ton. Increase in TN concentration started occurring in 2006 and reached a high 76 lbs/ton in 2014/2015. The phosphorus concentration and moisture content in the litter has remained fairly stable since 2001. During this period, the TAN:TN and TN:TP has been very stable at 0.21 and 1.37, respectively.

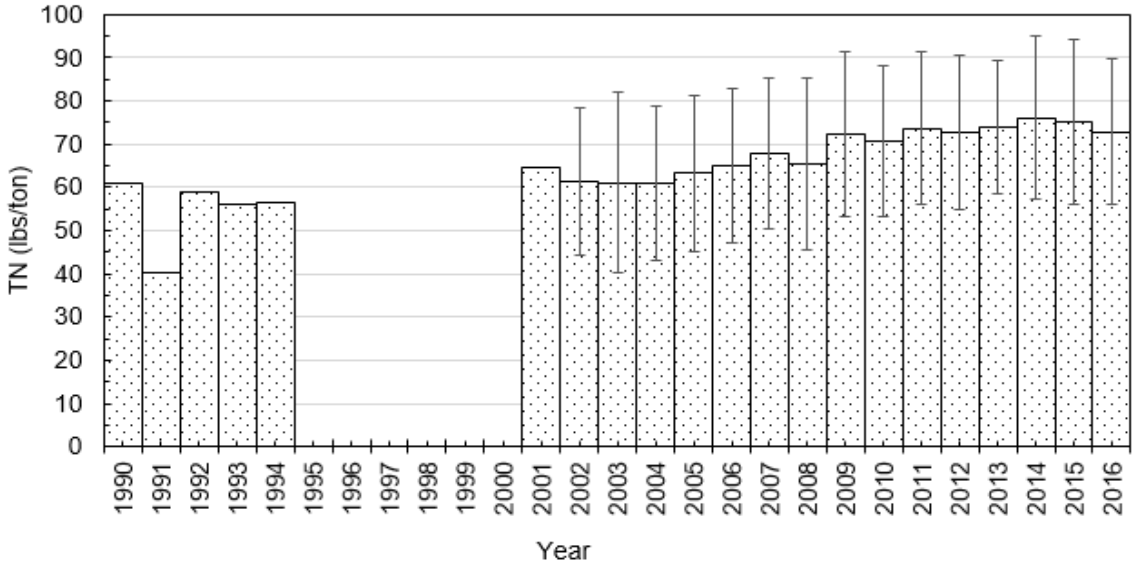

Figure 11. Concentration of total nitrogen in turkey litter, 1990 to 2016

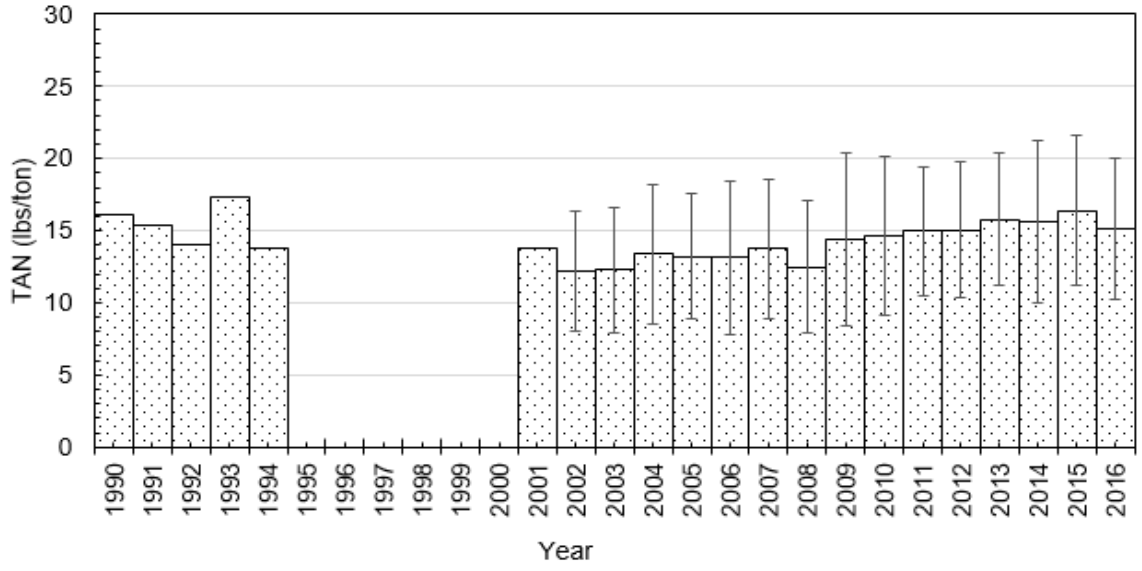

Figure 12. Concentration of total ammonium nitrogen in turkey litter, 1990 to 2016

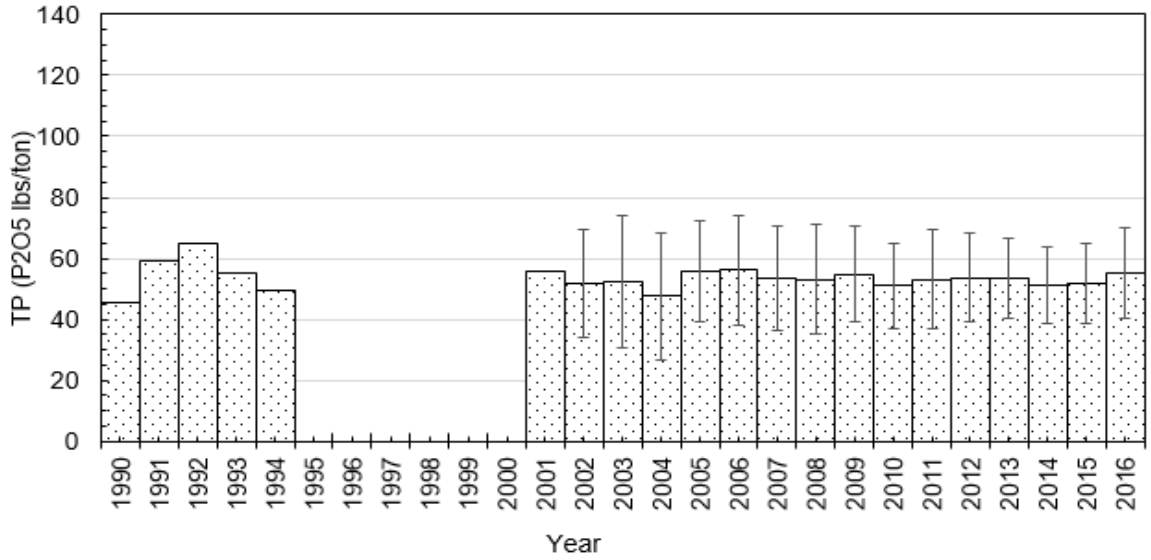

Figure 13. Concentration of total phosphorus in turkey litter, 1990 to 2016

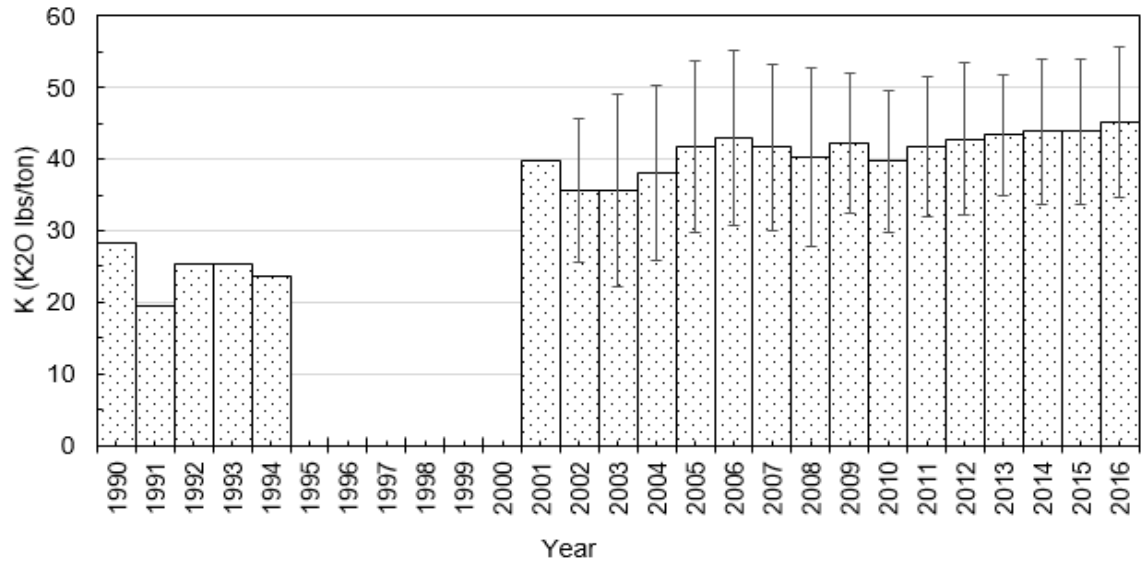

Figure 14. Concentration of potassium in turkey litter, 1990 to 2016

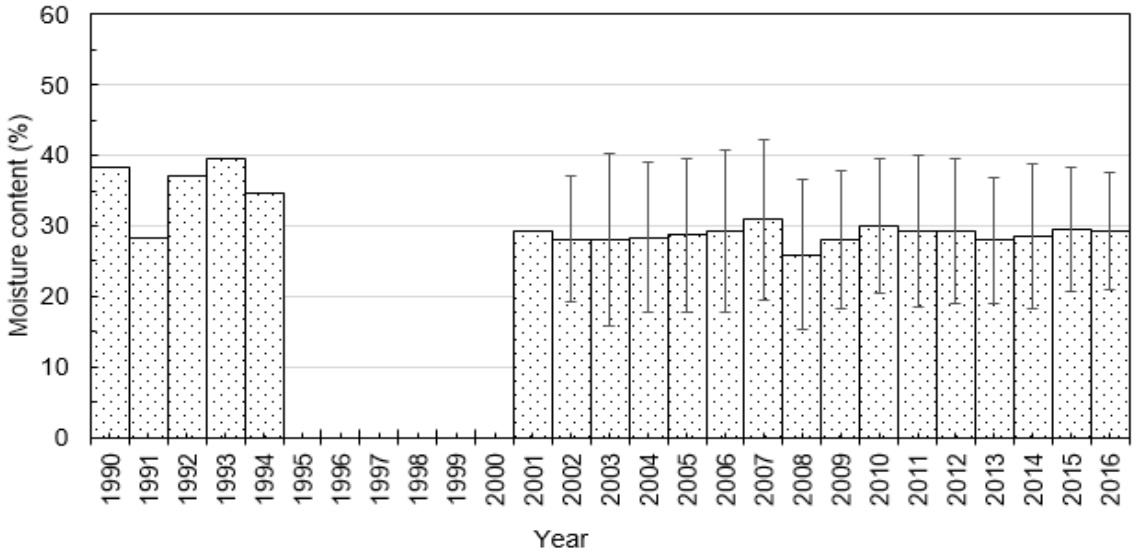

Figure 15. Turkey litter moisture content from 1990 to 2016

5.0 Summary Recommendations

Because the correlation between litter generated per bird and average bird market weight is weak, linear equations relating the two quantities, expressed in Equations (3) and (4) may not be appropriate to use in calculating the annual nutrient loading from turkey litter. Instead, the coefficients specific to bird and production type and the relevant nutrient concentration should be used. If the number of birds raised per year (Y) is known, coefficients presented in Table 3 can be used to estimate annual nutrient loading based on Equations (5) and (6).

Equation (5): Nitrogen

$$Annual\ N\ load\ (\text{lbs}) = \text{LGB}\left(\frac{\text{lbs}}{\text{bird}}\right) \times \text{TN}\ \left(\frac{\text{lbs}}{\text{ton}}\right) \times \left(\frac{1\ \text{ton}}{2000\text{lbs}}\right) \times \frac{\text{Y Birds}}{\text{year}}$$

Equation (6): Phosphorus

$$Annual\ P\ load\ (\text{lbs}) = \text{LGB}\left(\frac{\text{lbs}}{\text{bird}}\right) \times \text{TP}\ \left(\frac{\text{lbs}}{\text{ton}}\right) \times \left(\frac{1\ \text{ton}}{2000\text{lbs}}\right) \times \frac{\text{Y Birds}}{\text{year}}$$

Table 3. Coefficients for estimating nutrient loads

Production and Bird Type	LGB (lbs/bird)	TN (lbs/ton)	TP (lbs/ton)
1SH	9.05	74.64	59.19
2SH	9.05	82.57	66.29
2SHH	9.05	82.57	69.36
FHH	9.05	74.64	66.29
1SHT	11.67	89.09	79.26
2SHT	11.67	82.57	69.36
FHT	11.67	82.57	59.19
BRE	tbd	63.91	79.26
B/P	tbd	63.91	41.62

tbd – to be determined

6.0 Data Gaps and Needs

The team recommends that collection of data to characterize turkey litter generation and nutrient contents be continued in Virginia and expanded to other regions of the Bay watershed. All production systems and bird types should be identified in each state and common terminology developed to describe them. Establish an ongoing system to accept farm specific bird production data summarized to eliminate disclosure of confidential business information and used as the foundation for improving litter generation rate and nutrient concentration goals.

Appendix A: Example Nutrient data used

YEAR	County	Operation type	Turkey Type	Sample Date	TAN	TN	TP (P2O5)	K2O	MC
					lbs/ton	lbs/ton	lbs/ton	lbs/ton	%
2012	Augusta	2 Stage	Hen	01/17/12	13.60	87.20	65.54	66.74	35.17
2012	Augusta	1 Stage	Heavy Tom	01/17/12	13.20	96.60	93.49	70.60	48.23
2012	Augusta	2 Stage	Heavy Hen	01/23/12	14.20	72.60	72.87	66.02	31.29
2012	Shenandoah	1 Stage	Heavy Tom	01/24/12	11.80	79.00	86.16	61.68	19.08
2012	Rockingham	2 Stage	Heavy Hen	02/10/12	6.80	50.00	50.87	39.27	23.40
2012	Rockingham	1 Stage	Heavy Tom	02/10/12	19.00	79.60	97.62	73.49	29.60
2012	Shenandoah	2 Stage	Heavy Tom	02/24/12	22.40	117.80	84.79	68.19	40.67
2012	Rockingham	1 Stage	Hen	03/05/12	13.40	58.00	80.66	62.16	36.21
2012	Rockingham	2 Stage	Hen	03/20/12	11.00	81.40	77.91	65.54	21.41
2012	Rockingham	2 Stage	Hen	03/20/12	25.40	112.20	64.16	59.27	31.03
2012	Rockingham	2 Stage	Hen	03/20/12	15.00	81.20	81.58	58.55	23.11
2012	Rockingham	2 Stage	Hen	03/20/12	15.00	81.20	81.58	58.55	23.11
2012	Highland	2 Stage	Hen	04/10/12	11.40	53.40	86.16	75.17	24.65
2012	Rockingham	1 Stage	Heavy Tom	04/10/12	18.00	89.40	101.28	64.57	27.65
2012	Shenandoah	2 Stage	Heavy Hen	04/17/12	22.60	83.60	77.45	73.97	29.83
2012	Augusta	1 Stage	Brooder/Poult	04/20/12	4.20	49.60	25.66	24.58	20.05
2012	Augusta	2 Stage	Hen	04/30/12	16.00	87.00	77.45	71.80	23.19
2012	Shenandoah	1 Stage	Heavy Tom	04/30/12	15.60	93.60	98.99	74.93	20.97
2012	Rockingham	1 Stage	Heavy Tom	05/08/12	22.20	98.00	105.87	73.73	20.89
2012	Augusta	2 Stage	Hen	05/22/12	9.20	85.80	62.33	53.73	21.12
2012	Rockingham	2 Stage	Heavy Hen	05/29/12	20.60	93.00	73.33	74.93	29.51
2012	Augusta	1 Stage	Hen	06/14/12	17.20	72.60	66.00	63.61	26.90
2012	Augusta	1 Stage	Hen	06/14/12	17.20	72.60	66.00	63.61	26.90
2013	Rockingham	2 Stage	Hen	07/05/12	14.80	72.00	75.16	67.46	35.57

2013	Rockingham	1 Stage	Hen	07/05/12	23.20	91.00	67.83	66.26	32.83
2013	Rockingham	1 Stage	Hen	07/05/12	16.20	69.40	71.49	62.40	14.19
2013	Rockingham	1 Stage	Heavy Tom	07/18/12	12.40	107.00	81.12	59.03	40.39
2013	Rockingham	1 Stage	Breeder	07/18/12	12.80	74.40	99.91	49.39	20.90
2013	Augusta	1 Stage	Hen	08/15/12	18.40	66.00	70.58	68.67	34.29
2013	Augusta	1 Stage	Breeder	08/22/12	21.20	51.00	112.28	56.14	32.66
2013	Rockbridge	2 Stage	Heavy Hen	08/30/12	22.00	95.20	77.45	66.98	28.80
2013	Greene	2 Stage	Hen	09/04/12	13.80	82.40	58.20	51.56	20.70
2013	Rockingham	1 Stage	Heavy Tom	09/12/12	13.80	82.80	68.75	53.49	18.87
2013	Rockingham	1 Stage	Hen	09/12/12	16.00	92.20	60.95	63.37	29.00
2013	Augusta	2 Stage	Heavy Tom	09/27/12	19.20	94.80	85.70	69.39	37.06
2013	Rockingham	1 Stage	Heavy Tom	09/27/12	17.20	109.00	96.70	57.34	39.43
2013	Rockingham	2 Stage	Hen	09/27/12	16.00	74.00	92.12	85.29	38.92
2013	Shenandoah	1 Stage	Heavy Tom	10/04/12	10.40	96.00	75.62	62.64	20.70
2013	Shenandoah	1 Stage	Heavy Tom	10/04/12	12.80	96.20	74.24	59.27	20.32
2013	Highland	2 Stage	Heavy Tom	10/09/12	10.80	84.00	112.28	66.50	26.81
2013	Augusta	1 Stage	Brooder/Poult	10/17/12	7.80	75.00	50.41	43.61	23.89
2013	Augusta	1 Stage	Brooder/Poult	10/17/12	6.80	71.00	41.71	37.59	17.33
2013	Augusta	1 Stage	Heavy Tom	10/22/12	15.60	56.60	102.20	57.10	26.41
2013	Augusta	1 Stage	Heavy Tom	10/22/12	15.60	56.60	102.20	57.10	26.41
2013	Rockingham	2 Stage	Heavy Tom	11/07/12	7.00	57.60	55.45	55.90	21.94
2013	Rockingham	1 Stage	Brooder/Poult	11/07/12	9.00	48.40	27.50	27.95	22.28
2013	Rockingham	1 Stage	Heavy Tom	11/07/12	16.80	92.20	84.79	64.57	25.38
2013	Rockingham	2 Stage	Heavy Tom	11/21/12	12.40	86.00	104.03	64.09	21.67
2013	Highland	2 Stage	Hen	12/05/12	12.80	66.00	63.70	57.10	35.49
2013	Augusta	2 Stage	Hen	12/13/12	14.80	79.60	82.49	67.22	26.40
2013	Warren	1 Stage	Heavy Tom	12/20/12	9.20	69.00	73.33	55.42	35.26
2013	Augusta	2 Stage	Hen	01/08/13	23.80	45.60	87.99	70.84	26.20
2013	Augusta	2 Stage	Heavy Hen	01/17/13	22.00	101.80	94.41	81.68	42.54

2013	Augusta	2 Stage	Heavy Hen	01/17/13	22.20	112.60	89.37	81.68	38.23
2013	Rockingham	2 Stage	Heavy Hen	01/24/13	22.40	84.40	87.54	73.49	31.55
2013	Rockingham	1 Stage	Brooder/Poult	01/24/13	15.80	100.20	61.41	49.39	20.35
2013	Augusta	1 Stage	Hen	02/07/13	12.80	74.20	71.04	59.75	29.63
2013	Rockingham	1 Stage	Heavy Tom	02/07/13	17.20	84.40	73.33	52.04	11.81
2013	Augusta	1 Stage	Heavy Tom	02/19/13	23.20	107.80	88.91	63.13	55.50
2013	Rockingham	1 Stage	Hen	02/19/13	15.60	71.80	76.54	70.35	32.22
2013	Rockingham	1 Stage	Hen	02/19/13	27.20	62.80	81.58	78.31	50.20
2013	Rockingham	2 Stage	Heavy Tom	02/19/13	15.40	64.20	94.87	75.41	44.99
2013	Rockingham	2 Stage	Heavy Tom	02/19/13	1.40	44.80	80.66	25.06	59.09
2013	Rockingham	1 Stage	Heavy Tom	03/04/13	20.60	92.40	87.99	63.61	24.53
2013	Augusta	1 Stage	Heavy Tom	03/07/13	10.00	98.20	68.75	47.71	28.17
2013	Rockingham	1 Stage	Heavy Tom	03/07/13	17.40	92.40	78.83	59.27	20.79
2013	Augusta	2 Stage	Heavy Tom	03/13/13	17.40	81.20	77.45	57.83	28.68
2013	Rockingham	1 Stage	Heavy Tom	03/13/13	18.80	78.00	87.99	59.75	36.00
2013	Shenandoah	2 Stage	Heavy Hen	03/13/13	22.60	73.00	76.54	63.13	31.47
2013	Rockingham	1 Stage	Hen	03/27/13	26.60	110.60	87.99	76.14	27.67
2013	Rockingham	1 Stage	Hen	04/02/13	22.20	101.80	76.08	73.00	26.32
2013	Rockingham	1 Stage	Breeder	04/03/13	8.20	51.00	84.33	35.90	24.57
2013	Rockingham	1 Stage	Breeder	04/03/13	22.40	102.80	139.32	51.08	24.30
2013	Rockingham	1 Stage	Breeder	04/03/13	12.80	84.80	92.12	47.71	7.56
2013	Rockingham	1 Stage	Breeder	04/03/13	8.60	49.60	49.50	37.35	22.93
2013	Rockingham	1 Stage	Breeder	04/03/13	16.20	73.20	90.74	44.09	19.62
2013	Rockingham	1 Stage	Breeder	04/03/13	13.00	45.80	121.45	47.22	24.75
2013	Rockingham	1 Stage	Breeder	04/03/13	14.40	53.40	129.24	51.56	21.27
2013	Rockingham	1 Stage	Breeder	04/03/13	9.40	56.00	93.03	38.31	41.05
2013	Rockingham	1 Stage	Hen	04/10/13	13.40	59.20	42.16	38.79	24.69
2013	Rockingham	2 Stage	Heavy Tom	04/10/13	18.60	86.60	94.41	67.95	43.45
2013	Rockingham	1 Stage	Heavy Tom	04/10/13	18.00	83.40	118.70	72.28	28.44

2013	Rockingham	1 Stage	Breeder	04/11/13	13.60	55.40	77.91	41.92	15.06
2013	Highland	2 Stage	Heavy Tom	04/15/13	32.20	85.60	85.70	60.96	26.21
2013	Rockingham	1 Stage	Heavy Tom	04/24/13	13.80	72.20	87.08	73.97	17.27
2013	Rockingham	1 Stage	Heavy Tom	04/24/13	15.40	102.60	78.83	61.68	45.73
2013	Rockingham	2 Stage	Hen	04/24/13	16.80	85.00	77.45	69.15	36.20
2013	Augusta	2 Stage	Heavy Hen	04/30/13	23.20	78.80	62.33	58.79	28.48
2013	Augusta	2 Stage	Heavy Tom	04/30/13	16.00	93.80	68.29	48.91	20.12
2013	Highland	2 Stage	Heavy Hen	04/30/13	23.80	84.00	83.87	76.62	47.83
2013	Augusta	2 Stage	Hen	05/07/13	18.40	71.20	93.03	85.77	42.22
2013	Rockingham	1 Stage	Heavy Tom	05/22/13	16.60	80.60	87.08	63.13	21.87
2013	Rockingham	1 Stage	Hen	05/29/13	6.00	37.80	23.37	22.17	11.12
2013	Rockingham	1 Stage	Hen	06/04/13	15.00	103.80	56.37	62.89	13.38
2013	Rockingham	1 Stage	Hen	06/12/13	16.20	103.00	68.75	66.26	31.67
2013	Rockingham	2 Stage	Hen	06/20/13	16.00	95.80	53.62	52.28	24.28
2014	Augusta	1 Stage	Hen	07/02/13	16.40	63.60	71.49	69.39	36.18
2014	Page	1 Stage	Brooder/Poult	07/02/13	6.40	63.00	43.54	40.24	13.28
2014	Highland	1 Stage	Heavy Tom	08/07/13	20.00	91.00	55.00	40.24	23.57
2014	Highland	1 Stage	Heavy Tom	08/07/13	18.40	79.00	80.66	73.97	26.83
2014	Highland	2 Stage	Heavy Tom	08/07/13	10.20	62.40	57.29	49.63	24.26
2014	Rockingham	2 Stage	Heavy Hen	08/07/13	14.80	70.80	73.79	53.73	14.38
2014	Rockingham	2 Stage	Heavy Hen	08/07/13	9.80	125.60	60.95	51.08	41.72
2014	Augusta	2 Stage	Hen	08/23/13	12.00	54.00	99.45	76.86	26.67
2014	Rockingham	1 Stage	Heavy Tom	09/02/13	11.80	79.40	75.62	59.27	20.26
2014	Rockingham	1 Stage	Hen	09/02/13	14.00	82.20	59.58	57.34	21.69
2014	Rockingham	2 Stage	Heavy Hen	09/04/13	18.40	60.80	50.87	51.80	20.81
2014	Rockingham	2 Stage	Heavy Hen	09/04/13	5.60	76.20	50.41	52.04	21.95
2014	Augusta	2 Stage	Hen	09/18/13	19.00	78.40	73.33	65.54	33.35
2014	Augusta	2 Stage	Hen	09/18/13	14.80	87.20	71.49	69.87	31.61
2014	Rockingham	2 Stage	Heavy Tom	09/23/13	18.00	65.40	78.83	74.45	37.64

2014	Rockingham	1 Stage	Hen	09/27/13	14.60	63.80	58.66	57.83	13.86
2014	Rockingham	1 Stage	Heavy Tom	10/01/13	19.60	108.00	79.74	63.85	28.84
2014	Rockingham	1 Stage	Heavy Tom	10/01/13	12.40	94.80	71.04	59.27	25.73
2014	Rockingham	2 Stage	Hen	10/11/13	4.40	85.80	71.95	63.37	18.01
2014	Rockingham	1 Stage	Heavy Tom	10/11/13	18.60	92.60	65.54	52.52	31.38
2014	Augusta	1 Stage	Heavy Tom	10/17/13	8.60	99.80	81.12	61.68	16.88
2014	Rockingham	2 Stage	Hen	10/17/13	15.80	111.40	80.66	66.50	15.64
2014	Rockingham	2 Stage	Hen	10/17/13	15.80	111.40	80.66	66.50	15.64
2014	Augusta	2 Stage	Heavy Tom	10/30/13	19.00	91.00	79.29	60.96	18.35
2014	Rockingham	1 Stage	Heavy Tom	10/30/13	23.60	110.60	84.79	68.67	34.78
2014	Rockingham	1 Stage	Heavy Tom	10/30/13	16.60	85.60	95.33	77.10	23.83
2014	Rockbridge	2 Stage	Heavy Tom	10/30/13	19.00	98.20	85.70	70.35	32.60
2014	Rockbridge	2 Stage	Heavy Hen	10/30/13	15.80	78.40	87.54	80.96	30.84
2014	Page	2 Stage	Hen	11/11/13	14.20	124.20	72.87	63.13	16.65
2014	Page	2 Stage	Hen	11/11/13	12.20	111.20	71.95	62.16	15.62
2014	Rockingham	1 Stage	Heavy Tom	11/11/13	12.00	86.80	81.12	57.34	18.05
2014	Augusta	1 Stage	Hen	11/12/13	18.80	85.60	65.08	66.02	34.78
2014	Rockingham	1 Stage	Heavy Tom	11/26/13	20.20	111.60	97.62	73.25	35.75
2014	Shenandoah	2 Stage	Heavy Tom	12/05/13	24.00	112.60	74.70	50.12	13.85
2014	Rockingham	2 Stage	Heavy Hen	12/09/13	12.80	111.20	63.70	60.24	29.46
2014	Rockingham	2 Stage	Heavy Hen	01/28/14	14.80	66.00	70.12	67.46	26.87
2014	Augusta	2 Stage	Hen	02/14/14	24.60	94.00	78.37	67.95	36.56
2014	Rockingham	1 Stage	Heavy Tom	02/14/14	13.60	88.80	104.95	90.11	40.24
2014	Augusta	2 Stage	Hen	02/14/14	14.40	48.60	59.58	50.12	31.86
2014	Augusta	2 Stage	Hen	02/14/14	17.20	98.60	78.83	76.62	33.90
2014	Augusta	2 Stage	Hen	02/14/14	24.60	94.00	78.37	67.95	36.56
2014	Augusta	1 Stage	Breeder	03/03/14	16.20	50.20	72.41	64.09	35.62
2014	Augusta	1 Stage	Breeder	03/04/14	7.60	56.00	64.16	62.40	43.47
2014	Shenandoah	2 Stage	Heavy Tom	03/12/14	16.60	74.00	71.04	53.73	26.94

2014	Augusta	2 Stage	Hen	03/19/14	18.60	86.60	66.00	65.05	24.44
2014	Page	1 Stage	Brooder/Poult	03/19/14	15.40	73.80	66.00	69.39	27.48
2014	Rockingham	2 Stage	Heavy Tom	03/27/14	18.20	104.00	83.41	60.72	20.96
2014	Rockingham	1 Stage	Heavy Tom	03/27/14	15.80	106.00	72.87	56.38	21.44
2014	Rockingham	2 Stage	Heavy Tom	04/01/14	16.40	73.40	64.62	51.08	31.60
2014	Shenandoah	2 Stage	Heavy Tom	04/01/14	15.80	94.00	78.83	53.73	48.54
2014	Shenandoah	1 Stage	Heavy Tom	04/02/14	17.80	103.40	80.66	59.03	20.29
2014	Page	2 Stage	Heavy Hen	04/10/14	20.80	93.20	69.20	60.48	18.60
2014	Rockingham	2 Stage	Hen	04/10/14	16.40	74.80	58.66	59.51	29.18
2014	Rockingham	1 Stage	Breeder	04/10/14	10.00	59.80	105.87	49.87	22.91
2014	Rockingham	1 Stage	Breeder	04/10/14	7.40	61.80	70.12	44.33	22.67
2014	Augusta	2 Stage	Hen	04/14/14	8.60	100.80	70.12	54.21	24.24
2014	Augusta	2 Stage	Hen	04/14/14	1.80	31.60	16.04	31.32	22.93
2014	Page	1 Stage	Hen	04/15/14	20.40	111.20	69.66	70.11	29.59
2014	Augusta	1 Stage	Hen	04/29/14	39.80	69.60	68.75	67.95	21.61
2014	Augusta	1 Stage	Heavy Tom	04/29/14	26.20	95.00	85.70	67.95	25.81
2014	Rockingham	1 Stage	Brooder/Poult	05/01/14	7.60	71.40	37.58	39.76	21.50
2014	Rockingham	2 Stage	Hen	05/01/14	15.60	97.60	66.45	65.05	25.66
2014	Rockingham	2 Stage	Hen	05/01/14	15.60	97.60	66.45	65.05	25.66
2014	Rockingham	1 Stage	Heavy Tom	05/19/14	19.00	93.40	80.66	58.55	26.11
2014	Augusta	1 Stage	Heavy Tom	05/28/14	13.60	86.80	68.29	57.10	23.75
2014	Shenandoah	2 Stage	Heavy Hen	06/02/14	23.00	115.00	76.08	66.74	21.46
2014	Rockingham	2 Stage	Hen	06/03/14	14.60	119.40	70.58	56.14	12.84
2014	Orange	2 Stage	Hen	06/17/14	12.80	87.80	87.99	76.62	14.55
2015	Shenandoah	2 Stage	Heavy Tom	07/31/14	19.40	98.00	99.45	76.14	33.50
2015	Highland	2 Stage	Heavy Hen	08/22/14	9.80	46.00	59.12	53.25	13.07
2015	Rockingham	1 Stage	Heavy Tom	08/22/14	16.60	82.60	79.74	63.13	22.59
2015	Page	2 Stage	Hen	08/29/14	24.80	97.60	69.66	63.13	27.87
2015	Rockingham	2 Stage	Heavy Hen	09/01/14	23.60	85.20	75.62	71.80	37.64

2015	Rockingham	1 Stage	Hen	09/01/14	12.40	73.60	81.12	73.49	17.80
2015	Rockingham	2 Stage	Hen	09/01/14	24.00	91.20	73.79	80.47	34.68
2015	Augusta	2 Stage	Heavy Tom	09/03/14	15.60	77.00	95.78	78.31	24.25
2015	Rockingham	2 Stage	Hen	09/03/14	21.40	105.00	52.25	51.32	42.44
2015	Shenandoah	2 Stage	Heavy Hen	09/03/14	25.20	127.80	75.62	67.22	28.29
2015	Rockingham	2 Stage	Hen	09/10/14	21.40	109.40	82.49	77.82	32.22
2015	Rockingham	1 Stage	Brooder/Poult	09/10/14	7.00	30.80	26.12	21.68	12.74
2015	Rockingham	1 Stage	Heavy Tom	09/10/14	12.40	69.20	75.16	60.96	18.97
2015	Rockingham	1 Stage	Brooder/Poult	09/18/14	9.00	72.40	44.91	38.07	26.54
2015	Augusta	2 Stage	Hen	09/24/14	3.00	30.60	30.71	24.58	17.87
2015	Rockingham	1 Stage	Heavy Tom	09/24/14	19.60	113.40	90.29	76.62	28.49
2015	Shenandoah	1 Stage	Hen	09/24/14	21.20	65.60	66.91	59.75	21.06
2015	Rockingham	2 Stage	Heavy Hen	10/29/14	23.20	138.80	68.75	72.28	33.84
2015	Rockingham	1 Stage	Brooder/Poult	10/29/14	10.60	107.00	64.16	53.49	8.78
2015	Rockingham	2 Stage	Heavy Hen	11/17/14	16.20	88.20	93.49	66.98	25.29
2015	Rockingham	1 Stage	Heavy Tom	01/29/15	22.80	127.40	99.45	83.85	14.13
2015	Augusta	2 Stage	Heavy Hen	01/29/15	18.00	64.80	48.12	47.95	30.67
2015	Rockingham	1 Stage	Brooder/Poult	01/29/15	10.40	37.80	44.91	36.86	33.80
2015	Rockingham	2 Stage	Hen	01/29/15	14.80	129.80	55.00	67.95	40.01
2015	Rockingham	2 Stage	Heavy Hen	02/04/15	20.20	124.60	71.95	63.37	31.52
2015	Rockingham	1 Stage	Breeder	02/04/15	16.60	78.60	70.58	50.60	25.95
2015	Rockingham	1 Stage	Heavy Tom	02/12/15	16.00	98.80	94.41	70.11	29.80
2015	Augusta	2 Stage	Hen	02/19/15	13.60	70.80	71.95	73.49	18.03
2015	Shenandoah	2 Stage	Heavy Hen	03/19/15	25.60	115.00	84.33	65.54	39.25
2015	Shenandoah	2 Stage	Heavy Tom	03/26/15	20.60	131.40	71.49	63.85	42.93
2015	Rockingham	1 Stage	Breeder	04/03/15	8.80	56.80	35.75	33.25	30.96
2015	Rockingham	1 Stage	Breeder	04/03/15	22.80	95.00	87.08	60.48	45.00
2015	Rockingham	2 Stage	Hen	04/17/15	19.60	92.20	71.49	70.35	19.13
2015	Augusta	1 Stage	Heavy Tom	04/17/15	17.20	90.20	87.08	74.21	38.63

2015	Rockbridge	2 Stage	Heavy Tom	04/30/15	20.20	105.20	82.04	62.16	45.02
2015	Augusta	2 Stage	Hen	04/30/15	15.40	90.40	83.41	75.90	19.06
2015	Rockingham	2 Stage	Heavy Hen	05/05/15	20.20	80.40	77.91	62.89	34.22
2015	Augusta	2 Stage	Heavy Hen	05/05/15	14.40	57.20	71.95	56.86	25.24
2015	Augusta	1 Stage	Breeder	05/05/15	9.60	62.20	57.75	42.89	27.03
2015	Rockingham	1 Stage	Hen	05/07/15	12.00	76.80	87.99	85.05	17.39
2016	Augusta	1 Stage	Brooder/Poult	07/29/15	0.60	35.40	59.12	23.61	24.72
2016	Augusta	1 Stage	Brooder/Poult	07/29/15	9.40	69.00	52.70	49.15	42.47
2016	Augusta	1 Stage	Brooder/Poult	07/29/15	5.20	46.40	24.75	26.50	20.36
2016	Shenandoah	2 Stage	Heavy Tom	07/29/15	19.40	78.60	53.62	48.91	25.65
2016	Rockingham	1 Stage	Heavy Tom	07/29/15	13.80	78.60	76.08	64.09	26.52
2016	Rockingham	1 Stage	Heavy Tom	08/04/15	21.20	88.60	85.24	70.11	19.51
2016	Rockingham	1 Stage	Breeder	08/21/15	7.20	52.00	59.12	49.63	27.06
2016	Rockingham	2 Stage	Heavy Tom	09/23/15	13.60	69.20	88.45	79.51	28.29
2016	Rockingham	1 Stage	Heavy Tom	09/23/15	13.60	90.40	81.12	66.74	26.72
2016	Highland	2 Stage	Hen	09/29/15	21.40	88.80	88.91	74.21	31.70
2016	Rockingham	1 Stage	Hen	10/01/15	8.80	59.80	51.79	47.22	23.12
2016	Augusta	1 Stage	Hen	10/01/15	13.20	67.20	54.54	53.01	26.85
2016	Page	1 Stage	Hen	10/02/15	16.00	80.00	44.91	46.26	24.89
2016	Rockingham	1 Stage	Heavy Tom	10/09/15	12.00	91.80	86.16	61.92	18.74
2016	Rockingham	2 Stage	Heavy Hen	10/09/15	12.40	77.20	91.20	68.19	31.04
2016	Rockbridge	2 Stage	Heavy Hen	10/27/15	17.40	108.00	82.95	72.04	34.51
2016	Rockingham	1 Stage	Heavy Tom	10/29/15	12.40	94.80	104.49	85.77	27.61
2016	Rockingham	2 Stage	Heavy Tom	11/11/15	18.40	90.60	90.74	81.44	41.87
2016	Madison	2 Stage	Heavy Tom	11/18/15	4.80	50.40	102.66	86.26	20.45
2016	Rockingham	2 Stage	Heavy Hen	12/09/15	17.20	79.40	82.04	65.78	31.38
2016	Rockingham	2 Stage	Heavy Hen	12/09/15	11.60	82.00	79.74	67.46	32.81
2016	Highland	Finisher	Heavy Tom	04/22/16	19.6	84.17	58.8	45.42	24.92
2016	Rockbridge	Finisher	Heavy Tom	05/13/16	10	68.88	46.49	34.81	21.91

2016	Augusta	Finisher	Heavy Tom	04/08/16	9.6	86	75.57	52.69	17.50
2016	Augusta	Finisher	Heavy Tom		16.4	82.51	66.73	44.71	
2016	Rockingham	Finisher	Heavy Tom		9.8	77.35	49	39.77	
2016	Rockingham	Finisher	Heavy Tom	09/23/15	13.6	79.84	59.4	48.92	26.72
2016	Warren	Finisher	Heavy Tom		13.8	64.41	47.27	39.23	41.02
2016	Shenandoah	Finisher	Heavy Tom		12.4	85.95	68.87	53.96	18.28
2016	Rockingham	Finisher	Heavy Tom		21.8	*111.27*	66.43	55.56	23.66
2016	Rockingham	Finisher	Heavy Tom		21.8	111.27	73.3	64.58	23.66
2016	Rockingham	Finisher	Heavy Hen		13.8	71.56	55.87	47.1	
2016	Rockingham	Finisher	Heavy Tom	08/04/15	18.8	79.07	50.42	38.96	31.20
2016	Rockingham	Finisher	Heavy Tom	06/27/16	13.8	71.56	55.87	47.1	
2016	Augusta	Finisher	Heavy Hen	01/08/16	8	70.31	50.98	38.02	19.92
2016	Rockingham	Finisher	Heavy Tom		11.2	64.88	44.07	39.67	15.59
2016	Rockingham	Finisher	Heavy Tom		12.2	47.8	45.1	31.9	
2016	Rockingham	Finisher	Heavy Tom		13.2	60.63	57.8	47.54	27.47
2016	Rockingham	Finisher	Heavy Tom		18.6	85.09	46.4	45.94	36.68
2016	Highland	Finisher	Heavy Tom	04/22/16	19.6	84.17	58.8	45.42	24.92
2016	Rockingham	Finisher	Heavy Tom	10/29/15	12.4	81.02	75.59	62.1	27.61
2016	Rockingham	Finisher	Heavy Tom	03/22/16	23.2	78.33	51.87	41.01	40.08
2016	Rockingham	Finisher	Heavy Tom		21	102.88	58.93	50.43	35.02
2016	Rockingham	Finisher	Heavy Hen		12.2	55.1	69.13	47.7	
2016	Rockingham	Finisher	Heavy Hen		23.2	78.3	51.87	41.01	
2016	Rockingham	Finisher	Heavy Tom	10/09/15	12	86.59	69.97	50.33	18.74
2016	Rockingham	Finisher	Heavy Hen		17	85.08	71.46	54.3	25.35
2016	Rockingham	Finisher	Heavy Hen		17.6	90.56	81.41	57.43	22.38
2016	Rockingham	Finisher	Heavy Hen		12.2	55.1	69.13	47.7	66.20
2016	Shenandoah	Finisher	Heavy Hen		12.4	85.95	68.87	53.96	18.28
2016	Highland	1 Stage	Heavy Tom	04/22/16	13.80	89.11	50.15	41.95	21.23
2016	Augusta	1 Stage	Heavy Tom		11.40	69.09	48.45	40.31	23.89

2016	Rockingham	1 Stage	Heavy Tom	03/10/16	18.20	93.94	69.37	54.03	25.01
2016	Rockingham	1 Stage	Heavy Tom	03/10/16	8.20	91.88	65.57	51.14	14.78
2016	Augusta	1 Stage	Heavy Tom		15.00	84.41	37.67	33.13	33.13
2016	Augusta	1 Stage	Heavy Tom	04/17/15	17.20	72.56	53.40	45.55	38.63
2016	Rockingham	1 Stage	Heavy Tom	09/23/15	13.60	79.84	59.40	48.92	26.72
2016	Rockingham	1 Stage	Heavy Tom	07/13/15	17.80	86.60	68.18	51.86	22.87
2016	Rockingham	1 Stage	Heavy Tom	07/29/15	17.80	86.60	68.18	51.86	22.87
2016	Rockingham	1 Stage	Heavy Tom		16.00	85.36	66.23	49.23	29.80
2016	Rockingham	1 Stage	Heavy Tom		18.60	85.09	46.40	45.94	36.68
2016	Warren	1 Stage	Heavy Tom		15.20	75.59	61.46	56.60	18.17
2016	Rockingham	1 Stage	Heavy Tom		9.00	66.31	63.58	56.74	18.82
2016	Rockingham	1 Stage	Tom	08/04/15	17.40	83.36	55.31	51.40	29.38
2016	Augusta	1 Stage	Hen	05/10/16	23.60	90.25	52.27	45.67	29.55
2016	Rockingham	1 Stage	Hen	04/18/16	15.20	75.59	61.46	56.60	18.17
2016	Rockingham	1 Stage	Heavy Hen	09/23/15	11.40	70.49	46.15	45.45	23.66
2016	Rockingham	1 Stage	Hen	01/28/16	17.20	66.68	53.69	46.59	23.88
2016	Rockingham	1 Stage	Hen	05/07/15	12.00	75.44	72.64	70.28	17.39
2016	Rockingham	1 Stage	Hen	03/22/16	15.60	83.90	61.05	52.35	17.72
2016	Augusta	1 Stage	Hen	02/24/16	7.60	40.60	39.36	38.77	31.25
2016	Rockingham	1 Stage	Hen		53.11	10.80	42.62	37.84	27.31
2016	Rockingham	1 Stage	Hen	02/11/16	19.60	91.67	55.98	50.40	29.35
2016	Augusta	1 Stage	Hen		14.40	62.13	48.65	44.09	34.43
2016	Rockingham	1 Stage	Hen		7.00	54.82	39.72	35.71	15.80
2016	Augusta	1 Stage	Hen	01/12/16	13.80	59.21	55.24	47.71	29.05
2016	Augusta	1 Stage	Hen	10/01/15	13.20	62.36	39.87	38.78	26.85
2016	Augusta	1 Stage	Hen	03/07/16	16.00	59.92	44.02	34.67	36.35
2016	Orange Culpeper	1 Stage	Hen	10/09/15	14.80	78.03	63.75	54.96	21.36
2016	Page	1 Stage	Heavy Hen		21.60	99.54	93.92	58.67	54.67
2016	Page	1 Stage	Heavy Hen		19.20	80.74	48.65	42.54	21.90

2016	Page	1 Stage	Hen		24.80	95.20	50.20	45.54	27.87
2016	Rockingham	1 Stage	Hen		20.00	92.60	56.23	47.18	33.64
2016	Rockingham	1 Stage	Hen	05/13/16	10.80	53.11	42.62	37.84	27.31
2016	Rockingham	1 Stage	Hen		59.27	17.80	48.51	40.69	35.80
2016	Rockingham	1 Stage	Hen	10/01/15	8.20	55.70	37.10	35.60	20.58
2016	Rockingham	1 Stage	Hen		14.60	69.70	52.27	41.34	27.31
2016	Rockingham	1 Stage	Hen	04/18/16	75.59	15.20	61.46	56.60	18.17
2016	Page County	1 Stage	Hen	10/02/15	16.00	76.08	33.71	34.75	24.89
2016	Shenandoah	2 Stage	Heavy Hen	04/15/16	25.6	95.46	51.20	39.82	39.25
2016	Highland	2 Stage	Hen	09/29/15	21.4	82.05	60.69	50.70	31.70
2016	Page	2 Stage	Hen		13.6	73.66	58.63	52.38	19.50
2016	Rockingham	2 Stage	Hen		17.4	96.49	68.67	56.79	17.61
2016	Rockingham	2 Stage	Hen		9	69.34	42.82	38.92	15.01
2016	Rockingham	2 Stage	Hen		12.80	62.86	47.71	45.90	22.27
2016	Rockingham	2 Stage	Hen	01/08/16	8.20	69.37	61.80	50.06	18.22
2016	Rockingham	2 Stage	Heavy Hen	10/09/15	16.20	58.60	55.44	46.57	24.82
2016	Rockingham	2 Stage	Heavy Hen	10/09/15	11.80	58.76	56.11	47.13	21.46
2016	Rockingham	2 Stage	Heavy Hen	10/09/15	20.80	84.33	68.33	52.95	25.78
2016	Rockingham	2 Stage	Hen	10/09/15	16.20	77.89	48.81	46.61	29.42
2016	Augusta	2 Stage	Hen		7.40	33.23	25.57	27.91	16.69
2016	Rockingham	2 Stage	Heavy Hen		11.80	64.23	38.91	31.06	26.77
2016	Rockingham	2 Stage	Heavy Hen		14.60	69.70	52.27	41.34	27.31
2016	Augusta	2 Stage	Hen		20.60	81.47	50.05	36.94	26.66
2016	Rockingham	2 Stage	Hen		14.60	67.92	49.28	44.61	20.89
2016	Rockingham	2 Stage	Heavy Hen	05/05/15	19.20	84.87	63.35	49.27	24.00
2016	Rockingham	2 Stage	Heavy Hen	06/09/16	16.80	88.51	77.54	59.01	13.18
2016	Augusta	2 Stage	Hen		13.60	71.63	58.94	60.25	18.03
2016	Rockingham	2 Stage	Hen	02/05/16	22.20	90.98	58.99	56.96	31.49
2016	Rockingham	2 Stage	Hen	06/07/16	10.00	69.39	53.39	45.37	21.23

2016	Rockingham	2 Stage	Hen	01/08/16	18.20	91.71	49.20	41.85	32.44
2016	Augusta	2 Stage	Heavy Hen	04/13/16	15.60	51.20	53.40	34.58	31.01
2016	Rockingham	2 Stage	Heavy Hen	12/09/15	11.60	66.69	53.54	45.34	32.81
2016	Augusta	2 Stage	Heavy Hen	05/05/15	14.40	57.16	53.75	42.52	25.24
2016	Highland	2 Stage	Hen	09/29/15	60.69	82.05	50.70	31.70	25.24
2016	Page	2 Stage	Heavy Hen	04/30/15	9.20	95.15	58.52	49.63	18.61
2016	Augusta	2 Stage	Heavy Hen		20.60	81.47	50.05	36.94	26.66
2016	Rockingham	2 Stage	Hen		14.80	92.67	32.97	40.77	40.01
2016	Highland	2 Stage	Hen	10/09/15	15.00	78.13	41.78	41.96	32.26
2016	Rockingham	2 Stage	Hen		16.20	77.89	48.81	46.61	29.42
2016	Augusta	2 Stage	Heavy Hen	11/11/15	17.20	76.00	52.09	42.68	40.77
2016	Rockingham	2 Stage	Heavy Hen		21.00	87.24	61.75	50.99	30.86
2016	Highland	2 Stage	Hen		15.00	78.13	47.78	41.96	32.26
2016	Highland	2 Stage	Heavy Hen		4.80	44.90	81.62	68.64	20.45
2016	Rockingham	2 Stage	Hen		14.80	92.67	32.97	40.77	40.01
2016	Augusta	2 Stage	Hen	05/05/16	17.60	90.56	81.41	57.43	22.38
2016	Rockbridge	2 Stage	Heavy Hen	10/27/15	17.40	88.13	54.29	34.51	34.51
2016	Augusta	2 Stage	Hen	12/15/15	17.00	85.08	71.46	54.33	25.35
2016	Page	2 Stage	Hen		60.68	106.04	52.47	15.62	
2016	Shenandoah	2 Stage	Heavy Tom		10.00	67.59	59.99	59.69	16.04
2016	Rockingham	2 Stage	Heavy Tom	09/23/15	19.40	83.85	69.16	61.90	22.17
2016	Rockingham	2 Stage	Heavy Tom	11/11/15	11.20	64.88	44.07	39.67	15.59
2016	Rockingham	2 Stage	Heavy Tom		14.20	72.25	49.24	45.41	43.42
2016	Louisa	2 Stage	Heavy Tom		19.80	100.95	66.20	48.81	26.63
2016	Rockbridge	2 Stage	Heavy Tom	04/30/15	20.20	78.04	45.08	34.19	45.02
2016	Shenandoah	2 Stage	Heavy Tom		14.80	78.67	30.92	32.91	24.14
2016	Shenandoah	2 Stage	Heavy Tom	04/06/16	16.40	72.21	63.74	46.36	27.14
2016	Shenandoah	2 Stage	Heavy Tom	04/20/16	19.40	85.16	67.23	62.89	34.76
2016	Madison	2 Stage	Heavy Tom	11/18/15	4.80	44.90	81.62	68.64	20.45

2016	Rockingham	2 Stage	Heavy Tom		8.20	55.70	37.10	35.60	20.58
2016	Augusta	2 Stage	Heavy Tom		14.80	63.95	61.07	53.06	22.47
2016	Shenandoah	2 Stage	Heavy Tom		8.40	68.28	55.29	40.39	20.58
2016	Shenandoah	2 Stage	Heavy Tom		22.40	92.29	50.27	40.46	24.14
2016	Augusta	2 Stage	Heavy Tom		7.80	49.34	66.58	59.49	20.12
2016	Highland	2 Stage	Heavy Tom		11.00	80.14	60.23	58.00	17.30
2016	Augusta	2 Stage	Heavy Tom		13.70	55.60	59.30	36.70	34.10
2016	Rockbridge	2 Stage	Heavy Tom		20.20	78.04	45.08	34.19	45.02
2016	Augusta	2 Stage	Heavy Tom	04/08/16	7.80	49.34	66.58	59.49	20.12
2016	Rockbridge	2 Stage	Heavy Tom		10.00	68.88	46.49	34.81	21.91
2016	Augusta	2 Stage	Heavy Tom		7.80	49.34	66.58	59.49	20.12
2016	Shenandoah	2 Stage	Heavy Tom	07/26/16	10.00	67.59	59.99	59.69	16.04
2016	Shenandoah	2 Stage	Heavy Tom		8.40	68.28	55.29	40.39	20.58
2016	Shenandoah	2 Stage	Heavy Tom		19.40	85.16	67.23	62.89	34.76
2016	Madison	2 Stage	Heavy Tom		4.80	44.90	81.62	68.64	20.45
2016	Shenandoah	2 Stage	Heavy Tom		21.20	92.28	68.24	50.12	16.04
2016	Louisa	2 Stage	Heavy Tom		19.80	100.95	66.20	48.81	26.63
2016	Rockingham	2 Stage	Heavy Tom		20.60	109.97	61.47	47.95	21.05
2016	Louisa	2 Stage	Heavy Tom	04/14/16	19.80	100.95	66.20	48.81	26.63
2016	Rockingham	2 Stage	Heavy Tom		21.80	111.27	66.43	55.56	23.66
2016	Rockingham	2 Stage	Heavy Tom		20.60	109.97	61.47	47.95	21.05
2016	Augusta	1 Stage	Breeder		18.80	116.54	68.98	43.83	19.89
2016	Augusta	1 Stage	Breeder		18.40	91.20	75.37	34.50	26.21
2016	Augusta	1 Stage	Breeder		7.00	44.60	66.28	44.67	18.70
2016	Rockingham	1 Stage	Breeder		12.80	94.50	67.92	43.62	27.31
2016	Rockingham	1 Stage	Breeder		4.40	49.20	41.12	38.08	16.09
2016	Rockingham	1 Stage	Breeder		9.40	59.88	77.17	36.74	27.06
2016	Rockingham	1 Stage	Breeder		15.20	67.77	99.03	48.98	23.59
2016	Rockingham	1 Stage	Breeder		8.80	48.01	24.66	22.96	30.96

2016	Rockingham	1 Stage	Breeder		22.80	75.05	47.86	33.27	45.00
2016	Rockingham	1 Stage	Brooder/Poult	06/09/16	8.80	68.60	27.07	30.35	14.33
2016	Augusta	1 Stage	Brooder/Poult		10.60	65.02	61.20	37.05	19.50
2016	Augusta	1 Stage	Brooder/Poult		10.60	65.02	61.20	37.05	19.50
2016	Rockingham	1 Stage	Brooder/Poult	07/09/15	8.20	59.23	49.07	30.10	22.92
2016	Augusta	1 Stage	Brooder/Poult		10.60	69.85	80.40	51.37	30.07
2016	Rockingham	1 Stage	Brooder/Poult		8.80	72.94	40.29	40.47	20.03
2016	Rockingham	1 Stage	Brooder/Poult		8.80	68.60	14.33	85.67	14.30
2016	Page	1 Stage	Brooder/Poult	01/25/16	7.20	50.83	22.45	24.38	20.95
2016	Rockingham	1 Stage	Brooder/Poult	01/12/16	7.00	73.35	59.96	46.97	19.68
2016	Rockingham	1 Stage	Brooder/Poult	07/26/16	9.20	54.90	33.25	32.97	23.58
2016	Rockingham	1 Stage	Brooder/Poult		5.40	41.94	21.93	23.72	11.31
2016	Rockingham	1 Stage	Brooder/Poult		8.20	50.80	31.84	27.27	26.04
2016	Augusta	1 Stage	Brooder/Poult		8.80	72.94	40.29	40.47	20.03
2016	Rockingham	1 Stage	Brooder/Poult		9.20	54.90	33.25	32.97	23.58
2016	Rockingham	1 Stage	Brooder/Poult		5.40	41.94	21.93	23.72	11.31
2016	Rockingham	1 Stage	Brooder/Poult		9.00	46.62	21.36	21.73	26.04
2016	Rockingham	1 Stage	Breeder	01/12/16	7.00	73.35	59.96	50.52	19.68

Appendix B: Review Comments and Responses

General Comment 1: Provide footnotes, where necessary throughout the report, describing the reason and validity of using values with significant digits out to the hundredths and thousandths.

Response: Done. Concentrations are reported to the hundredths (significant digits as reported by analyzing lab, Clemson, based on the accuracy/capability of their measurement method).

General Comment 2: More explanation needs to be provided to allow us to feel comfortable with accepting the results of this report to inform the model for use in all six states. It is difficult to discern if the study sample size is large enough to warrant extrapolation to the entire Bay watershed.

Response: At a previous meeting, the Ag Work Group discussed statistics and minimum number of samples that should be used to represent trends in an industry, species, or type of livestock. While many of the members of the Ag Work Group acknowledged their limitations in the knowledge of statistics, they agreed on 30 as a minimum number for any type, number of samples, analysis, or sub-species to be used to represent an industry in the input side of the phase 6 Bay Model.

It should be noted that we did not get cooperation from integrators PA and WV, therefore data from these states were not included within the timeframe of the study. Del. and Md. indicated that they did not have enough turkey populations to be of any significance to the study. We anticipate that as the study is expanded in future years, WV and PA will be included, if the integrators cooperate in the work.

Comment Page 6 Introduction. In the list of CBP partners, it looks like West Virginia, Delaware, and New York were missed.

Response – was an oversight. Missing states have been listed.

Comment Page 7. What is the overall population of turkeys (and integrators) in the watershed and what is proportion of birds/integrators of that overall population that were included in the study? How will data from this study be extrapolated to all six states? What are the thoughts regarding the expected change with more data?

Response: The total overall population is unknown at this time. We could use the NASS Ag Census data but the census may not be reliable. The Ag Census gets about a 27% return on an average basis and in some cases entire farms populations do not respond. We should obtain accurate estimates as additional work is performed in future years, to include discerning the total populations of birds.

Comment Page 8: Litter Management and Production. The sentence beginning "However, if litter nutrients are applied at levels…" does not fit with the rest of the section. Recommend striking from the report. Litter Management and Production. Due to changes in industry practices over the years, we recommend adding language to state that the cleanout and management of litter described in this section is current practice. Is it an issue to only utilize data from one laboratory?

Response: Statement deleted. Statement about current litter management practice also added. Using data from one lab is not an issue. Clemson Agricultural Services Lab where the analysis was done is a certified lab and actively participates in the required QA/QC protocols to maintain its certification. Additionally, Clemson Agricultural Services Lab performs more than 2,500 samples per year for Virginia alone. They also perform sample analysis for other clientele as well. Their testing protocol (http://www.clemson.edu/public/regulatory/ag_svc_lab/animal_waste/waste_procedures/index.html) is similar to what many other labs in the country e.g. Wisconsin, Pennsylvania, North Carolina, and many private laboratories, use. Getting results from other labs and states to include in the analysis is welcome idea. However, for this report, other states did not offer to assist in laboratory analysis. WV indicated that all analysis performed in their state was "privileged" and could only be provided if growers gave explicit permission for the information to be used. Again, the integrators did not provide any information on growers in WV for a study of their population to be interviewed and samples during the timeframe of this study.

Comment Page 10: Each data point is an individual operation, correct? The report states that the litter generation rates are smaller than using ASABE standard. Please provide further explanation as to what the overall effect of this study will be on the model.

Response: Each data point is an individual grower in this study. About 300 turkey growers were contacted and sampled as a result of this study. Additional explanation on ASABE numbers provided in report