IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA, ex rel,	§	
W. A. DREW EDMONDSON,	§	
in his capacity as ATTORNEY GENERAL	§	
OF THE STATE OF OKLAHOMA,	§	
and OKLAHOMA SECRETARY	§	
OF THE ENVIRONMENT	§	
C. MILES TOLBERT, in his capacity as	§	
the TRUSTEE FOR NATURAL RESOURCES	§	
FOR THE STATE OF OKLAHOMA,	§	
	§	
	§	
Plaintiff,	§	CASE NO. 05-CV-329-GKF-SAJ
	§	
V.	§	
	§	
TYSON FOODS,	§	
TYSON POULTRY, INC., TYSON CHICKEN, INC.,	§	
COBB-VANTRESS, INC., AVIAGEN, INC.,	§	
CAL-MAINE FOODS, INC.,	§	
CAL-MAINE FARMS, INC., CARGILL, INC.,	§	
CARGILL TURKEY PRODUCTS, LLC,	§	
GEORGE'S, INC., GEORGE'S FARMS, INC.,	§	
PETERSON FARMS, INC., SIMMONS FOODS, INC.	§	
AND	§	
WILLOWBROOK FOODS, INC.	§	

Defendants.

EXPERT REPORT OF GORDON V. JOHNSON, Ph.D

1. Introduction

I, Gordon V. Johnson, grew up and lived on a small diversified farm in North Dakota until attending North Dakota State University, where I received a B.S. in agriculture majoring in Soil Science in 1963. I received a M.S. in Soil Science from the University of Nevada (Reno) in 1966 and a Ph. D in Soil Science from the University of Nebraska in 1969. From 1969 to 1977 I taught undergraduate and graduate classes, and conducted laboratory and field research in nutrient management at The University of Arizona. From 1977 to my retirement in 2004 I served as State Specialist in nutrient management for the Cooperative Extension Service at Oklahoma State University. In this capacity I provided educational programs in nutrient management to OSU County Extension Agents and Area Specialized Agents in Agronomy, and to State, District and Field technical staff of the Natural Resource Conservation Service (NRCS). I also developed, taught, and provided the exams for the statewide Nutrient Management Certification program for NRCS and for the Certified Crop Advisory program for Oklahoma. I have served in many regional and national professional organizations, received numerous achievement awards and published over 100 journal articles and fact sheets on nutrient management. From 1977 to 1990 I served as Director of the Soil, Water, and Forage Analytical Laboratories at OSU. I retired from OSU as Regents Professor of Soil Science and retain Emeriti status. Professional activities, including publications are identified in my attached curriculum vita.

2. <u>Professional Service</u>

a. I have been retained by the State of Oklahoma to evaluate:

i. The agronomic reasonableness of poultry litter application to land in the Illinois River Watershed (IRW);
ii. Behavior of phosphorus in soils and the environment.
iii. Phosphorus (P) as an essential macronutrient for plants.
iv. Nutrient Management.
v. Litter as a P nutrient source.
vi. STP and P management in the IRW.
vii. Soil amendments.
viii. NRCS 590 and P index use.
ix. STP and soluble P in field runoff.
x. Litter land application practices.

Agricultural practices are considered "agronomic" if the practices are essential to effective and economic soil management and crop production. As a result of my study, research, and teaching of nutrient management for agronomic crops, I am familiar with the soils and crops in the Illinois River Watershed. I have presented educational programs on nutrient management to land owners and operators of farms in the Illinois River Watershed and I am familiar with their practice of application of poultry litter to pasture and hay (forage) fields.
My rate of compensation is $110 per hour and I have billed a total of $81,573.07 to date. In rendering my opinions I am relying on my career professional experiences and scientific literature that I have reviewed and considered. I have testified in no other cases, either by trial or deposition, within the past four years.

3. Behavior of Phosphorus in Soils and the Environment.

a. Elemental P does not exist in nature, and is only a phenomenon of the laboratory and industry. White elemental P is a very reactive solid at room temperature and must be stored under water to prevent its reaction with oxygen (O_2). When exposed to the atmosphere it reacts violently with O_2. In nature P exists in combination with oxygen as the oxy-anion, orthophosphate (PO_4^{3-}), which is relatively stable, but bound with cations to form a variety of compounds. When hydrogen (H^+) is the only cation (laboratory situations), phosphate is present in the moderately strong phosphoric acid, H_3PO_4.

b. In soil solutions, PO_4^{3-} will react with whatever cations have the highest charge and are present in highest concentration. A deciding factor in what compound will eventually be formed by reacting with PO_4^{3-}, is the stability of the final compound formed. Thus, because aluminum phosphate ($AlPO_4$) and iron phosphate ($FePO_4$) are extremely stable, they are formed in soils acidic enough to cause aluminum (Al^{3+}) and iron (Fe^{3+}) to dissolve and be present to react with PO_4^{3-}. In soils where the pH is above 5.5 there is enough calcium (Ca^{2+}) present to form calcium phosphates, the least soluble (most stable) being rock phosphate or the mineral apatite ($Ca_5(PO_4)_3OH$). Rock phosphate is mined commercially from geologic marine deposits and is the primary raw material from which commercial fertilizer is manufactured.

c. Whenever fertilizer is added to soils the soluble phosphate will begin to react with calcium present in the soil to form various calcium phosphates of low solubility (plant availability) the final product (after about two years) being rock phosphate. In soils of pH suitable for plant growth (pH 5 to 8), the hydrogen (H^+) concentration in the soil solution is very low (1 x 10^{-5} to 1 x 10^{-8} mole/liter). These concentrations allow small amounts of PO_4^{3-} to be present in combination with H^+ in the form of $H_2PO_4^-$ and HPO_4^{2-}, the ionic forms of P taken up by plants.

d. Soils typically contain forms of organic and inorganic P in total amounts ranging from about 200 to 6,000 lb/acre. As plants grow they absorb inorganic water soluble P from the soil. Water soluble P removed by plants is repeatedly replenished by chemical transformation of less soluble forms of P in the soil to water soluble forms as a result of mass-balance, chemical equilibrium reactions.

4. Phosphorus (P) as an essential macronutrient for plants.

a. Phosphorus is one of 16 chemical elements essential for plants to grow and complete their life-cycle. Three of the elements, carbon (C), hydrogen (H) and oxygen (O) are supplied through absorption from air and water. The remaining 13 are absorbed primarily from the soil and are categorically grouped according to their common deficiency in soils, which is also closely related to the amount used by plants. Nitrogen (N), P, and potassium (K) commonly become deficient in intensively cropped soils because plants contain large amounts of these nutrients compared to available soil levels. They are classified as “primary nutrients” or “macronutrients”. Less commonly deficient are the “secondary” nutrients calcium (Ca), magnesium (Mg) and sulfur (S). The “micronutrients” iron (Fe), manganese (Mn), copper (Cu) zinc (Zn), boron (B), chlorine (Cl) and molybdenum (Mo) are found in the lowest concentration in plants and are seldom deficient in soils.

b. Plants use much larger amounts of N (1 to 3 %) and K (about 1 %) than P (about 0. 2 to 0.4 %). Phosphorus is absorbed by plants in the form of orthophosphate, an inorganic anion of single ($H_2PO_4^-$) or double charge ($H_2PO_4^{2-}$). A primary function of P within the plant is in energy transfer, as a component of ADP (adenosine di-phosphate) and ATP (adenosine tri-phosphate), and it is easily transferred from old tissue to new tissue when soil supplies are deficient. Deficient leaves become discolored, and appear chlorotic (yellow) and often purple.

5. <u>Nutrient Management.</u>

a. The management of nutrients for agronomic production developed as farmers and soil scientists observed that crop yield could be maintained in intensively cropped fields with the addition of fertilizer. Early in American agriculture fertilizer materials included animal manure, rock phosphate, wood ashes, and various forms of mined nitrates. The amounts of these materials applied to a given field depended upon the cost and availability of the materials. Use of these fertilizers was also influenced by the anticipated increase in crop yields. Early research led to the common understanding that crops most often responded to soil inputs of nitrogen (N) phosphorus (P) and potassium (K), although other “secondary” (Ca, Mg, and S) and “micronutrients” (Fe, Zn, Mn, Cu, B, Cl, and Mo) were also essential for plant growth and development. Therefore, interest grew in developing technology that could identify how much N, P, or K should be applied to a field to gain the maximum crop yield at the least cost. The development of soil test procedures for N, P, and K followed.

b. Although most soil P exists in solid form and plants absorb water soluble P, neither soil analysis evaluating water soluble P nor total soil P accurately predicted the soils capacity to provide a crop’s P need for maximum crop yield. Instead, chemical extractants were developed that successfully mimicked plant use of P. Using these extractants a relationship was developed between P extraction amounts (soil test P, or "STP") and crop yield. This relationship is called soil test correlation. Finally, the STP results were related to crop yield response from fertilizer P addition through field experiments performed on farmer's fields and at OSU Agricultural Experiment Stations. The result of this work is that the tests are calibrated, and we know that an STP of 65 lb P/acre (ppm times a factor of 2.0 is equivalent to lb/acre) provides a maximum benefit of 100% P sufficiency for efficient forage crop production of bermudagrass and fescue and an STP of 40 provides 95% yield sufficiency for these crops. Because there is no P benefit to crops once the STP is 65 lb/acre or higher, this STP becomes the agronomic critical level (ACL). Bermudagrass and fescue are the predominate forages grown in the IRW.

c. These correlation-calibration P relationships that establish good agronomic use of P as a fertilizer have been published by the Oklahoma State University in OSU Bulletins and "Fact Sheets" that include tables showing the relationship and the need, if any, for additional P as a fertilizer to accomplish maximum crop yield. These publications include a table showing the categorization of soil test results and identify a STP value of 65 as being adequate , i.e., any additional input of P fertilizer would have no agronomic benefit. This calibration was originally published in 1965 and has been verified by field research through time (Baumann, 1965.) The following tables are reproductions of the tables that were first published in the OSU Fact Sheet 2225 (Baker and Tucker, 1973) and are in the current OSU fact sheet widely used for nutrient management and soil test interpretation (Zhang, H., et al., 2006).

Table 1. Soil test P calibrations for fescue and bermudagrass.

Calibration for fescue:

PHOSPHORUS REQUIREMENT		
Soil Test P (STP)	COOL SEASON GRASSES BROME, ORCHARD, FESCUE	Fertilizer P_2O_5
Lbs/A	Percent Sufficiency	Lbs/A
0	30	80
10	50	60
20	70	40
40	**95**	**30**
65+	**100**	**none**

Calibration for bermudagrass:

PHOSPHORUS REQUIREMENT		
Soil Test P (STP)	BERMUDA	Fertilizer P_2O_5
Lbs/A	Percent Sufficiency	Lbs/A
0	50	75
10	65	60
20	80	40
40	**95**	**20**
65+	**100**	**none**

These tables show the relationship between soil test P (STP) values (in the range of 0-65 lb P/acre), the percent sufficiency of maximum crop yield associated with an STP value, and the amount of P fertilizer to correct the identified deficiency and improve crop yield to 100 percent of maximum. These long standing evaluations, illustrated in the graph below from a recent fact sheet, show that additional P fertilizer is not needed when the STP is greater than 65 (Zhang, et al., 2002).

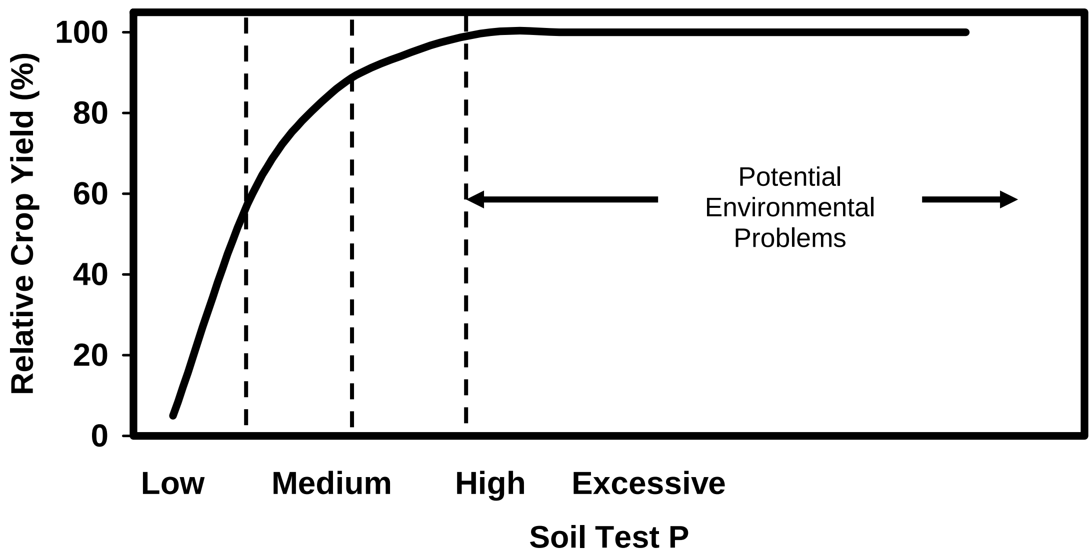

Figure 1. Relationship between soil test P and relative crop yield.

The first OSU fact sheet, published to help farmers understand the use of soil test results (Baker, 1974) recognized the value of prudent use of P fertilization and stated:

> "Ideally all soils of Oklahoma would be liberally fertilized with phosphorus until the soil test value reached 40 pounds per acre. Once this value is reached only maintenance applications would be needed. Occasionally, a soil will have been fertilized or will contain enough native phosphorus that it will test above 65 pounds per acre. In these cases, no phosphorus should be applied. Applying phosphorus to soils that test above 65 pounds per acre is not only costly but could eventually be detrimental."

The fact sheet tables also show that when the STP is moderately deficient (STP of 40) there is only a 5% loss in crop yield and that an input of only 20 to 30 lb/acre of P_2O_5 would correct the 5% deficiency.

d. I have reviewed STP calibrations of other Land Grant universities in the Southern Region of the US and found that these states use a similar calibration and agronomic critical level (ACL). The table below was published by the Southern Region SERA-6 work group on soil testing and plant analysis (Savoy, 2007).

Table 2. 2007 critical STP levels in the Southern Region of the US.[1]

States using Mehlich-1			VL	L	**M**	H	VH
State	Soil	Crop			**Phosphorus, lb/acre**		
AL	CEC<9[3]	All except peanuts	0-12	13-25	**26-50**	51-100	101-200
FL	All	All	0-20	21-30	**31-60**	61-100	120+
GA	Coastal Plains	Forage grasses		0-30	**31-60**	61-100	101+
	Piedmont	Forage grasses		0-20	**21-40**	41-75	75+
SC	Coastal Plains	All except peanuts	0-10	11-30	**31-60**	61-120	121-240
	Piedmont	All except peanuts	0-6	7-20	**21-40**	41-80	81-240
TN	All	All except Cotton		0-18	**19-30**	31-120	121+
VA	All	All	0-3	4-11	**12-35**	36-110	111+
States using Mehlich-3							
AR	All	Forage grasses		0-59	**60-100**	>100	
KY	All	Corn, soybean	0-5	6-27	**28-60**	61+	
LA	Costal Plains	All	0-10	11-40	**41-80**	81+	
NC	All	All	0-21	22-54	**55-107**	108-214	215+
OK	All	All	0-20	21-40	**41-65**	65+	
TX[2]	All	Forages			**100**		

[1] Savoy, H.J. 2007.
[2] Texas Cooperative Extension Service.
[3] CEC is an abbreviation for cation exchange capacity, the ability of the soil to adsorb cations (positive charged ions), and is also an indicator of the soil's surface area and likelihood of surface P adsorption.

For the five states using the Mehlich-3 procedure, the ACL is in the range from 60 to 107 lb P/acre. States using the Mehlich-1 typically have smaller ACL values because the extractant is less acidic. A general conversion for Mehlich-1 to Mehlich-3 is provided by the regression equation below (Southern Regional Fact Sheet. 2005).

$$M\,3 = 1.43 \times M\,1 + 18.6$$

The specific STP value identified with the ACL would be the largest STP value in the medium (**M**) category, since larger values would move the STP into the H category which is identified with the definition, "Yield increase to the added nutrient is not expected. The soil can supply the entire crop nutrient requirement. No additional fertilizer is needed."

6. Litter as a P nutrient source.

a. All plant materials contain each of the 16 essential plant nutrients, listed in paragraph 4, in various forms and concentrations depending upon the condition or state of the material. Similarly, animal manure, having originated primarily from plant material will also contain these elements. Historically, animal manure was a good source of nutrients for plants because it was deposited on the soil over an area from which the animals harvested plants. In the natural animal-plant setting, animal manure deposition would not be expected to occur repeatedly on the exact same area, and it may have been several years before the same area received a second "application" of animal manure. Small amounts of P and large amounts of K required by plants could be supplied by native soil sources to support vigorous growth in native grass ecosystems. Large amounts of N required by plants could be supplied from native soil organic matter sources and decay of legume (plants that fix N from the atmosphere by symbiotic association with bacteria in the soil) residue.

b. The N content of grass forages high in protein (19 % Crude protein) may be as great as 3 %, more than 10 times the content of P and 3 times the content of K. Expressed in the form common for fertilizers, (N, P_2O_5, and K_2O) this is about a 6:1:2 ratio. By comparison, poultry litter generally has about a 1:1:1 ratio. Nitrogen can be lost from animal waste by leaching (as nitrate) and volatilization (as ammonia and nitrous oxides) depending on the pH and moisture conditions under which the waste accumulates and is transported. Phosphate is not subject to loss by volatilization, thus the P_2O_5 content of litter may often be higher than that for N or K_2O.

c. Poultry litter is a good source of P for soils that have low STP. However, it is not a good fertilizer as a whole, because it does not provide the nutrients in the ratios and amounts required to maintain grass forage production as exists in the IRW. Unlike commercial, inorganic fertilizers like urea, ammonium nitrate, and diammonium phosphate, the N and P_2O_5 in litter is not all readily available to plants because much of it is bound in the organic portion of the litter. These nutrients become plant available during the growing season of the crop as a result of microbial decomposition of the litter. Most of the P_2O_5 and over one-half of the N will become available the first year after application. The remaining N will become available in the second and third years after litter application. When litter is applied to meet the N requirement of high protein forage there will be about 6 times more P_2O_5 applied than required by the crops. While this may be beneficial when the STP is below the ACL, it is inconsistent with good agricultural practice and especially undesirable when the STP is above the ACL and the field is in a P-limited watershed, such as the IRW. Applied P that is in excess of crop uptake will accumulate in the soil and raise the STP about 1 lb P/acre for every 10 to 15 lb excess P_2O_5/acre.

Similarly, when no P is added the STP will decrease by about the same factor. Consequently, when STP is excessively high it may take decades of forage removal by haying to reduce it to 65 lb P/acre. For example, when the STP is 300 lb P/acre it would require the removal of 3 ton of forage as hay for 85 years to lower the STP to 65 lb P/acre, with no P inputs. It would take centuries to cause the same reduction in a pasture situation because 90 %, or more, of the P in forage consumed by the animals passes through them and is returned to the soil. When all the Arkansas soil samples tested in 2003, identified for forage production are considered for agronomic input (STP <65 lb P/acre) and crop removal the average STP for all the samples, even those exclusively for hay production, require a few hundred years to reach near 65 lb P/acre. Figure 2 illustrates the extreme time period required for average STP values to approach ACLs, especially when the land is used for pasture. Since 2003 STP values were used instead of the 2006 – 2007 values that are more representative of poultry waste disposal and about 2 times higher, this estimate is very conservative.

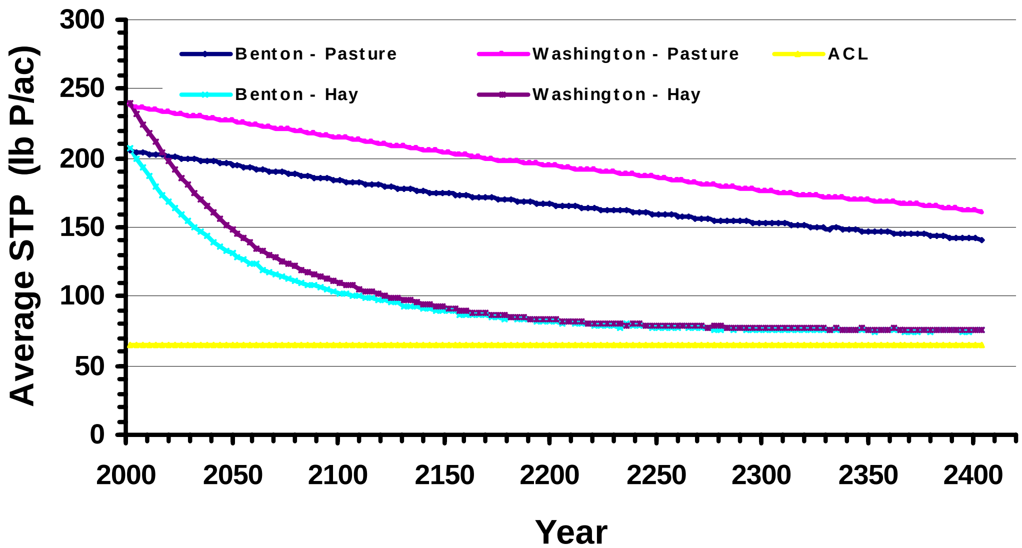

Figure 2. Projected decline in average STP values for Washington and Benton counties when P depletion is by haying, pasture use, and runoff using 2003 STP values as a basis. P input is projected when STP is <65 and results for 3 years from an input of 3 ton of poultry litter per year.

Concern for P management from animal manure and poultry litter is common among land-grant university faculty and has been expressed in their publications (Zhang, et al., 2002; Daniels et al., 2004)

7. STP and P management in the IRW.

a. I have evaluated available information to determine if I can form an opinion on the agronomic P needs in the Illinois River Watershed using the STP correlations and calibrations discussed above. Based on the 2002 Census of Agriculture, 92.3 % of the total cropland is forage production (pasture or hay) for the counties within which the IRW resides in Oklahoma and Arkansas (2002 Census of Agriculture). Fescue and bermudagrass are the primary forages used for pasture and hay production. For these crops an STP value of 65 produces the maximum crop yield. Therefore, application of P to fields where soils are at or above an STP of 65 is not an agronomically reasonable practice. If the STP levels in IRW soils reach this maximum agronomic level, then those soils would not reasonably require additional P inputs from poultry litter.

b. I have reviewed the STP results from a Court supervised, land application of litter project in the Eucha-Spavinaw watershed in Eastern Oklahoma and Western Arkansas for 2006 and 2007. These soil tests were performed as a prerequisite to land application of poultry litter on managed for pasture and hay production. Integrators, identified in the database provided by the manager are Peterson Farms, Simmons, Tyson, Cobb-Vantress, Georges, Cargill, and Moark (see Excel data files). The test results would be typical for fields where poultry litter application occurs in Oklahoma and Arkansas. As such, they reflect STP for pasture soils in the IRW because of the similarity of land use, poultry operation and soil types in these contiguous watersheds. Of 617 observations in Arkansas, 601 (97%) had STP values in excess of 65 lb/acre and only 5 (< 1%) had values less than 40. The average STP (290 lb P/acre)for Arkansas samples was more than four times the agronomically reasonable STP of 65. For the 678 samples from Oklahoma the average STP was 165, 81 % had STP values greater than 65 and 91 % of the samples were greater than 40. The average STP was 2.5 times the agronomically reasonable STP of 65 (Figure 3). The sampling depth was set at 4 inches by the court and thus the calculated lb/acre STP is likely less than it would be for a 6-inch depth.

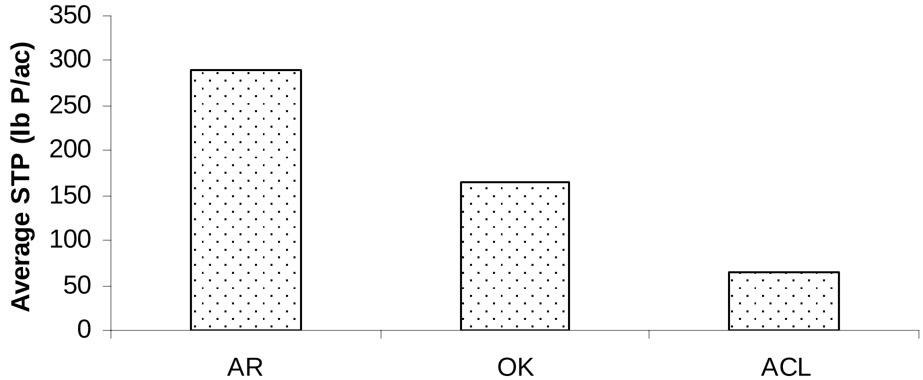

Figure 3. Average STP of samples from fields where poultry litter was applied in the Eucha – Spavinaw Watershed in 2006 and 2007 relative to the agronomic critical level of 65 (ACL).

c. A second data set of STP values for IRW soils from growers for defendants Georges and Tyson is shown in Table 2.

Table 2. Soil test N and P values for samples from Georges and Tyson growers.

	Georges			Tyson		
	Average N and P soil test values (lb/ac)					
Year	number	N	P	number	N	P
2000				35	13	66
2001	147	97	141	23	13	135
2002	63	74	354	47	13	268
2003	8	94	507	52	17	495
2004	34	63	763	12	35	752
2005	19	71	1166	4	14	1211
ALL	274	88	345	173	16	333
Range			19-1746			27-1529
Average STP of highest 1/4			792			667
Average STP of samples >65			395			364
% of samples with STP>65			85			90
% of samples with STP<40			6			3

For the period 2000 – 2005, the 173 values identified with Georges averaged 345 lb P/acre, over 5 times the ACL. Eighty five percent were greater than 65 and only 6 % of the samples had an STP less than 40. The upper 25% of these samples had an average STP of 792 (more than 10 times the ACL). The samples identified for Tyson growers averaged

333 (also 5 times the ACL), with 90 % above 65 and only 3 % less than 40. Additionally, the average available N was 16 for the samples associated with Tyson and 88 lb N/acre with samples associated with Georges, indicating a long practice of excess N and P input to these soils. Application of poultry litter sufficient to raise STP and available N to these levels is not a reasonable agronomic practice. Rather it indicates that such poultry litter application was disposal of waste. As a comparison, where land application of poultry waste is not common, as in 18 eastern Oklahoma counties where litter production is less than 1,000 tons per year, the average STP is 38 lb P/acre for the 2004-2006 period (OSU soil testing lab STP data and 2002 Census of Agriculture poultry production data, see Excel data files).

d. I have also examined results of soil tests from the public soil testing labs at the University of Arkansas and Oklahoma State University for the last three years data from counties within which the IRW resides (Benton and Washington counties in Arkansas and Adair, Cherokee, Delaware and Sequoyah counties in Oklahoma). These samples represent all samples collected within each county from fields identified for forage production. Therefore this collection of samples would be expected to include fields that have historically had P input from poultry litter, those with historic input of P from commercial fertilizer, and those that may be sampled for the first time to diagnose production problems. Commercial fertilizer is likely used when fields are not close to a source of poultry litter. Because commercial fertilizer-P is more costly than litter-P, farmers generally do not apply more than will be beneficial for the crop and STP values are generally maintained near 65 (as indicated in (6d) above, by the average STP of 38 for 18 eastern Oklahoma counties where annual litter production is less than 1,000 tons.) To the extent commercial fertilizer is used instead of poultry litter-P in these counties, the county average STP will be less than what is reported for fields receiving poultry litter-P (paragraphs (6b) and (6c) above). Nevertheless, even for these county-wide results, the average STP was 402 lb P/acre and 90 % of the 6558 samples from Arkansas counties from 2005 to 2007 had STP values in excess of 65 lb/acre, and 96 % had values greater than 40 lb/acre, the 95% crop yield sufficiency level (Arkansas soil testing lab). Results from the Oklahoma counties for 2005 to 2007 had an average STP of 102 lb P/acre and showed that of 4,216 samples, 78 % had values greater than 65 and 83 % had values greater than 40 lb/acre (OSU Soil, Water and Forage Analytical Laboratory, annual summaries).

e. The Arkansas legislature recently passed new laws that went into effect on January 1, 2006. These laws require STP analysis before poultry litter can be land applied. The effect of this legislation became evident in review of soil test results for Benton and Washington counties. From 2000 to 2005, the average number of soil samples tested each year associated with forage production, was 299 and 223 for Benton and Washington counties, and the average STP values, although more than double the ACL of 65, were 174 and 140, respectively. The total number of samples increased dramatically in 2006 and 2007, to an annual average of 1088 for Benton County and 1803 for Washington County. The respective STP values also greatly increased and averaged 453 and 426 respectively. The upper 25 % of samples averaged over 900 lb P/acre, with the highest 17 samples exceeding 3,000 lb P/acre.   Phosphorus deficiency (i.e., less than 65 STP) was indicated for only 5.0 % of the samples for Benton County and 8.3 % of the samples for Washington County. Although the results for these two years still include samples outside of the IRW and samples where commercial fertilizer is the source of nutrients, the dramatic change in number of samples is a result of newly required tests where poultry litter has been, and was intended to be, applied. The dramatic increase in average STP values, which are more than six times the adequate level for crops, and the presence of such astronomically high soil test results, is a clear indication excessive poultry litter P has been applied in the past and fertilizer P is no longer needed for the vast majority (93 %) of these fields.

f. I have reviewed the Arkansas Natural Resources Commission annual reports that record STP values associated with comprehensive nutrient management plans developed for land application of litter.

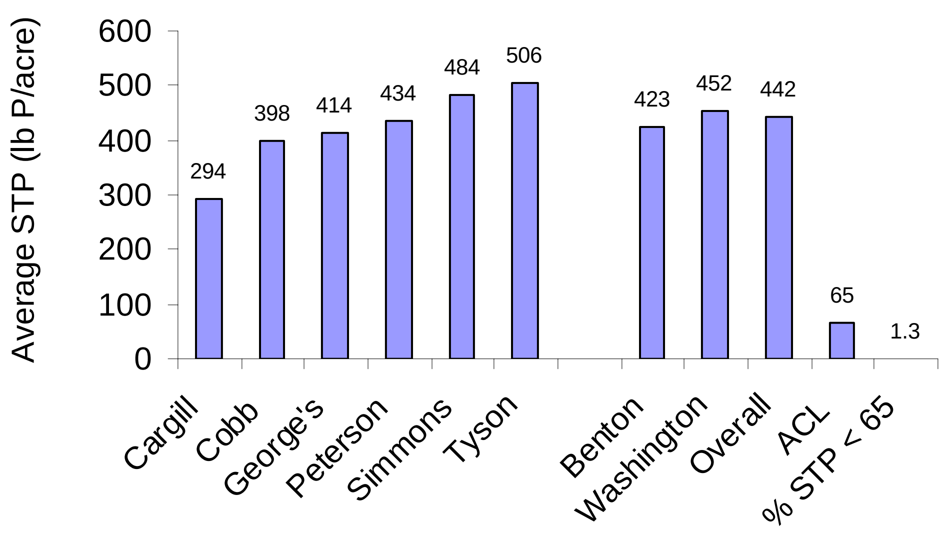

Figure 4. Soil test P values from Arkansas Natural Resources Commission registry for litter management, 2007. Integrators were identified only for Benton County.

This data represents STP values for fields where poultry litter waste was being land applied in the IRW in 2007 by growers associated with the indicated integrators. Overall there were 224 STP values expressed as "Avg. P Level". Each "Avg. P Level" often representing several hundred acres. For example, an "Avg. P Level" of 539 lb P/acre was identified with 886 acres associated with the integrator Cargill. Similarly, an "Avg. P Level" of 761 lb P/acre was associated with 500 acres for a Tyson grower(s).

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g. I have also reviewed recent studies by the USDA that have examined the capacity of counties to assimilate nutrients from animal manure. Using animal census data from 1982 and 1997 these USDA studies have shown that nationally over 50 % of the on-farm excess N and P is from poultry production (Gollehon, et al., 2001) An estimated 97 % of the animal manure produced and land applied in the IRW is poultry litter (from 2002 Census of Agriculture livestock data). Using 1997 data, the USDA concluded categorically that between 75 -100 % of the on-farm N and P from animal manure generated in Washington and Benton Counties in Arkansas and Delaware County in Oklahoma was in excess of the farms' ability to reasonably assimilate the nutrients as fertilizer. Adair, Cherokee and Sequoyah counties in Oklahoma were categorized as 50 – 75 % in excess of the farms' ability to agronomically assimilate the nutrients (Confined Animal Production and Manure Nutrients. USDA 2001. pg 25-26; Fig 25-26.). This 1997 "excess" of these nutrients is now likely to have become even greater because poultry production has increased since 1997 and IRW soils have become more nutrient saturated. The government studies did not consider available soil nutrients identified by current soil tests, and thus are conservative estimates of the P excesses.

h. A recent study relating N and P inputs from fertilizer and manure, removal by harvested crops, and the balance of deficiency or excess was conducted in Arkansas (Slaton, et al., 2004). Separating the state into nine districts, the five-year study concluded that poultry litter accounted for 96 % of the total manure-derived N, P, and K in the state. They also concluded that although forage uptake of P is high for areas of western Arkansas where poultry litter production is greatest, "nutrients removed by forage crops are usually fed or recycled on-farm rather than exported outside the district boundaries". They further stated that "…most soils used for warm-and cool-season grass production in Arkansas already have adequate Mehlich 3-extractable P levels that do not require additional P fertilization for forage production…" With regard to the balance of inputs and removal of P they concluded “The greatest excess of N and P exists in District 1 …” within which Benton and Washington counties are included. They also concluded that “The results from this assessment may help reinforce the thought that current nutrient application strategies in western Arkansas are not sustainable without the danger of creating and/or exacerbating water quality issues from excessive nutrients. Transport of excessive N and P contained in poultry litter outside of the central and western Arkansas districts that have restricted land area available for nutrient application is needed if the current poultry production levels are to be maintained.” Similar to the USDA study in (g.) above, they did not consider soil contributions to provide crop P when they calculated the balance between manure inputs and crop removal and, consequently, the statements of excess P are greatly underestimated.

i. Based upon my review of the above STP values and reports of nutrient excesses, it is clear that land application of poultry litter has led to excessive P build-up in land within the IRW. The need for additional widespread land application of poultry litter as a P fertilizer does not exist. Almost all continued land application of poultry litter within the IRW should be judged as a waste disposal practice rather than fertilization. Given the low percentage of fields with STP values less than 65 and the large amount of litter produced in the IRW, most of the litter should not be applied within the IRW. Very few forage fields in the IRW would reasonably require additional application of poultry litter under good agronomic practices.

8. Soil amendments.

a. Amending soils is a practice where materials are added to soils to correct conditions that have been identified as limiting normal soil productivity. Under State law, only materials that are proven to correct these limiting conditions may be licensed as soil amendments (Oklahoma Soil Amendment Act). Unmanipulated animal manures are specifically excluded from the definition of soil amendments . Additionally, to be effective, soil amendments must typically be incorporated into the soil by tilling and used to correct an identified production-limiting, soil property. Land application of poultry litter to pasture and hay land in the IRW usually involves only surface spreading without tilling. Consequently, land application of litter in the watershed does not qualify as a soil amending practice and it is unlikely that significant non-fertilizer benefits could be obtained.

9. NRCS 590 and P index use.

a. I have examined the NRCS Code 590 guidelines and the use of phosphorus indexes (PI) in the Southern Region of the US. Most of the states have 590 tables identifying applicable animal waste application rates based upon “environmental threshold” STP levels. States that do not have such tables suggest use of a PI instead.

b. The widespread use of these guidelines, in the US as well as the Southern Region, should not be interpreted as a sign of widespread scientific support, as is sometimes suggested, but rather as a result of a large NRCS presence in every state.

c. The 590 documents typically identify limits for commercial fertilizer inputs on the basis of agronomic critical levels (ACL) from long-standing, scientifically based STP calibrations. These ACL tables are used by NRCS to identify the limits for subsidizing (cost-share) fertilizer inputs for conservation practices by farmers receiving government assistance. NRCS has no enforcement authority except to deny assistance when guidelines are not followed.

d. The 590 documents typically include separate tables to identify animal waste application rates for “Non-Nutrient Limited watersheds” and “Nutrient Limited Watersheds”. Application rates in these tables are not science-based, but rather the result of opinions on what may or may not cause environmental impact. These opinions have produced tables identifying animal waste land application rates related to N crop requirement and STP environmental threshold levels. Nitrogen crop requirements are scientifically based, incorporating crop N content and projected yield levels. Table STP values are not scientifically based and the levels used have not been related (calibrated) to actual soluble P in runoff or reaching surface water bodies. The Oklahoma NRCS 590 table for Non-Nutrient Limited Watersheds, for example, uses five categories of STP from “Low” to “Severe”. The low category applies to STP values from 0 – 65 and allows animal waste rates to meet crop N requirements. STP values for other categories have no rational basis and range from 66 to 400 lb P/acre. The table for Nutrient Limited Watersheds is similar, with the exception that the upper limit STP value is 300 lb P/acre.

e. Implementation of both the 590 guidelines and PIs is based on the premise that relative risk to the environment is evaluated by the tool, and animal waste application rates governed accordingly. While much scientific effort has gone into calculating relative risk values, the acceptable maximum risk has not been identified. Furthermore, these tools have failed to adequately recognize that for P Nutrient Limited Watersheds, such as the IRW, the minimum risk is achieved by not applying P after the STP reaches 65. Use of the Arkansas PI has been defended because “A significant positive relationship was found between the average SRP

(soluble reactive P) concentration in runoff … and the P index…" in a recent Arkansas study (DeLaune, et al., 2004). The same research stated that "In contrast, poor relationships were observed between soil test P and SRP concentrations in runoff on each farm (Table 5). This can be attributed to the overwhelming influence of soluble P applied to the plots." Thus, even though STP may be excessive and contribute harmful levels of soluble P to surface waters, it is not considered independent of soluble P in the litter. Instead, the contribution of STP as a P source component in the PI is minimal because the PI risk calculations always include a component for soluble P in the litter.
Use of these tools are only a short-term solution to disposal of excess waste, and in the long-term waste P input must match agronomic use, as expressed by scientists of the Southern Region of the US, (Maguire et al.).

f. The philosophy of litter applications after STP levels have exceeded the ACL is to provide crop N requirements. However, when litter applications are made according to the NRCS 590 Code guidelines in Oklahoma and the Arkansas PI, neither litter N content nor soil test N are measured and used as a part of the comprehensive nutrient plans.

10. <u>STP and soluble P in field runoff.</u>

a. I have evaluated scientific literature related to STP and soluble P in runoff to form an opinion on the impact to surface water quality as a result of continued litter application based on phosphorus indexes, or other rules or guidelines, which allow litter application in excess of agronomic P requirements. Surface water runoff is a commonly accepted mechanism for P transport over the landscape (Figure 4 from Zhang et al., 2002).

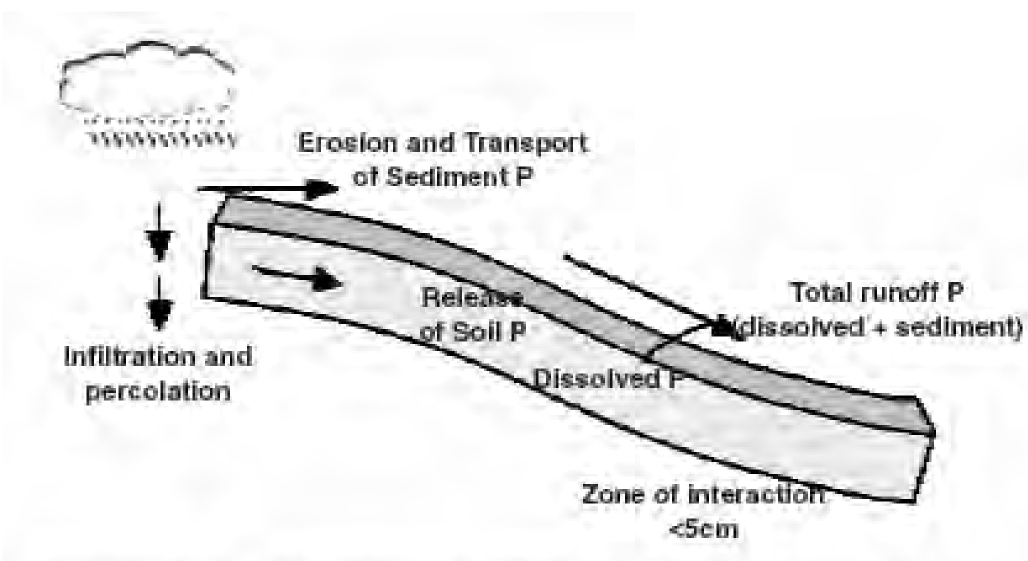

Figure 4. Mechanisms of phosphorus transport over landscape: erosion and runoff.

b. The average STP value was 38 lb P/acre (19 ppm) from forage land sampled during the period 2004 to 2006 for 19 Eastern Oklahoma counties for which poultry litter production was estimated to be less than 1,000 tons per year. For the same crops and period, the average STP was 80 lb/acre (40 ppm) for 10 counties for which poultry litter was greater than 1,000 tons per year. Within the IRW, 58 % of the land use is estimated to be pasture.

c. A recent review of published research on the relationship of STP to runoff P examined results from 17 studies representing 31 soils and a variety of management conditions (P.A. Vadas et al., 2005). They concluded "Overall, a single extraction coefficient (2.0 for Mehlich-3 P data,…) could be used in water quality models to approximate dissolved P release from soil to runoff for the majority of soil, hydrologic, or management conditions. " (Figure 5). Using the prediction equation from this publication (2 times ppm STP = ppb runoff P), the calculated concentrations of runoff P would be 0.038 ppm for the average STP values of counties with < 1,000 tons litter production per year. The estimated runoff concentration would be 0.80 ppm for counties with > 1,000 tons litter production per year.

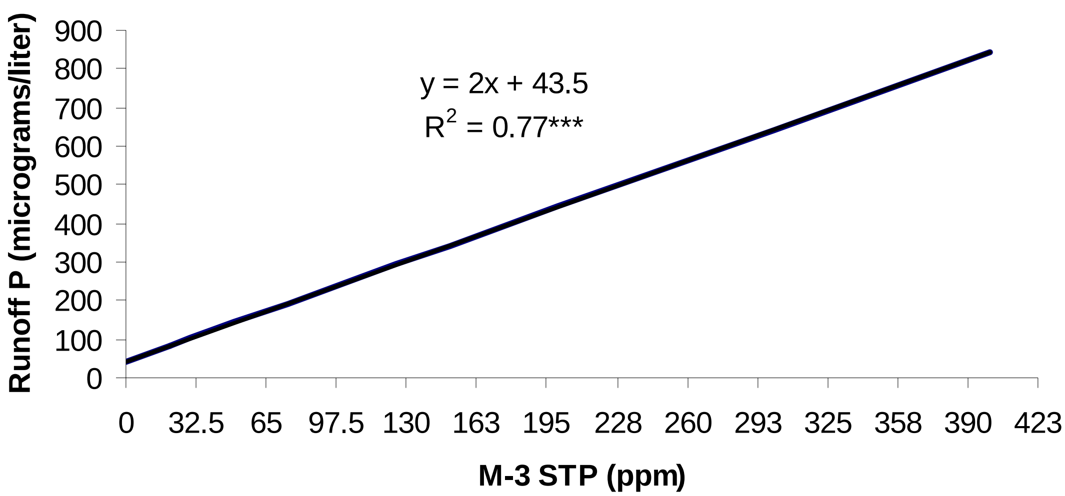

Figure 5. Relationship between Mehlich 3 soil test P and runoff P (P.A. Vadas et al., 2005).

d. The use of phosphorus indexes and/or NRCS 590 Code tables, as guides for animal waste management, promotes the land disposal of waste for its N value without adequate consideration of long-term impact of soil-P buildup on surface water quality. Scientists of the SERA-17 work group (Organization to Minimize Phosphorus Losses from Agriculture), presented their “Position of SERA17 on Phosphorus-Indices**”** and concluded, “However, it should be understood that the implementation of P-Index based management only addresses short-term P loss issues. For long-term sustainability, applications of P must approach a balance with crop removal” (Maguire et al.). When these guides are used long-term most of the soils that can receive poultry litter will have attained the limiting STP value. In Oklahoma that value will be 300 lb P/acre, the NRCS highest value for nutrient limited watersheds. In Arkansas it will be 1100 lb P/acre, the maximum allowed by the Arkansas Phosphorus Index under Title XXII rules.

e. When the Vadas, et al. coefficient is used to calculate runoff concentration in the IRW, values of 300 ppb would result for Oklahoma and 1100 ppb for Arkansas. Adjusting these values for land use (only pastureland, 58 % of total area, would receive litter) in the IRW would result in concentrations of between 174 and 638 ppb P in runoff for the entire IRW. In contrast, when litter application is governed by agronomic benefit from P the concentration would be only 38 ppb even if all the pastureland soils tested 65 lb P/acre. In reality, a sufficient acreage of soils would not qualify for litter application because of slope, depth, and distance from streams, etc. so that less than 58 % of the land area would receive litter and the watershed concentration of P would be proportionately less.

f. Based upon the above considerations it is my opinion that continued use of NRCS Code 590 allowances for litter application rates in Oklahoma and rates allowed by the Arkansas Phosphorus Index-Title XXII rules in Arkansas, will lead to increasing concentration of soluble P in surface waters for many years in the future.

11. <u>Evaluation of practices</u>.

a. Given the forgoing evaluation, land application of poultry litter in the IRW has not been and would not be, for all but a few cases, an agronomically reasonable practice from a P nutrient or soil amendment perspective. Consequently, such practices have been and would continue to be poultry litter disposal rather than a soil fertilization or amendment.

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Gordon V. Johnson

Subscribed and sworn to me by Gordon V. Johnson on the 13th day of May, 2008.

Signature

T J Payne
Printed Name

OFFICIAL SEAL
T J PAYNE
NOTARY PUBLIC OKLAHOMA
PAYNE COUNTY
COMM. EXP. 04-18-2011
COMM. NO. 07003848

Notary Public, Payne County, Oklahoma

My Commission Expires: 04-18-2011