

Memorandum

Date: March 21, 2011
To: Jim Cauley, Attorney for the City of Wilson NC
From: Trevor Clements, Water Resources Director
Cc: Clark Wright
Subject: Preliminary Evaluation of Potential Water Quality Concerns Associated with a Proposed Poultry Processing Facility in Nash County

1. INTRODUCTION

The City of Wilson (North Carolina) and Nash County (North Carolina) entered into a Consent Decree in June 2001 which, among other provisions, contains the following (item 5):

During the term of this Consent Decree, Nash County and the City of Wilson will cooperate to avoid taking any actions adverse to regulation and protection of the water supply at Buckhorn Reservoir.

Buckhorn Reservoir provides the majority of storage for potable water distributed by the City of Wilson. Per item 3 of the agreement, the City agrees that it will allow Nash County (through the year 2025) to withdraw raw water from Buckhorn Reservoir on an emergency basis provided certain conditions are met. Thus, it appears to be in the best interest of both parties to act together to protect the water supply.

Nash County is currently recruiting Sanderson Farms Inc. to locate a large poultry processing facility in the County. Current proposed site plans indicate that, as a part of the proposed operation, treated effluent from the poultry processing plant would be land applied within the Toisnot Swamp watershed, which provides a portion of the drinking water for the City of Wilson (drawn from Toisnot Reservoir). In addition, information provided to the County by Sanderson Farms estimates that the new processing facility will result in 496 broiler chicken houses, 48 breeder chicken houses, and 24 pullet chicken houses. Nash County and Sanderson Farms indicate that these chicken houses will be located on farms within a 75 mile radius of the plant, including locations within the Wilson water supply watersheds. A map showing the watershed boundaries above the four reservoirs comprising Wilson's water supply (Buckhorn, Wiggins Mill, Lake Wilson and Toisnot) along with Sanderson Farms' proposed processing facilities is provided in Figure 1.

Tetra Tech has been commissioned by the City to evaluate the potential threat to the water supply from the proposed processing plant effluent and chicken farms that would locate in or near the City's watersheds. Tetra Tech is a leading provider of consulting, engineering, and technical services worldwide, and has been ranked first by *Engineering News-Record* (ENR) in Water Resources Planning and Design and in Environmental Management for the past eight consecutive years. Because of its widespread knowledge and experience, Tetra Tech's North Carolina staff were the lead authors for the national guidance on watershed planning, *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (EPA 841-B-05-005). This same staff conducted the evaluation on behalf of the City of Wilson.

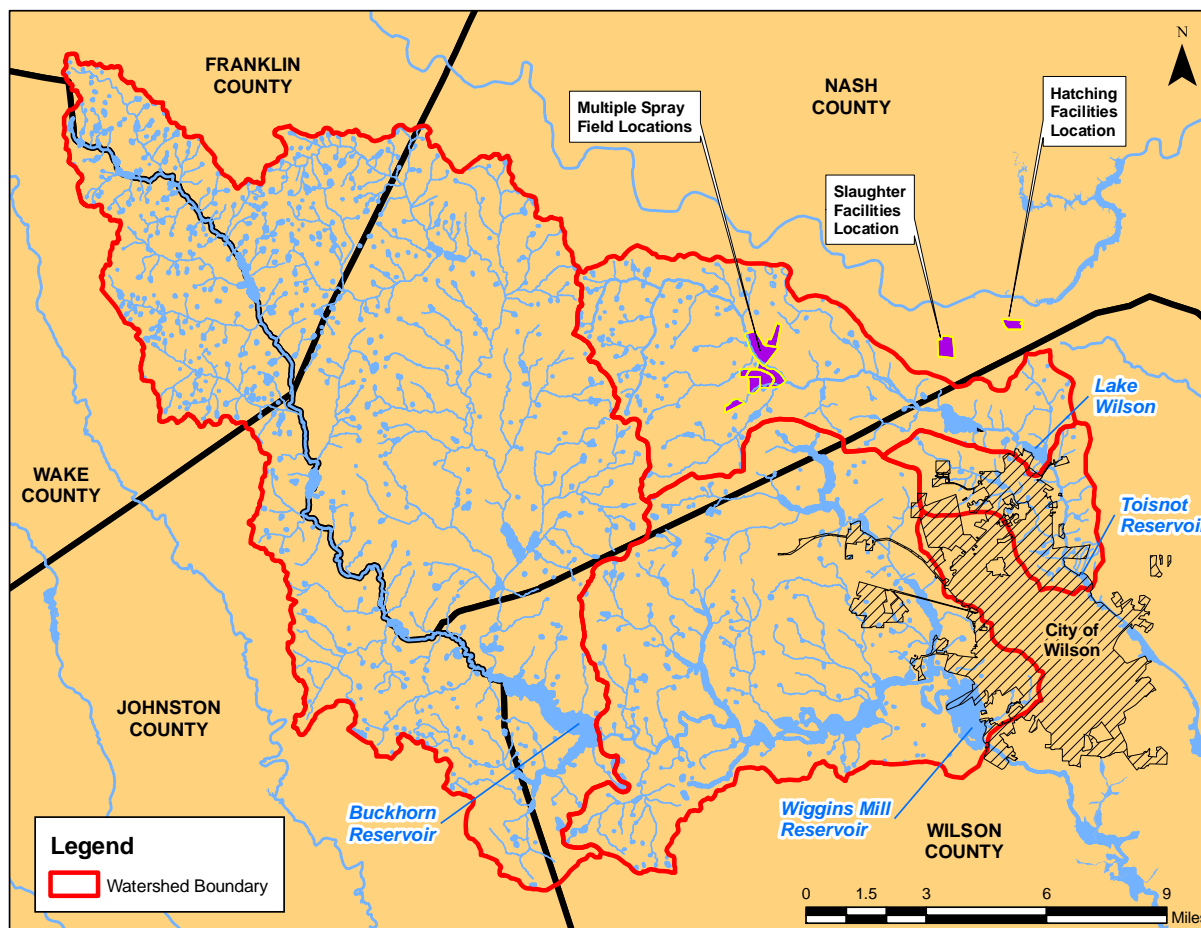


Figure 1. City of Wilson Water Supply Watersheds and Proposed Sanderson Farms Facilities

2. METHODS

To conduct its evaluation, Tetra Tech drew on information from previous water quality studies involving animal operations including poultry farming, conducted additional literature research, examined existing land use and land cover within Wilson’s water supply watersheds, reviewed local water quality data, and interviewed research and extension personnel, as well as staff in charge of operating the City’s water supply collection, treatment and distribution facilities. Information was compiled and analyzed to form the content of this memorandum.

3. FINDINGS

According to a 2005 NC Cooperative Extension literature review, the poultry industry is faced with three major water quality and nonpoint source pollution issues: 1) processing plant waste; 2) mortality management; and 2) manure/litter management. The North Carolina Division of Water Quality (2010 Tar-Pamlico River Basin Plan NSW Strategy, Chapter 6) identified the lack of regulation and information and the concomitant uncertainty in the impacts of poultry operations as a key concern. Below we have highlighted main research findings regarding poultry processing facilities and mortality management, chicken farm facility and manure management, and regulatory gaps, as well as the corresponding potential risks to water quality.

Poultry Processing Facilities and Mortality Management

- Poultry slaughter is characterized by relatively high water use, most of it for nonconsumptive purposes. In 2008, U.S. poultry processors slaughtered nearly 9 billion broilers, using an average of 7 gallons of potable water per bird and generating approximately 63 billion gallons of high-strength wastewater. Potable water is used in poultry processing for electrical stunning, scalding, defeathering, carcass washing, carcass chilling, transport of product, and plant sanitation. It is also the primary means by which offal is transported out of the various processing areas for collection and separation from the poultry processing wastewater (PPW) stream. PPW is the cumulative wastewater stream generated during the slaughter of poultry after physical screening that removes the waste portions of the butchered meat. For environmental regulatory monitoring purposes, PPW is most often characterized by the form and concentration of the organics, particulate solids, and selected minerals it contains (Kiepper, 2009).
- Nitrogen and phosphorus are nutrients commonly used to characterize PPW because of their direct environmental impact on the acceleration of the enrichment process of waterbodies, known as eutrophication. One common analytical measure of the concentration of nitrogen in PPW is total Kjeldahl nitrogen (TKN). Total Kjeldahl nitrogen is a measure of combined organically bound nitrogen and ammonia in PPW. Total Kjeldahl nitrogen concentration is an effective measure of protein and thus tissue loss to PPW because the average protein molecule contains 16 percent nitrogen and poultry meat contains 20 to 25 percent protein (Kiepper, 2009).
- Phosphorus has received significant attention in the scientific literature in association with PPW. Rusten et al. (1998) reported mean phosphorus levels in PPW ranging from 14.1 to 18.5 mg/L. Eremektar et al. (1999) reported average phosphorus levels in PPW at 48.0, 16.0, 18.0, and 40.0 mg/L during four separate sampling events. Pierson and Pavlostathis (2000) reported that post-dissolved air flotation PPW contained phosphorus concentrations ranging from 5 to 20 mg/L.
- Total phosphorus measured in effluent from a poultry processing plant in Cumming, Georgia ranged from 21.6 to 32.6 mg/L; soluble reactive phosphorus (SRP) ranged from 21.2 to 27.5 mg/L; and chloride concentrations ranged from 114 to 137 mg/L. Discharge has resulted in a build-up in phosphorus in the sediment that could continue to be a source (Pollock and Meyer, 2001).
- A North Carolina Cooperative Extension research report (2005) found that mortality from poultry production units must be handled in such a way that disposing of the mortality does not pollute ground and surface waters. Another major conclusion of the study was that with more and larger poultry operations confined to smaller areas of land, the likelihood of water contamination increases.

Chicken Farm Facilities and Manure Management

- In Eastern NC, each poultry house produces about 5-7 flocks per year, depending on the size of the chickens being raised. Generally, after a cleanout, fresh bedding made of wood shavings is spread in the house. After each flock, a litter de-caker is used to remove the top two inches of bedding that becomes saturated with waste. In some cases, this top layer is replaced with more shavings. Some growers repeat this process for one to three years before doing a full cleanout (personal communication, Shah Sanjay, Associate Professor, NCSU Biological and Agricultural Engineering, 02/02/11).
- After the cake is removed from the chicken house, it is generally stored and stockpiled on site. When weather permits and there is a prospect for plant growth, the litter is land applied (generally

to cropland in the spring and fall and to pasture in the summer). This is a way both to improve soil fertility and to maintain good vegetative cover on pasture land.

- Based on two studies conducted by NCSU, chicken houses with large birds (i.e., 9 pounds each), on average produce approximately 230 tons of waste per year. This includes litter and cake. Houses with smaller birds generate approximately 65 tons of waste per year (personal communication, Shah Sanjay, Associate Professor, NCSU Biological and Agricultural Engineering, 02/02/11).
- Animal operations including poultry farms are a significant source of nitrogen into the atmosphere. In their fact sheet on Air Quality and Livestock Operations, the U.S. Department of Agriculture Natural Resource Conservation Service (USDA NRCS, 2008) states that storage, handling, and the breakdown or decomposition of feed, bedding material, and manure (including land applied poultry litter) can produce ammonia nitrogen and nitrogen oxides (NO_x). These nitrogen particles in the atmosphere frequently deposit back down on the land and water as sources of pollution. Atmospheric deposition of nitrogen oxides (NO_x) and ammonia (NH₃) is a significant source of nitrogen input into the Neuse Estuary, estimated at more than 37 million lbs/yr (Whitall et al., 2003). In North Carolina, animal agriculture is responsible for over 90 percent of all ammonia emissions; in turn, ammonia comprises more than 40 percent of the total estimated nitrogen emissions from all sources (Aneja et al., 1998).
- Poultry litter application to land increases both soluble and particulate bound nutrients in soils. Soluble nutrients are carried through the soil profile and enter streams through overland flow and interflow during storms, and through groundwater interception during baseflow. Particulate bound nutrients are primarily transported to streams through overland flow during storm events. Litter application on no-till land allows for more washoff of litter directly into drainages and streams (Blankenship, 2004).
- Disposing of poultry litter for fertilization presents a challenge for phosphorus management because the ratio of nitrogen to phosphorus in litter is lower than required by grasses. If poultry litter is the sole source of fertilization, meeting soil nitrogen requirements will result in an over application of phosphorus (Sharpley, 1998; Harmel, 2009). High runoff nitrogen and phosphorus can occur on well-managed fields (Harmel, 2009).
- The NC Extension Service study (NCSU, 2005) found that nonpoint source pollution from animal waste runoff can reduce surface and groundwater quality by introducing excessive levels of nutrients such as nitrogen and phosphorus, organic matter, and pathogens into the environment. In 114 watersheds studied throughout the U.S., excessive levels of nitrogen and phosphorus were derived primarily from excessive or irresponsible manure applications. The NCSU research indicates that typical phosphorus applied with poultry waste (i.e., chicken litter is the source of fertilizer) is approximately 110 pounds of phosphorus per acre. This is roughly five times more than what a typical crop requires.
- A U.S. Department of Agriculture report (Golleson et al, 2001) reported excess nitrogen and phosphorus in both Nash and Wilson counties; that is, the amount of animal manure generated by the production farm exceeds the production farm's ability to assimilate the nutrients on site. These findings were also substantiated in follow-up research by North Carolina State University's Departments of Soil Science and Biological and Agricultural Engineering, and the North Carolina Agricultural Research Service (NCSU, 2005). The USDA report indicated that poultry farms accounted for 55 percent of the excess phosphorus and 66 percent of the excess nitrogen on production farms.
- Study of long-term application (2-6 tons of litter per acre for 20-30 yrs) in Wilkes County North Carolina revealed levels of phosphorus (P), potassium (K), copper (CU), and zinc (Zn) in the soil

above the NC Alert levels, with accumulation within 1-2 feet of the surface. Nitrate-nitrite and bacterial levels exceeding water quality standards (Section NC 2L) were detected in groundwater. Zinc levels exceeding water quality standards (Section NC 2B) were found in surface waters (Wang et al., 2007).

- The high solubility of Arsenic (As) from litter and its apparent ready mineralization to inorganic forms coupled with the large quantity litter that is annually land-applied in the USA suggests a potential detrimental effect on soil and water quality in the long term (Jackson et al., 2003).
- Pathogens can be transmitted from animals to humans from stormwater runoff on manured surfaces to surface waters or to groundwater via percolation (Gerba and Smith, 2005). Water supply concerns include human disease outbreaks from *Salmonella spp.*, *Campylobacter spp.*, *Listeria monocytogenes*, *E. coli*, *Cryptosporidium parvum*, and *Giardia lamblia* all of which are endemic in poultry flocks (Center for Disease Control and Prevention, 1998).
- Research being performed jointly at Kansas State and North Carolina State universities indicates that extensive use of antibiotics as growth promoters in the livestock industry constitutes strong selection pressure for evolution and selection of antibiotic resistant bacterial strains. Insects such as house flies (*Musca domestica*) and German cockroaches (*Blattella germanica*) can move freely between animal waste and food and may play a significant role in the dissemination of antibiotic resistant bacteria within and between animal production farms and from farms to residential settings (Ahmad et al., 2011).
- Analyses of poultry litter confirmed the presence of veterinary pharmaceuticals in poultry waste, and thus identify poultry litter as a vehicle for spreading veterinary pharmaceuticals into the environment. The antimicrobials virginiamycin, monensin, salinomycin, narasin and nicarbazine used as a feed additive by the poultry industry can be detected in poultry litter. This, combined with findings from other studies on persistence and fate of veterinary pharmaceuticals, emphasizes the importance of proper storage, treatment and monitoring of animal waste for veterinary pharmaceuticals (Furtula et al., 2009).
- Field studies have indicated that estrogens (present in livestock wastes land applied to agriculture fields) are sufficiently mobile and persistent to impact surface and ground water quality (Hanselman et al., 2003). The impacts on human health from endocrine-disrupting compounds such as estrogens are a major research area currently.

Regulatory Gaps

- Effluent guidelines for the Meat and Poultry Processing industry (40 CFR 432) allow for daily maximum levels of total nitrogen up to 194 mg/L and monthly average concentrations up to 134 mg/L. Phosphorus is not limited.
- In North Carolina, poultry houses fall under general statute 143-215.10. To date, the NC Division of Water Quality (DWQ) has not issued any NPDES permits under subsection C of the statute to any dry litter facilities. DWQ interprets subsection B definitions of animal operations to apply only to liquid manure operations. Although subsection C indicates that 40 CFR 122 [Confined Animal Feeding Operations (CAFO) regulations] can be applied to facilities with greater than 125,000 chickens (if non-laying hens) or 85,000 laying hens, DWQ indicates that USEPA requires permitting only if the dry litter operation is discharging or proposes to discharge directly to surface waters of the state. Currently, there are no individual NPDES permits in North Carolina issued to dry litter operations under the federal CAFO regulations (personal communication, Christine Lawson, AFO Permitting and Compliance, NCDENR Division of Water Quality, 2/21/11).

- Under NC general statute 143-215.10C, chicken houses with more than 30,000 birds that use a dry litter manure system are currently deemed permitted by DWQ and are required to develop and maintain records for a waste management plan. Under subsection F of the regulations, DWQ can inspect the plan and records, and if the plan is deemed insufficient can require an individual NPDES permit. To date, no such enforcement actions have taken place. Additionally, under current state regulatory and non-regulatory management practices and policies, there are no centrally maintained publicly available records kept for tracking purposes which indicate where poultry litter is applied, in what amounts, and when it was applied. Therefore, there are no existing means for evaluating simultaneous operations and watershed scale management practices (personal communication, Christine Lawson, AFO Permitting and Compliance, NCDENR Division of Water Quality, 2/21/11).
- Both the Neuse River Basin and Tar River Basin (which drain the Nash and Wilson County areas) are classified as Nutrient Sensitive Waters. The Neuse River Basin is impaired due to excessive nitrogen loading, and a 30 percent reduction in sources of nitrogen has been mandated as part of a total maximum daily load (TMDL) implementation strategy (Deamer, 2009). The Tar-Pamlico River Basin is also impaired by nitrogen and a 30 percent reduction is mandated (NCDENR, 2010). The 2010 Basin Plan document for the Tar-Pamlico Basin contains several references to the lack of knowledge and management on poultry operations:
 - P.6-21: There is also a need to better understand the potential magnitude of nutrient loading from animal housing, holding, waste storage facilities and sprayfields used by CAFOs, such as dairies, hog farms, and poultry operations.
 - P. 6-21: The continued growth in the poultry industry in the coastal plain of NC is adding to the current nutrient loading from nonpoint sources. Most poultry operations produce a dry litter byproduct which is deemed permitted under current regulations. The locations of poultry operations and the disposal of their waste is not known to environmental regulators due to the fact that there are no permitting requirements, making it very difficult to get a complete picture of the possible nonpoint source contributions within a specific watershed. This makes managing and protecting water quality more challenging.
 - P. 6-22: The 2007 USDA census data indicates in 2007 there were 7,370,874 chickens in the Tar-Pamlico basin. The number of chickens has likely increased by at least another 3,000,000 totaling over 10,000,000 chickens due to the Rose Acres egg farm continuing to stock their facility. This would result in an increase of at least 35 percent since 2002. The data that is currently available for the Rose Acres Farm indicates that poultry operations are likely having an impact on the water quality in the Tar-Pamlico River Basin and other coastal basins. It is estimated that 40 percent of the nitrogen entering the Albemarle-Pamlico Sound originates from atmospheric sources (DENR-DAQ, 1999; Costanza et al., 2008). Due to the prevailing wind direction, the highest nitrogen depositional rates from CAFOs are in the Neuse and Tar-Pamlico watersheds (Costanza et al., 2008). This is likely to increase overtime with the continued growth of the poultry industry in coastal North Carolina.
 - P. 6-30: Continue to work with the US Fish and Wildlife Service to evaluate the impact of the Rose Acres egg-laying operation on the Pocosin Lakes National Wildlife Refuge and the surrounding aquatic ecosystem. Develop recommendations on how to reduce the impacts from this and other poultry operations.
 - P. 6-30: Characterize the geographic extent and quantify the potential magnitude of nutrient loading from dry litter poultry facilities, animal housing and waste storage.

Wilson Water Supply

Drinking water managers have long advocated applying a triple line of defense to source water quality protection. The first line of defense is managing activities in the watershed to limit sources and risk of contamination. The second line of defense is managing the resource, a reservoir for example where operations are managed to impact quality of the intake water (e.g., mechanical circulation, aeration, chemical treatment, intake management). The third line of defense is treatment of the intake water before distributing it to users.

How water utilities apply these three lines of defense depends on a number of factors including existing conditions in the water supply watershed(s), reservoir(s), and treatment facilities. Land use and water quality information on the watershed was obtained from the City, along with anecdotal information on operations and treatment. Reservoir information was obtained from Hazen and Sawyer, the City's engineer for the Buckhorn Reservoir development. Streamflow information in Contentnea Creek was obtained from the USGS (Station Number 02090380).

Water quality data for three locations in the Contentnea Creek watershed and one location in the Toisnot Swamp watershed (station below Toisnot Reservoir) were obtained from the 2009 Lower Neuse Basin Association (LNBA) Monitoring Report provided by the City. USGS data collected between 1965 and 2010 indicate that median annual average flow at Lucama (just below Buckhorn Reservoir) is 138 cfs. The annual average flow in 2009 (i.e., corresponding to the 2009 LNBA data) was 106 cfs, approximately the first quartile (25th percentile) for the USGS historical record of annual flow.

Twelve monthly observations for nutrients were collected at each of the four LNBA stations. Mean (avg), minimum (min), and maximum (max) concentrations for total phosphorus and total nitrogen are listed below (Table 1):

Table 1. Observed Phosphorus and Nitrogen Concentrations (LNRB, 2009)

Station Location	Avg TP (mg/L)	Min TP (mg/L)	Max TP (mg/L)	Avg TN (mg/L)	Min TN (mg/L)	Max TN (mg/L)
Turkey Creek @ SR 1101	0.12	0.04	0.47	1.02	0.51	1.40
Moccassin Creek @ SR 1131	0.13	0.02	0.13	1.04	0.40	1.94
Contentnea Creek @ US 301 (below Buckhorn Reservoir)	0.11	0.02	0.51	1.05	0.48	1.72
Toisnot Swamp @ SR1539 (below Toisnot Reservoir)	0.16	0.05	0.53	1.67	0.47	7.47

Water quality observed in streams reflects among other things the composition of land use and land cover within the watersheds draining to those streams. Land use and land cover analysis performed by the City of Wilson and provided to Tetra Tech for the area above Buckhorn Reservoir (correlated with the Turkey and Moccassin Creek LNBA stations, and the Contentnea Creek station below Buckhorn Reservoir) is estimated as follows (Table 2):

Table 2. Percent of Land in Various Use in the Buckhorn Reservoir Watershed (Source: City of Wilson GIS analysis, 2010)

Land Use Land Cover Category	Percent
Barren Land	0.1
Cultivated Cropland	19.4
Forest/Shrub	42.9
Low Intensity Development	8.2
Medium/High Intensity Development	0.3
Open Water	3.0
Pasture/Hay/Fallow Field	18.1
Wetland	8.0

This can be compared to the land use in the watershed above Toisnot Reservoir (Table 3):

Table 3. Percent of Land in Various Use in the Toisnot Reservoir Watershed (Source: City of Wilson GIS analysis, 2010)

Land Use Land Cover Category	Percent
Barren Land	0.1
Cultivated Cropland	50.5
Forest/Shrub	13.8
Low Intensity Development	8.8
Medium/High Intensity Development	0.8
Open Water	1.0
Pasture/Hay/Fallow Field	4.3
Wetland	20.7

Understanding typical runoff nutrient concentrations from various land use types can help explain variation in downstream water quality. NCSU (Line et al., 2002) published event mean concentrations for phosphorus and nitrogen running off various land use types in their research in the Upper Neuse River Basin in North Carolina. Event mean concentrations represent the average concentration you would expect to see if the annual load of the pollutants of concern are divided by the annual volume of runoff. Between 28 and 70 runoff events occurred at various stations during the three-year study conducted by NCSU in the late 1990s, with the researchers sampling between 44 and 83 percent of the events. Median (med) event mean concentrations (EMCs) for four land use types are summarized below for reference (Table 4):

**Table 4. Event Mean Concentrations from Stormwater Runoff
in the Upper Neuse River Basin (Line et al., 2002)**

Land Use Type	Med TP (mg/L)	Med TN (mg/L)
Residential	0.40	1.97
Industrial	0.23	1.30
Pasture	1.56	3.61
Wooded	0.25	1.47

Note that these concentrations are higher in comparison to the LNBA stream sampling results. We would expect to see lower concentrations in the receiving waters due to losses between the upland area and downstream locations (e.g., from processes including binding and settling, plant uptake, and microbial activity) and the fact that the stream samples are not all associated with storm events. However, the EMCs illustrate for us that agricultural activities on average are generating more nutrients than other typical land uses. Although the Line et al. (2002) research focused on pasture, extensive research by Beaulac and Reckhow (1982) showed median nitrogen and phosphorus loading rates for cropland to be approximately twice that of pasture land. This research was updated in 2008 as part of the MANAGE (“Measured Annual Nutrient loads from Agricultural Environments”) database of 55 studies sponsored by the USDA Agricultural Research Service (Harmel et al., 2008). The MANAGE update indicates that across all agricultural land uses, annual runoff loads averaged 14.2 kg/ha (12.7 lb/ac) for total nitrogen and 2.2 kg/ha (2.0 lb/ac) for total phosphorus. On average, these runoff loads represented 10 to 25 percent of applied fertilizer nitrogen and 4 to 9 percent of applied fertilizer phosphorus.

The Toisnot Reservoir watershed has considerably more land in agriculture than does the Buckhorn Reservoir watershed (55 percent versus 37 percent) and considerably less forest/shrub land (14 percent versus 43 percent). Based on expected relative runoff of phosphorus and nitrogen from these land uses (i.e., the rates in Table 4), we would expect to see higher instream nutrient concentrations in Toisnot Swamp than Contentnea Creek at the bottom of these watersheds. This expectation is matched by observation, as the average phosphorus concentration in Toisnot Swamp below the reservoir is 45 percent higher than the average phosphorus concentration in Contentnea Creek below Buckhorn Reservoir. Similarly, the average nitrogen concentration at the Toisnot Swamp station is 49 percent higher than the Contentnea Creek average. At current nutrient loadings and concentrations, as noted below, both reservoirs are already periodically experiencing water quality stresses due to overenrichment of nutrients and excessive Total Organic Carbon (TOC) such that the City of Wilson is unable to use Toisnot reservoir during the summer months, and is challenged at times in meeting drinking water supply standards when treating water from Wiggins Mill Reservoir.

Based on the information summarized above for the poultry processing wastewater land application and poultry litter land application, we would expect the proposed processing facility to add more agricultural activity generating considerably more nutrients than currently cycle within the Wilson water supply watersheds. Per the information on poultry house waste from NCSU, we would expect 544 large bird chicken houses and 24 small bird chicken houses to generate approximately 126,680 tons of additional waste each year that would be deemed permitted and essentially go unregulated. Vest et al (2004) found that stockpiled chicken litter averaged 36 lbs of total nitrogen per ton of manure and 55 lbs of phosphorus per ton of manure. Thus the expected annual amount of litter associated with the proposed Sanderson Farms production farms would correspond to approximately 4.6 million lbs of nitrogen per year and 7.0 million lbs of phosphorus per year.

The USDA MANAGE database information (Harmel, 2008 and 2009) and USDA (Golleson et al., 2001) and NC Cooperative Extension (NCSU, 2005) manure studies would suggest that the City can expect a significant amount of the excess nutrients generated by the production farms to runoff the land, enter through groundwater, or be deposited from the atmosphere into the streams and reservoirs that comprise the City's raw water supply. If we apply the USDA ARS estimates of 10 – 25 percent export of nitrogen load and 4 – 9 percent of phosphorus load export, then we estimate loading to receiving waters of approximately 460,000 lbs to 1,150,000 lbs of nitrogen and approximately 280,000 to 630,000 lbs of phosphorus. USDA NRCS (2008) and Whitall et al (2003) information indicates that a significant additional amount of nitrogen loading to nearby waterbodies can be expected from poultry operations ammonia emissions and subsequent deposition. To place this in context, the combined total nitrogen load of the 22 permitted NPDES facilities in the Neuse River Compliance Association (representing a combined average wasteflow of approximately 102 mgd in 2010) was approximately 925,000 lbs in 2010 (NRCA, 2010).

The survey of literature, *Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality* (Thorne et al., 2007), documents a number of potential health related impacts from animal feeding operations that have particular relevance for public water supplies (both surface water and private groundwater sources). Potential issues related to nutrients include:

- High levels of nutrients in slow moving waters such as reservoirs typically produce eutrophic conditions (excessive algae). Cyanobacteria (blue-green algae) in surface water can produce toxins that are known neurotoxins and hepatotoxins. Acute and chronic health impacts can occur from exposures to both raw water and treated water. Some algae produce taste and odor problems that can be passed through treatment and impact consumers. Algae can also produce dissolved organic chemicals that react with chlorine to form trihalomethane (known carcinogen).
- High nitrate levels (≥ 10 mg/L) in water used for mixing infant formulae have been associated with risks for methemoglobinemia (blue baby syndrome) in infants under 6 months.
- Epidemiologic studies of non-cancer outcomes and high nitrate levels in drinking water have reported an increased risk in hyperthyroidism from long-term exposure levels between 11 and 61 mg/L.
- Drinking water nitrate levels < 10 mg/L have been associated with insulin-dependent diabetes, central nervous system malformations, and neural tube defects.

Other potential health related impacts from animal feeding operations documented in the Thorne et al. (2007) study included:

- Water-borne pathogens can cause diarrhea and other gastrointestinal distress.
- Exposure to low levels of antibiotics and other pharmaceuticals in drinking water (in the micrograms per liter or nanograms per liter range) represent unintentional doses of substances used for medical purposes to treat or prevent disease. Impacts are uncertain at this time.
- Endocrine-disrupting compounds are chemicals that exhibit biological hormonal activity. Although very low levels of estrogenic compounds can stimulate cell activity, the potential for human health effects, such as breast and prostate cancer, is in debate.

USEPA (2011a) lists potential health impacts from exposure to elevated metals such as zinc, arsenic, and copper (e.g., above maximum contaminant level) in drinking water supplies. Such impacts can include stomach cramps, skin irritations, vomiting, nausea, anemia, respiratory disorders, problems with the liver, kidney, or central nervous system, and increased risk of cancer.

Finally, impacts from existing agricultural activities on the water supply reservoirs and treatment and distribution systems are already issues of concern. Wilson City staff provided laboratory and anecdotal

information on existing drinking water utility operations. The Safe Drinking Water Act and corresponding federal regulations governing drinking water protection identify disinfection byproducts (DBPs) in finished (delivered) water as a potential public health threat. DBPs are formed when disinfectants used in water treatment plants react with chloride, bromide and organic matter present in the source water. Different disinfectants produce different types or amounts of disinfection byproducts. Disinfection byproducts for which regulations have been established include trihalomethanes, haloacetic acids, bromate, and chlorite which are of concern because of their potential carcinogenic effects. To help avoid excessive levels of DBPs, drinking water treatment facilities try to maintain levels of total organic carbon (TOC) at or below 2 mg/L in their finished water prior to disinfection and distribution.

Wilson public utilities managers indicate that it becomes difficult to achieve 2 mg/L or less in the finished water if the intake water exceeds 10 mg/L (personal communication, Barry Parks, Assistant Director of Public Services/Water Resources, 1/21/11). Laboratory data collected by the City and summarized monthly from January 2006 through November 2010 indicate that TOC concentrations exceeded 10 mg/L for 36 months during that period for the Toisnot intake water and for 15 months in the Wiggins Mill intake water (below Buckhorn Reservoir). When this occurs, the City must take extra measures to minimize risk including optimizing components of the system and use of relatively expensive additional chemicals such as activated carbon. Increasing TOC in the watershed increases the risk of not meeting drinking water standards for DBPs and exposing public water supply consumers to carcinogenic chemicals above recommended risk levels.

Both poultry processing wastewater and chicken litter contain significant organic matter, thereby creating a threat to increase TOC in the watershed directly through conveyance over land and within near-surface groundwater flow. Additionally, the excess nutrients generated by the poultry processing wastewater and chicken farms are likely to increase algae production in the water supply storage reservoirs and holding basins. Decaying algae contribute to increased TOC concentrations, and the algae stimulated by increased nutrients can pose threats to treatment operations and public health. The City already has to cope with periodic outbreaks of bryozoans that thrive in nutrient enriched waters, and which coat bar screens and produce foul odors when ruptured upon removal. Other algae-related impacts include fouling of treatment facilities, taste and odor problems in the finished water, and for some forms (e.g., blue-green algae) toxic substance release into the water supply. Current information suggests that Wilson's water supply is already challenged by the eutrophic condition of its reservoirs, and increased levels of nutrients in the watersheds from PPW and poultry farms and poultry litter risks increasing the problems further.

4. CONCLUSIONS

Research shows that poultry processing operations and chicken farm facilities can increase risk to water quality and human health in numerous ways. Processing facilities historically have been associated with high water use and high strength wastewater characterized by higher concentrations of organics, particulate solids, and nutrients such as nitrogen and phosphorus. In terms of increased risks posed from land application of poultry litter, the typical phosphorus application with poultry waste is roughly five times more than what a typical crop requires. In addition to phosphorus building up in the soil, potassium, copper, zinc, arsenic, pharmaceuticals, and endocrine disrupting compounds contained in the litter can buildup and washoff and pose a risk of detrimental impacts or potentially expose the public to unknown risks. Nitrogen produced from the poultry operations enters the waterways via surface runoff, groundwater baseflow and atmospheric release and deposition. Based on USDA and related research, estimated nitrogen loading from the applied fertilizer comprised of the dry chicken litter could potentially exceed the total nitrogen loading of the entire Neuse River Compliance Association membership of 22 facilities that discharged over 100 mgd of wastewater in 2010. Finally, pathogens from poultry waste can be transmitted from animals to humans via runoff from manured surfaces and groundwater percolation. With more and larger poultry operations confined to smaller areas of land, the likelihood of water contamination increases.

Two studies over the last decade by the USDA and NCSU have reported excess nitrogen and phosphorus in both Nash and Wilson counties (i.e., the amount of manure being generated in each County exceeds the production farming capacity to assimilate the nutrients). Agricultural land in general has higher concentrations of nutrients in stormwater runoff than most other land uses. At this time, 55 percent of the land in the Toisnot watershed is either cropland or pastureland, and 37 percent in the Buckhorn watershed is agriculture. Current information suggests that even with existing levels of agricultural activity in its water supply watersheds, Wilson's water supply is periodically challenged by the eutrophic condition of its reservoirs. Additional PPW, poultry farms, and poultry litter in the watershed risk exacerbating the eutrophication problems, as well as increasing risk of buildup and washoff of copper, zinc arsenic, pharmaceuticals, and pathogens contained in the litter.

At this time, state and federal regulations and management programs are not in place to mitigate these multiple risks. There are no phosphorus limits in the effluent guidelines for the Meat and Poultry Processing industry, and nitrogen limitations allow for effluent concentrations ranging between 134 and 194 mg/L. There are no individually issued NPDES permitted facilities in North Carolina under the federal Confined Animal Feeding Operation (CAFO) regulations for dry litter poultry operations, and DWQ has documented substantial concerns about the lack of knowledge and management of poultry operations. Although Best Management Practices (BMPs) exist that can be used to help mitigate risks, research has shown that high runoff of nitrogen and phosphorus can occur even on well-managed fields.

The primary objective of drinking water source protection is to reduce the vulnerability of the source to contamination and public health risk. The Source Water Collaborative, an association of USEPA and 17 other national organizations with an interest in safe drinking water, lists the following goals for source water protection (USEPA, 2011b):

- Contain or prevent contamination.
- Promote development patterns that limit threats to drinking water sources.
- Encourage matching uses of land with locations least likely to affect drinking water sources.
- Preserve the land needed to protect the quality of current and future sources of drinking water.

Given the preponderance of increased risks to water quality associated with the proposed poultry processing plant and associated poultry farms, the lack of adequate regulation for poultry farming operations, and the existing water quality conditions that already pose operational challenges and concerns for the City of Wilson's drinking water supply, Tetra Tech concludes that Nash County's proposed large poultry processing facility would be contrary to regulation and protection of the water supply at Buckhorn Reservoir and the other water supply reservoirs for the City.

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