IMPACT OF POULTRY MORTALITY PITS ON FARM GROUNDWATER QUALITY

Lee M. Myers[1], Parshall B. Bush[2], W. I. Segars[3], and David E. Radcliffe[4]

AUTHORS: [1]State Veterinarian, Assistant Commissioner of Animal Industry, Georgia Department of Agriculture, Capitol Square, Atlanta, Georgia 30334-4201; [2]Extension Pesticide Residue Chemist, The University of Georgia Cooperative Extension Service, Athens, Georgia 30602; [3]Professor, Extension Water Quality Coordinator, The University of Georgia Cooperative Extension Service, Athens, Georgia 30602; and [4]Professor, CAES Department of Crop and Soil Sciences, The University of Georgia, Athens, Georgia 30602.
REFERENCE: Proceedings of the 1999 Georgia Water Resources Conference, held March 30-31, 1999 at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. Results of a 15-county survey revealed that intensive animal agriculture may impact shallow groundwater resources. Objectives of this study are to assess water quality on poultry farms and determine if there is a relationship between waste disposal practices and groundwater quality. Twenty poultry farms representing concentrated areas of commercial poultry production and four major soil provinces were evaluated using site assessments, questionnaires, electromagnetic (EM) survey readings, and chemical and microbiological analysis of domestic well water. Based upon the EM survey results, five farms were instrumented with lysimeters and test wells to determine possible nutrient and microbiological movement to groundwater. Site evaluations revealed that 10 of the 47 (21%) domestic wells did not have appropriate well head protection to prevent surface water contamination. Five of the 47 (11%) wells were located downslope and/or within 100 ft of a nitrogen source other than pits and averaged nitrate-N (NO_3-N) levels above background (3 ppm). Thirty-eight percent had elevated coliform levels and 10.6% contained *Salmonella* in at least one sample during the sampling period. EM surveys and monitoring data indicated that nutrients migrate less than 100 ft laterally downgradient from the pits. Poultry mortality pits on the 20 farms did not appear to elevate nitrate levels above background. Groundwater nitrate-N levels were higher on farms containing uncovered litter stacks. Preliminary results indicate that uncovered litter stacks may have a greater impact on groundwater quality than poultry mortality pits. Additional testing on various soil types is needed.

INTRODUCTION

Poultry production is Georgia's number one agricultural commodity and supports over 4,000 producers statewide. Results of a 15-county survey conducted by the University of Georgia Extension Service in 1994 revealed that intensive confined-animal agriculture may have an adverse impact on shallow groundwater resources (Bush *et al*, 1996 and 1997). Confined livestock, such as swine, dairy, and poultry, may cause elevated nitrate-N levels in the farm's groundwater. In the study, 7.5% of the farms producing only livestock or poultry had wells that exceeded 10 ppm nitrate-N. The U. S. Environmental Protection Agency has established 10 ppm of nitrate-N as the Maximum Contaminant Level (MCL) for the National Primary Drinking Water Standard in public drinking water supplies. The specific source of this nitrate-N rise in farm wells was not determined. There is, therefore, a need to pinpoint sources of nitrate-N and encouraging responsible farm waste and nutrient management plans.

Soil type and hydrogeology influence soil percolation rates and vulnerability of groundwater to nutrient contamination. Seven aquifer systems supply Georgia with an abundance of groundwater. Aquifer recharge areas and shallow groundwater (bored wells <100 ft) are the most vulnerable to nutrient contamination. Contamination of shallow wells usually reflects on-farm activities, while deep well (>100 ft) contamination represents activities in recharge zones that may be miles offsite. Deep aquifers in the Coastal Plain are usually protected by one or more confining layers.

Disposal of dead poultry on the farm during grow-out is a potential problem. Disposal methods include disposal pits, incineration, composting and "in-vessel" composting. Mortality pits are the most common method of poultry carcass disposal, but questions have been raised about potential groundwater contamination. Previous studies have shown elevated groundwater ammonia and nitrate levels near pits (Ritter and Chirnside, 1995; Hatzell, 1995). The impact of mortality pits on shallow groundwater has not been investigated in Georgia; there is no documentation whether pits cause a problem for local groundwater quality. According to the Georgia Department of Natural Resources, the Georgia Department of Agriculture and the University of Georgia Cooperative Extension Service, circumstantial evidence indicates that burial pits are not a source of contaminants for domestic wells or surface water. No formal studies have addressed this potential problem in Georgia.

A cooperative study involving the Georgia Department of Agriculture and the University of Georgia College of Agricultural and Environmental Sciences was initiated in the spring of 1998 to examine the impact of poultry mortality pits on farm groundwater. This study's objectives were to 1) assess water quality on participating poultry farms, 2) relate any groundwater contamination to poultry disposal pits or other specific on-farm waste disposal practices and 3) determine the necessity for alternative methods of poultry mortality disposal and environmental management practices.

MATERIALS AND METHODS

Twenty poultry farms representing concentrated areas of poultry production and four major soil provinces were evaluated using site assessments, questionnaires, electromagnetic (EM) surveys and analysis of domestic well water. Jackson County, located in the Piedmont area of northeast Georgia, contains Cecil soils. Coffee, Marion, and Mitchell Counties have deep, porous, sandy soils of the Dothan, Goldsboro and Norfolk series, respectively. Based on EM survey results, five farms were instrumented with test wells to determine possible nutrient and microbiological movement to groundwater. Data were collected from April through October, 1998. Soils at all locations were near saturation from January through March. Rainfall for the period April through October, 1998 was significantly below normal at all sites.

Poultry farm characteristics - questionnaires

A questionnaire was developed to gain information about on-farm domestic wells and poultry production practices, including poultry and litter disposal. Questions addressed the type of wells installed, the age, depth, and distance to the nearest disposal pit from the well, the grade and slope from the well to the pit, and the protection of the well head. The age and construction of the pits, annual bird mortality, litter disposal practices, and additional nitrate sources were also identified.

Electromagnetic survey

The relationship of the poultry mortality pits, suspected local groundwater flow, and proximity to domestic wells was assessed to find the best sites on each farm for analysis via EM conductivity surveys. Each site was surveyed with an EM 34-L3 and an EM 31-MK2 conductivity meter (Geonics Ltd., Mississisauga, Ont.). Conductivity is a function of pore water conductivity, degree of saturation, porosity, magnetic permeability, cation exchange capacity (CEC) of soil and geologic material in the measurement zone. A fixed distance of 12 ft separates the EM 31 coils, whereas, the distance between coils of the EM 34 is variable. All EM 31 measurements were taken in vertical dipole orientation, where the meter is most sensitive to conductivities at a depth of 5 ft. EM 34 measurements were taken in the vertical and horizontal dipole orientation with a 32.5 ft spacing, which measured shallow (sensitivity greatest between 0 and 6 ft) and deep (sensitivity greatest at 15 ft depth) conductivity.

An EM survey was made on a grid pattern surrounding the mortality pits. Each grid section was marked using surveyor flags in 15 ft squares and EM readings were recorded at each grid intersection. The readings over the pit areas were compared with an average background reading on the farm. Contour plots of the EM readings in mS m^{-1} were drawn using the SURFER computer program (Golden Software, Inc., Golden, CO) with a kriging interpolation scheme. The contour maps were evaluated to determine the placement of subsequent lysimeters and test wells. The EM data identified the terrain conductivity and determined possible plumes of solutes from the poultry mortality pits.

Water quality monitoring

All operational domestic wells were identified, and samples from each were collected monthly for the chemical and microbiological parameters listed in Table 1. Seventeen test wells were installed on five farms at a depth of 10 to 15 ft with a 5 ft slotted screen at the bottom. A diagram was constructed for each of the five farm sites using a SURFER mapping program.

Table 1. Chemical and microbiological analytical detection limits and target[1] levels for well water sample analysis

Parameter	Detection Limit	Target Level	Analytical Method
NH_4	0.30 ppm	0.50 ppm	Standard Method 4500
NO_3-N[2]	0.20 ppm	3.00 ppm	AOAC Method 892.01
P	0.05 ppm	0.10 ppm	IPC EPA Method 200.7
Total bacteria count	1 colony/mL	500 colonies/mL	FDA Bacteriological Analytical Manual
Lactose pos coliforms	1 colony/mL	1 colony/mL	FDA Bacteriological Analytical Manual
Salmonella	1 colony/mL	positive culture	FDA Bacteriological Analytical Manual

[1]Quantities greater than target are considered to be evidence of artificial introduction of contaminants.

[2]Nitrate levels <3 ppm are considered background by USGS and >10 ppm is above the drinking water standard.

RESULTS

Domestic well water samples from 20 participating farms were collected monthly from April to October, 1998 and evaluated for parameters presented in Table 1. Nitrate levels (Table 2) ranged from 12 ppm in Jackson County to non-detectable in Coffee and Marion Counties, reflecting at least three differences: 1) depth of water source, 2) age and density of the county poultry industry, 3) surface water contamination. Most Jackson County wells are bored and draw water from a near-surface saturation zone, vulnerable to nutrient leaching. Coffee, Marion and Mitchell County wells are usually deep (>100 ft), protected by one or more confining layers. The Jackson County well with >10 ppm nitrate-N was bored (<100 feet deep), improperly sealed, and downgradient of a poultry house. Wells upgradient of the poultry house contained 4.1-5.1 ppm nitrate-N. The other Jackson County well approaching 10 ppm nitrate-N was bored and downgradient of an old poultry house. All three wells with >3 ppm nitrate-N in Mitchell County were located on one farm. Wells QA and QB are near litter application areas and old litter stack storage. The house well (QC), containing 6.5 ppm nitrate-N, is across the road from the poultry farm and located ~100 ft from an open-bottom septic tank, a possible N source.

Phosphorus is considered a non-leachable element and, thus, an indicator of possible surface water well contamination. Phosphorus monitoring showed that spring and fall samplings are subject to surface water contamination. Incidences of P in the October sampling in Mitchell, Marion and Coffee Counties reflect heavy rainfall in September, 1998, which produced >10 inches in 24 to 48-hours. October samples contained a high incidence of P (>0.1 ppm P), along with relatively high total bacterial counts (9.9 x 10^4). The relatively high incidence of P in the spring Jackson County sampling reflects the near-surface water recharge of bored wells (<100 ft deep).

Total coliform bacteria is an indicator of surface or septic bacterial contamination. Well samples from Mitchell and Coffee Counties were relatively free of coliform contamination. Incidences of coliform bacteria contamination in Jackson County occurred primarily during spring and fall recharge, when surface water may have entered poorly sealed shallow wells. Water samples collected in Marion County in June and October, 1998 contained coliform bacteria and P, but may have been contaminated in sample collection or handling. All well water samples were screened for *Salmonella*. Five samples collected August 27, 1998 from on-farm domestic wells (Wells HA-6, JA-6, NA-6, SB-6 and IA-6) were positive for *Salmonella*. All other well water samples were *Salmonella*-free.

Table 2. Test results on farm domestic wells. Samples were collected monthly from April to October, 1998. Values are # of positive samples out of total # of wells tested (one positive out of 7 monthly samples is recorded as a positive.)

County	# Wells	Nitrate-N[1] (ppm)			Coliform[2]	P[3]		
		#<3	# 3-10	# >10	+ Wells	April	May/Sept	Oct
Coffee	8	8	0	2	0	0	0	4
Jackson	10	4	5	1	7	0	0	0
Marion	18	18	0	0	10	2	12	9
Mitchell	11	8	3	0	1	8	0	6

[1] Due to sampling difficulties, N results are for the 3-month period Aug.-Oct., 1998.
[2] + indicates at least 1 colony/mL during at least 1 or more of the 7 sampling periods.
[3] Number of samples containing detectable P levels. April and October represent one sampling period each, while May/September is a summation of 5 sampling dates.

In general, the EM survey showed elevated conductivities directly over mortality pits. This could have been due to high soluble salts or water content in the pits. The interrupted soil structure and pits themselves may have increased permeability and soil moisture. At 16 sites, there was no evidence that conductivities downslope of the pits were higher than conductivities upslope of the pits, indicating the absence of a detectable high-salt plume. At Farm F in Coffee County , there was an area of elevated shallow (EM 31) conductivities downslope of a pit (Fig. 1) and an area of very high shallow conductivities downslope of an uncovered manure stack (Fig. 1). Similarly, at Farm J in Coffee County, there was an area of elevated EM 31 conductivities downslope of the pit area and an area of higher conductivities downslope of an uncovered manure stack (data not presented). In Mitchell County on Farm R, EM 31 conductivities were elevated downslope of the pit and upslope near where an uncovered litter stack had been located (Fig. 2). At Farm E in Jackson County, (Fig. 3) there was an area downslope (surface gradient) of the pits where deep conductivities (measured with the EM 34 in vertical dipole orientation) were elevated. None of the EM transects indicate nutrient movement more than 50 lateral ft downgradient. Soil variability could cause changes in EM conductivities; a detailed soil map at each site was not developed. It is unlikely that soil variability would cause changes as large as those seen near the manure stacks.

In general, nitrate levels in monitoring wells on farms with uncovered manure stacks were above the 10 ppm nitrate-N drinking water standard (Farms F and J, Coffee County, Table 3). Farms in Mitchell and Jackson Counties which had only burial pits contained nitrate-N levels <3.0 ppm, considered background level by the USGS (Table 3). The 4.27 ppm nitrate-N in Jackson County probably resulted from litter application to the fescue pasture. The Marion County down-gradient monitoring well contained 20.6 ppm nitrate-N. Due to the 1998 drought, up and lateral gradient wells were dry, so there are no upgradient monitoring well data for comparison. The source of nitrate may be the pit or

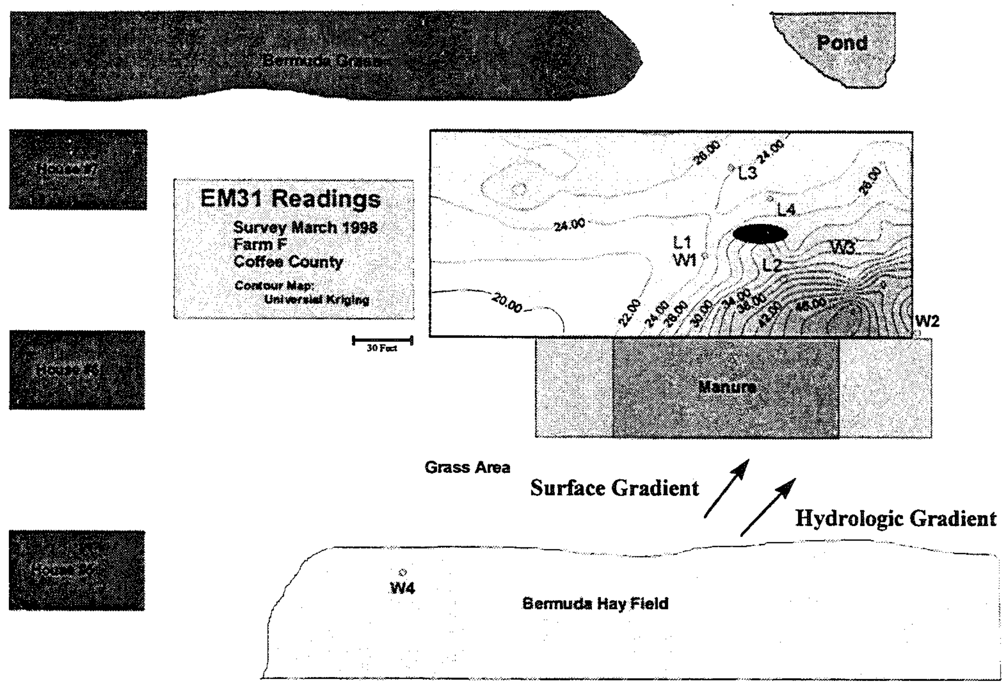

Figure 1. Diagrammatic representation of Coffee Co. Farm F drawn to scale. Three chicken houses are surrounded by Bermuda grass fields. Area designated manure is an uncovered litter clean-out stack. Hydrologic gradient was calculated using groundwater elevations from wells W2, W3 and W4, Jan. 6, 1999. Legend: Monitoring wells = W1, W2, W3, W4; Burial pit = Pit; Lysimeters = L1, L2, L3, L4.

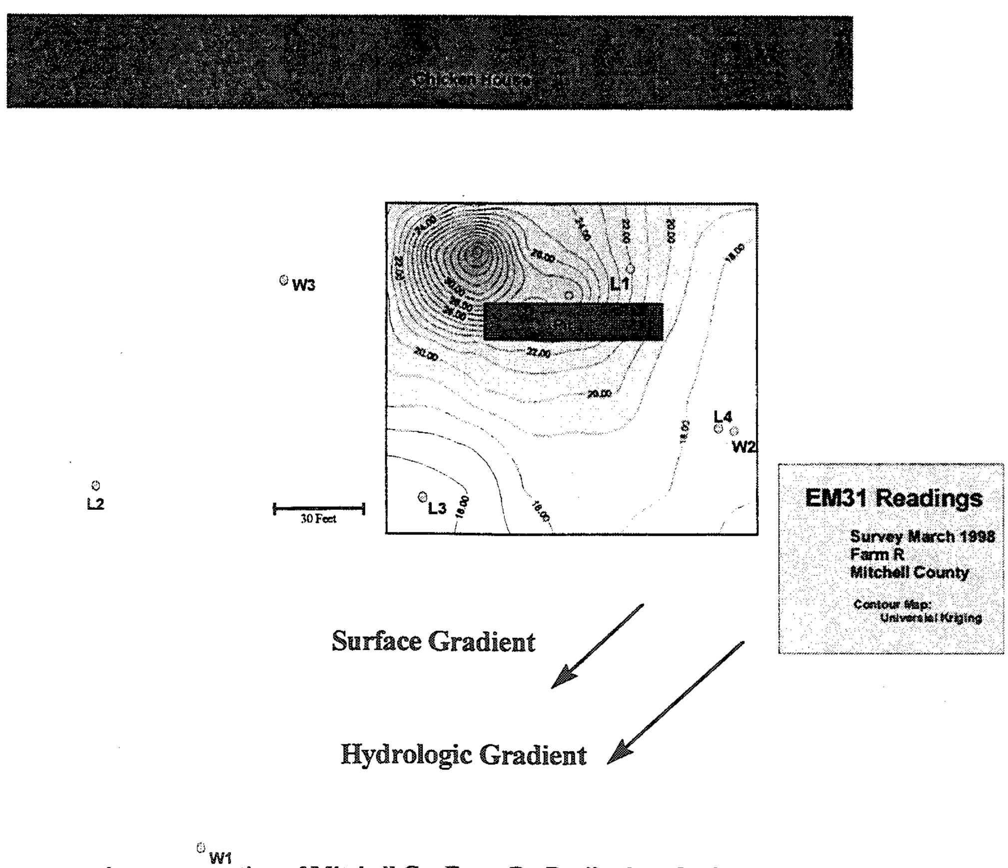

Figure 2. Diagrammatic representation of Mitchell Co. Farm R. Broiler breeder houses are surrounded by grass area. Litter was stored (2 weeks) adjacent to the chicken house during a previous clean-out. Hydrologic gradient was calculated using groundwater elevations from wells W1, W2 and W3, Jan. 6, 1999. Legend: Monitoring wells = W1, W2, W3; Burial pit = Pit; Lysimeters = L1, L2, L3 and L4.

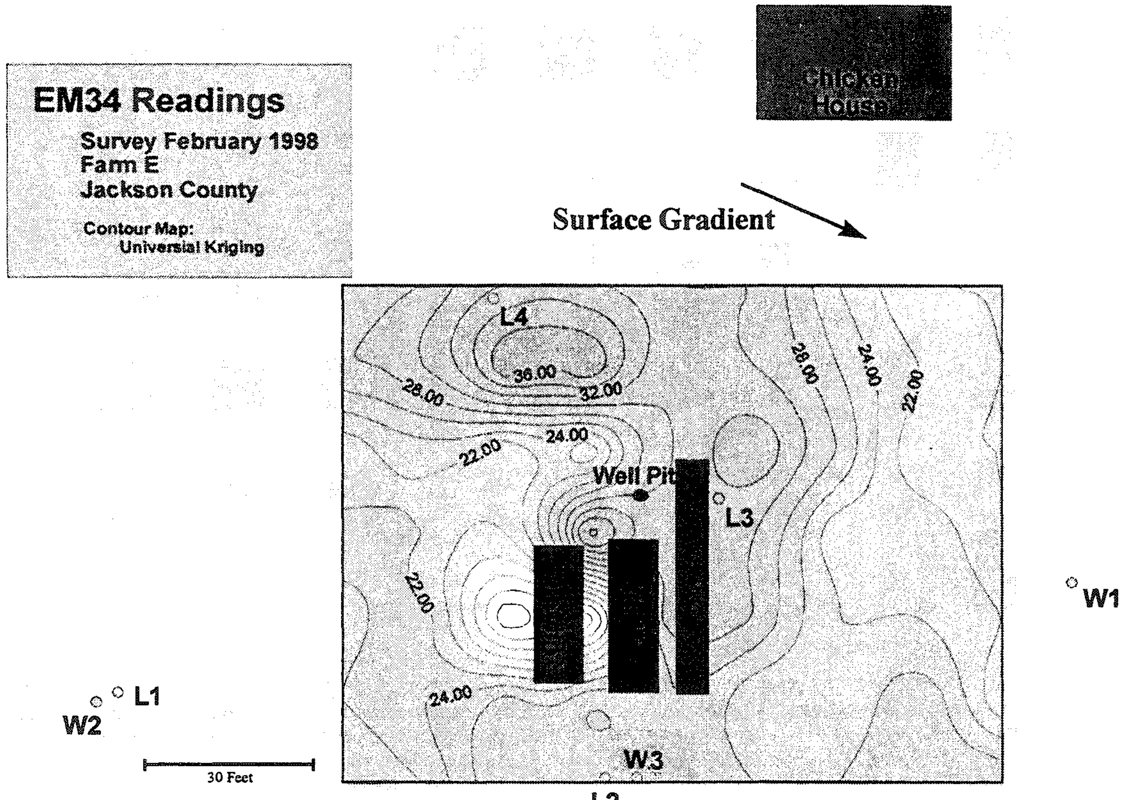

Figure 3: Diagrammatic representation of Jackson Co. Farm drawn to scale. One broiler grow-out house is surrounded by fescue pasture where litter has been applied. Hydrologic gradient has not been calculated due to dry upgradient well. Legend: Monitoring wells = W1, W2 and W3; Burial pit = Pit; Lysimeters = L1, L2, L3 and L4.

Table 4: Results of Microbiological Evaluation of Monitoring Well Samples for Pit Study

Gradient Position	Farm F Coffee Co. [1]					Farm R Mitchell Co. [2]			Farm E Jackson Co.[3]				
	Date (1998)					Date (1998)			Date (1998)				
	6/2	6/24	8/12	8/27	10/8	8/6	8/27	10/8	5/14	7/8	8/4	8/27	10/8
Coliform Bacteria													
Downgradient	*	*	*	*	*	*	+20	*	*	*	*	*	*
Upgradient	NS	NS	NS	*	*	NS	NS	*	NS	NS	*	*	*
Mid/lateral gradient	*	*	*	*	*	NS	NS	NS	NS	NS	*	*	*
Downgradient of litter stack	+	*	*	*	*								
Salmonella													
Downgradient	*	*	*	*	*	*	*	*	+	*	*	+	*
Upgradient	NS	NS	NS	*	*	NS	NS	*	NS	NS	*	*	*
Mid/lateral gradient	*	*	*	*	*	NS	NS	NS	NS	NS	*	*	*
Downgradient of litter stack	*	*	*	*	*								
Total Bacteria (colony forming units/mL)													
Downgradient	2,000	99,000	10,000	44,000	8,000	990,000	83,000	99,000	71,000,000	990,000	15,000	4,600	0
Upgradient	NS	NS	NS	99,000	99,000	NS	NS	99,000	NS	NS	0	0	0
Mid/lateral gradient	5,000	99,000	22,000	990,000	99,000	NS	NS	NS	NS	NS	990,000	99,000	18,000
Downgradient of litter stack	5,000	99,000	4,000	15,000	8,100								

[1]See Figure 1 for well location ; [2]See Figure 2 for well location ;[3]See Figure 3 for well location ; * = Negative result, NS = No sample

heavy application of litter to the adjoining pasture.

Since previous studies indicated the presence of ammonia in groundwater adjacent to poultry mortality pits (Ritter and Chirnside, 1995), ammonia-N levels were determined in monitoring wells. Only the monitoring well directly downgradient of the manure stack at the Coffee County Farm F contained 0.78 ppm ammonia-N. All other wells contained <0.2 ppm ammonia-N.

With increased concern about potential P mobility in surface water and to test for surface water contamination of lysimeters and test wells, P levels were determined. With three exceptions, no lysimeters or test wells had an average P above target level (>0.10 ppm). The Jackson County downgradient well (EL3) averaged 0.10 ppm P. The Coffee County well (FTW2) directly downgradient of the uncovered manure stack contained an average value of 0.24 ppm P. The Mitchell County downgradient well (RL3) contained an average P of 0.14 ppm.

Little or no coliform or *Salmonella* was detected in test well samples (Table 4). The only three *Salmonella*-positive samples (positive culture) were collected in Jackson County, one each in an upgradient (EL1), midgradient (EL2) and downgradient (ETW1) well. Since the lysimeters and test wells were all within 100 ft of the poultry mortality pits, coliform and *Salmonella* bacteria do not appear to move with the near-surface groundwater flow. The total bacterial counts were consistently high (>1000 colony forming units/mL) in all lysimeters and test wells.

CONCLUSIONS

1. Uncovered litter stacks cause elevated nitrate and P levels in near-surface groundwater. Litter should be stacked on an impervious surface and covered.
2. Poultry mortality pits on the five test farms did not elevate nitrate-N above 3 ppm or P levels above background.

Table 3. Nitrate-N Levels in Monitoring Wells Installed on Poultry Farms Surrounding Poultry Mortality Pits[1]

Well Position	Coffee Co. [2]		Mitchell Co.	Jackson Co.[3]	Marion Co.[3]
	Farm F	Farm J	Farm R	Farm E	Farm M
upgradient	4.99 ppm	39.7 ppm	<0.2 ppm	NS[4]	NS
mid/lateral	22.8	14.9	<0.2	4.27 ppm	NS
downgradient	38.4	2.0	0.56	0.48	20.6

[1]Monitoring well depth is 10-15 ft (screened at lower 5 ft)
[2]Coffee county farms are complicated by having uncovered litter storage stacks. Values are average of at least 5 monthly samples collected in the fall of 1998.
[3]Due to dry weather the upgradient wells in Marion and Jackson counties were dry.
[4]No sample due to dry weather

3. Coliform and *Salmonella* did not move laterally more than 100 ft in near-surface groundwater flow.
4. Sites for future pits should be located >100 ft and downgradient of domestic wells.
5. This preliminary data suggests that if pits are constructed in accordance with Georgia Department of Agriculture standard construction and maintenance policies, alternate methods of disposal of dead birds would not be required to protect domestic well water. Additional data is required to determine potential contamination from pits located on various soil types.

ACKNOWLEDGMENTS

The authors thank David Brussat, John Peacock, L.C. Pruitt and the Georgia Department of Agriculture inspectors for sampling assistance and coordination.

LITERATURE CITED

Bush, P. B., R. N. Hitchcock, W. C. Johnson, R.G. Perkins, W.I. Segars and A.W. Tyson, 1996. Georgia domestic well water testing results for 1995. University of Georgia Cooperative Extension Service Agricultural Services Laboratory, Athens, GA.

Bush, P.B., A.W. Tyson, R. Perkins and W.I. Segars, 1997. Results of Georgia domestic well water testing program. Proc. of University of Georgia Water Resources Conference. March 20-22, 1997.

Hatzell, H.H., 1995. *Effects of Waste-Disposal Practices on Ground-Water Quality at Five Poultry (Broiler) Farms in North-Central Florida, 1992-93.* U.S. Geological Survey Water-Resources Investigations Report 95-4064.

ICP EPA Method 200.7 *Methods for the Determination of Metals in Environmental Samples - Supplement I. EPA/600-R-94-111, May 1994.* Published by ORD Publications, U.S. Environmental Protection Agency, 26 W. Martin Luther King Dr., Cincinnati, OH 45268.

Modification of Method 892.01. *Official Methods of Analysis of AOAC International, 16th Edition, Vol. 1, 1996.* Edited by Patricia Cunniff, published by AOAC International, Suite 500, 481 North Frederick Ave., Gaithersburg, MD 20877-2417.

Ritter, W.F. and A.E.M. Chirnside, 1995. *Impact of Dead Bird Disposal Pits on Ground-Water Quality on the Delmarva Peninsula.* Bioresource Technology 53.

Standard Method 4500-NH4. *Standard Methods for the Examination of Water and Wastewater, 19th Edition, 1995.* Prepared and published jointly by American Public Health Association, American Water Works Association, and Water Environment Federation.

U.S. Food and Drug Administration. *Bacteriological Analytical Manual, 8th Ed., Revision A, 1998.* AOAC International, Gaithersburg, MD.