Title: **Effect of Barnyard Management Practices on Groundwater Quality in the Central Sands of Wisconsin**

Project I.D.: DNR Project No. 9

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Period of Contract: July 30, 1985 to June 30 1991

Background/Need: The Central Sands region of Wisconsin has highly permeable soils and shallow depths to groundwater. Consequently, the area is highly vulnerable to groundwater contamination. Cattle barnyards have been suspected as a potential source of nitrate groundwater contamination due to significant increases in number of cattle per farm and per acre manure production. Contamination of local water supplies is a concern.

Objectives: To determine the extent of groundwater impact by barnyards, and the effectiveness of state-of-the-art manure storage and handling systems.

Methods: Soils from five barnyard were sampled seven times between May and September of 1986, and analyzed for organic carbon (OC), Kjeldahl-N, NH_4-N, $N0_3$-N + $N0_2$-N and water content. Sampling sites included a range of barnyard management conditions. Groundwater elevation determinations were made throughout the study period. Multilevel monitoring wells were installed upgradient and downgradient of the barnyards. Water samples were taken monthly, and biweekly during spring snow melt and fall wet periods. Analysis of samples included $N0_3$-N, NH_4, N, K^+, Cl^-, and electrical conductivity. Sampling continued from 1985 to present. Manure management included reducing the size and paving the barnyards and providing solid and liquid manure storage facilities.

Results and Discussion: Three of the five barnyards had considerable quantities of accumulated organic nitrogen and OC in the upper foot of soil. Lower animal density and manure removal accounted for less OC in the remaining two sites. Field moisture capacities varied with the quantity of OC. Soil compaction was present at all sites and increased with animal density. Contaminant plumes containing elevated concentrations of nitrate, potassium, chloride and reactive phosphorous were found in downgradient groundwater samples. Groundwater quality varied widely. Variability in downgradient water quality indicated point sources of contamination. Subsurface nitrate occurred in highest concentrations with well-drained surfaces and insufficient surface seals. Aerated, permeable soil conditions contributed significantly to groundwater contamination, even in areas of limited usage. Soil type, depth to groundwater, animal density and barnyard management also influenced the impact barnyards had on groundwater quality. At densities greater than one animal per 80 m^2 there was sufficient hoof compaction to prevent infiltration. Compaction, however, increased the amount of runoff to adjacent fence lines and nearby depressions where leaching to groundwater could occur. Lower animal densities may not result in decreased infiltration, and may cause greater leaching than higher densities. Sites with more than 300 m^2 per animal resulted in higher nitrate concentrations than sites with higher animal densities. This density was high enough to overload soils with nitrogen, yet did not permit adequate hoof compaction to prevent leaching. Regular scraping to reduce manure buildup did not prevent nitrate leaching because hoof compaction did not develop. Groundwater nitrate levels increased where barnyards were reduced in size and paved with concrete and manure storage

was implemented. The abandoned barnyards lost the hoof compacted layer quickly and began to leach very high amounts of nitrogen. It is not clear how long it takes to deplete leachable nitrogen stored in the barnyard residual, but it is evident that abandoned barnyards should have at least the upper 0.3 m of manure/soil removed to prevent nitrate leaching. Downgradient wells manifested high concentrations of K in the wells receiving leachate from animal waste. Potassium is found in higher concentrations than other mineral elements in manure and appears to move similarly to NH_4N in sandy soils. Potassium may be useful as a tracer to determine the extent of groundwater impacted by animal waste.

Conclusions/Implications/Recommendations: In barnyards where manure remains in place, hoof compacted soil forms a seal which limits direct chemical leaching, though runoff and infiltration do occur at fence lines and field depressions receiving runoff. Organic nitrogen and ammonium buildup poses a potential nitrate problem upon abandonment through drying of the soil leading to aeration, nitrification and leaching. Low use yards and those with regular manure removal lack an effective barrier to nitrification, infiltration, and subsequent leaching. An effective surface seal and containment of runoff may eliminate much of the groundwater contamination associated with confined cattle facilities. Clean water diversions, including rain gutters plus sealed, curbed barnyard perimeters with runoff collection, and elimination of undersized or oversized exercise lots may decrease groundwater nitrate contamination. A concrete curbed surface with manure removal, runoff containment and land spreading of waste at appropriate rates would provide the most contaminant prevention. It does not appear that the same manure management scheme that works for one barnyard will necessarily work for another. Many factors, including economics, local soil type, local groundwater characteristics, animal density, and annual precipitation need to be considered. Further study is suggested in the following areas: 1) To monitor and analyze denitrification indicators which could follow dynamics of nitrogen in groundwater; 2) To assess impacts of runoff to uncompacted soil areas along barnyard edges and fence lines; 3) To use potassium as a soil parameter to measure the degree of manure loading a soil profile has received from the presence of a barnyard; and 4) To define an animal density where nitrate leaching would not be a concern to groundwater.

Related Publications:

Bowen, Bryan Daniel, 1987. Potential for Nitrogen Groundwater Contamination from Animal Confinement Areas in Central Wisconsin. Unpubl. M.S. Thesis, UW-Stevens Point, Stevens Point, Wisc., 170 pp.

Travis, Michael J., 1988. Nitrogen Contamination of Groundwater from Barnyards in the Central Sand Plain Aquifer of Wisconsin. Unpubl. M.S. Thesis, UW-Stevens Point, Stevens Point, Wisc., 127 pp.

Key Words: Ammonium-nitrogen, barnyard runoff, Central Sands, nitrate, organic carbon, potassium

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Project Report: A report on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706.