Illinois Stewardship Alliance
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STATE OF ILLINOIS
Pollution Control Board

April 23, 2001

Ms. Dorothy M. Gunn, Clerk
Pollution Control Board
100 West Randolph, Suite 11-500
James R. Thompson Center
Chicago, IL 60601

Re: Livestock Waste Regulations
35 Ill. Adm. Code 506
R01-28 (Rulemaking-Land)

Dear Ms. Gunn:

Enclosed with the letter please find and original and nine (9) copies of the following documents for the above stated rulemaking:

Notice of Filing
Testimony of the Illinois Stewardship Alliance
Service list

If you have any questions or concerns, please do not hesitate to call me at 217-498-9707. Thank you for your assistance in this matter.

Sincerely,

Pam Hansen
Industrial Agriculture Coordinator
Illinois Stewardship Alliance

Enclosures

RECEIVED
CLERK'S OFFICE

APR 25 2001

STATE OF ILLINOIS
Pollution Control Board

ILLINOIS POLLUTION CONTROL BOARD

IN THE MATTER OF;)
)
AMENDMENTS TO LIVESTOCK)
WASTE REGULATIONS) R01-28
(35 ILL ADM.CODE 506) (RULEMAKING-LAND)

TESTIMONY REGARDING AMENDMENTS TO THE LIVESTOCK WASTE REGULATIONS

My name is Pam Hansen and I am employed by the Illinois Stewardship Alliance where I am the Industrial Agriculture Coordinator. As such, I work with rural residents and farmers in their concerns about the seeming invasion of industrial sized livestock operations. While most agree that farms are increasing in size, their concerns stem from the degradation in their quality of life and the potential health impacts and contamination of their air and groundwater. Our members are farmers, rural residents and urban citizens who all share a concern for the production of safe, healthy food in a manner that is sustainable for the environment.

When the first set of rules for the Livestock Management Facilities Act was being promulgated, the Alliance brought before you some of these farmers and rural residents to share their concerns. Being in the midst of planting season, we regret we are unable to bring these people back to you. Rest assured their concerns have not changed. It is their views I represent today.

The proposed 506 rule covering enhanced construction standards for large-scale animal feeding operations appears to be a step forward in the protection of environmental quality in the State of Illinois. Members of the Livestock Advisory Committee and stakeholder groups, including the Illinois Stewardship Alliance, worked tirelessly to ensure the rules were both protective and fair.

The Board, in questions submitted at it's first hearing in Chicago April 2, 2001, inquired of the Department whether they were aware of any environmental problems associated with livestock waste handling facilities located in karst areas. The Department has answered they were unaware of any such problems and specifically referred to known facilities in Illinois. It should be noted that other states in the Midwest have been experiencing problems with lagoons in karst areas. Minnesota, for example, published draft guidance documents concerning the siting of lagoons in karst areas after the collapses of several municipal waste lagoons located in karst. While the size of those lagoons were much larger than their average manure lagoon, they do note that the contaminant concentrations of manure lagoons is often 100 times that of a municipal waste lagoon and would pose greater environmental consequences in the event of a collapse.

In Kentucky, an estimated 1. 5 million gallons of manure drained into a karst aquifer. The lagoon had a synthetic liner across the bottom and 4 feet up the sides, however the collapse occurred along the side and above the liner which quickly expanded to drain the entire lagoon. Illinois' construction standards are more stringent requiring that lagoon structures constructed in karst be of concrete or rigid materials. We feel that to provide protection, a portion of this concrete or rigid material should extend above grade to allow for inspection of cracks or other potential subsurface problems. The Kentucky report also recommends that during a karst investigation a dye trace should be performed to identify the receiving spring or springs in the event of a leak. The spring(s) should then be tested periodically for groundwater contamination associated with the livestock waste. The draft guidance for Minnesota and the report of the manure lagoon collapse in Kentucky are attached.

In addition facilities, constructed prior to the July 1999 amendment to the Livestock Management Facilities Act requiring a site investigation for the presence of karst material, should be identified and monitored for potential problems. Utilizing the IDNR-ISGS map 8 as referenced in Section 506.202, large-scale facilities located in known areas of karst should be identified along with the potential receiving spring(s) or waters and those waters tested routinely for the presence or increase in presence of contaminants associated with livestock manure. The purpose here is not to identify and indict but to prevent possible catastrophic contamination of groundwater. In the previous information submitted from Kentucky and Minnesota, some lagoons had existed for 18 years before a breech occurred.

An experience at a dairy facility recently pointed out the need for rulemaking in an area that has not been addressed. In attempts to make sure that administrative rules and construction standards are protective of the environment and fair to the producer regarding new facilities and new construction, existing large-scale facilities that may be in need of upgrades have been ignored. There may be large facilities that are not subject to inspections because they predate the 1996 Livestock Management Facilities Act or the most current amendments, and are potentially way behind the current standards for livestock operations. Rules should contain some minimum standards for identifying existing facilities in order to prevent pollution. For example, requirements making sure lagoons have visual markers for liquid levels, making sure there is adequate freeboard of 2 feet 6 inches and adequate diversion of storm water along with secondary containment in the event of a breech. All facilities should also have and maintain a waste management plan regardless of age. Again our intent is not to identify and indict, but to prevent pollution.

Also missing are standards governing such items as emergency /temporary lagoons as recently approved for a large scale dairy in Elmwood Illinois. These two emergency, temporary lagoons were allowed for a period of 6 months to allow the owner/ operator to temporarily divert excess manure to avoid a repeat of illegal dumping. While that action is commendable, we question by what authority did the Department approve such facilities, and to what construction standards? As witnessed in television reports, these emergency storage facilities appear to be depressions in the land with plastic thrown on top .

While we are sure the Department of Agriculture did what it thought was best at the time in order to prevent further pollution, it points up the need for rules to govern such situations. It is short sighted to think that the situation in Elmwood will never be repeated Instead the Department and the IEPA as well as DNR and IDPH should work together to develop a set of standards/rules concerning these type of emergency situations

In conclusion the Alliance believes these rules are a step forward towards protecting Illinois' environment. Working around flaws in the statutory language, they appear to cover many of the requirements necessary to adequately site a proposed new facility. Thank you for the opportunity to comment and we look forward to implementation of final rules.

LEAKAGE AND SINKHOLE COLLAPSES UNDER HOG WASTE LAGOONS IN KENTUCKY

Nicholas C. Crawford, Ph.D.
Western Kentucky University

Surface ponding and concentration of water on the ground surface is the leading cause of sinkhole collapses in Kentucky (Figures 1 and 2, and Appendix 1). Farm ponds frequently collapse and drain into karst aquifers in a matter of a few hours. When hazardous waste is pumped into surface lagoons, the leakage can be very serious. Crawford performed a dye trace on the surface lagoon at the Rockwell Site in Russellville, Kentucky. Leakage from the lagoon into the groundwater was pumped into a storm sewer by a nearby sump pump. Groundwater contaminated with PCBs traveled through the storm sewer into a ditch that leads to Town Branch. PCBs were carried by Town Branch into the Mudd River. The fish tested in Mudd River and Town Branch had levels of PCBs as high as 300 ppm, the highest levels ever found in the United States. This problem has cost Rockwell approximately 40 million dollars to clean up the contaminated soils and groundwater under the site. They are now in the process of cleaning up soils along Town Branch for an estimated cost of 200 million dollars and a successful lawsuit against Rockwell resulted in an additional 200 million dollar expense.

Hog waste lagoons upon karst terrain appear to be at a very high risk of contaminating karst aquifers and surface streams downstream from springs. Figure 3 is a photograph taken in 1984 of a sinkhole collapse that occurred under a hog waste lagoon in southwest Barren County. Figure 4 is a sinkhole collapse of the, secondary lagoon located downstream for the primary lagoon that collapsed in April 1990. A dye trace performed after this collapse indicated that during both the 1984 and 1990 collapses, hog waste flowed into Mammoth Cave National Park to resurge at Turnhole spring on the Green River. In less than five hours 2.4 million gallons of hog waste flowed into the karst aquifer.

Figures 5, 6 and 7 are photographs of sinkhole collapse under a hog waste lagoon that occurred in Warren County on January 6, 1998. The estimated loss of settled hog waste was approximately 15,000 gallons. The Kentucky Division of Water recommended that a synthetic liner be placed under the lagoon. Figures 8, 9 and 10 are photographs of a sinkhole collapse under a hog waste lagoon that occurred in Logan County on April 29, 1991. The pond was 125 feet by 100 feet and 12.8 feet deep with hog waste when the collapse occurred. The entire pond drained quickly into the karst Aquifer for an estimated loss of 1,050,000 gallons of hog waste. This pond had a synthetic liner that extended across the bottom and 4 feet up the sides. The collapse occurred where the

LEAKAGE AND SINKHOLE COLLAPSES UNDER HOG WASTE LAGOONS IN KENTUCKY

August 5, 1998

Prepared For:

The Honorable Hank Graddy
103 Railroad Street
Midway, KY 40347

Prepared by:

Dr. Nicholas Crawford, Ph.D.
Center for Cave and Karst Studies
Department of Geography and Geology
Western Kentucky University
Bowling Green, KY 42101

FIGURE 3. Sinkhole collapse under hog waste lagoon in March 1984 on Barren County, Kentucky. Approximately 2.4 million gallons of hog waste sank into the karst aquifer in less than 5 hours. Impoundment of water and concentration of surface runoff are the leading causes of sinkhole collapses in the karst areas of Kentucky. Photograph by Kentucky Division of Water.

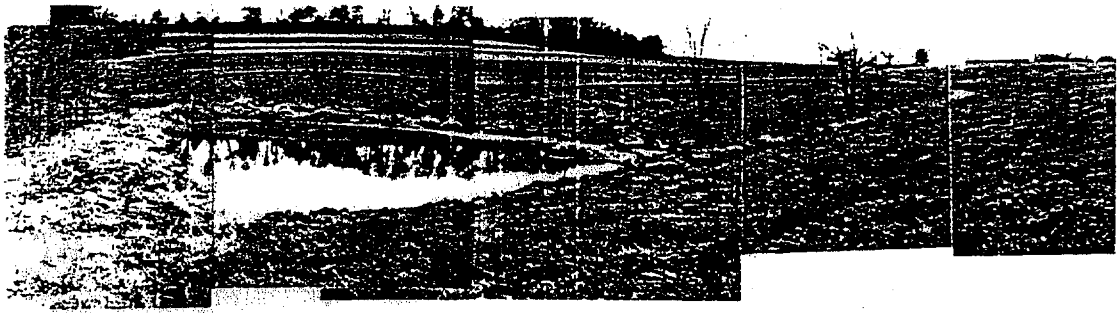

FIGURE 4. Sinkhole collapse in April 1990 of the secondary hog waste lagoon, located downslope from the primary lagoon that collapsed in March 1984 (Figure 3). A dye trace of this collapse indicated that hog waste flowed into mammoth Cave National Park to discharge at Turnhole Spring on the Green River during both collapses. Photograph by Kentucky Division of Water.

FIGURE 5. Sinkhole collapse under a hog waste lagoon in Warren County, Kentucky on January 6, 1998. Photo by Kentucky Division of Water.

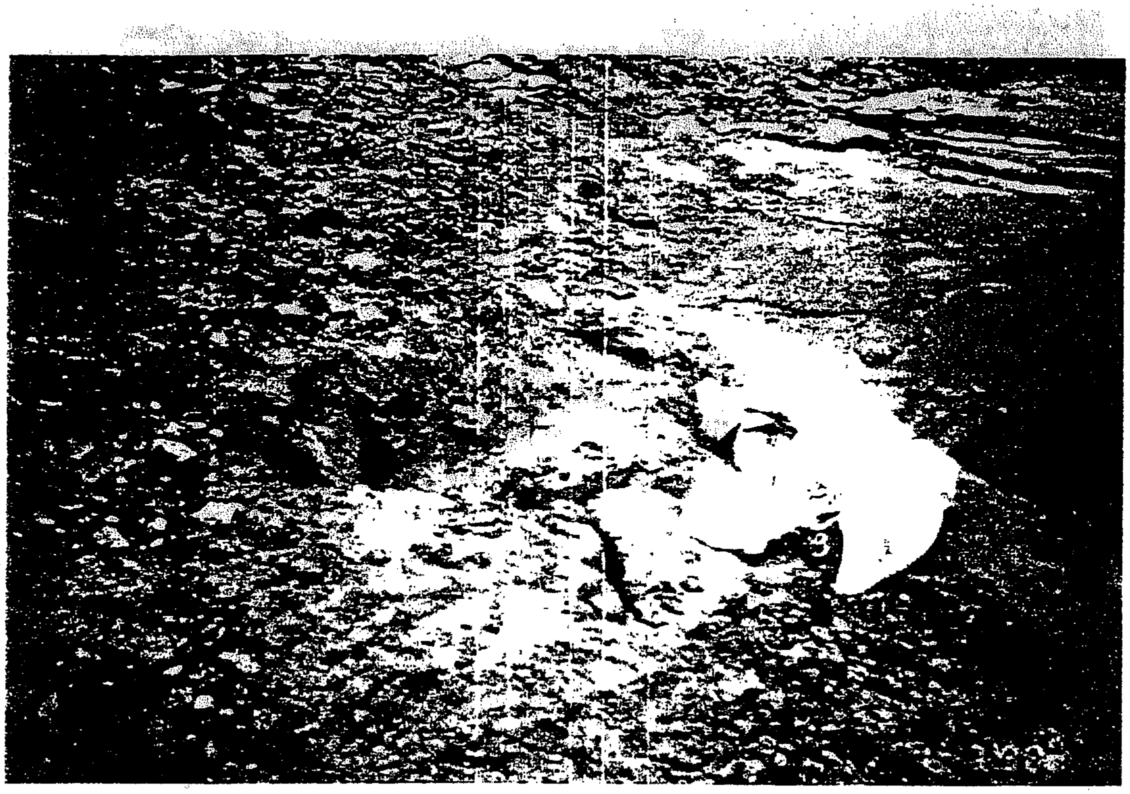

FIGURE 6. Sandbags were placed around the collapse to prevent additional loss of hog waste. Photo by Kentucky Division of Water.

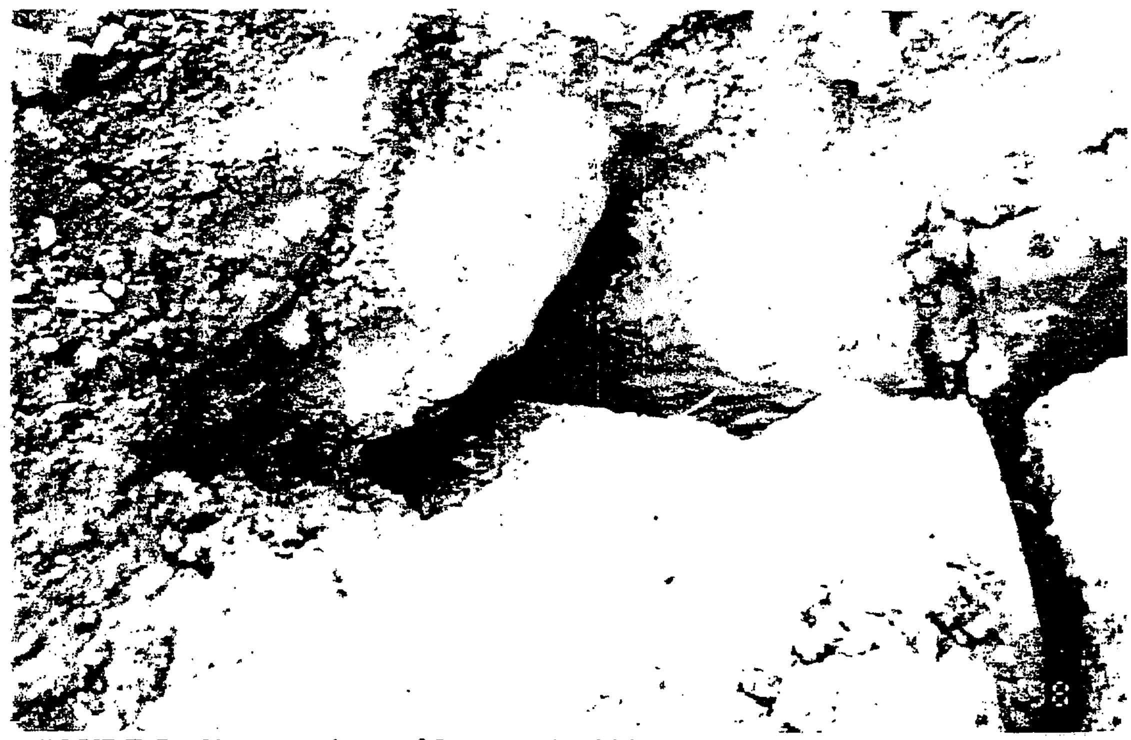

FIGURE 7. Close up photo of January 6, 1998 Warren County Sinkhole collapse.

FIGURE 8. Sinkhole collapse under a hog waste lagoon in Logan County on April 29, 1991. The plastic liner under the lagoon extended across the bottom and 4 feet up the sides. The collapse occurred above the liner when the lagoon was 12.8 feet deep.

FIGURE 9. An estimated 1,050,000 gallons of hog waste sink quickly into the karst aquifer.

FIGURE 10. A Rhodamine WT dye trace performed by the Kentucky Division of Water was visually positive at the above spring on Sinking Creek.

pond was 12.8 feet deep along the side but above the liner. The collapse then expanded to drain the entire pond. A dye trace using Rhodamine WT dye was performed by the Kentucky Division of Water and visually observed at a nearby spring on Sinking Creek. The Kentucky Division of Water recommended that the hole be repaired and that a .20 mil or thicker liner be installed to above the high water line of the pond.

Hog waste lagoons do not have to experience catastrophic sinkhole collapses to contaminate karst aquifers. Leakage can result in contamination of karst aquifers and surface streams. Figures 11 through 18 show dye traces of two leaking hog waste lagoons in Logan County, Kentucky. The leakage from surface lagoons appears to be through macropores (macrotubes). These tubes through the soil can be made by desiccation cracks, worms or tree roots which rot and leave small tubes through the soil. If these tubes reach the epikarst, a very high permeability zone in the vicinity of the soil - bedrock contact, this permits water to drain rapidly through the low permeability clay subsoil into the karst aquifer below. This leakage through macrotubes may produce soil piping that results in a sinkhole collapse. Also, the practice of excavating the soil for the lagoon tends to reduce the thickness of soil above existing regolith (unconsolidated material above bedrock) arches. This greatly increases the chances of a sinkhole collapse above an existing regolith arch. There are thousands of regolith arches per square mile in most karst areas. Plates 1 and 2 are maps of the karst areas of Kentucky. It shows that over one half of the Commonwealth is underlain by carbonate rock with varying degrees of karstification.

FIGURE 11. Black Spring as it flows into a spring fed clear stream. This stream sinks into a cave about 300 feet downstream of Black Spring.

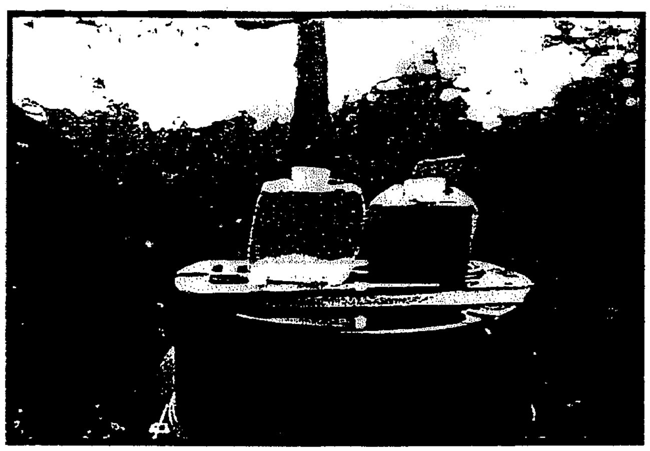

FIGURE 12. Water samples collected from Black Spring (right) and from the clear stream upstream from Black Spring (left).

FIGURE 13. Euthrophication downstream from Black Spring before the stream sinks into a cave.

FIGURE 14. Rhodamine WT dye trace of one of the four hog waste lagoons.

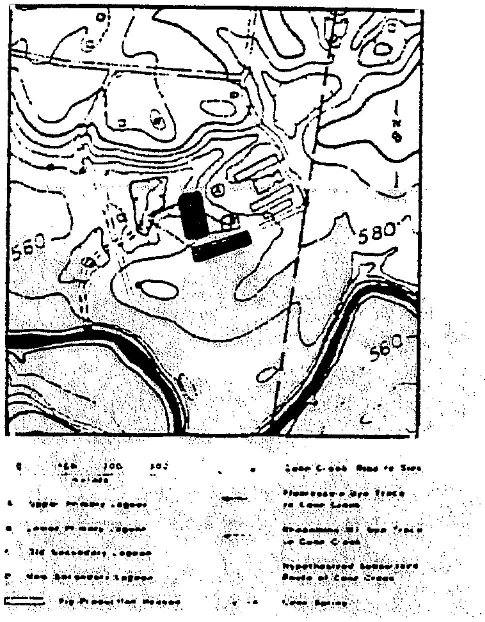

FIGURE 16. Two of the four waste lagoons were tested for leakage by injecting Rhodamine WT and Fluorescein dyes. The map shows the approximate route taken by the two dyes from the hog waste lagoons to Black Spring on the clear surface stream. This stream sinks into a cave and then resurges at a spring on the nearby river.

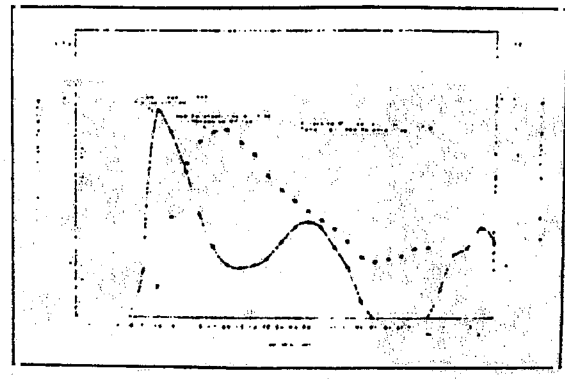

FIGURE 17. Quantitative dye breakthrough curves for Rhodamine WT and Fluorescein dyes at Black Spring. First arrival for Fluorescein was 16 hours and for Rhodamine WT it was 20 hours.

FIGURE 18. Synthetic liner installed in modified lagoon to prevent leakage into karst aquifer.

CONCLUSIONS

All hog waste lagoons built upon karst should have a synthetic liner (at least 60 mils thick) installed to prevent leakage and possibly sinkhole collapses. Also, a karst hydrogeologic investigation that includes a dye trace should be performed to identify the receiving spring, or springs, in the event of a leak. The spring(s) should then be tested periodically for groundwater contamination associated with hog waste.

CONSTRUCTING NEW MANURE STORAGE SYSTEMS IN THE KARST REGION

draft guidance document 2/8/99

Minnesota Pollution Control Agency

SUMMARY

Construction of large liquid manure storage systems has greatly increased during the past decade in the karst region of southeastern Minnesota. Soil subsidence under a liquid manure storage system could breach the integrity of the liner, causing either a catastrophic release of manure to ground water or a slow undetected manure seepage problem. The probability of soil subsidence varies greatly across this region of the state. Construction of new liquid manure storage systems in higher risk areas for sinkhole formation creates heightened concerns about water quality protection. To minimize the risks of siting new manure storage systems in the karst region, the Minnesota Pollution Control Agency has developed and implemented a policy to evaluate relative risks of soil subsidence prior to approving feedlot construction permits. Permitting decisions depend on the results of a site-specific karst investigation, the proposed volume of manure to be stored and the type of liner proposed for the storage system. Precautionary measures required of some livestock producers have included one or more of the following: locating the feedlot in a less vulnerable area, using less permeable liner materials, and rerouting roof runoff waters.

BENEFITS AND RISKS TO WATER QUALITY

Benefits of Livestock and Manure Storage Structures

Livestock agriculture has some water quality benefits in the karst region that help to offset some of the risks to water quality. Manure applied to land planted to row crops can reduce soil erosion. Hay-land and pasture associated with cattle operations results in very little soil erosion and pesticide transport in this region of steeply sloping soils.

The trends to construct new and expanded feedlot facilities and the associated liquid manure storage systems typically result in further protection of surface water quality. Liquid manure storage structures increase management flexibility, making it easier to apply at proper rates and to avoid winter-time manure application. Also, may of the older feedlot facilities are located adjacent to streams and do not have containment of manure or manure-contaminated runoff. Most facilities with new liquid manure storage structures have total containment of manure such that there is no manure discharge into surface waters from rainfall and snowmelt. Also, the liquid manure in containment structures is usually injected below the soil surface and is less subject to surface runoff compared to the typical soil surface spreading practices of many feedlot facilities without liquid manure storage.

Risks of Manure Storage Systems in Karst Regions

While there are a number of water quality benefits associated with liquid manure storage systems, there are also several heightened risks. One possible risk is the failure of the walls of the manure storage system to hold the manure with a resulting river of manure flowing down a valley and into a stream. This has not been known to occur in Minnesota, likely due in part to engineering review and regulation of construction activities. What has occurred in Minnesota are basin overflows and intentional discharges from manure storage structures. Enforcement of such violations has increased substantially during recent years in an effort to curb blatant violations and mismanagement.

Three potential water quality risks associated with liquid manure storage systems in the karst region include: 1) seepage of contaminants through the liner and underlying soil to fractured bedrock and subsequently to ground water; 2) soil subsidence below the structure which breaches the integrity of the concrete, geosynthetic or soil liner, causing a slow and perhaps undetectable leaking of manure from the storage system to ground water; and 3) a large sinkhole forming below a manure storage system leading to a rapid flow of manure into ground water or causing a collapse in a basin sidewall and a pouring out of manure onto the ground surface.

Manure entering ground water will discharge into streams within a period of time ranging from hours to decades depending on the site-specific hydrogeology. The karst region of Minnesota maintains a large number of high quality trout streams. A rapid discharge of a large quantity of manure into a stream will destroy the aquatic life for a stretch of the stream and also result in increased nutrient loading into the receiving waters of the Mississippi River system. Manure which flows in the ground water for a longer period before discharging into streams will be more diluted and may not destroy aquatic life, but will threaten drinking water supplies as it travels toward the stream, and contribute to stream pollution upon discharge.

Risks associated with slow seepage through the liner are reduced somewhat by Minnesota requirements for a minimum ten-foot separation distance between the bottom of standard reinforced concrete and earthen manure storage structures and underlying bedrock. If a composite liner or other nearly impermeable liner system is used, then the required minimum separation distance from bedrock is five feet. Requirements to minimize the risks associated with soil subsidence as new liquid manure storage systems are constructed in the karst region is the primary subject of these guidelines.

EVALUATING RISKS OF SOIL SUBSIDENCE

Learning experiences from sinkholes forming under municipal wastewater treatment ponds

Between 1974 and 1992, sinkholes opened below three of the twenty-two municipal wastewater treatment ponds in Minnesota's karst region. Sinkholes developed in Altura's ponds in 1974 during construction and in 1976 when it first filled to capacity (Alexander and Book, 1984). A sinkhole developed in a Lewiston pond in 1991 after eighteen years of use (Jannik et al., 1992). Several sinkholes developed in a Bellchester pond in 1992 after twenty-two years of use (Alexander et al., 1993). The amounts of partially treated wastewater draining into sinkholes at the three respective sites was 3.7, 2.3, and 7.7 million gallons. The ponds were constructed of earthen materials with a designed seepage rate not to exceed 3500 gallons per acre per day. Several sinkholes are located within about a mile from all three sites, yet no sinkholes have been identified within a quarter of a mile from the sites.

These failures clearly demonstrate the potential for sinkholes to develop in southeastern Minnesota when large quantities of liquids are stored in sinkhole prone areas with minimal barriers between the liquid and underlying materials. Similar problems could develop when storing liquid manure on top of permeable liner materials. However, there are several notable differences between these failed municipal wastewater treatment systems and manure storage systems currently being constructed. The maximum allowable design seepage rate for manure storage systems is 500 gallons/acre/day, seven times less than the old municipal wastewater ponds. These design seepage rates assume that the ponds remain full and they do not account for seepage reductions caused by the physical, chemical and biological sealing which takes place at the manure/soil interface. In addition, the size of even the largest manure storage systems is smaller than the municipal ponds. These differences between the failed municipal systems and manure storage structures are worth recognizing, but they are not great enough to warrant complete disregard of the risks associated with siting liquid manure storage systems in sinkhole prone areas. It is also important to note that the contaminant concentrations in manure are often over 100 times greater than municipal wastewater pond liquids, and thus the environmental consequences of a catastrophic manure release could be much worse than municipal pond failures.

Sinkhole Probability Mapping and Research

Sinkhole mapping and research completed during the past two decades has made it easier to determine the relative soil subsidence risks when siting new liquid manure storage systems in Southeastern Minnesota. Sinkhole probability maps have been completed for three counties (Dalgleish and Alexander, 1984; Alexander and Maki, 1988; Witthuhn and Alexander, 1995) and additional hydrogeologic investigation has been conducted in the other karst areas. The probability of sinkhole formation has been found to vary tremendously across the region. Some areas have in excess of 50 sinkholes per square mile and other areas have no sinkholes. Often high density clusters of sinkholes are adjacent to areas with scattered individual sinkholes. Bedrock composition, topographic position in the landscape and thickness of glacial materials over bedrock have all been found to affect the likelihood of sinkhole formation.

Most sinkholes in southeastern Minnesota appear where there is less than 50 feet of surficial cover over carbonate and sandstone bedrock. The proximity of nearby sinkholes remain the single best predictor of new sinkhole development (Witthuhn and Alexander, 1995). Magdalene and Alexander (1995) concluded that on the scale of several kilometers, new sinkholes in Winona County tend to develop in the areas of existing sinkholes, especially near newly developed sinkholes. The risk of soil subsidence has generally been found to increase in areas of ponded or intermittently flowing water, and in areas with indications of more extensive karstification, including areas with disappearing streams, caves, dry valleys, springs and solution cavities.

REGULATORY POLICY TO MINIMIZE RISKS

Overview

The rapid increase in the construction of large liquid manure storage structures in southeastern Minnesota, coupled with experiences of sinkhole development in three municipal wastewater treatment ponds, prompted the Minnesota Pollution Control Agency (MPCA) to consider measures to minimize risks associated with construction of liquid or semi-solid manure storage structures in sinkhole prone areas.

Beginning in 1995, the MPCA has worked to develop and implement a policy to reduce environmental risks associated with construction of liquid manure storage systems in sinkhole prone areas, yet maintain the feasibility of constructing manure storage systems throughout much of the karst region. These guidelines were developed so that a general indication of environmental risk can be readily evaluated in karst regions and precautionary measures can be taken. The information used to evaluate the potential for sinkhole formation, and, in general, how this information is used in making permitting decisions, is described on the following pages. Specific permitting decisions are made on an individual case-by-case basis after considering numerous factors. The intent of the guidelines is to allow the producers and their technical advisors to understand sinkhole risk considerations early in the planning and site selection process, prior to substantial investment of time and money.

Listed below are three steps which producers are required to take when considering construction of a liquid or semi-solid manure storage system in areas where sinkholes could potentially form (e.g. areas mapped with a sinkhole probability of "low to moderate" or greater; or unmapped areas with less than 50 feet to bedrock).

Step 1 - Conduct site investigation for sinkholes and other karst features.
Step 2 - Submit site investigation to state and/or county officials so that the karst risk factor may be determined.
Step 3 - Determine manure storage system options and requirements.

Step 1- Site Investigation for Sinkholes and Karst Features

A site specific investigation is used to gather information needed to evaluate the risks of soil subsidence at a proposed manure storage site. The following is required for the site investigation. A checklist of these requirements is included as attachment A.

- **Sinkhole Maps -** A copy of any published sinkhole location and/or probability maps showing the area within about 2 miles of the proposed facility. If a sinkhole map shows the proposed manure storage site location to be in an area designated as "low" or "no" probability, then the other steps for the site investigation need not be completed.

- **Field Inspection -** a map of the proposed site showing the location of all small and large depressions in the landscape. At a minimum, all land within a 700 foot radius of the potential manure storage structure location must be closely inspected. The best period of time to conduct this investigation is when crop-cover, leaf cover, and snow-cover are minimal.

- **Sinkhole/depression Characteristics -** a description of the following for all sinkholes and potential sinkholes identified in steps 1 and 2: a) whether the sinkhole is currently open or has been filled; b) decade when formed, if known; c) position on landscape; d) depression diameter and depth, and e) other possible explanations which may explain the hole or depression.

- **Other karst features -** a description of other notable potential karst features located within 1 mile of the proposed facility, including disappearing streams, caves, dry valleys, springs or solution cavities.

- **Soil borings or soil trench information -** The minimum soil boring depth must be to a point 10 feet below the bottom of the proposed manure storage system. The karst risk factor (step 2) will be determined by assuming that the bedrock elevation is at the bottom of the shallowest boring. Deep soil borings which extend beyond the minimum required depth are optional and can be used to demonstrate a lower sinkhole risk potential. A minimum of four borings are required for the first one-half acre of storage system surface area. A minimum of two additional borings shall be taken for each additional one-half acre of storage structure surface area. If the borings indicate an uneven bedrock surface or highly variable soil conditions, additional borings will be required. PLEASE NOTE: The minimum soil thickness between manure and bedrock for all standard concrete and clay-lined structures is 10 feet. If a composite (compacted cohesive soil plus a geomembrane or geosynthetic liner) or upgraded concrete liner system is used, the required separation distance between manure and bedrock is 5 feet. An upgraded concrete liner includes steel reinforced floors and a waterstop or water sealant in all construction joints and control joints, including the joint between the sidewall and floor of the structure.

- **Other Potential Diagnostic Work -** The MPCA may require other work as deemed necessary by agency staff, possibly including: deeper borings to determine the characteristics of underlying bedrock, ground penetrating radar or other geophysical investigations to better diagnose subsurface conditions, trenching, or other karst investigative techniques.

The following additional information is needed for liquid manure storage structures proposed in counties where a sinkhole location/probability map has not been prepared:

- **Soils Maps and Aerial Photos** - topographic maps, soil survey maps and aerial photos of all land within a one mile radius of the site. All known open and filled sinkholes must be highlighted on these maps. Closed depressions identified on topographic maps are to be identified and inspected.

- **Land owner interviews** - a list of all long-term residents (living in area at least 15 years) and land owners in the area who were interviewed and asked about the location of existing and filled sinkholes located within a 1 mile radius of the proposed facility. All sinkholes or potential sinkholes (open or filled) are to be identified on a map or photo of the site.

- **Well Logs** - Geologic information from well logs within a 2 mile radius of the proposed site location

Step 2. Determination of Karst Risk Factor

Information obtained under Step 1 is submitted to the MPCA or delegated county authority so that a karst risk factor for the site under consideration may be estimated. The karst risk factor is determined from available sinkhole probability map information, along with site specific soils, landscape function, geology, and sinkhole information. Karst experts from other organizations may be consulted during the review of more complex cases. The following site specific information is considered when determining the karst risk factor:

a) density of sinkholes;
b) the topographic and geologic setting which sinkholes are found;
c) patterns and characteristics of nearby sinkhole formation;
d) type and condition of first encountered bedrock;
e) depth to bedrock;
f) soil and subsoil types;
g) identification of other karst features (e.g. disappearing streams, blind valleys, dry valleys, caves, springs, and karst features observed in exposed bedrock along roadways); and
h) proximity to nearest sinkhole or karst feature.

Sinkhole characteristics roughly representing various karst risk categories are listed below. While these general descriptions largely refer to proximity to sinkholes and sinkhole densities, the other site specific variables noted above are often evaluated for proposed sites in order to determine the most fitting risk category. The following descriptions are only intended to serve as general guidelines.

- **No Risk** - Areas where the first encountered bedrock is not subject to sinkhole formation.

- **Low Risk** - Areas underlain by carbonate bedrock, but in which very few sinkholes are found. No known sinkholes exist within a 1 mile radius of the proposed site, and the soils and geologic information indicate that there is minimal risk of sinkhole formation at the site under consideration.

- **Moderately Low Risk** - No sinkholes or buried sinkholes are known within a 1/2 mile radius of the proposed site. However, widely scattered sinkholes have been identified in the area and the depth to bedrock is less than about 50 feet.

- **Moderate Risk** - No sinkholes or buried sinkholes are known within a 1/4 mile radius of the site. However, there are scattered sinkholes (e.g. 2 - 5 sinkholes in a 1 mile radius of proposed site) and/or other geologic factors that make the area susceptible to sinkhole formation.

- **Moderately High Risk** - Similar sinkhole densities as high risk zones, but the soils and other information about karst features indicate that the specific site of construction has a lower sinkhole risk than the high risk category.

- **High Risk** - There is typically either 1 sinkhole or buried sinkhole within a 1/4 mile radius or 2-4 sinkholes or buried sinkholes within a 1/2 mile radius and the soils and karst feature information indicates minimal protection.

1320 ft.
(2640 feet)

- **Very High Risk** - Sinkholes are common in the area, but sinkhole densities are less than in the extremely high risk areas (e.g. 2 to 4 sinkholes in a 1/4 mile radius or 5 or more sinkholes within a 1/2 mile radius).

- **Extremely High Risk** - Sinkholes are the dominant landform, with typical sinkhole densities exceeding about 4 sinkholes in a 1/4 mile radius from any point.

Step 3. Determine Manure storage system options and requirements

MPCA requirements are that the proposed liquid or semi-solid manure storage systems be:

a) located as far as possible from topographic lows, depressions or ravines;
b) located as far as possible from existing or historically filled sinkholes;
c) located in an area with the greatest thickness of fine-textured soils;
d) constructed so as to minimize the amount of rainfall and roof runoff water infiltrating soils in the area of the manure storage system;
e) not constructed when very large volume manure storage systems are proposed in high risk karst areas;
f) not constructed when soil excavation reveals indications of historic or potential future sinkhole formation.

After the sinkhole risk factor and the combined storage capacity of all structures on site has been determined, Table 1 is used as a general guideline for identifying recommended options for manure storage structures and associated liners. The options for manure storage are intended to be guidelines only. Best professional judgment is used when determining allowable manure storage system options. Consideration is given when a new manure storage structure is designed to correct existing surface or ground water pollution problems without a significant expansion in operation size. For example, at existing operations, it can be better for the environment to have a new liquid containment structure built in a sinkhole prone area than to have direct feedlot runoff into streams or the continued use of an old structure that was constructed using less stringent standards. Other considerations include: maximum manure volume to be stored in any single manure storage structure, site history and management, planned contingency efforts, and specific properties of cohesive soils.

Table 1. General guidelines for manure storage system options in different karst risk zones. The letters A-G correspond with letters in the table. For example, a five million gallon storage structure proposed in a moderate karst risk area could be constructed using options D, E, F, or G. Design capacity considers the combined storage capacity of all manure storage structures on the property.

A. Cohesive soil liner designed/constructed to seep no more than 0.018" per day when full (of water) and a design thickness of 2 feet or greater.
B. Reinforced concrete structure constructed in accordance with MPCA standard requirements.
C. Cohesive soil liner designed/constructed to seep no more than 0.012" per day when full (of water) and with a liner thickness of 3 feet or greater.
D. Cohesive soil liner designed/constructed to seep no more than 0.0089" per day when full (of water) and a thickness of 4 ft or greater.
E. Composite liner system or upgraded concrete liner. A composite liner system consists of a combination of compacted clay covered by an approvable geomembrane or geosynthetic liner. For concrete, an upgraded system includes a steel reinforced floor and a waterstop or water sealant in all construction joints and control joints.
F. Above ground storage system.
G. Solid manure handling systems only.

	Design capacity in millions of gallons						
Karst Risk	**≤0.25**	**0.25-0.5**	**0.5 - 1**	**1 - 2**	**2 - 4**	**4-8**	**≥8**
No Risk or Low risk	A-G	A-G	A-G	A-G	A-G	A-G	A-G
Moderately low risk	A-G	A-G	A-G	A-G	B-G	C-G	C-G
Moderate risk	A-G	A-G	A-G	B-G	C-G	D-G	E-G
Moderately high risk	A-G	A-G	B-G	C-G	D-G	E-G	G
High risk	C-G	C-G	D-G	E-G	F-G	G	G
Very high risk	E-G	E-G	F-G	G	G	G	G
Extremely high risk	E-G	G	G	G	G	G	G

Other requirements

For all sites constructed in areas considered as "Moderate Risk" or greater the following additional precautions must be met:

Subsoil Inspection - The MPCA must be notified at least 3 days prior to construction of the proposed structure and be given the opportunity to inspect the soils during excavation. Also, at many sites a soil scientist or geologist will be required to be on-site following removal of the soil B horizon to determine whether there is any indication of potential sinkhole development observed in the soil (piping, voids, channels, topsoil found at deeper depths or other indications of soil subsidence). When required, a subsoil inspection report signed by the on-site soil scientist or geologist must be submitted to the MPCA or permitting authority. If any indications of potential sinkhole development are observed, the permittee must notify the MPCA and the design engineer so that an evaluation can be made of whether the site must be abandoned or if alternative measures can be implemented to prevent sinkhole formation.

Rerouting roof runoff and site grading - The amount of water infiltrating soils in the area of the manure storage system must be minimized. This can be accomplished by sloping soils away from the manure storage system, and routing all barn roof runoff and perimeter tile waters to a discharge point as far as possible from the manure storage system into a sloped runoff channel or to some other area where ponding water will not occur. Plans for rerouting facility runoff waters will be required for all permits in sinkhole prone areas.

CONCLUSIONS

There are currently many environmental protection demands surrounding feedlots, including enforcement of intentional manure discharges, open lot runoff problems, land application of manure issues, engineering review for new sites, hydrogen sulfide and other air emission issues, feedlot abandonment concerns, manure storage system construction problems, livestock access to public waters, manure stockpile runoff, silage liquids runoff, dead animal disposal, old and poorly lined manure storage systems, and other problems stemming from mismanagement of manure. The intent of the MPCA feedlot program is to allocate limited staff resources in a manner which balances addressing the issues which are causing immediate environmental problems, with the need for taking preventative measures to minimize the chances of catastrophic problems in the future. Regulating the siting and designs of new manure storage systems in areas prone to sinkholes should help to reduce the chances of catastrophic and chronic problems resulting from soil subsidence.

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