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A HYDROGEOLOGICAL ASSESSMENT OF THE PROPOSAL FOR SYNTHETIC LINERS IN MANURE PONDS AT THE C&H HOG FARM, NEWTON COUNTY, ARKANSAS.

TESTIMONY FOR PRESENTATION AT A PUBLIC HEARING SEPTEMBER 29, 2015 AT JASPER, ARKANSAS.

Tom Aley, Arkansas Professional Geologist #1646
President and Senior Hydrogeologist
Ozark Underground Laboratory, Inc.

An assessment prepared at the request of the Buffalo River Watershed Alliance.

My name is Tom Aley. I am President and Senior Hydrogeologist at the Ozark Underground Laboratory, Inc., 1572 Aley Lane, Protem, MO. 65733.

I have been continuously licensed as a Professional Geologist in Arkansas (License #1646) since 1991 and I have similar current licenses in Missouri, Kentucky, and Alabama. Since 1983 I have continuously held national certification as a Professional Hydrogeologist from the American Institute of Hydrology (PHG #179). I hold university degrees from the University of California (Berkeley) awarded in 1960 and 1962. A copy of my resume is available on-line at www.ozarkundergroundlab.com. I am submitting my testimony as a Professional Hydrogeologist and a Professional Geologist licensed to practice in the State of Arkansas. This assessment of the proposal for synthetic liners in the manure ponds at the C&H Hog Farm was requested by the Buffalo River Watershed Alliance.

In my profession I specialize in the hydrology of karst areas and in the subsurface migration of pollutants. On August 27, 2015 in a public hearing at Jasper, Arkansas I testified about the inadequacy of the Environmental Assessment for federally guaranteed loans for this hog farm. In that testimony I commented at length on the risk of catastrophic sinkhole collapses beneath these manure ponds and resulting risks to water quality from the manure ponds and other features associated with the C&H Hog Farm operation. Rather than repeat that testimony I am attaching a copy of my earlier testimony and request that it be made a part of tonight's public record. Comments 6 and 7 in my previous testimony specifically relate to the manure ponds.

In my professional work in karst areas I have had substantial personal experience with stormwater detention basins, manure ponds, sewage lagoons, and industrial waste lagoons in karst areas that have experienced severe leakage and/or catastrophic collapse into sinkholes. Unfortunately, it is a very common problem even in states (such as Texas) with stringent regulatory controls designed to protect groundwater quality. Arkansas lacks effective groundwater protection controls as is demonstrated by the existence of this hog farm and its manure ponds. Most of the wastewater impoundments that have experienced severe leakage and/or catastrophic collapse have had compacted clay liners, but some have had synthetic liners that have been ruptured by land subsidence or catastrophic collapse. This has been the case even when the liners were installed during the initial construction of the impoundments. Retrofitting liners in the C&H manure ponds so that they will not leak or rupture will, at best, be a very challenging operation.

If there is to be a reasonable chance that the liners will be beneficial then ADEQ, in their oversight of this modification, needs to ensure the following:

- That all manure and any ponded water or super-saturated sediment is removed from the ponds before any liner installation is begun. The liners must not be installed over "boggy" areas, ponded water, or depressions filled with manure.
- The empty and effectively cleaned ponds must be searched by a qualified person (preferably an experienced geologist licensed in Arkansas) for evidence of

subsidence or small collapses expressed in the sediments on the floors or sides of the ponds. Such features are likely to be filled with manure and this is why all manure must be removed before examination.

- That sediments on the floors and sides of the basins are compacted with appropriate compaction equipment prior to installation of the liners and any underlying cushion materials.
- That all tears or other damage to the liners are repaired before the liners are placed in service.
- That, after installation of the liners, the manure ponds are refilled with water and/or manure to prevent any portions of the liners from floating on any water that builds up between the top of the compacted sediments and the liners. Segments of liners that float are subject to being unequally stressed and torn when liquids are subsequently added to the ponds.

Examining the empty and effectively cleaned ponds for evidence of subsidence or small collapses expressed in the sediments on the floors or sides of the ponds is critically important. Areas that have experienced subsidence or small collapses are critically important evidence of underlying instability. In this karst setting such underlying instability extends into the underlying limestone bedrock, which is of substantial but unknown depth at this site due to the absence of an appropriate and adequate subsurface investigations. Since the manure ponds have already been constructed, effective remediation of the underlying instability will almost certainly require pressure grouting that would extend from underlying cavities in the limestone up through the residuum to the base of the ponds. I recommend the following publication as the best available current reference on sinkhole and subsidence remediation: Waltham, Tony; Fred Bell; and Martin Culshaw. 2005. "Sinkholes and subsidence; karst and cavernous rocks in engineering and construction." Springer/Praxis Publishing. 382p.

The proposal to install the liners suggests that one or both of the manure ponds may already be experiencing major leakage to groundwater. If so, given the hydrogeologic nature of the site and the underlying Boone Formation Aquifer, that leakage is likely to be concentrated in a few points that quickly convey contaminants into the underlying groundwater system. Such discrete recharge zones are subject to subsidence and/or collapse. A thin synthetic liner lacks the strength to span even relatively small subsidence or sinkhole features. As demonstrated a couple of years ago, a six or eight inch thick concrete floor at the Corvette Museum in Bowling Green, Kentucky was unable to span an underlying sinkhole collapse. A 60 mil synthetic liner will not do nearly as well as the concrete. The manure ponds and the Corvette Museum have important factors in common; both are in karst areas and neither received adequate subsurface investigations before construction.

In summary, while the proposed liners in the ponds may be beneficial, they do not negate the serious pollution risks associated with the manure ponds or with the entire operation of the C&H Hog Farm. Adequately preparing the ponds for installation of the liners will be difficult and, especially if evidence of subsidence or collapse is found, expensive. It is not likely to occur. Inadequate preparation of the ponds for the liners

will compromise the leakage integrity of the synthetic liners even if they are well installed. What we have here is little more than a public relations effort to conceal the major pollution threat posed to the Buffalo River by C&H Hog Farms.

Thank you for your attention.

Tom Aley, Arkansas PG 1646
President and Senior Hydrogeologist
Ozark Underground Laboratory, Inc.

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A TECHNICAL ASSESSMENT OF THE ADEQUACY AND ACCURACY OF THE DRAFT ENVIRONMENTAL ASSESSMENT FOR C&H HOG FARMS, NEWTON COUNTY, ARKANSAS

TESTIMONY FOR PRESENTATION AT A PUBLIC HEARING AUGUST 27, 2015 AT JASPER, ARKANSAS.

Tom Aley, Arkansas Professional Geologist #1646
President and Senior Hydrogeologist
Ozark Underground Laboratory, Inc.

August 18, 2015

An assessment prepared at the request of the Buffalo River Watershed Alliance.
Prepared for presentation at a public hearing on the adequacy of an
Environmental Assessment for the C&H Hog Farm
August 27, 2015, in Jasper, Arkansas.

This written testimony is being submitted at the public hearing, and for the public record, on the Environmental Assessment for the C&H Hog Farm. My oral testimony will, in the interest of time, be a condensation of this written testimony. This assessment is in response to a request from the Buffalo River Watershed Alliance.

Qualifications of Tom Aley

My name is Tom Aley. I have been continuously licensed as a Professional Geologist in Arkansas (License #1646) since 1991 and I have similar current licenses in Missouri, Kentucky, and Alabama. Since 1983 I have continuously held national certification as a Professional Hydrogeologist from the American Institute of Hydrology (PHG #179). I hold university degrees from the University of California (Berkeley) awarded in 1960 and 1962. A copy of my resume is available on-line at www.ozarkundergroundlab.com.

I am submitting my testimony as a Professional Hydrogeologist and a Professional Geologist licensed to practice in the State of Arkansas. This assessment of the adequacy of the Environmental Assessment was requested by the Buffalo River Watershed Alliance.

I have over 50 years of hydrogeologic experience in the Ozarks, with this work largely focused on interactions of surface water and groundwater in karst areas and on the subsurface migration of pollutants in karst areas. During this period I have conducted multiple hydrogeologic contract studies in the Arkansas Ozarks funded by federal agencies including the National Park Service, U.S. Forest Service, and U.S. Fish and Wildlife Service. I have similarly done hydrogeologic contract studies for Arkansas state agencies including Arkansas Highway and Transportation Department, Arkansas Natural Heritage Commission, Arkansas Game and Fish Commission, Arkansas State Parks, and Arkansas Department of Planning. Finally, I have done many other hydrogeologic investigations in the Arkansas Ozarks for various corporate, non-profit, and private clients. Most of these investigations have focused on issues related to water movement from the surface of the land into and through the Boone Formation, the extensively karstified geologic unit that underlies the C&H hog farm site and almost all of the land application fields.

Specific Comments

Comment 1. The National Environmental Policy Act (NEPA) requires that the environmental impacts of activities by federal agencies must be assessed. If this assessment demonstrates a Finding of No Significant Impacts (a FONSI), then an Environmental Assessment (EA) can be prepared. If there are significant impacts then an Environmental Impact Statement (EIS) must be prepared. The agencies have prepared an EA.

Federal agencies are required to make competent and accurate environmental assessments. The resulting document must identify all significant environmental impacts and accurately and competently identify and characterize them.

The FSA and SBA, through a private contractor, have totally failed to accurately identify and characterize the nature and extent of the very significant adverse impacts that this hog farm operation will have on groundwater quality within the Buffalo River Basin. They have also failed to consider and assess the terrible risk to the Buffalo River that would be created by a catastrophic sinkhole collapse of the manure ponds. I will deal with both of these topics in greater detail later in this testimony.

Comment 2. The EA conducted for the FSA and SBA shows a gross lack of understanding of the intimate and integral interactions of surface water and groundwater in karst areas of the Ozarks. This demonstrates a lack of hydrogeological expertise relevant to conditions found in karst areas of northern Arkansas. Under Arkansas state law geologic work and geologic interpretations (including hydrogeological work and hydrogeological interpretations) in Arkansas must be conducted by, or under the direction of, a person licensed to practice geology in the State of Arkansas. This law was enacted to protect the people and the resources of the State of Arkansas from persons lacking the training and experience to conduct geologic and hydrogeologic work in the state.

EA Page 5-1 lists consultation, coordination, and preparers of the EA. Krista Dearing with Ecosphere Environmental Services of Durango, Colorado, is the only geologist listed. The website for the Arkansas State Board of Registration for Professional Geologists was searched on August 14, 2015 and Ms. Dearing is not listed as a Professional Geologist. While it is doubtful, perhaps the list is not up to date or (equally doubtful) perhaps Ms. Dearing is working under some special reciprocity agreement (she is licensed as a Professional Geologist in Arizona). Absent these possibilities, any geological or hydrogeological conclusions in this EA must be dismissed as not being the work product of a Professional Geologist licensed to practice in the State of Arkansas. If such geological and hydrogeological conclusions are dismissed, and they are crucial to a FONSI (Finding of No Significant Impact), then for this reason alone the EA should be found to not be in compliance with the provisions of NEPA.

Comment 3. The EA fails to recognize that this entire hog farm operation and the associated manure disposal fields (with the exception of portions of Field 17) are located on top of a well developed karst aquifer within the Boone Formation and possibly other deeper geologic units. Were it not for the karst development in the region, there would be much more water on the surface of the land within the Big Creek topographic basin than is the case.

In karst areas the adjective "Dry" is commonly applied to streams and valleys where the proportion of surface water lost to the groundwater system is exceptionally great. The vicinity of the C&H Hog Farm is characterized by an exceptionally large

proportion of the surface water being lost to the groundwater system as illustrated by the following:

- Dry Creek, a stream with a topographic basin of 7.23 square miles, is located along the southern margin of the hog farm operations. Three of the manure disposal fields (Fields 15, 16, and 17) are topographically tributary to Dry Creek.
- Dry Branch, a stream tributary to the Left Fork of Big Creek at a point 11,600 feet west of Field 5.
- Dry Branch, a northward flowing stream tributary to Big Creek. The small community of Mt. Judea is on the ridge between Dry Branch (to the east) and Big Creek (to the west) and roughly parallels Big Creek. Dry Branch is within 2200 feet of Field 1 and is 3,500 to 6,100 feet from Fields 5, 6, 7, 9, and 10.

The hog farm operation is bordered on the west, south, and east by streams named Dry Creek and Dry Branches. The hog farm operation is on the Mt. Judea 7.5 minute topographic quadrangle map. There are few if any other 7.5 minute quadrangle maps in the karst areas of north Arkansas that have three separate streams with the adjective "Dry" in the name. The hog farm is clearly in the middle of a well developed karst area.

Comment 4. EA page 3-7. "To accurately assess the potential point source impacts from C&H Hog Farms on water quality, concentrations of nutrients and bacteria would need to be monitored at and adjacent to the site and the fields where nutrients are applied. By monitoring immediately upstream and downstream of the farm and at the fields, any measurable increase in nutrient or bacteria concentrations discharging from the operations would be recorded and the contribution from other sources would be eliminated or minimized."

This strategy would be relevant only if all the water leaving the land application sites was as surface water runoff. This is not the case in this karst setting. In this karst setting much of the annual water runoff does not contribute directly to streams but instead moves downward through permeable soils and then into limestone units of the Boone Formation. Once into the limestone units the water then flows hundreds to tens of thousands of feet to discharge from springs.

A recharge area of about 1.5 square miles is required to supply karst springs draining the Boone Formation with a mean annual flow rate of 450 gallons per minute. This represents a mean annual contribution to karst groundwater of about 245,000 gallons of water per acre per year.

Fields 3, 5, 6, 7, 8, 9, 10, 12, and almost all of Field 16 are located on moderately permeable alluvium and terrace deposits (USGS mapping of Mt. Judea Quadrangle). The most common soil series on these fields are the Spadra and Razort Soil Series (USDA, SCS 1988; EA page 3-21 and 3-22). The alluvium and terrace deposits underlying these fields are in turn underlain by the karstic Boone Formation.

Fields 1, 2, 4, 11, 13, 14, 15, and a small amount of 16 and 17 are in upland areas and are underlain by the Boone Formation. The most common soils on these fields are Noark Series soils (EA page 3-21 and 3-22). Table 1 presents data from the Newton

County soil survey (USDA, SCS 1988) and shows permeability rates in the four soil series underlying the majority of the manure application fields.

Table 1 Soil depth and permeability for the major soils in the manure application fields. Data from Newton County Soil Survey by USDA-Soil Conservation Service.

Soil Series	Depth (inches)	Permeability (in/hr)
Arkana	0- 7	0.6 to 2.0
	7-13	0.06 to 0.2
	13-33	<0.06
	33-35	----
Noark	0-14	0.6 to 2.0
	14-43	0.6 to 2.0
	43-72	0.6 to 2.0
Razort	0-12	0.6 to 2.0
	12-43	0.6 to 2.0
	43-63	2.0 to 6.0
Spadra	0- 7	0.6 to 2.0
	7–40	0.6 to 2.0
	40-72	0.6 to 2.0

As seen in the above table all of the upper horizons of the soils (and except for Arkana Series soils) all of the deeper horizons have permeability rates of 0.6 to 2.0 inches per hour. Very few precipitation events in the Arkansas Ozarks have intensities as great as these permeability rates, and when more intense precipitation period do occur they usually persist for only a few minutes. The result is that almost all of the precipitation that falls on these soil units infiltrates into the soil rather than running off on the surface and flowing into surface watercourses.

The water that infiltrates into the soil moves downward until the soils are saturated. Plants, through transpiration, extract water from the soils down to the bottom of their rooting depths which is probably about 1.5 feet for the hay and pasture species present on the manure application fields. Water volumes in excess of soil moisture saturation continue to move downward toward and into the underlying epikarstic zone of the karst units. Most of this downward movement of water and manure contaminants occurs during the period of the year when there is little to no transpiration by the plants.

EA page 3-23 states: "Surficial deposits underlying the farm consist of an approximately 4-foot thick veneer of soil and alluvium (BCRET 2014a)." This is shallower than the soil profile descriptions found in Table 1. It is also shallower than the depths of evaluation borings in the vicinity of the waste holdings ponds and hog buildings. These borings, with a maximum reported depth of 18 feet, failed to encounter bedrock.

In reality, the thickness of unconsolidated material overlying the Boone Formation is highly variable. The upper 30 feet or so of the underlying limestone bedrock (called the epikarstic zone) has been modified by solution and weathering into a

hydrologically complex matrix of cavities that conveys water to systems of dissolved out conduits in the bedrock that in turn convey groundwater to springs. Much of this water discharges from springs in a matter of a few days to a few weeks. However, some of the water is detained in the epikarstic zone and will not reach the receiving springs for many months. This detained water helps maintain the flow of springs during drier periods of the year.

Groundwater tracing with fluorescent tracer dyes is one of the methods used to identify springs that receive water from particular parcels of land. No tracing has been done to determine which local and/or regional springs will receive water and contaminants from the C&H Hog Farm operation. This is basic data essential for an adequate environmental assessment under the provisions of NEPA.

An understanding of the scale of karst groundwater flow in the Buffalo River basin is provided by data from groundwater tracing associated with Mitch Hill Spring, one of the largest springs in the Buffalo River area. This spring is located about 11 miles northeast of the C & H hog farm site and most of its recharge area is underlain by the Boone Formation. Aley and Aley (1989) details 26 successful groundwater traces in and around the Mitch Hill Spring recharge area. Straight-line travel distances to Mitch Hill Spring through the karst groundwater system were as great as 29,000 feet and first arrival times were as rapid as 13 days or less. For comparison purposes, the straight-line distances from the manure application fields to the Buffalo River varies from 19,100 to 33,100 feet, and the straight-line distance to the River from the manure storage ponds is 21,600 feet.

Returning to the statement quoted from the EA in Comment 5 that states that potential point source impacts from C&H Hog Farms on water quality can be accurately measured by monitoring immediately upstream and downstream of the farm (this would be in Big Creek) and at the fields. This is clearly not true since the majority of the water containing contaminants derived from the manure will move downward into the karst groundwater system rather than overland to Big Creek. This is especially true since manure is not land applied (at least as required by C&H permits) when it is raining, when rain is predicted within 12 hours, or on frozen ground.

EA pages 3-14 to 3-19 uses monitoring data from BCRET for surface water quality monitoring on Big Creek upstream and downstream of the farm in an effort to show that the C&H Hog Farm is not detectably impacting water quality. The strategy is grossly flawed because it ignores the predominant contribution of Hog Farm contaminants to the karst groundwater system and incorrectly presumes that contaminants from the Farm, if they existed, would be present in Big Creek downstream of the Farm. NEPA requires that assessments be factual and technically credible. The strategy used in the EA does not comply with this basic requirement.

The EA would have us believe that nutrients and other contaminants in the manure applied to local fields would not enter the karst groundwater system and subsequently discharge from off-site springs and reach the Buffalo National River. That

is clearly false. The following is the complete abstract from a paper in an EPA document entitled "Nonpoint source contamination of ground water in karst-carbonate aquifers in Iowa"

"There are two components of groundwater recharge in karst-carbonate aquifer systems: (1) conventional infiltration, and (2) the direct entry of surface water through sinkholes. Thus, in karst areas, the better known problems of nonpoint source pollution, associated with the runoff of sediment and chemicals from agricultural land into surface waters, directly merge with the ground water system and the poorly-understood problems of the infiltration of agricultural chemicals. Three years of detailed water-quality monitoring and water, mass-balance studies show: (1) during major surface-runoff events high concentrations of suspended sediment, pesticides, and bacteria enter the ground water and move as a 'slug' through the carbonate aquifer, creating brief, but acute water quality problems; but, (2) over a water year the infiltration component delivers to ground water the greatest mass and highest concentrations of NO_3 and the greatest mass of the pesticides detected. Many of the more widely used herbicides are detected commonly in ground water, and are now present year-round. The amount of NO_3-N discharged in ground water and surface water per year, from a 267 km^2 study basin, has equaled about 30-50 percent of the fertilizer-N applied, an economic as well as an environmental concern."

The data in the Hallberg et al. (1985) paper are from Big Spring, Iowa. "Conventional infiltration" is the water that moves downward through the soil. The authors found that 30 to 50% of the nitrogen applied by farmers moved downward through the soil and discharged from the spring. The Iowa farmers paid lots of money for this fertilizer; it is a valuable resource. To the hog farmers manure is a waste; it costs money to get rid of it. As a result, we must expect at least 30 to 50% of the nitrate in the hog manure spread on the Newton County fields to flow out of springs and into the Buffalo River. Because it is a waste the percent could well be even greater.

In the Ozarks, nitrate is the primary nutrient causing excessive algal growth in streams and reductions in water clarity. High water quality clarity is one of the great attractions of the Buffalo National River. The EA's conclusion that the tons and tons of hog manure dumped on farm fields will not significantly impact the Buffalo River is utterly ridiculous and totally inconsistent with requirements of NEPA.

Comment 5. The manure storage ponds pose a significant risk of creating off-site water quality problems due to leakage into groundwater supplies. They are also at risk of catastrophic sinkhole collapses that could introduce large amounts of manure into the underlying karst groundwater system.

Information about the waste holding ponds is scattered through the EA. Important information, from the EA and other sources, includes the following:

- EA Page 1-1 identifies the location of the two waste holding ponds as being in the SW ¼ NW ¼ Section 26, T15N, R20W, Newton County, Arkansas.
- EA Page 1-2 indicates that the site elevation ranges between 940 to 960 feet.

- Based on USGS geologic mapping the ponds are underlain by limestone and chert units assigned to the Boone Formation.
- EA Page 1-2 indicates that the ponds are capable of holding approximately 2.1 million gallons of waste annually. The actual length, width, and depths of the ponds are not identified in the EA. These values are of critical importance since allowable leakage (EA Page 3-20) is 5,000 gallons per acre per day and without knowing the horizontal dimensions of the ponds the allowable leakage rate per pond cannot be calculated. Knowing the depth is also important since the greater the depth the greater the rate of leakage. If the ponds were full and the average depth was 3 feet then the surface area of the ponds would be 2.8 acres and the allowable daily leakage into the karst groundwater would be 14,000 gallons of raw hog manure per day.
- EA Page 1.4 indicates that on May 7, 2015 the Hog Farm submitted a Major Modification Request to ADEQ to install 60 mm HDPE liners over a geotextile base material in both waste ponds and to install and 80 mm cover and methane flare system on Pond 1., noting that these modifications would reduce the potential for seepage of wastes into groundwater. This would be a desirable modification, however, it is not in place now and is unlikely to be in place for some time. Unfortunately, the operation of the ponds for the past two years may have already substantially hydrologically destabilized conditions at depth beneath the ponds.
- EA Page 2- 1 indicates that the ponds are earthen and are lined with 18 inches of compacted low permeability soil. The EA indicates that at installation these liners met the specifications for ASTM D-698. Together the ponds have a capacity of 2,735,922 gallons that reportedly equates to 270 days of storage, accounting for maximum capacity of 6503 animals and a 25-year 24-hour rainfall event.
- EA Page 2-6 indicates that approval for installation of a HDPE liner could take up to 180 days and it is not clear when or whether the changes would be approved.
- EA Page 3-23 gives results from six soil samples collected from the vicinity of the manure ponds. The samples were from borings 2 and 3 and at maximum depths of 9.5 to 11 feet.
- EA Page 3-23 states: "The soil used for the holding pond liner was the fat clay with sand identified at depths of 7 to 11 feet in bore numbers 2 and 3". This statement is inconsistent with Table 3-2. The table shows that the "fat clay with sand" is limited to the interval from 7.0 to 8.5 feet. The interval from 8.5 feet to 11 feet is "sandy fat clay" in boring 2 and "clayey gravel with sand" in boring 3. This discrepancy suggests that the characteristics of the native materials used for the liner were very variable and may not have been ideal for minimizing leakage. In addition, there is no evidence that more than three borings were made. The greatest depth of any reported boring was 18.5 feet (EA Page 3-24); the text indicates that no limestone was encountered in the borings. While the extent of the subsurface investigations and the nature of the on-site materials used for the liners of the waste ponds might have been adequate for a minor facility in a rural area where the values of off-site resources were minimal, they are not adequate in view of the potential to adversely impact waters of the Buffalo National River.

Leakage of raw hog manure out of the C&H ponds represents major environmental degradation that is not even identified much less discussed in the EA. Let me make some simple calculations. Let's assume that the average surface area of the ponds is 1.4 acres (half of the estimated maximum surface area). The allowable leakage rate is 5,000 gallons per day per acre of surface area so this equals 7,000 gallons of raw hog manure per day. The EA states that C&H went into operation in April 2013; that was about 882 days before our hearing today. The Arkansas Department of Environmental Quality (ADEQ) has allowed, by permit, leakage of hog manure out of the ponds totaling 6.17 million gallons during this period of operation. Given the hydrogeologic setting and the negligible subsurface investigation prior to pond construction, it is unlikely that the total leakage of hog manure into the karst groundwater system and ultimately to the Buffalo National River is smaller than this volume. In a giant omission, the EA does not even address where all this manure leakage has gone.

Comment 6. The EA gives no consideration to the risk of catastrophic sinkhole collapse of one or both of the manure holding ponds. Sinkholes in karst areas triggered by human activities, including the construction of sewage lagoons, waste storage ponds, and other impoundments, are unfortunately common events.

A number of earth-lined sewage lagoons and agricultural wastewater storage ponds were constructed in karst areas of the Ozarks during the 1960s and 1970s. Major leakage problems and, sometimes, catastrophic collapses plagued a number of these waste facilities and it was necessary to replace some of them with more dependable facilities. Engineers familiar with the major risks that such lagoons create in karst areas seldom recommend earth-lined lagoons in karst areas today. The probability that a particular lagoon or waste holding pond will collapse into a sinkhole is relatively low, but the risk of severe off-site impacts are substantial. In the case of the C&H Hog Farm manure ponds the off-site risks are enormous.

The Missouri Geological Survey (Aley et al., 1972) published an engineering geology monograph on catastrophic sinkholes induced by leaky impoundments in karst terrain that included case histories of two major sewage lagoon failures in Missouri. The following case histories of sinkhole collapses that have destroyed waste facilities in the karst areas of the Ozarks provide insight into the severity of the problem.

The **West Plains Sewage Lagoon** system was initially constructed as two lagoon cells. The system is located on the floor of the Howell Creek Valley, and is underlain by the Jefferson City/Cotter Formations, which are primarily dolomite. The lagoons both had compacted clay liners derived from local source material. Reference material for this case history is Aley et al. (1972) for the 1964 and 1966 collapses and Britton and Gerba (1984) for the 1978 collapse.

Two sinkholes formed in the smaller 7-acre cell of the West Plains system in 1964. A large sinkhole formed in the 42-acre cell in 1966 and completely drained all water in the lagoon into the groundwater system in a 52-hour period. This represented a mean flow out of the lagoon of 13,000 gallons per minute. Wastewater from the collapse

discharged from Mammoth Spring, Arkansas. The straight-line distance from the lagoons to the spring is about 20 miles.

During the period May 5 to 6, 1978 new sinkholes formed in the lagoon system and a total of 18 million gallons of sewage entered the groundwater system. During the period May 7 to 26, 1978 there were several outbreaks of gastroenteritis traced to this collapse. There were at least 759 cases of gastroenteritis associated with ingestion of sewage-contaminated water linked to this collapse. A viral etiology was suspected as the causative agent

The town of **Republic** is located about 10 miles west of Springfield, Missouri. The town's sewage lagoon system experienced a sinkhole collapse on October 29, 1968 which introduced 4 million gallons of sewage into the groundwater system in 24 hours. On October 31, 1968 a second sinkhole collapse occurred. Several springs in Shuyler Creek and two wells 1.5 miles away were contaminated (Aley et al., 1972). This lagoon system is underlain by geologic units that are part of the Boone Formation as mapped in Arkansas. The lagoon system had a compacted clay liner that failed.

A sinkhole formed catastrophically in the bottom of a lagoon serving the **Barnhart Dairy south** of Highlandville, Missouri and completely drained the lagoon. The collapse occurred on or about October 7, 1982. The U.S. Department of Agriculture, Soil Conservation Service, had provided technical and financial assistance to the landowner for construction of the lagoon. The lagoon had a compacted clay liner derived from local sources and the site had been evaluated prior to construction by the Missouri Geological Survey.

A fish kill began on October 8, 1982 at the Mountain Spring Trout Farm, which relies on water from Montague Spring. A total of 65,000 trout were killed. The spring is about 6,200 feet from the failed lagoon. Water from the spring turned chocolate brown in color and contained numerous particles. Microscopic examination showed the particles to be essentially identical with particles in fresh cow manure. Water at the spring had low dissolved oxygen and was covered with foam that had bubbles up to ¾ inch in diameter. Water from the spring had high fecal coliform and high fecal streptococcus bacterial numbers. The mean flow of the spring is about 5 cubic feet per second and the size of the recharge area is about 7.5 square miles. Based on soil maps of the area (USDA, SCS 1985) the site was underlain by Goss series soil with published permeability rates in the first 25 inches of soil of 2.0 to 6.0 inches per hour. Permeability rates for depths of 25 to 63 inches are 0.6 to 2.0 inches per hour. The site is underlain by geologic units that are part of the Boone Formation as mapped in Arkansas.

A final example is even closer to the vicinity of the hog farm and involved a small lake at a **golf course near Ridgedale, Missouri**. The site is near US Highway 65 and about 5 miles north of the Arkansas state line. The site is underlain by geologic units that are part of the Boone Formation as mapped in Arkansas. The collapse was covered by the press and the following information is derived from information available to the

public. I am professionally involved and cannot disclose information that has not already been made available to the public.

A large sinkhole about 80 feet long, 60 feet wide, and 35 feet deep formed on May 22, 2015 in the edge of a small lake. It drained much of the water from the lake. Photos indicate that no limestone bedrock was exposed in the large sinkhole. The lake was underlain by a compacted clay liner.

The waste ponds at the hog farm can store up to 2,735,922 gallons of hog manure. A sinkhole collapse involving one or both of the ponds would be a major ecological and public health disaster for the Buffalo National River and would do major economic damage to the tourism economy in Arkansas and nearby parts of Missouri. While sinkholes related to human activities may seem like rare events, they are not. That is why you can purchase insurance that covers damage from land subsidence and sinkhole collapses. In my 50 plus years of hydrogeology studies in karst areas I have investigated over 1,000 newly formed sinkholes that directly resulted from human activities. The issue is clearly of sufficient importance that it should have been included in an adequate environmental assessment for the C&H hog farm.

Perspective on the drastic impact of a large catastrophic discharge on a river is provided by the August 5, 2015 spill of 3 million gallons of mine water into a tributary of the Animas River in Colorado. The spill turned the river a sickly yellow and seriously impacted downstream water users in Colorado, New Mexico, and Utah. It also gained national press attention. On August 16, 2015 the flow rate of the Animas River at Durango, downstream of the spill, was 379 cfs; this was over 3 times the flow rate of the Buffalo River at Highway 65 on the same date (110 cfs). While acidic mine water is more colorful than manure, the volume of manure in the waste ponds at capacity is only slightly smaller than the volume of the spill into the tributary to the Animas River.

The manure ponds, like the Silver King Mine, represented a low probability but high risk situation. From press reports it appears that EPA is accepting liability for the costs associated with the mine spill. Since the FSA and SBA have failed to require an adequate level of hydrogeologic investigation for the manure ponds before guaranteeing the loans, will they assume the economic losses and cleanup costs of significant manure discharges or, worse yet, catastrophic collapses? I find nothing in the EA to indicate that they have. Because of the high risk of the manure operations, have these federal agencies required C&H Hog Farms and/or Cargill Pork to carry Environmental Risk insurance sufficient to pay for off-site damages? Again, I find nothing in the EA to indicate that this has been required. In the absence of agency guarantees or adequate insurance, it will be those who use the Buffalo River, and those who derive income from this pristine river, that will bear the burden of economic losses. If this hog operation is to continue then a condition of the guaranteed loans should be that either C&H Hog Farms or Cargill Pork carry adequate Environmental Risk insurance valid until the operation ceases and environmental restoration of the site has been completed. Based on the resources at risk, an Environmental Risk policy with total payout limited to $50 million would be

reasonable. This is part of the cost of doing risky operations in areas with extremely valuable resources.

Comment 7. The subsurface hydrogeologic investigation of the site for the manure ponds was inadequate for such a facility overlying the Boone Formation in an area where waters that would be impacted by a catastrophic failure have high resource values.

It appears that there were only three test borings made in the area, and it is unclear if any of them were beneath the area where the ponds have been constructed. The testing that was done was clearly done to characterize the sediments encountered and their possible utility for a compacted soil liner. That is fine, but is not indicative of an adequate subsurface hydrogeologic investigation. There are no data to indicate that any of the borings extended to a depth greater than 18 feet, and the EA states that none of the borings encountered limestone.

An appropriate investigation would have included many more borings. Furthermore, for an adequate investigation the borings should have extended to bedrock. Borings in areas especially prone to sinkhole collapse commonly encounter voids within the residuum and these voids are often near the contact between residuum and underlying rock. The depth to rock is nearby borings is an important parameter to record since substantial variations in depth are indicative of pinnacled bedrock and an elevated risk of sinkhole collapses. In-situ hydrologic testing of borings is highly desirable. Electrical resistivity or natural potential geophysical surveys are often useful in site characterization for risky structures in karst areas.

The fact that the hog farm now seeks to modify the manure holding ponds by adding a liner is a good idea. The rationale for taking this step is unknown. It could be that excessive leakage has been noted or is suspected. It could also be that C&H Hog Farms and/or Cargill Pork recognize the risks of major leakage or collapse and view this approach as a prudent action (which it is). However, while this action would likely reduce the risk, most sinkhole collapses are large enough to destroy the integrity of such a synthetic liner. Furthermore, the ponds have been used for manure storage for over two years and this use has likely destabilized the underlying residuum.

Comment 8. EA page 1-5. "Given that the facilities have been constructed and are currently in operation, it is not possible to conduct fieldwork or sampling to characterize conditions as they were prior to the land acquisition and construction that occurred in 2012 and 2013, and ongoing operations, which commenced in April of 2013."

This is not true. An adequate assessment under NEPA must consider the impacts of all lands used by this operation and conduct necessary fieldwork and sampling related to all of these lands. This operation is located in a karst area where contaminated waters disposed of on the surface can readily move into the underlying groundwater system without effective natural cleansing. Given this hydrogeologic setting an adequately

detailed evaluation is required for not just the portion of the 23.43 acre tract where the CAFO and waste holding facilities are located, but also for all of the lands planned for waste disposal.

C&H Hog Farms has chosen to locate this operation in an area that has high potential to contaminate groundwater supplies that contribute to the flow of the Buffalo River. The FSA and SBA have likewise chosen to take federal actions that require compliance with the National Environmental Protection Act (NEPA). The Buffalo River is a unit of the National Park System. The River is also identified as "Outstanding National Resource Water" and as "Extraordinary Resource Water". Because of these designations more stringent water quality standards apply. Because of the risks involved, and the major state and national significance of the waters involved, a comprehensive EA, if not an actual EIS, is necessary for this facility. A less risky activity or a less risky site would not have required the level of hydrogeologic scrutiny necessary for this operation.

The lands that must be assessed include the 23.43 acre tract, a portion of which is used for the CAFO and waste holding ponds, plus 17 fields encompassing 630.7 acres (based on EA Table 2-1) identified for waste disposal. Some portions of the 23.43 acre tract could actually be investigated as part of a "hard look" and certainly all of the waste disposal acreage (which represents approximately 96% of land used for this operation) should have been investigated. The EA is acknowledging that the responsible federal agencies and/or their consultants have not conducted the on-site field work necessary for an acceptable assessment in compliance with NEPA or, it would appear, with the intent of the Federal Court for the Eastern District of Arkansas.

Some of the features that a qualified and competent hydrogeological investigator would search for on and adjacent to the fields identified for manure disposal would include:

- Surface evidence of land subsidence or sinkholes. This would include the use of air photos plus a detailed on the ground inspection of all the tracts of land involved. The air photos would not be the Google type, but instead would be those available through the NRCS (another USDA Department). Air photos would need to be examined under a stereoscope for proper analysis.
- Locations of intermittent and perennial springs in or near the tracts on which manure would be deposited. Reconnaissance measurements of water temperature and specific conductance (at a minimum) should be made in streams and springs. Specific conductance measurements in any waters that might be present in the channel of Big Creek could identify springs discharging within the bed of the stream.
- Identification of gaining or losing stream segments on Big Creek and Dry Creek adjacent to, or within a mile of, fields identified for manure disposal.
- Location of any unplugged dug or drilled wells in or near fields identified for manure disposal.
- Any other features potentially reflective of the site's surface and groundwater hydrology.

Comment 9. EA page 3-3. "Animal wastes can impact surface water quality from organic matter, nutrients, and fecal bacteria."

This is an incomplete list; a complete list and assessment of each contaminant that can impact surface water and/or groundwater is needed. This is especially true in view of the fact that surface water and groundwater derived from the hog operation flows into the Buffalo National River. Many people using the River come in direct contact with the water and some, while it is not a desirable thing to do, many people accidentally or intentionally ingest water from the River and/or from tributary springs.

In addition to the parameters listed in the EA, animal wastes also deplete dissolved oxygen in water. Manure contains viruses and other pathogens, some of which have long survival times. Antibiotics and other pharmaceuticals in feed and/or given orally or by injection can pass through the digestive systems of the confined animals and become incorporated in manure. When transported off-site in surface water and/or in groundwater, they pose health risks to people and the environment. There is scientific concern that antibiotics in waste storage facilities can build antibiotic resistance in manure before it is spread. This issue needs to be discussed. At a minimum the EA needs to identify the following:

- The scientific names of all bacterial, viral, and other pathogens or potential pathogens likely to occur occasionally or routinely in hog manure.
- The technical names of all pharmaceuticals likely to be used and thus likely to occur occasionally or routinely in hog manure from the facility.
- Any other potential water contaminants likely to be present in hog manure including chloride and heavy metals and information on their likely concentrations.

Comment 10. EA page 3-6, bottom paragraph: "Spring discharge may be contributing to increased nitrate levels at these sites. There is evidence to indicate that nitrate contamination may be coming from sources outside the river's surface water drainage area."

The nitrate contamination from outside of the river's surface water drainage area is primarily attributable to livestock grazing on permanent pasture underlain by karstic rock units, and particularly the Boone Formation. Nitrates in livestock manure leach through the soil and into the underlying karst groundwater system where they are readily transported to springs. Macropores are especially important in moving water and contaminants through soils that overlie karstic groundwater units. The loading rates for nitrates in hog manure deposited on fields by the C&H operation is undoubtedly greater than the loading rates for nitrates from cattle on permanent pasture. It is incorrect to assume or imply that some of the nitrates in manure applied to permanent pasture or hayfields underlain by the karstic Boone Formation will not reach the groundwater system and be transported to off-site wells and to springs and ultimately into the Buffalo River.

Comment 11. In the section of the EA entitled "Affected Environment", subsection "Surface Water" pages 3-7 to 3-8 the BCRET studies are identified.

The EA described the BCRET study as an "in depth case study of the C&H Hog Farms". The BCRET team was established in late 2013 as a direct political response to citizen concern about the adverse environmental impacts of the C&H Hog Farm. The BCRET team consists of 13 people with PhDs, 3 with M.S. or M.B.A. degrees, 3 people with B.S. or B.A. degrees, and one person with an unidentified educational background.

Despite a platoon of PhDs and a squad of lesser degreed people, there is very little information about the BCRET "in depth" study that has been incorporated into the EA. The apparent explanation for this is that the study is long term academic research. It is not a gathering and assessment of information useful for determining health and environmental impacts expected to result from this hog operation or for protecting the River and springs that feed it. It is certainly not what people concerned with the Buffalo National River had expected from the appointment of this academic body.

The primary information from the BCRET work that is relevant to the EA is surface water quality data discussed and illustrated from pages 3-14 to 3-19. The data suggest, at least for the parameters measured, that surface water quality in Big Creek downstream of the hog farm operation is generally very similar to conditions upstream of the hog farm. An exception is nitrate-nitrogen which is higher downstream of the hog farm, however total nitrogen values upstream and downstream of the hog farm are similar.

It must be emphasized that these water quality data are for surface water. The impacts on groundwater have not been assessed. This omission is a critical fatal flaw to the adequacy of this EA. Although not mentioned in the EA, there is a large spring in the channel of Big Creek approximately 1,400 feet north of Field 5. This is the northern-most manure application field. To the best of my knowledge no work has been done to determine which manure application fields (if any) contribute recharge water to this spring or whether or not the manure holding ponds may contribute water to this spring. The lack of these data are a major omission in data needed for adequate compliance with NEPA.

Based on my count, graphs in EA Figures 3-2 through 3-7 show approximately 87 data points for the period September 1, 2013 to June 1, 2015. That is approximately one sample per week. If the contaminants that were sampled for entered the creek as surface water runoff pulses (the likely case because of the preponderance of water movement into the groundwater system rather than overland to the creek) they could easily be missed by once a week samples. Given site conditions, the few cases where downstream values substantially exceeded upstream values might be the only credible values from this portion of the BCRET studies.

Comment 12. EA Page 3-11. "One groundwater well (ID#930439555) is located adjacent to the farm buildings and supports farm operations (ANRC 2015c).

The well was completed in 2013. It was drilled to a total depth of 325 feet below ground surface (bgs), and the static water level in the well was 1,138 feet bgs."

This is clearly impossible. Perhaps the values are reversed; perhaps neither is correct. Missing such a glaring error suggests that the FSA did not carefully read the EA prepared on behalf of the agency.

In addition, the reference cited (ANRC 2015c) is for well number 930355365453. There is no well by that number in the well database. Also, there is no well number 930439555 in the database. How could you confuse the two numbers and not get either of them right? The EA clearly lacks professional quality work.

Comment 13. EA Page 3-13. "Since C&H Hog Farms and the fields where wastes are applied are located along a perennial waterway..."

This is incorrect. A perennial waterway is one that has flow throughout the year. Manure Fields 15, 16, and 17 are in the Dry Creek topographic basin, a tributary to Big Creek. The Dry Creek topographic basin encompasses 7.23 square miles. I examined this watercourse on May 17, 2013 and found it to be totally dry at a point 800 feet upstream of the mouth of this creek. This point was reached by car from a public road. Unless there is major water movement into karst groundwater systems, topographic basins of about 0.5 square miles or more in this area should have had surface water flow in the middle of May, and topographic basins of about 1 square mile or more should have perennial flow.

The watershed area for Big Creek upstream of the mouth of Dry Creek is 28.50 square miles. The watershed area for Big Creek upstream of the crossing of County Road 6330 (3,700 feet downstream of the furthest downstream manure field) is 42.10 square miles. The watershed area for lands tributary to Big Creek between these two points is 13.60 square miles.

I examined an aerial photo from the National Agriculture Information program taken in the summer of 2010. At the time of the photo Big Creek appears to have dried to pools without obvious flow between pools in Big Creek downstream of the mouth of Dry Creek and upstream of a spring located about 1,400 feet north of Manure Field 5. This observation indicates that a drainage basin area of approximately 13.60 square miles in which manure application fields are located is a major groundwater recharge area for the Boone Formation aquifer. The watercourse of Dry Creek and Big Creek in this area cannot be characterized as perennial waterways.

References

Aley, Thomas and Catherine Aley. 1989. Delineation and Characterization of the Recharge Area for Mitch Hill Spring, Buffalo National River, Arkansas. Ozark Underground Laboratory contract study for Buffalo National River, National Park

Service under PO PX7150-7-0314. Available in the research library at the Superintendent's Office, Buffalo National River, Harrison, Arkansas.

Aley, Thomas. 1988. Complex Radial Flow of Ground Water in Flat-Lying Residuum-Mantled Limestone in the Arkansas Ozarks. Proc. Second Environmental Problems in Karst Terranes and Their Solutions Conference. Pp. 159-170. National Water Well Association.

Aley, Thomas; James H. Williams; and James W. Massello. 1972. Groundwater contamination and sinkhole collapse induced by leaky impoundments in soluble rock terrain. Engineering Geology Series No. 5, Mo. Division of Geology and Land Survey. 30p.

Britton, Gabriel and Charles P. Gerba. 1984. Groundwater pollution microbiology. Wiley-Interscience Publications, pp. 149-150.

Hallberg, George R.; Robert D. Libra; and Bernard E. Hoyer. 1985. Nonpoint source contamination of ground water in Karst-carbonate aquifers in Iowa. IN: USEPA. Perspectives on nonpoint source pollution, EPA440/5-85-001, pp. 109-114.

U.S. Department of Agriculture, Soil Conservation Service. 1985. Soil survey of Christian County, Missouri. 115p. + maps.

U.S. Department of Agriculture, Soil Conservation Service. 1988. Soil survey of Newton County, Arkansas. 188p. approx. + maps.

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