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Comments on C&H Conceptual Closure Plan
Submitted via electronic delivery to
http://info.adeq.commentinput.com/?id=dV7hW
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The following are comments from the Buffalo River Watershed Alliance on the Conceptual Closure Plan prepared by Harbor Engineering for closure of the C&H waste storage ponds. These comments encompass two important areas: A) disposal of waste, and B) testing and monitoring.

A) Waste Disposal Recommendations

We strongly support the proposal to transfer all liquids, sludge and solids removed from both waste storage ponds to an appropriate location, or locations, outside of the Buffalo River watershed.
We also recommend that any " approved disposal facility", whether a licensed landfill or waste water treatment plant, also be located outside of the Buffalo River watershed due to the technical difficulties of removing all phosphorus from the discharge stream, a risk amplified in a karst terrain.

B) Testing and Monitoring Recommendations

BRWA recommends that the Conceptual Closure Plan be revised to include the following testing and monitoring components:

1) Include the use of grid soil sampling or soil borings after sludge and solids removal to measure nitrate and electrical conductivity to determine the extent of contaminant movement beneath the pond floors. The results will determine the extent of

soil removal required and establish whether monitoring wells are needed.

2) Depending on soil test/boring results, consider the installation of monitoring wells. Regardless of test results, continue monitoring the House Well, per BCRET protocols, and add the second house well as a second monitoring point. Wells should be tested both pre-closure and post-closure and should continue to be monitored for at least 3 years.
3) Continue monitoring at least the Big Creek Downstream station for phosphorus and dissolved oxygen and consider monitoring for E. coli at both the Downstream and Upstream stations. Continue stream monitoring for three years and reassess.

Supporting Comments

Following is Part A, the rationale for removing all waste components from the watershed, and Part B, testing and monitoring.

Part A) Waste components from the collection ponds need to be completely removed from the watershed.

Over the course of operation, pond waste has been spread within the Big Creek watershed, and as this activity has presented undue risks to the Buffalo National River and is, in fact, the very reason the State of Arkansas has negotiated C&H closure, it is critical that remaining waste be completely removed and processed outside of the watershed so as not to add to or exacerbate existing damage. There are several reasons why this is important, and they generally coincide with why it is necessary to establish a permanent moratorium on medium and large CAFO operations neat the Buffalo National River. These reasons are as follows:

- **The geology of the drainage area is underlain by the Boone Formation which is karst geology, making the Buffalo watershed particularly vulnerable to pollutants**

- **CAFO waste is spread on pastures using the Arkansas Phosphorus Index (API) which fails to account for groundwater or karst.**
- **Soils in the Buffalo River watershed are too thin to accommodate industrial level distribution of CAFO waste**

- **The record shows agency concerns and degradation in regard to the single facility permitted.**
- **The majority of the existing spreading fields used in the operation of C&H are already "above optimum" in regard to phosphorus.**

See Appendix A for additional detail and scientific opinion on the above.

Part B) Pre-Closure Testing and Post-Closure Monitoring must be included to provide assurances of adequate cleanup.

We recommend that the closure plan include requirements for pre-closure testing and post closure monitoring. BRWA has long contended that the C&H ponds were improperly designed and constructed and did not meet the regulatory requirements of the AWMFH, which justifies enhanced monitoring.

See Appendix B for substantiating comments supportive of this position.

<u>Other Guidance for Testing and Monitoring</u>

While ADEQ does not specify either testing or monitoring in its Waste Storage Pond Closure Guidelines, these steps are warranted in this case due to: 1) the inadequate design and construction of the ponds and, 2) indications that the ponds have contaminated groundwater, as evidenced by BCRET test results of the nearby House Well showing the ongoing presence of nitrate and chloride.

These two factors present sufficient reasons to justify and require further investigation.

While ADEQ's closure guidelines are brief and general, other states and NRCS provide more detailed regulatory guidance which should be incorporated into the closure plan as pre-closure and post-closure requirements for the C&H site:

Oklahoma

Regulation 35:17-4-21 **http://www.oar.state.ok.us/viewhtml/35_17-4-21.htm** includes the following requirements for post-closure monitoring:

(d) A post closure monitoring program shall be conducted for a period of at least three (3) years.

(f)(6)The owner shall grid sample soil from the bottom of the waste retention structure and, at the owner's election, shall either:

(A) have the samples analyzed in a State certified laboratory for nitrate-nitrogen and electrical conductance; or

(B) analyze samples in the field for nitrate-nitrogen and electrical conductance using field leaching procedures and a test kit, with laboratory confirmation by sending one sample per every twenty (20) samples to a laboratory for analysis.

(f)(7) The owner shall develop a plan, subject to Department approval, regarding soil removal, if necessary, based on the grid sample data.

(f)(9)The Department may require monitoring wells if evidence indicates that contamination has migrated to the groundwater based on site specific conditions.

NRCS Code 360, Waste Facility Closure

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1253367.pdf includes the following recommendation for pre-closure testing:

1. *Conduct preclosure soil and water (surface and subsurface) testing to establish baseline data surrounding the site at the time*

of closure. Establishing baseline data can be used in the future to address soil and water issues.

Nebraska

The University of Nebraska prepared a white paper titled, "Closure of Earthen Manure Structures (Including Basins, Holding Ponds and Lagoons)"

https://digitalcommons.unl.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1003&context=biosysengpres

The abstract states (emphasis added), *"This paper is a summary of what is known scientifically about the closure of earthen manure structures without artificial liners, including lagoons, storage basins, and runoff holding ponds, and what needs to be examined further to increase our understanding of the dynamics of closing them in an environmentally safe manner.* ***This information should be useful as a guide for state regulatory agencies considering rules for closure*** *and for academicians and consultants who work with livestock production facilities.*"

BRWA contends that the C&H ponds were poorly designed and constructed (see Appendix B). Therefore more attention to pre-closure testing and post-closure monitoring is justified. The following Nebraska recommendations provide guidance in that regard:

The **Introduction** states (emphasis added),

"Poorly designed or poorly constructed earthen liners, as well as badly eroded ones, can allow significant movement of contaminants into the soil adjacent to or below the structure before the time of closure. ***Soil borings may be necessary to accurately assess the movement of nutrients below inadequate earthen structures at the time of closure and to determine the proper procedures necessary for closure***."

The section on **Nutrient Issues** includes the following regarding monitoring (emphasis added):

"Nitrogen is the contaminant that is most likely to affect ground water. ***Movement of nitrogen from an abandoned storage facility can be***

***estimated by measuring organic, nitrate and ammonium nitrogen in the ground water, both up and down slope of the structure**."*

The section on **Seepage and Contamination Potential** includes the following warning regarding ponds which were improperly designed or constructed, supporting the need for enhanced monitoring (emphasis added):

*"…when a lagoon is closed and allowed to dry, ammonium could convert to NO3-N and move more rapidly towards the groundwater. … **Any facility that was improperly sited, designed, and constructed would have a greater risk of groundwater contamination due to excessive seepage losses**."*

Need for Ongoing Monitoring of Big Creek

In addition to monitoring in the area of the ponds, water monitoring is also required in Big Creek. Dr. Andrew Sharpley and others have written extensively about the risks of "Legacy Phosphorus".

"*Water Quality Remediation Faces Unprecedented Challenges from "Legacy Phosphorus"*
https://bigcreekresearch.org/docs/Legacy%20P%20viewpoint.pdf states (emphasis added),

*Agricultural conservation and nutrient management programs have been very successful at reducing P losses in runoff at the edge-of-field, but there has often been disappointingly little improvement in downstream water quality and ecology. Growing evidence indicates that a major reason for this is the chronic release of P from "legacy P" stores, which have accumulated in watersheds and water bodies. As a result, we face unprecedented challenges in meeting water quality targets, given that **P legacies from past land management may continue to impair future water quality, over time scales of decades, and perhaps longer.***

"Phosphorus Legacy: Overcoming the Effects of Past Management Practices to Mitigate Future Water Quality Impairment"
https://bigcreekresearch.org/docs/Legacy%20P%20across%20the%20watershed%20continuum.pdf states (emphasis added),

A portion of P inputs from nonpoint and point sources within a watershed can accumulate at various locations along transport pathways within the land–freshwater continuum. These include soils, in downslope areas, and in ditch, stream, river, lake, wetland, riparian, and estuarine sediments and biomass (Fig. 1). ***Accumulated P can be remobilized or recycled, acting as a continuing source to downstream water bodies for years, decades, or even centuries*** *(McDowell et al., 2002). This has been referred to as legacy P (Kleinman et al., 2011a). Legacy P is particularly problematic because it is characterized by intermediate storage and remobilization along slow or tortuous flow paths between the original source (agricultural fields or point-source discharges) and the watershed outlet.*

According to soil test reports for the application fields provided in C&H annual reports, and in BCRET reports, almost all of the fields currently contain phosphorus levels which far exceed crop requirements. As stated above, these fields will continue to discharge phosphorus for years, if not decades, to come. Monitoring of Big Creek at the Downstream Station established by BCRET should continue. Phosphorus is a major contributor to algae blooms, low dissolved oxygen, and eutrophication of streams and the proximity of the Buffalo National River requires and justifies ongoing monitoring.

In addition, Big Creek has been found to be impaired due to E. coli contamination and low dissolved oxygen. ADEQ must take steps to identify and mitigate the sources of this contamination, which will require ongoing monitoring. Big Creek is a major tributary of the Buffalo River and steps should be taken to ensure that Big Creek is not contributing to its degradation.

<u>APPENDIX A</u>

Substantiating Comments Regarding the Need for Complete Removal of Waste Pond Material from the Buffalo River Watershed.

A**) The geology of the drainage area is underlain by the Boone Formation which is karst geology, making the Buffalo watershed particularly vulnerable to pollutants**

The bluffs, springs, and caves that make the Buffalo so valuable as a nationally recognized tourism destination, also highlight its sensitivity to pollutants. The presence of karst is not subjective but obvious to the casual observer from the weathered dissolution features exposed throughout the watershed. Though karst geology in the area has long been scientifically recognized, there has been intense discussion on this topic over the last six years in regard to its nature and importance in regard to safeguarding the Buffalo. To that end, we are including limited selective references to recent studies and quotations to illustrate the importance of considering karst in regard to protecting the Buffalo River watershed from pollutants.

- Thomas Aley, Arkansas Professional Geologist 1646, president Ozark Underground Laboratory, Inc. in a report regarding C&H Farms provided to Ozarks Society and Buffalo River Watershed Alliance on May 24, 2018:

  "It is my opinion that an average of about 65% of the water that reaches the Buffalo River from areas underlain by the Boone Formation has passed into and through the karst aquifer. The remaining 35% of total water yield is surface runoff. Water enters the karst aquifer through both discrete and diffuse recharge. Discrete recharge zones include sinkholes, losing streams, and multiple other points that have little or no surface expression. Sinkholes and losing stream segments are abundant in the Boone Formation." "It is my opinion that karst groundwater systems, specifically including those in the Boone

Formation, are highly vulnerable to groundwater contamination and pollution."

- J. Berton Fisher, Ph.D., CPG, PG (TX#0201) of Lithochimeia, LLC from expert opinion prepared for BRWA regarding C&H Farms provided May 27, 2017:

  "Specifically, the Facility and nearly all Fields are located on the Lower Mississippian Boone Formation, a course-grained fossiliferous and fine grained limestone interbedded with anastomosing and bedded chert. The Boone Formation is well known for dissolution features, such as sinkholes, caves and enlarge fissures." "Karst terrain presents hazards to both water quality and the integrity of physical structures. In karst terrain, surface water can rapidly enter groundwater systems after passing through thin layers of permeable soil and solution-enlarged fractures in bedrock."

- Michael D Smolen, Ph.D. Lithochimeia, LLC from expert opinion prepared for BRWA regarding C&H Farms provided June 1, 2018:

  "Groundwater flow direction is an important concern to this application because of the karstic geology, where it cannot be assumed that groundwater follows surface topography. Dye studies by Brahana et al., Electrical Resistivity studies by Fields and Halihan, Ground Penetrating Radar studies by Berry et al., and drilling by Harbor(2016), have confirmed the existence of karstic limestone, epikarst vadose zone, and gravel deposits in the application fields that result in diverse patterns of subsurface flow."

- Lee J. Florea, Ph.D., P.G., from expert opinion prepared for Ozark Society in the matter of C&H Farms, June 4th, 2018:

  "The area surrounding Mt. Judea, and the larger Big Creek watershed are most certainly a karst landscape. Sinkholes, cave entrances, and springs were all observed during my 2014 visits, first sponsored by BCRET and later that same year as a participant in the Friends of Karst meeting hosted by Dr. Matt Covington, also of the University of Arkansas. Sections of Big Creek may gain and lose flow along the reach of the main step and of the tributaries, a strong indication of underflow through conduits." "Karst is easily one of the most complex aquifer types to develop accurate models to predict groundwater flow."

- James C. Petersen, aquatic biologist and a water-quality hydrologist and worked for more than 36 years with the U.S. Geological Survey Arkansas Water Science Center, in opinion prepared for Ozark Society in the matter of C&H farms on May 31, 2018:

  "In my opinion, the karst topography and geology of the area near C&H Hog Farms, including part of Big Creek located upstream from BCRET monitoring site BC6 and downstream to the Buffalo River, present issues for agricultural activities and the collection of data used for hydrologic studies. These issues are not applicable, or not applicable to

the same degree, in areas without karst. These karst-specific attributes include rapid movement of groundwater (up to thousands of feet to miles per day; Brahana and others, 2017), little decrease of contaminants, relatively common movement of groundwater beneath surface elevation divides, loss of surface water from streams to groundwater, and gain of groundwater to streams."

- Dr. Robert Blanz chief technical officer for ADEQ in deposition on the matter of C&H farms responding to questions regarding ADEQ's permit denial determination:

  "We don't know anything about the subsurface permeability, nor do we know the flow direction, which in karst is very difficult to determine. So the question there is, what — which way is the groundwater going and in what speed and what amount, and given the environment there, it could very well be impacting the surface water."

- Jamal Solaimanian, Engineering Supervisor at ADEQ in deposition on the matter of C&H farms responding to a question of where waste might end up if there were a catastrophic failure in a pond liner:

  "You know, as we discussed that before, the karst is very -- the karst is very difficult to basically know the groundwater flow directions because, you know, it's -- but if we hit that, you know, this can pretty much -- if it gets such a hole, it's pretty much all the ways you get to the groundwater and eventually it recharges to any type of spring or to any -- recharges back into any of the surface waters, then that would be a problem, yes."

- Jon Fields and Dr. Todd Halihan of Oklahoma State University prepared a taxpayer funded report for the Big Creek Research & Extension Team entitled: *Electrical Resistivity Surveys of Applied Hog Manure Sites, Mount Judea, AR.* The geographic description in the report included the following:

  "The hydrologic setting for the sites is a mantled epikarst (soil over epikarst over competent carbonate bedrock). Precipitation enters the subsurface through the soil zone and enters the epikarst area. Fluids move through the epikarst area and enter the unweathered competent bedrock through fractures and other openings. Understanding the storage and transmission properties of these three zones is essential to understanding the migration of nutrients from applied hog manure in the area. This section will discuss the hydrologic settings of the soil zone, epikarst zone, bedrock, the local water table and the application of hog manure at the time of data collection."

- David Mott, an engineering geologist, former hydrologist with NPS, former regional hydrologist with the U.S. Forest Service, and having held various leadership positions with the USGS states in the *Water*

Resources Management Plan prepared for the Buffalo National River at the request of the National Park Service in 2004 states:

> ***"Discrete recharge is a concentrated, rapid movement of water to the subsurface drainage network, most common in areas dominated by karst, which is typical in the Ozarks. Sinkholes and losing streams are examples of discrete recharge. Most sinkholes and losing streams (where a portion of the reach goes dry) are found to be underlain by the Boone formation in northwest Arkansas and most springs emerge in the Boone, as shown in Figure 19 (Aley, 1999). Groundwater pollution is most common in limestone and dolomite areas such as the Boone formation because discrete recharge does not allow for the effective filtration and absorption of pollutants. Faster travel rates provide less time for bacterial and viral die off as well. This is important for water quality management of the Buffalo River since almost 32% of the watershed is underlain by the Boone formation (Aley, 1982)."***

- Dr. Van Brahana produced a peer reviewed report (in press 2017) entitled: "*Utilizing Fluorescent Dyes to Identify Meaningful Water-Quality Sampling Locations and Enhance Understanding of Groundwater Flow Near a Hog CAFO on Mantled Karst—Buffalo National River, Southern Ozarks".* Dr. Brahana's conclusions were as follows:

> ***"Based on the results of the dye tracing described herein, the following observations of groundwater flow in the Boone Formation in the Big Creek study area can be used for designing a more reliable and relevant water-quality sampling network to assess the impact of the CAFO on the karst groundwater and to gain further understanding of the karst flow."***
>
> 1. ***Although the study area is mantled karst, subsurface flow is very important, and forms a significant part of the hydrologic budget.***
> 2. ***Groundwater velocities in the chert/limestone portion of the middle Boone Formation were conservatively measured to be in the range of 600-800 m/d.***
> 3. ***Conduits in pure-phase limestones of the upper and lower Boone have flow velocities that can exceed 5000 m/d.***
> 4. ***Groundwater flow in the Boone Formation is not limited to the same surface drainage basin, which means that anomalously large springs should be part of the sampling network (Brahana, 1997).***
> 5. ***Because the Buffalo National River is the main drain from the study area, and the intensive contact of the river water by uses such as canoeing, fishing, swimming, and related activities, large springs and high- yield wells should be included in the sampling network.***
> 6. ***Maximum potential transport times of CAFO wastes from the land surface appear to be greatest during and shortly after intense precipitation events. Minimum groundwater flow occurs during droughts. Sampling should accommodate these considerations.***

- ADEQ statement of basis in the denial of CAFO permit No. 5264-W AFIN 51-00164:

  "The facility is located on the Boone Formation, an area known to have karst. The hydrology of karst terrain is 'created from the dissolution of soluble rocks, principally limestone and dolomite.' Karst terrain is characterized by springs, caves, and sinkholes.6 'Karst hydrogeology is typified by a network of interconnected fissures, fractures and conduits emplaced in a relatively low-permeability rock matrix.' In karst, the groundwater flow usually occurs through these networks of interconnected fissures, and groundwater may be stored in that matrix. Aquifers in karst are extremely vulnerable to contamination.

  The presence of karst triggers additional considerations for siting and design as stated in the Animal Waste Management Field Handbook (AWMFH). The following examples illustrate some of the issues presented by karst:

  > ***AWMFH, 651.0702(c) states:***
  > ***Sinkholes or caves in karst topography or underground mines may disqualify a site for a waste storage pond or treatment lagoon.***
  >
  > ***AWMFH, 651.0702(l) states:***
  > ***Common problems associated with karst terrain include highly permeable foundations and the associated potential for groundwater contamination, and sinkholes can open up with collapsing ground. As such, its recognition is important in determining potential siting problems.***

  ADEQ has determined that a detailed geological investigation of the facility is required because karst includes highly permeable foundations with the associated potential for groundwater contamination and potential for sinkholes to open up with collapsing ground or cause differential settlement."

- John Bailey, Arkansas Farm Bureau Federation, in public comments submitted in regard to permit 5264-W:

  "Although ADEQ spends a significant amount of time in the statement of basis discussing karst, Arkansas Farm Bureau has never argued that karst was not present."

B) CAFO waste is spread on pastures using the Arkansas Phosphorus Index (API) which fails to account for groundwater or karst.

The API formula used in CAFO nutrient management planning uses special calculations in regard to surface run-off allowing an operator to distribute phosphorus in excess of what crops can absorb. A significant weakness of the API is its failure to consider karst or any subsurface geological risk factors when determining the risk of waste applications to waters of the state. As the API fails to account for groundwater or karst, this presents undue risks relative to CAFOs in regard to the Buffalo River watershed. Smolen (2017) had this to say in regard to limitations of the API in regard to various aspects including subsurface flows:

> ***"The API, as used in planning the NMP, has several severe shortcomings. First, although it purports to address risk of degrading water quality, it does not address some important factors affecting transport to the receiving waters. In reality it only compares the source term of the Index not the risk of polluting the receiving waterbody. The PI was derived from a series of rainfall simulator studies of runoff produced from application of a synthetic rainstorm on a small area of soil. This makes it very sensitive to application rate and characteristics of the waste, but not to many other physical factors such as karst, surface drainage, gravel bars, or management factors that affect delivery to the stream."***
>
> ***"Because it was developed from very short-term, micro-studies, it cannot address the larger- scale effects of season, groundwater pathways, or weathering, leaching, or eroding of enriched soils."***
>
> ***"The API does not address the risk due to increased runoff due to soil compaction from livestock hoofs or increased drainage efficiency due to subsurface gravel bars, karst geology, or increased drainage efficiency through surface or subsurface features."***

The allowed use of the API by CAFO operators in Arkansas is a compelling reason to not permit CAFOs in the sensitive geological watershed of Arkansas' singular national river.

C**) Soils in the Buffalo River watershed are too thin to accommodate industrial level distribution of CAFO waste**

An electrical resistivity survey commissioned by the Big Creek Research and Extension Team (BCRET) under the authorization of ADEQ was performed on three of the spreading fields. As part of this study Dr. Todd Halihan's Oklahoma State University team performed a *Soil Structure Analysis.* The following discussion from the reporting results (6.2.1) Fields, Halihan (2016) will reference fields as they were numbered under their prior Reg 6 permit. An excerpt from the analysis:

“***The soil structure analysis consists of soil thickness and soil properties. Soil thicknesses for each site were picked and confirmed through hand dug borings on site conducted during previous University of Arkansas work on these fields. The borings were dug to refusal, or where the soil turns to epikarst (significantly weathered bedrock).”***

The following are excerpts from the soils analysis of the three distinct fields. The reader should take note of the thinness of soils particularly to references under 40” in depth and also under 20” in depth.

Field 5a analysis:

“***Field 5a is a low-lying grazing area with low relief and an uneven topsoil surface. Field 5a exhibits average soil thicknesses of 0.5 to 4.5 meters (1.5 to 14.75 feet). Soil thickness on Field 5a varies throughout. There is a significant resistivity difference between the highly to very resistive north and more electrically conductive southern portion (Figure 10). A broad topographic mound is situated northwest of the center of Field 5a; the soil thickness is thinner to the far north and far west of the field (see Appendix 3). This trend is consistent with the direction to which the alluvium would be deposited nearest to the stream. Soils on transects MTJ06 and MTJ07 (Figure 12A) are electrically conductive features, <u>which thin to near zero soil thickness toward the far north</u>.”***

Field 12 analysis:

“***Field 12 exhibits similar average soil thicknesses at 0.7 to 4 meters <u>(2.25 to 13 feet). Soil thickness on Field 12 is not as variable as Field 5a, but there is a very resistive region of the site in the shallow soil area of the southwest portion</u> of the investigation area (Figure 11). Field 12 is flatter and the soil thins to the west (see Appendix 3). MTJ12 (Figure 13A) shows thinning where the electrically conductive features become thicker as the image gets closer to the stream. This trend is consistent with the direction to which the alluvium would be deposited nearest to the stream. Areas where the soil profile is thinner on the images are consistent with the rocky soils encountered when electrodes were placed for data collection.”***

Field 1 analysis:

“***Field 1 is a grazing area situated on a hillside east of the stream. It has low to moderate relative relief and an uneven topsoil surface. <u>Field 1 shows an average soil thickness of 0.5 meters (1.5 feet)</u> determined from the ERI surveys of MTJ111 and MTJ112 (Figure 17) and soil sampling. Hand dug confirmation borings were not conducted on this field. This site was not studied extensively enough to determine differences in resistivity correlations across the entire field. Field 1 has thinner and rockier soils than either Fields 5a or 12.”***

The AWMFH 651.0504(d) *Soil Characteristics, depth to bedrock* states the following in regard to thin soils:

> ***"The depth to bedrock or a cemented pan is the depth from the soil surface to soft or hard consolidated rock or a continuous indurated or strongly cemented pan. A shallow depth to bedrock or cemented pan often does not allow for sufficient filtration or retention of agricultural wastes or agricultural waste mineralization by-products. Bedrock or a cemented pan at a shallow depth, less than 40 inches, limits plant growth and root penetration and reduces soil agricultural waste ad- sorptive capacity. <u>Limitations for application of agricultural wastes are slight if bedrock or a cemented pan is at a depth of more than 40 inches, moderate if it is at a depth of 20 to 40 inches, and severe at a depth of less than 20 inches.</u>"***
>
> ***"Agricultural wastes continually applied to soils that have moderate or severe limitations because of bed-rock or a cemented pan can overload the soil retention capacity. This allows waste and mineralization byproducts to accumulate at the bedrock or cemented pan soil interface. When this accumulation occurs over fractured bedrock or a fractured cemented pan, the potential for ground water and aquifer contamination is high. Reducing waste application rates on soils that have a moderate limitation diminishes ground water contamination and helps to alleviate the potential for agricultural waste overloading. If the limitations are severe, reducing waste application rates and split applications will lessen overloading and the potential for contamination."***

Field 1's average depth falls into the *severe limitation* range. Field 5a has areas that include both *moderate* and *severe* limitations and field 12 has areas that fall under the *moderate limitation*. In addition, it is a serious concern that the point of refusal is epikarst which means that unabsorbed nutrients applied to thin soils will filter directly into fractured limestone pathways. The Oklahoma State study identifies epikarst beneath the soil layer for all three fields:

6.2.2 Epikarst Structure

> ***"The epikarst zone consists of the weathering profile of the underlying competent bedrock. Epikarst is visible on Field 5a (Figure 12), Field 12 (Figure 13), and Field 1 (Figure 17) as a more resistive to electrically conductive region below the base of the soil and above the highly resistive competent bedrock zones. No confirmation borings are available to evaluate rock properties in these zones on any of the sites. The thickness of the epikarst zone is highly variable (thicknesses range from 2 to 23 meters or 6.5 to 75.0 feet) throughout each field but averages 4 to 7 meters (13 to 23 feet) thick."***

AWMFH 651.0703(2) page 7-15 *Factors affecting groundwater considered in planning* states the following regarding shallow soils over epikarst:

> ***"Deeper soil increases the contact time a contaminant will have with mineral and organic matter of the soil. The longer the contact time, the greater the opportunity for attenuation. Very shallow (thin to absent) soil overlying permeable materials provides little to no protection against groundwater contamination."***

As testing was limited to only three fields and they *all* had thin soil limitations, it is reasonable to expect that most pastures in the Buffalo River watershed will have similar thin soil limitations. These were not upland pastures of which there are many in the watershed. Such highlands will be particularly prone to cherty thin soils underlain by epikarst. The thinness of soils in the watershed combined with karst groundwater flows clearly underscores the potential risk from the spreading of industrial levels of CAFO waste to a watershed that supports national tourism destination.

D) The record shows agency concerns and degradation in regard to the single facility permitted.

During the operation of the C&H CAFO from 2013 to present, there have been a number of concerns expressed by state and federal agencies along with data from studies that indicate degradation potentially linked to CAFO run-off. We have listed a handful of these here:

- Big Creek Research & Extension Team (BCRET) testing of Big Creek immediately downstream of the facility shows degradation for nitrates

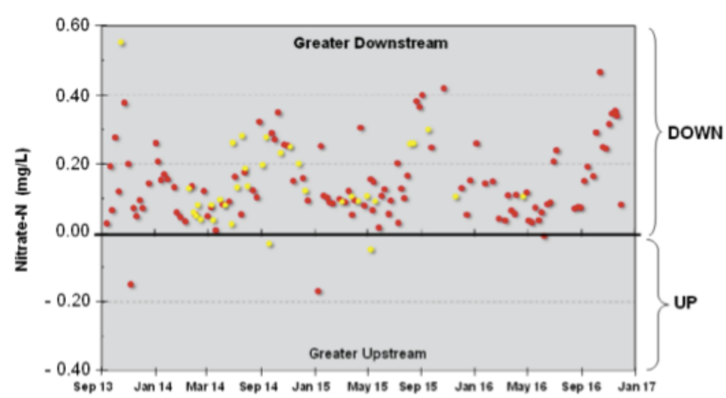

Figure 1. Difference in NO_3^-N concentration in Big Creek up- and downstream from the C&H CAFO. Following the "upstream vs. downstream" comparative criterion that is the basis of the BCRET study, the data clearly indicate that the C&H CAFO is contaminating Big Creek with nitrate. From BCRET (2017a; note that explanation was not given for the yellow versus red color-coding).

Nitrates are being measured by the *Big Creek Research and Extension Team* (BCRET) of the *University of Arkansas Division of Agriculture* both upstream and downstream of the facility and nearby spreading fields Figure 1.

Regarding this data illustration, Burkholder in a report to Buffalo River Watershed Alliance (2017) states:

"The data clearly indicate that the C&H CAFO is contributing swine waste pollution to adjacent public trust waters. The nitrate levels downstream from this CAFO commonly are levels that have been shown in other research to be toxic to sensitive aquatic life (Camargo et al. 2005, Guillette et al. 2005). The nitrate signal is stronger than the E. coli signal because nitrate does not adsorb to sediment particles and settle out (Stumm and Morgan 1996); instead, nitrate is highly soluble and is transported rapidly from swine CAFOs to receiving surface and groundwaters (Evans et al. 1984, Stone et al. 1998, Ham and DeSutter 2000, Mallin 2000, Krapac et al. 2002), the latter problem being exacerbated in underlying karst geology (Mellander et al. 2012, Knierim et al. 2015) which is characteristic of the region that includes the C&H CAFO (Hudson et al. 2001, 2011)."

ADEQ has acknowledged Petersen's analysis (aquatic biologist and a water-quality hydrologist) as compelling evidence that between the upstream and downstream stations, C&H is likely to be a contributing factor:

"-BCRET data document that nitrate-N is variable; however, Figure 12 of the April 1 to June 30, 2018 BCRET Quarterly Report demonstrates that nitrate-N is higher downstream (BC7) than upstream (BC6). Chlorides and nitrates follow similar seasonal fluctuations in that they are higher during summer and autumn months when stream discharge is most influenced by groundwater. ADEQ reviewed Petersen's May 31, 2018 expert report, which presents an analysis of temporal trends among nitrate-N and E. coli from January 2014–December 2017 at ---BC6 and BC7. Mr. Petersen's analysis presents decreasing trends of ammonia and chlorides and increasing concentrations of E. coli at BC6. Yet, increasing concentrations of nitrate-N were observed downstream at BC7. The conflicting temporal analysis prompted Mr. Petersen to further review trends upstream to downstream. By analyzing paired concentration data (collected same day) at BC6 and BC7 from January 2014 through December 2017, Mr. Petersen reports significant increases in total nitrogen, ortho-phosphorus, and chlorides, but nonsignificant changes in E. coli and nitrate-N. The significant increase of nitrate-N in the house well and

ephemeral stream does correspond to increases of total nitrogen at BC7. Mr. Petersen's analysis illustrates the complexities of evaluating water chemistry in karst systems. "

- M.D. Smolen, PH.D. who's specialty is water quality analysis as affected by agricultural waste management, examined the BCRET data and had this to say in regard to phosphorus measurements captured at the monitoring stations upstream and downstream of C&H:

  "Total Phosphorus concentration increases with low stream flow, and this relationship is stronger at the downstream station than at the upstream station, supporting the conclusion that C&H is the source."

- M.D. Smolen, PH.D. examined the BCRET data and noted statistically significant changes in nitrate contamination in the C&H house well and also the ephemeral stream:

  "Sampling of the ephemeral stream and house well both suggest there is nitrate contamination from hog manure sources. The results, however, are difficult to interpret definitively due to lack of controls."

- In a letter dated October 6, 2015, Kevin Cheri, Superintendent for the National Park Service (NPS) to Director Keogh of ADEQ noted the following (excerpt):

  "NPS has also been monitoring the United States Geological Survey (USGS) sites collecting dissolved oxygen data on tributaries to the Buffalo River. Two of these sites have chronically been below the allowable limits in Regulation 2.505. These are Bear Creek near Silver Hill (USGS Site 07056515) (ADEQ site- BUFT12) (Figure 2) and Big Creek at Carver (USGS Site 07055814) (ADEQ site- BUFT06) (Figure 3). These streams have had minimum dissolved oxygen values of 3.9 and 4.5 mg/L, respectively, well below the standards."

- Chris Racey, Chief - Fisheries Division, Arkansas Game and Fish Commission wrote to Jim Wise of ADEQ on March 16, 2016 (excerpt):

  "AGFC Biologists are also concerned with the Dissolved Oxygen levels of Big Creek, a Buffalo River tributary in Newton County near Gene Rush Wildlife Management Area. Summer algal blooms, likely caused by excess nutrient levels, appear to be impairing this creek. Smallmouth bass require 6.0 mg/L DO for optimal growth, and this

water quality standard is not being met for several months of the year, per the USGS gage station at Big Creek. We concur with the recommendations of the National Parks Service that Big Creek should be considered for the list of 303(d) streams."

- On December 15th, an *Assessment Methodology* session was sponsored by ADEQ at their N Little Rock headquarters to review with selected stakeholders the process for producing the 303(d) list. During this meeting, Billy Justus and Lucas Driver of the *U.S. Geological Survey (USGS) Lower Mississippi-Gulf Water Science Center* presented a slide presentation entitled: *An Evaluation of Continuous Monitoring Data for Assessing Dissolved-Oxygen in the Boston Mountains.* Big Creek was one of five waterbodies reviewed in the presentation. Notable was the slide listed in Appendix D5 showing dissolved oxygen at 20.5% of unit values below 6mg/L. The exceedance level over which impairment is indicated is 10% at 20 degrees centigrade. These USGS statistics show a clear indication of impairment.
- ADEQ's 2018 proposed 303(d) list of impaired waterbodies include Big Creek and 14.32 miles of the Buffalo National River. The Buffalo shows impairment both upstream and downstream of Big Creek's confluence. ADEQ describes the proposed impairment of Big Creek and the Buffalo in the following response to comments on the Regulation 5 permit from January:

"ADEQ considers all readily available data to determine the status of water quality in Arkansas and to identify waterbodies that fail to meet standards defined in APC&EC Regulation 2. ADEQ recently completed water quality assessments for the development of a proposed 2018 303(d) List and 305(b) Integrated Report as required by the Clean Water Act. In the Buffalo River Watershed, four Assessment Units (two sections of Big Creek and two sections of the Buffalo National River) have been identified as impaired: three for bacteria, and one for dissolved oxygen. Based on data for submitted by USGS for the 2018 303(d) list, ADEQ proposes listing Big Creek (AR_11010005_022) as impaired for dissolved oxygen."

The concerns and the data speak for themselves in that allowing medium and large CAFO operations in the watershed of a National River presents undue risk to the value of the resource.

E) The majority of the existing spreading fields used in the operation of C&H are already "above optimum" in regard to phosphorus.

M.D. Smolen, PH.D. who has 35 years of experience in water quality management as affected by agricultural waste management has this to say about phosphorus in the spreading fields in a report (Smolen, 2017).

> ***Nutrient Management and Waste Disposal***
> ***"The C &H Hog Farms nutrient management plan (NMP) is based on Nitrogen, resulting in excess Phosphorus application. This amounts to disposal of Phosphorus as most of the fields already have medium to very high soil test P levels. Table 1 shows the P-status of each field in the Permit Application with its most recent Soil Test Phosphorous (STP) and the Phosphorus (P2O5) fertilizer recommendation from the Arkansas Cooperative Extension Service. According to these recommendations these fields need very little or no P2O5. Note virtually all the fields included in the NMP, particularly those that were used previously have "Above Optimum" P-status."***
>
> ***"In my opinion, application of wastes to fields with P-Status higher than "Above Optimal" should be considered waste disposal, making them subject to storm water rules . Considering the number of fields at Optimal or Above Optimal STP, using a P-basis for nutrient management would severely reduce the amount of land available for waste application without additional BMPs".***

TABLE 1 SOIL P-STATUS, FERTILITY RECOMMENDATION, AND SUITABILITY FOR WASTE APPLICATION BASED ON STEEPNESS AND SHAPE OF APPLICATION AREA

Field	spread-able ac	STP	P-Nutrient Status	Recommendation P2O5 lb/ac	Suitability for waste application
Field 1	8.4	95	Above Optimum	0	Fair – contorted
Field 2	6	108	Above Optimum	0	Poor – Steep, contorted
Field 3	15	89	Above Optimum	0	Good
Field 4	7.2	75	Above Optimum	0	Poor – steep, contorted
*Field 5**	9.7	63	Above Optimum	0	Good
*Field 6**	5.6	116	Above Optimum	0	Good
Field 7	64	89	Above Optimum	0	Good
Field 8	7.2	82	Above Optimum	0	Good
Field 9	25	82	Above Optimum	0	Good
Field 10	14	72	Above Optimum	0	Good
Field 11	14	62	Above Optimum	0	Poor - contorted
Field 12	11	88	Above Optimum	0	Good
Field 13	12	86	Above Optimum	0	Good
Field 14	8.1	75	Above Optimum	0	Fair - steep
Field 15	23	72	Above Optimum	0	Good
Field 16	15	66	Above Optimum	0	Good
Field 17	32	86	Above Optimum	0	Good

APPENDIX B

Substantiating Comments Regarding Inadequate Pond Engineering and Maintenance

BRWA has previously commented extensively regarding the deficiencies of the C&H engineering plans and their failure to comply with the AWMFH, particularly the lack of adequate geological investigations and analysis and lack of acknowledgement of the presence of karst geology. The following comments support this position and justify the need for pre-closure testing and post-closure monitoring:

The permeability determination for liner material does not include particle analysis as per AWMFH guidance

The AWMFH appended 10D under soil properties page 10D-5 describes the criteria for determining permeability.

"The permeability of soils at the boundary of a waste storage pond depends on several factors. The most important factors are those used in soil classification systems such as the Unified Soil Classification System (USCS). The USCS groups soils into similar engineer- ing behavioral groups. The two most important factors that determine a soil's permeability are:

1. ***The percentage of the sample which is finer than the No. 200 sieve size, 0.075 millimeters. The USCS has the following important categories of percentage fines:***

Soils with less than 5 percent fines are the most permeable soils.
Soils with between 5 and 12 percent fines are next in permeability.
Soils with more than 12 percent fines but less than 50 percent fines are next in order of permeability.
Soils with 50 percent or more fines are the least permeable.

2. The plasticity index (PI) of soils is another parameter that strongly correlates with permeability."

To recap, point #1 is the particle analysis of the soil determining percent of "fines". Point #2 is the *plasticity index* (PI). To review some of the testing documents in the original NOI, reference Appendix C3. The information in Appendix C3 looks at the geologic soil testing process in the original NOI that resulted from drilling 3 holes: B1, B2, B3. Only B2 and B3 are in proximity to the ponds so only these samples are used to evaluate liner material. Note that the number of holes drilled does not conform to AWMFH guidelines.

First page of Appendix C3 shows *3. Geologic Investigation* page from the original NOI. The arrow pointing to the statement by the engineer regarding at what level the liner material will be sourced from bore holes B2 and B3. The chart on the page shows the calculated *plasticity index* (PI) after it has been determined by lab analysis. The text identifies the unified soil classification system (USCS) designation as *CL - Fat Clay w/sand*.

Step 2: The boring log designates the sample numbers from the targeted depth of 7 to 11 ft where the liner material is to be sourced. The USCS designations are included here are all *CH - FAT CLAY*.

Step 3: The Plasticity Index(PI) is determined by the lab. For B2 sample 5 it is 55. The PI is one of the two suggested criteria for determining permeability.

Step 4: The unified soil classification system (USCS) designation is noted as determined visually.

Step 5: Note that the particle analysis has not been performed. All values in the *percent passing* column next to *sieve size* are listed as “N/A”. Sieve and percent fine is the particle analysis and the 2nd of the two listed criteria.

Step 6: Although an experienced engineer will likely do pretty well at determining the USCS visually, a precise determination is suggested by AWMFH via particle analysis. The USCS of CL in step 1 is different than the USCS of CH in the bore logs which suggests there are different people in the process making different estimations.

Conclusions: The engineer has determined only one of the two suggested criteria for permeability and that is the (PI) plasticity index. The engineer is also using his experience to estimate the USCS.

The lab determined PI of the samples between 7 & 11’ which will be the depth of the material used in the liners:

1. Boring 2, sample 5, PI: 55
2. Boring 2, sample 6, PI: 41
3. Boring 3, sample 5, PI: 22
4. Boring 3, sample 6, PI: 37

AWMFH states that when the PI values are above 20, this suggests a flocculated (blocky) structure subject to high desiccation and shrinkage which also affects permeability. This high PI suggests a USCS closer to CH in the type IV permeability group . For soil types III and IV the AWMFH appendix 10D page 10D-6 under *Permeability of soils* states:

"Some soils in groups III and IV may have a higher permeability because they contain a high amount of calcium. High amounts of calcium result in a flocculated or aggregated structure in soils. These soils often result from the weathering of high calcium parent rock, such as limestone. Soil scientists and published soil surveys are helpful in identifying these soil types.

High calcium clays should usually be modified with soil dispersants to achieve the target permeability goals. Dispersants, such as tetrasodium polyphosphate, can alter the flocculated structure of these soils by replacement of the calcium with sodium. Because manure contains salts, it can aid in dispersing the structure of these soils, but design should not rely on manure as the only additive for these soil types."

The facility is located atop the Boone formation which is karst limestone. The soil laboratory notes in the visual classification "chert fragments". There is a likelihood that high calcium limestone is the parent rock of this soil. However, no tests for calcium levels were mentioned in the geological investigation. The lack of the particle analysis or determination of calcium levels in the liner source material suggests weakness in the geological investigation that is not proportional to the significant of risk factors.

Laboratory compaction analysis to determine hydraulic conductivity uses only one sample

Though the engineers did not perform the particle analysis suggested in AWMFH, they did perform a laboratory compaction to determine hydraulic conductivity. The one sample used is described as a "grab sample". The testing documents indicate it came from bore #2 from 7 to11 ft. There are several problems with using only a single grab sample.

1. Hydraulic conductivity can vary from 7 to 11 ft. We know the PI varies between from 41 to 55 in bore #2. Also, the level of calcium in soils can affect permeability, though no calcium testing was performed. As soil levels approach the soil-to-epikarst transition zone, chert along with calcium levels will tend to rise. Tai Hubbard, the geologist who participated in the Harbor Environmental Drilling study suggested the epikarst zone starts at about 13.5 ft :

*"T**he highly weathered limestone bedrock and unconsolidated clay intervals observed between 13.8 and 28.0 ft.bgs. appeared to have the characteristics of epikarst. With the understanding that epikarst is the weathered zone found at the***

interface of unconsolidated soils and bedrock, the Site setting would support this characterization."

A single grab sample from 7 ft could have different calcium content resulting in different hydraulic conductivity than a sample from 11 ft.

2. Hydraulic conductivity can vary between bore hole locations. First it should be mentioned that AWMFH suggests based on the area of the ponds that six bore holes should have been drilled . However, even with only two bore holes the samples have PI ranges that vary from 22 to 55. This PI variability can exhibit significantly different hydraulic conductivity.

In regard to the grab sample used, we don't know the exact depth from which it was taken and we don't know the calcium content. Likewise, the soils from Bore hole #3 which were also used in pond construction have very different PI readings which can result in variable hydraulic conductivity. M.D. Smolen, PH.D. who has 35 years of experience in water quality management as affected by agricultural waste management and other aspects of watershed management, had this to say in a report dated Jan 2nd, 2014:

"The liner design was based on a single sample of in situ clay that was used as a liner. With only one sample, there is no way to determine how consistent this clay is, and whether or not the conductivity measured is representative of the entire stock pile. The inspection report from July 23, 2013 indicates that "gravel to cobble-sized coarse content" was observed in the clay liner (073447-INSP.pdf). This suggests the final clay liner could be quite different from the sample tested, which was supposed to be "fat clay." The presence of coarse particles can reduce the permeability of the liner. Cracks and rocks are visible in the photograph by ADEQ, Tony Morris 7/23/13, show."

The single grab sample was not sufficient to represent overall hydraulic conductivity.

Type IV soils to be used for the liner suggest special considerations in AWMFH that were not addressed

This discussion assumes that soils used for the liners were in or near the type IV soils group due to the high plasticity index (PI) determined by the laboratory analysis. There was no particle analysis performed to make an exact soil group determination. For soils types III and IV the AWMFH appendix 10D page 10D-6 under *Permeability of soils* states:

"Some soils in groups III and IV may have a higher permeability because they contain a high amount of calcium. High amounts of calcium result in a flocculated or aggregated structure in soils. These soils often result from the weathering of high calcium parent rock, such as limestone. Soil scientists and published soil surveys are helpful in identifying these soil types."

"High calcium clays should usually be modified with soil dispersants to achieve the target permeability goals. Dispersants, such as tetrasodium polyphosphate, can alter the flocculated structure of these soils by replacement of the calcium with sodium. Because manure contains salts, it can aid in dispersing the structure of these soils, but design should not rely on manure as the only additive for these soil types."

As the Boone formation is the predominant limestone geology in the region and evidence of chert is mentioned in the lab analysis, it is very possible that the soil has a high calcium content.

AWMFH suggests modification with soil dispersants to achieve permeability goals. More on dispersant recommendations discussed in AWMFH appendix 10-D page 10D-32:

Design and construction of clay liners treated with soil dispersants

"Previous sections of this appendix caution that soils in groups III and IV containing high amounts of calcium may be more permeable than indicated by the percent fines and PI values. Groups III and IV soils predominated by calcium usually require some type of treatment to serve as an acceptable liner. The most common method of treatment to reduce the permeability of these soils is use of a soil dispersant additive containing sodium."

Unfortunately no particle analysis was performed and calcium levels were not determined either. No mention of a dispersant modification in the geological investigation of the NOI.

Under appendix 10D: *Construction considerations for compacted clay liners* under *Soil Type* on page 10D-20:

"The most ideal soils for compacted liners are those in group III. The soils have adequate plasticity to provide a low permeability, but the permeability is not excessively high to cause poor workability. Group IV soils can be useful for a clay liner, but their higher plasticity index (PI greater than 30) means they are more susceptible to desiccation. If clay liners are exposed to hot dry periods before the pond can be filled, desiccation and cracking of the liner can result in an increase in permeability of the liner. A protective layer of lower PI soils is often specified for protection of higher PI clay liners to prevent this problem from developing."

The notation mentions plasticity levels > 30. Three sources of the liner material are over > 30. If used in equal parts the average PI will be 38.75.

1. Boring 2, sample 5, PI: 55
2. Boring 2, sample 6, PI: 41
3. Boring 3, sample 5, PI: 22
4. Boring 3, sample 6, PI: 37

There is no mention in the NOI engineering of a protective layer of lower PI soils as suggested in AWMFH. Note that high PI soils are generally highly flocculated (coarse granularity with clods). Although flocculation is suggested, we don't know for a certainty since there was no particle analysis. AWMFH Appendix 10D page 10D-23 states:

Macrostructure in plastic clay soils

"Clods can create a macrostructure in a soil that results in higher than expected permeability because of preferential flow along the interfaces between clods. Figure 10D–13 illustrates the structure that can result from inadequate wetting and processing of plastic clay. The permeability of intact clay particles may be quite low, but the overall permeability of the mass is high because of flow between the intact particles."

This permeability concern with type IV soil is reiterated in AWMFH Appendix 10D under *Permeability of soils* page 10D-6:

"Soils in group IV usually have a very low permeability. However, because of their sometimes blocky structure, caused by desiccation, high seepage losses can occur through cracks that can develop when the soil is allowed to dry. These soils possess good attenuation properties if the seepage does not move through cracks in the soil mass."

Desiccation, cracking, and coarse content consistent with type IV soils with suggested permeability risk is identified by an ADEQ inspector on July 23 2013.

"3.) The wastewater pond liners were observed to have erosion rills, desiccation cracks and gravel to cobble-sized coarse content within the liner clay. If the liner is to be exposed for extended periods of time, it should be protected from deterioration by erosion and desiccation."

On Jan 23rd, 2014 (six months later), a second ADEQ inspection noted that the liner desiccation continued to be a problem.

"The holding pond embankments were not stabilized and erosion rills were found within the inside banks of the holding ponds. Stabilization of the embankments needs to occur to 1) prevent sediment from entering the holding ponds which may decrease the capacity of the holding ponds, and 2) ensure the integrity of the holding ponds are maintained. Please see Photographs 1 and 2."

The inspector recognized deterioration characteristics consistent with type IV soils as an ongoing problem that should have been addressed immediately following construction as stated in this passage in AWMFH Appendix 10D under *Permeability of soils* page 10D-6:

"High plasticity soils like those in group IV should be protected from desiccation in the interim period between construction and filling the pond. Ponds with intermittent storage should also consider protection for high PI liners in their design."

The AWMFH also suggests construction techniques for high PI soils:

Clods in borrow soil

"If borrow soils are plastic clays at a low water content, the soil will probably have large, durable clods. Disking may be effective for some soils at the proper water content, but pulverizer machines may also be required. To attain the highest quality liner, the transported fill should be processed by adding water and then turned with either a disk or a high-speed rotary mixer before using a tamping roller."

The construction specification does not mention what techniques were used in laying down the clay liners. M.D. Smolen, PH.D. who has 35 years of experience in water quality management as affected by agricultural waste management and other aspects of watershed management, mentions that ponds will be subject to ongoing exposure issues that may have risk implications:

"The storage ponds at C&H are designed to be pumped down very close to the bottom periodically (at least once every 6 months). Consequently much of the clay liner will be exposed for long periods. This will lead to cracks developing in the liner, reducing the effectiveness of the seal. [Note cracking has already been observed during a site inspection on July 23, 2013 (see item 3 in letter from Jason Bolenbaugh, ADEQ, to Jason Henson in reference 073447-INSP.pdf).] The NRCS recommends protecting the clay liner from cracking by applying a layer of lower PI material over the clay, not allowing the liner to dry out, or using a more specialized system with dispersants or bentonite added. If the ponds are pumped dry and cracking occurs at the bottom, consequences could be very serious."

Conclusion: What is known for sure is that the material used in the liners has a very high plasticity index (PI) with chert suggesting the possibility of high calcium content. No testing for calcium was done. One grab sample was used to determine hydraulic conductivity for the entire range of material used in the liners though PI was variable. No dispersant modifications are mentioned. No protective layer of lower PI soils is mentioned. Inspections confirm desiccation, cracking, and coarse content consistent with type IV soils. No protection or maintenance for the liner for at least six months prior to filling as suggested in AWMFH. Exposure of liner floor to drying after pump down risks cracking. Construction technique is not mentioned in specifications. These issues are all suggestive of a low level of due diligence that is not proportional to the high cost of potential consequences.

The pond subsurface investigation does not conform to AWMFH guidance

Regulation 5.404 *Subsurface Investigation Requirements* states:

"The subsurface investigation for earthen holding ponds and treatment lagoons suitability and liner requirements may consist of auger holes, dozer pits, or

backhoe pits that should extend to at least two (2) feet below the planned bottom of the excavation."

The AWMFH 651.0704(4) *Guide to detailed geologic investigation* page 7-21 goes further suggesting the following for sampling the subsurface where ponds are planned. This is noted as to be particularly applicable for complex and inconsistent environments such as karst.

"For structures with a pool area, use at least five test holes or pits or one per 10,000 square feet of pool area, whichever is greater. These holes or pits should be as evenly distributed as possible across the pool area. Use additional borings or pits, if needed, for complex sites where correlation is uncertain. The borings or pits should be dug no less than 2 feet below proposed grade in the pool area or to refusal (limiting layer)."

The original NPDES Reg 6 NOI specifies pond area in section C2 "*design calculations"* as follows:

• Top of Waste Storage Pond 1 20,857 Square feet • Top of Waste Storage Pond 2 35,262 Square feet

It should be noted that the Reg 5 permit application specifies different square footage areas for the two ponds than the original NOI. Likewise the application also specifies square footage for a total drainage area. None of these figures agree, but for the purposes of this comment they do not vary enough to make a difference.

The original NPDES Reg 6 NOI shows records for three borings in the *Geologic Investigation* document. These are numbered B-1, B-2, B-3. Only B-2 and B-3 were in the area of the ponds. Using the guide from AWMFH page 7-21(4), there should have been at least 6 distributed borings if "pool area" is interpreted as encompassing both pools. More borings if "pool area" is interpreted as per pool. It is unclear how much latitude Chapter 7 provides the engineer regarding the detailed investigation. Certainly the risk factors were present to justify the AWMFH recommendations. The fact that the engineer recognized that drilling two holes was important but chose not to follow AWMFH guidance for the recommended number in the pond area suggests that the geologic investigation in this permit application is not proportional to the risk factors as discussed in Part A. The sensitivity of the watershed calls for the detailed geologic investigation to be revisited.

The berm subsurface investigation was not performed as per AWMFH guidance

The AWMFH 651.0704(4) *Guide to detailed geologic investigation* page 7-21 specifies the following for sampling the subsurface where ponds are planned:

"For foundations of earthfill structures, use at least four test borings or pits on the proposed embankment centerline, or one every 100 feet, whichever is greater. If correlation of materials between these points is uncertain, use additional test borings or pits until correlation is reasonable. The depth to which subsurface information is obtained should be no less than equivalent maximum height of fill, or to hard, unaltered rock or other significant limiting layer."

The berm walls of the pits are on the opposite sides from the barn and come to roughly 335ft in length. There were no test borings recorded in the original NOI geologic investigation. There is a "core trench" noted in the *Engineering Plan Sheets* but this was a trench to be filled with material to reduce berm wall permeability; it was not a geological investigation. That the engineer chose not to follow the AWFMW detailed investigation guidance suggests that the geologic investigation in this permit application was not proportional to the risk factors present.

Geologic karst is clearly identified beneath the facility in the Harbor Environmental single drill hole study

The *Water Resources Management Plan* for the Buffalo National River prepared by David Mott and Jessica Laurans for the National Park Service in 2004, says the following about the presence and behavior of karst in the Buffalo watershed:

"Discrete recharge is a concentrated, rapid movement of water to the subsurface drainage network, most common in areas dominated by karst, which is typical in the Ozarks. Sinkholes and losing streams are examples of discrete recharge. Most sinkholes and losing streams (where a portion of the reach goes dry) are found to be underlain by the Boone formation in northwest Arkansas and most springs emerge in the Boone, as shown in Figure 19 (Aley, 1999). Groundwater pollution is most common in limestone and dolomite areas such as the Boone formation because discrete recharge does not allow for the effective filtration and absorption of pollutants. Faster travel rates provide less time for bacterial and viral die off as well. This is important for water quality management of the Buffalo River since almost 32% of the watershed is underlain by the Boone formation (Aley, 1982)."

At the C & H facility, Harbor Environmental drilled a single bore hole to a depth of 120 ft as a result of an electronic resistivity study (ERI) performed by Dr. Todd Halihan of Oklahoma State University published 2016. The slides that resulted from Dr. Halihan's study suggested conductive zones consistent with high moisture content. The mixture of conductive and resistive zones suggests karst typical of the Boone formation. Bore holes were suggested by Dr. Halihan to "ground truth" the results of the ERI transects.

The Harbor Environmental report unfortunately does not speak directly to the ERI transects, but it does strongly detail karst features. Here is their overview of the geology:

2.2.3 Geology

"The uppermost geologic formation below the site is the Mississippian-age Boone Formation (Haley, et al., 1993). The Boone formation consists of gray, fine- to coarse-grained fossiliferous limestone interbedded with chert. Some sections may be predominantly limestone or chert. The cherts are dark in color in the lower part of the sequence and light in the upper part. The quantity of chert varies considerably both vertically and horizontally. The sequence includes an oolite (Short Creek) member near the top of the Boone Formation in western exposures and the generally chert-free St. Joe Member at its base. The Boone Formation is well known for dissolutional features, such as sinkholes, caves, and enlarged fissures. Thickness of the Boone Formation ranges from approximately 300 to 350 feet in most of northern Arkansas (McFarland, 2004)."

Note in the following passage in the Harbor report that water used in the drilling process as a lubricant was lost in the 20 to 28.5 ft zone indicating the open space of a fracture or void. Note the terms "weathered and fractured and increased fracturing". These are all indicative of karst.

Subsurface Conditions Encountered

"Yellowish red silty clay (CL) with chert and limestone fragments was encountered from the surface to a depth of 8 feet bgs. This material appeared to be fill soil placed during construction of the hog farm and adjacent waste ponds. Yellowish red fat clay (CH) was encountered from 8 feet to 13.5 feet bgs. Fine-grained, fossiliferous, gray limestone was encountered from 13.5 feet to 20 feet with a six- inch seam of fat clay as above occurring from approximately 18 feet to 18.5 feet bgs. Weathered and fractured, fossiliferous gray to buff limestone was encountered from 20 to 28.5 feet. The driller reported potable drilling water loss in this zone. Competent, fossiliferous gray limestone (consistent with the Boone Formation), with some minor fracturing and bedding planes was encountered at 28.5 feet bgs, which generally extended to the TD of 120 feet bgs. Zones of increased fracturing were encountered around 70 feet and 90 feet bags..."

The boring log selected entries are indicative of karst throughout:

-At 20 ft: "LIMESTONE, fine grained, weathered and fractured, gray (5Y 5/1) to buff, fossiliferous."

-At 28 ft: "LIMESTONE, competent w/ some fracturing and bedding planes, gray (5Y 5/1) to buff, fossiliferous."

-At 60 ft: "LIMESTONE, competent w/ some fracturing and bedding planes, gray (5Y 5/1) to buff, fossiliferous."
At 65 ft: "Fractured"

-At 85 ft: "Increased fractures"

-At 100 ft: "LIMESTONE:, competent, interbedded with thin to medium bes of shaley limestone, gray (5Y 5/1) fossiliferous."

The on-site geologist, Tai Hubbard, made this notation:

"The highly weathered limestone bedrock and unconsolidated clay intervals observed between 13.8 and 28.0 ft.bgs. appeared to have the characteristics of epikarst. With the understanding that epikarst is the weathered zone found at the interface of unconsolidated soils and bedrock, the Site setting would support this characterization."

The indication of epikarst at 13.8 to 28 ft below ground level confirms porous weathered rock at a depth that is *above* the floor of the ponds with the pond #2 invert at 20 ft below the surface of where the bore hole was drilled . The AWMFH table 10-D notes the following regarding karst in the *Vulnerability to Risk* matrix when siting a facility: *"large voids e.g. karst, lava tubes, mine shafts) as a* ***very high*** *vulnerability suggesting that the engineer "****Evaluate other storage alternatives".*** No such alternatives were considered. As a result, this permit does not comply with AWMFH guidance.

The containment ponds are located on a geologic foundation near voids and/or fractures

Harbor Environmental drilled a single bore hole to a depth of 120 ft as a result of an electronic resistivity study (ERI) performed by Dr. Todd Halihan of Oklahoma State University published in 2016. The transects that resulted from the study suggest conductive zones consistent with high moisture content. The concern that prompted the Harbor drilling exercise was possible leakage and/or fractures near the ponds. The comments and logs from the drilling process say on several occasions that "no voids were encountered". However, there were some very noticeable events in the process of drilling and filling the bore hole that the members of the Harbor drilling team did not address. In 3.2 *Subsurface conditions encountered* it states:

"Weathered and fractured, fossiliferous gray to buff limestone was encountered from 20 to 28.5 feet. The driller reported potable drilling water loss in this zone."

This loss of water is noted in the drilling log as well. The drilling process uses a 6" turning pipe with water pumped into the pipe and exiting around the sides. The water pumped in serves to a degree as a lubricant and it should all be recaptured as part of the process unless it is lost into an open subsurface space of some sort. The Harbor report does not indicate how much water was recovered vs how much was used, though it should have provided this as it is critically important. A large void will generally be noticeable during the drilling process, but not necessarily. A narrow fracture or cobble filled void that may be of considerable volume may not be noticeable by the driller. An example of typical fractures in the Boone formation that would not easily be detected by a driller are illustrated in this cross section photo.

When filling the hole with cement there was a similar issue encountered discussed under 3.3 *Borehole Abandonment*:

"After completion of the drilling and sampling operations and geophysical logging, the borehole was abandoned in accordance with the Arkansas Water Well Construction Commission Rules and Regulations (May 2016) and ADEQ Interim Policy 96-4. The borehole was grouted to the land surface via tremie method (from bottom up) using Portland cement (no bentonite). Due to fracture zones encountered in the subsurface, the borehole took more grout than calculated for its volume (see boring log in Appendix B). Borehole volume was estimated at 23.6 cubic feet (176 gallons). Total estimated grout placed in the borehole was approximately 280 gallons. The borehole was grouted on Friday, 9/23/16; however, the driller ran out of grout and was unable to grout the borehole to the surface."

It is important to note that the loss of grout occurred in the same zone as the loss of water which was between 20 and 28.5' ("about 25' "). Experienced drillers will do a pretty good job at estimating the amount of grout to mix for filling a hole as they don't want to find themselves short. As described above, they pumped all that they had Friday afternoon and stopped for the day, hoping that the fracture(s) were narrow enough that the grout pumped would set and seal the openings. On Monday, the fractures did apparently seal and they were able to finish the process. What should be noted is that the fractures may have taken quite a bit more grout Friday had they chosen to mix additional grout and continue pumping at that time. The amount of extra grout used before they ran out was determined to be 23.6 cubic ft, about the size of a small closet. It would be much more indicative of the size of this subterranean opening if we knew instead how much water was lost, which was not provided. Experts indicate that to come across an underground opening like this is generally unlikely with a single drill hole. This raises some concern in regard to the extent of possible subsurfaces openings that may exist around the ponds. In fact Tai Hubbard, the onsite geologist noted the limited scope of the Harbor study:

"Evaluation of lithologic contacts and bed orientations are limited, both horizontally and vertically, due to the inability to correlate observations collected at a single location to any other bore holes."

The extent of voids or fractures can't be known but to find one with only one bore hole suggests heightened risk. This indication of a subterranean opening tends to validate Dr. Todd Halihan's ERI transects which suggest fractures. What we know for certain is that there is at the very least 23.6 cubic ft area of subsurface open space at a depth of 20 to 28.5 ft where drilling water was lost and where the grout would not rise. The elevation of where the bore hole was drilled was about 914.3 ft which means the subterranean opening occurred at an elevation between 894.3 and 885.8 ft (where water was lost) or 889.3 (where grout would not rise). The elevation of the floor of Pond #2 is 894.3 ft which places a clearly identified opening of some sort roughly even with the floor of pond 2 or a few feet below.

AWMFH table 10-4 that identifies *vulnerability to risk*, lists *"Large voids (e.g, karst, lava tubes, mine shafts) OR highest anticipated ground water elevation within 5 ft of invert"* as a "**Very high"** vulnerability and suggests **Evaluate other storage alternatives.**

In AWMFH Appendix 10-D under *When a liner should be considered* the following is stated:

"Some bedrock may contain large openings caused by solutioning and dissolving of the bedrock by ground water. Common types of solutionized bedrock are limestone and gypsum. When sinks or openings are known or identified during the site investigation, these areas should be avoided and the proposed facility located elsewhere."

The evidence of subsurface openings discovered so readily this close to the pond inverts suggests that the impoundment locations present risk that is disproportional to the surrounding environment. Note that ADEQ has approved a modification allowing for the installation of synthetic pond liners, but they have not yet been installed. Synthetic membranes are inadequate to address the risk identified in the Harbor drilling investigation. Had a proper subsurface investigation been conducted prior to construction, AWMFH guidance table 10-4 would clearly have directed that *"these areas should be avoided and the proposed facility located elsewhere".*

There is evidence of perched groundwater close to pond inverts

The ERI transects resulting from Dr. Todd Halihan's study were compiled as a result of two separate visits. On the 2nd visit, Dr. Halihan's team produced ERI transects on field 1 and also generated four transects around the ponds. Note his description of the conditions that day:

"Precipitation previous to and during the investigation resulted in both sites having moist to saturated soil conditions. The site soil of Field 1 was saturated."

Three of the ERI transects from the study around the ponds noted several highly conductive zones indicative of moisture in the 13' to 28' range.

The bore hole drilled by Harbor Environmental was drilled Sept 21st through the 23rd during and following dry conditions. As this hole was only drilled near the middle of the west ERI transect, the following discussion is limited to that area. The Harbor Environmental report noted loss of water at 20 to 25' and they had difficulty grouting above 25'. We know for certain (Comment C12) that there is at least 23.6 cubic ft of subsurface open space at a depth of 20 to 28.5 ft. This corresponds with where the drilling water was lost and the grout would not rise.

Dr. Halihan's west transect indicates moisture at this depth. We know that conditions were very wet and that field 1 which he had tested earlier was described as "saturated". The conductivity in Halihan's west transect suggests the possibility of perched groundwater in the same subsurface zone where Harbor Environmental lost water and grout. See Appendix C13. Dr. Halihan describes in his report the likelihood of perched ground water in epikarst:

"In geologic settings like northern Arkansas, the epikarst zone is a significant source of water storage and transmission and many springs have been tapped to support local communities (Galloway, 2004). These types of groundwater systems can include perched water tables, which exist above regional water tables. These are called perched because they are places where low permeability soil or bedrock layers hold water above an unsaturated zone and often produce springs on the side of a bluff or sometimes in an open field if the relief is high enough to expose this feature."

Tai Hubbard, the on-site geologist monitoring the drilling process for Harbor Environmental, described this exact zone as characteristic of epikarst which Halihan points out as a significant source of water storage:

"The highly weathered limestone bedrock and unconsolidated clay intervals observed between 13.8 and 28.0 ft.bgs. appeared to have the characteristics of epikarst. With the understanding that epikarst is the weathered zone found at the interface of unconsolidated soils and bedrock, the Site setting would support this characterization."

The Harbor Environmental drilling log confirms subsurface conditions suggesting that perched groundwater might be supported by consolidated material at the 28' level.

- At 20 ft: "LIMESTONE, fine grained, weathered and fractured, gray (5Y 5/1) to buff, fossiliferous."

- At 28 ft: "LIMESTONE, competent w/ some fracturing and bedding planes, gray (5Y 5/1) to buff, fossiliferous."

AWMFH 651.0701 *Overview of geologic material and groundwater* under *Aquifers* page 7-7 says this about perched aquifers:

"A perched aquifer (fig. 7–8) is a local zone of unconfined groundwater occurring at some level above the regional water table, with unsaturated conditions existing above and below it. They form where downward-percolating groundwater is

blocked by a zone of lesser permeability and accumulates above it. This lower confining unit is called a perching bed, and they commonly occur where clay lenses are present, particularly in glacial outwash and till. These perched aquifers are generally of limited lateral extent and may not provide a long-lasting source of water. Perched aquifers can also cause problems in construction dewatering and need to be identified during the site investigation."

The elevation of where the bore hole was drilled was about 914.3 ft (see Appendix C12 page 2) which means the subsurface opening that likely contained perched groundwater during Halihan's ERI occurred at an elevation between 894.3 ft and 885.8 ft (where water was lost) or 889.3 ft (where grout would not rise). The elevation of the floor of Pond #2 is 894.3 ft which places a clearly identified open space of some sort (Comment 12) within 5 ft of elevation of the invert of pond #2.

AWMFH table 10-4 (Appendix C10) that identifies *vulnerability to risk*, lists *"Large voids (e.g, karst, lava tubes, mine shafts) OR highest anticipated ground water elevation within 5 ft of invert"* as a "**Very high"** vulnerability and suggests "**Evaluate other storage alternatives".**

The evidence of a subsurface opening combined with the saturated conditions during Halihan's ERI study and the conductivity shown in the west ERI transect suggest that the pond impoundment inverts are located within five ft of perched groundwater tables.

The pond seepage limit in original NOI design is incorrect

In the original NOI for C & H, pond seepage was estimated for each pond (see chart below).

M.D. Smolen, PH.D. who has 35 years of experience in water quality management as affected by agricultural waste and other aspects of watershed management, had this to say regarding the calculated seepage rate in a report dated Jan 2nd, 2014:

"The standard used by DHG for design of the waste storage pond clay liners at C&H was a seepage rate of 5,000 gal/acre/day, based on recommendation in the NRCS FOTG and AWMFH. As indicated earlier, these NRCS documents do not actually set standards but defer to state requirements. The NRCS AWMFH recommends, "In the absence of a more restrictive State regulation, assume an acceptable specific discharge of 5,000 gallons per acre per day."

AWMFH states in Appendix 10-D under *Detailed Design Steps for Clay Liners,* page 10D-15:

"If no regulations exist, a value of 5,000 gallons per acre per day may be used. If a designer feels that more conservative limiting Agricultural Waste Management Field Handbook seepage is advisable, that rate should be used in computations."

Seepage levels calculated in the original NOI (above) are somewhat lower than 5,000 per acre per day. Unfortunately, the figures are based on a hydraulic conductivity test using one grab sample which is hardly representative of liner materials whose PI ranged from 22 to 55 and calcium levels that are likely variable but were not tested.

M.D. Smolen PH.D. describes his concern in a report dated 8/28/2015:

"The ADEQ permit provides minimal protection from storage pond leakage, allowing as much as 5,000 gal/acre per day to leak through the clay liner. C&H's clay liner was designed based on analysis of only one soil sample and there was no testing of the permeability of the final liner construction. The high shrink-swell potential of the liner materials have a tendency to crack when allowed to dry, increasing the potential for leakage during the cycle of filling and emptying the ponds. An EPA inspection conducted April 15-17, 2014 found that the upper edge of the clay liner were protected by erosion control fabric, but did not indicate any effort to prevent liner cracking."

An important factor that allows seepage up to 5,000 gal per acre per day is the *manure sealing credit*. *Construction Guidelines for Impoundments Lined with Clay or Amendment-treated Soil*, page 10-D2 discuss the *manure sealing credit*:

"When credit for a reduction of seepage from manure sealing (described later in the document) is allowed, NRCS guidance considers an acceptable initial seepage rate to be 5,000 gallons per acre per day. This higher value used for design assumes that manure sealing will result in at least a half order of magnitude reduction in the initial seepage. If State or local regulations are more restrictive, those requirements should be followed."

"If State or local regulations prohibit designs from taking credit for future reductions in seepage from manure sealing, then NRCS recommends the initial design for the site be based on a seepage rate of 1,000 gallons per acre per day. Applying an additional safety factor to this value is not recommended because it conservatively ignores the potential benefits of manure sealing."

Dr. Smolen comments on the manure sealing credit on 1/2/2014:

"***NRCS recommendations allow up to one order of magnitude reduction in permeability due to clogging of liner material by solids from the manure. Credit for manure sealing is not recommended by NRCS in the most vulnerable situations, such as areas with karst geology or high seasonal water tables"***

Smolen refers to the *vulnerability to risk matrix* table 10-4 which can be found in Appendix C10 of this document. Below are the vulnerabilities we have identified in earlier comments that are listed in the above referenced table 10-4 which provides guidance for use of the *manure sealing credit.*

Very High Vulnerability

1. Voids
2. Karst

3. Highest groundwater within 5 ft of invert (C13) 4. <600 ft from improperly abandoned well

The recommendation for all risk options for very high vulnerability doesn't mention the *manure sealing credit* but simply states *Evaluate other storage alternatives.*

High Vulnerability

1. Bedrock (assumed fractured) within 2 ft of invert
2. Highest anticipated groundwater elevation is between 5 and 20 ft of invert
3. 600 to 1,000 ft of an improperly abandoned well

The recommendation for all risk options for high vulnerability is *No manure sealing credit*

Moderate Vulnerability

1. Flocculated or blocky clays (typically associated with high Ca)

2. Highest anticipated groundwater elevation is between 21 and 50 ft of invert (C13).

3. 600 to 1,000 ft of an improperly abandoned well .

The "Moderate Risk" selection applies here as the ponds are within 600 to 1,000 ft of an abandoned well. Recommendation is *No manure sealing credit*

Table 10-4 *vulnerability to risk* is clear that for this facility, the *manure sealing credit* should never have been used. That being the case "*NRCS recommends the initial design for the site be based on a seepage rate of 1,000 gallons per acre per day*".

Smolen also noted on 8/28/2015:

"The EA indicates that C & H intends to install a HDPE plastic liner in the existing waste storage ponds. The original concerns for leakage could be alleviated by installation of such a liner, but retrofitting it to the C&H facility is not a simple matter. All seams must be carefully welded and tested, and there must be no organic matter decomposing under the liner as a gas bubble would cause the liner to float. Until I can be assured this liner is installed properly, my concern for leakage from the ponds remains."

The pond liner leakage rate permitted in Arkansas is lax compared with other state standards making it particularly inappropriate for a location in geological karst

Smolen (2017) states the following regarding the Arkansas leakage standards compared to those of other states:

Comparison of leakage rate with the rate allowed in other states.

"The leakage rate allowed in Arkansas is higher than many other states. I reviewed eight state standards, and the "10-State Standard" for comparison. This analysis (see Appendix C15) showed that most of these states hold animal waste structures to a higher standard than Arkansas. In this comparison I looked at leakage rate based on a 6-foot depth. Ohio's standard generally allows a leakage rate of 277 gal/ac/day, but restricts leakage further in a karst area. Missouri restricts leakage to 500 gal/ac/day in a basin where potable groundwater might become contaminated, Oklahoma restricts leakage to 462 gal/ac/day and requires installation of monitoring wells. The 10-state standard restricts leakage to 500 gal/ac/day."

That the Arkansas standard allows ***ten times*** the leakage of the *10-state standard* is excessive under any circumstances, but to apply the Arkansas standard in a geologically sensitive karst environment is nothing less that irresponsible, particularly when considering the disproportionate risk factors.

Karst as a predominant and well known geological risk factor in the Springfield Plateau and topographic vicinity of the facility and its spreading fields, was not recognized or investigated adequately before siting the ponds

The AWMFH devotes the entirety of Chapter 7 to guidance around *"Geologic and Groundwater Considerations".* AWMFH 651.0702 *Engineering Geology Considerations in Planning* states the following under Part (I) Topography:

"Karst topography is formed on limestone, gypsum, or similar rocks by dissolution and is characterized by sinkholes, caves, and underground drainage. Common problems associated with karst terrain include highly permeable foundations and the associated potential for groundwater contamination, and sinkholes can open up with collapsing ground. As such, its recognition is important in determining potential siting problems."

The original Environmental Assessment (EA) with a finding of no significant impact submitted by the Farm Services Agency (United States Department of Agriculture) on Sept 26th 2012, does not discuss any topographic concerns.

The words "karst" and "groundwater" are conspicuously absent. Neither does the original permit or the new permit application mention karst as a risk factor. The original EA of 2012 was challenged as insufficient and a court order was filed 12/2/2014 by U.S. District Judge D.P. Marshall finding that Farm Services Agency (FSA) and Small Bus Administration (SBA) violated the provisions of the National Environmental Policies Act (NEPA) and the Endangered Species Act (ESA) and that they "arbitrarily and capriciously guaranteed the loans" to C & H Hog Farms. The court required the agencies to re-do their "cursory and flawed" Environmental Assessment.

A new Environmental Assessment was submitted by FSA in August of 2015. The rewritten EA provided responses to concerns regarding the original EA, one of which was that the original EA did not consider karst. The response of the 2015 EA on the subject of karst topography was as follows (excerpt page 22 under "Karst"):

"As stated in Section 3.3 of the EA, the soluble nature of limestones gives rise to karst terrain in the southern Ozarks region. Highly soluble conditions in certain areas of the Buffalo River watershed, distant from the C&H Farms, including the western and north-central parts of the watershed, have produced pervasive occurrence of karst features, including caves, sinkholes, springs, and sinking streams (Hudson et al. 2001 and Soto 2014). However, the C&H Hog Farms site and vicinity do not exhibit strongly developed karst landforms as demonstrated by a review of the Mt. Judea USGS 7.5 Minute Topographic Quadrangle Map and aerial photograph information. Our topographic and aerial photography review indicates that limited numbers of karst ponds are located on upper reaches of floodplains, where a separation of shallow perched groundwater in alluvial and epikarst (Hudson et al. 2013) from deeper groundwater in the Boone Formation may explain development of sinkhole ponds in overburden, due to dewatered secondary porosity in the underlying bedrock."

Further, a report titled "Surface-Water Quality In The Buffalo National River, 1985-2011" by the Watershed Conservation Resource Center, 2017 states:

"The Ordovician through Mississippian rocks [which characterizes the Buffalo River watershed geology] host a complex karst terrain where losing streams, sinkholes, springs, and caves dominate much of the landscape. Most of these rocks are carbonates, either limestone or dolomite. They are particularly susceptible to dissolution. These rocks are highly permeable to the movement of groundwater. Subsurface flow directions and rates of groundwater flow are difficult to predict and may rapidly change based upon the hydrologic events."

Dr. Van Brahana produced a peer reviewed report (in press 2017) entitled: "*Utilizing Fluorescent Dyes to Identify Meaningful Water-Quality Sampling Locations and Enhance Understanding of Groundwater Flow Near a Hog CAFO on Mantled Karst—Buffalo National River, Southern Ozarks".* Dr. Brahana's dye tracing results can be observed topographically in Appendix E2. In this appendix illustration the swine facility and many of the primary spreading fields lie directly in the path between the dye introduction point and the corresponding dye detection points. Dr. Brahana's conclusions were as follows:

Based on the results of the dye tracing described herein, the following observations of groundwater flow in the Boone Formation in the Big Creek study area can be used for designing a more reliable and relevant water-quality sampling network to assess the impact of the CAFO on the karst groundwater and to gain further understanding of the karst flow.

1. ***Although the study area is mantled karst, subsurface flow is very important, and forms a significant part of the hydrologic budget.***
2. ***Groundwater velocities in the chert/limestone portion of the middle Boone Formation were conservatively measured to be in the range of 600-800 m/d.***
3. ***Conduits in pure-phase limestones of the upper and lower Boone have flow velocities that can exceed 5000 m/d.***
4. ***Groundwater flow in the Boone Formation is not limited to the same surface drainage basin, which means that anomalously large springs should be part of the sampling network (Brahana, 1997).***
5. ***Because the Buffalo National River is the main drain from the study area, and the intensive contact of the river water by uses such as canoeing, fishing, swimming, and related activities, large springs and high- yield wells should be included in the sampling network.***
6. ***Maximum potential transport times of CAFO wastes from the land surface appear to be greatest during and shortly after intense precipitation events. Minimum groundwater flow occurs during droughts. Sampling should accommodate these considerations.***

The history of both the old and new permit applications and the corresponding EA (both old and new) appear to have avoided the discussion of karst as a risk factor and have only acknowledged it vaguely when forced to respond directly, despite the fact that the AWMFH devotes extensive guidance on its recognition as it pertains to risk factors and design considerations. This failure to acknowledge even the possibility of the presence of karst suggests a low level of investigative due diligence that is not proportional to the high cost of potential consequences.

The criteria for location of a CAFO in karst geology were not adequately developed or implemented

The standards that are being applied to the location of the C&H facility are the same as those that would be applied to any location in Arkansas. The standard ignores the fact that the C&H facility is located in a karst geology, which greatly exacerbates the potential for migration of any contaminants that are or may be released from the facility, and the difficulty of containing or even locating any such contaminants, once released.

The AWMFH provides the entirety of Chapter 7 as guidance to the engineer regarding karst and groundwater as a risk factor, and yet the engineering documents do not acknowledge or allude to fast moving ground water as a concern, though the circumstances identified in Chapter 7 regarding karst geology were certainly present.

ADEQ did not conduct or require *an enhanced geological and hydrological assessment of the facility site*. It is important to know the nature and extent of the geology; the degree to which the underlying rock formations have been fractured; the potential routes of migration of contamination in the event of a release; the environmentally-sensitive areas that might be affected from a surface or sub-surface release due to groundwater flow direction; and other related facts. ADEQ has the legal authority and the mandate to require additional conditions or investigations where special risk factors are present.

BRWA incorporates these comments contributed by noted Hydrogeologist, Thomas J. Aley, PHG & PG, in response to the C&H Conceptual Closure Plan:

I commend ADEQ for several features in it.

- *C&H is not doing the closure.*
- *In the closure, no fluids will be land applied within the Buffalo River Watershed.*
- *In the closure, no solids or liner disposal will occur within the Buffalo River Watershed.*

One thing that would be relevant is that, after the excavation has been completed, what should now be a clean surface should be examined to determine if there are any zones with evidence of leakage through the walls or floors of the ponds or of sinkhole collapse or subsidence within the structures. If such evidence or features is discovered then those areas should be excavated to remove contaminated earth materials and, if they are sinkholes, to remediate the features prior to backfilling and grading. I think it would be best for everyone if this inspection were made by an experienced geologist with the Arkansas Geological Commission. If further excavation and/or remediation were found to be needed then both the PE for the work and a AGC geologist should be involved. If this approach is used then I am no longer concerned with trying to protect the liner, if there actually was one that amounted to anything.

Thomas J. Aley, PHG & PG,President and Senior Hydrogeologist, Ozark Underground Laboratory, Inc.1572 Aley Lane, Protem, MO 65733, www.OzarkUndergroundLab.com

Thank you for the opportunity to submit these comments.

On behalf of the Buffalo River Watershed Alliance,
Gordon Watkins, President