Detailed Comments of the Ozark Society, Dr. Alan Nye, Dr. David Peterson and Mr. Robert Cross.

Reg. 5.102 states:

> The purpose of this regulation is to establish **minimum** qualifications, standards and procedures for issuance of permits for confined animal operations using liquid animal waste management systems within the state and for the issuance of permits for land application sites within the state. (Emphasis added).

Thus, the regulation contemplates more stringent "qualifications, standards and procedures for issuance of [CAFO] permits" where circumstances require them. This is consistent with other guidance for siting large swine CAFO's and with our position that there are certain areas in the State where large swine CAFOs should not be sited. The C & H Hog Farms (C&H) CAFO generates more than three times as much phosphorous as the entire human population of Newton County, is the largest CAFO in the Buffalo River Watershed, and is located in an area of karst geology less than 5 stream miles upstream of the Buffalo National River, America's First National River and perhaps the most important tourism destination in Arkansas. Yet, the qualifications, standards and procedures contained in the draft permit are no more stringent than those for any other swine CAFO in Arkansas. This means that ADEQ has approached this CAFO the same as it would a similarly sized CAFO anywhere else in Arkansas instead of one located in one of the most sensitive areas of the State and directly upstream from our most pristine river.

As discussed throughout these comments, the BCRET study (notwithstanding its flaws), United States Geologic Survey (USGS) data, National Park Service (NPS) data, and other sources referenced herein, including the list of reference materials attached to our comments, all demonstrate that C&H is causing or contributing to measurable water quality degradation in Big Creek, the Buffalo River, and the karst aquifer that feeds these two streams.

ADEQ should not issue a "no discharge" permit to C&H. The facility was originally designed and has been operating in a manner that results in a discharge of wastes to Waters of the State. The planning, studies and assessments required by Regulation 5 and the NRCS Agricultural Waste Management Field Handbook (AWFMH) have not been conducted. The facility is causing or contributing to water quality impacts. For these reasons, the facility should be closed, with all wastes remaining at the facility removed from the Buffalo River Watershed.

C&H commenced operations in 2012 under NPDES permit No. ARG590001. C&H has applied for and received a draft permit pursuant to APCEC Regulation 5. In the Statement of Basis, ADEQ uses the terms "no-discharge facility" and "no-discharge permit" repeatedly. (*See*, *e.g*. second sentence in Statement of Basis -- "This draft permit decision is for the issuance of a **no-discharge facility** under draft permit number 5264-W and AFIN 51-00164." Paragraph 3 of the Statement of Basis -- "The permittee submitted a permit issuance application for a **no-discharge permit** . . ." "It is proposed that the water **no-discharge permit** be issued." Paragraph 12 – "The [ADEQ] has made the determination to issue a draft permit for the **no-discharge facility** described in the application and NMP.")

The draft permit contains a prohibition against discharges: "Waste shall not be discharged from this operation to Waters of the State or onto land in any manner that may result in . . . runoff to Waters of the State." See Part II, Specific Condition 2. The permit goes on to define Waters of the State:

> **'Waters of the State'** means all streams, lake, marshes, ponds, watercourses, waterways, wells, springs, irrigation systems, drainage systems, and all other bodies or accumulations of water, surface and underground, natural or artificial, public or private, which are contained within, flow through, or border this state or any portion of the state as defined by the Act. *See*, Part IV, *Definitions*.

C&H's Nutrient Management Plan (NMP) submitted with its permit application makes it clear that it contemplates discharges to Waters of the State:

> **Purpose of Plan** – The goal of nutrient management is to effectively and efficiently use the nutrient resources to adequately supply soils and plants with the proper amount of nutrients to produce food, forage, fiber, and cover <u>while minimizing transport of nutrients to ground and surface water</u> and environmental degradation. (emphasis added).

C&H concedes in its NMP that there will be "transport of nutrients to ground and surface water" and that its "goal" is to "minimize" these discharges. (Whether or not it is actually meeting this goal is discussed in detail below. It is not.) The NMP is incorporated into and made a part of the permit. See, Part II, Specific Conditions, para. 2. ADEQ fails to explain how it can issue a <u>no-discharge permit</u> to a <u>no-discharge facility</u> prohibiting the <u>discharge of waste to Waters of the State</u> when the permit application contemplates, and the facility design and operation necessitates, discharges of wastes to "Waters of the State." Moreover, the BCRET work actually documents discharges. BCRET set up three flumes to measure flow from waste fields and to sample discharges. One of these flumes is depicted in Figure 5 below. The results of sampling from this discharge point reflect the presence of elevated nutrients and other parameters. It is important to note that because the ISCO samplers cannot meet *Escherichia coli (e.coli)* bacteria holding times, there is no bacteria data from field flumes or most Big Creek storm flow samples even though bacteria is undoubtedly present in these storm flow events.

The waste holding ponds were designed and constructed to permit waste leakage to "Waters of the State." Based on construction certification documents, it is estimated that leakage rates are 1,090 gallons per acre per day for Pond 1 and 1,334 gallons per acre per day for Pond No. 2. Pond 2 is also designed to permit a discharge in the event of a large (25 year 24 hour) precipitation event ("the storm volume is only encroached during a 25 year 24 hour storm event)." C&H NMP at p. 14. The recent "Harbor Drilling Report" concludes that the waste holding ponds sit atop karst features. Karst features provide a mechanism for rapid transport of wastes that leak from the waste ponds to ground and surface waters.

The waste application sites contain excess phosphorous, the nutrient that most directly contributes to water quality impairment by stimulating nuisance algae blooms. It is undisputed that phosphorous will migrate from these sites both through groundwater infiltration and during storm events. This phosphorous will end up in Big Creek and the Buffalo River. As discussed in greater detail below, stream monitoring shows impacts in water quality downstream of the facility, both in Big Creek and the Buffalo River.

In summary, the prohibition both in Regulation No. 5 and the draft permit against discharging wastes to "Waters of the State" will be violated if this permit is granted. That the facility is discharging wastes to Waters of the State is plain both from the current permit, the Regulation 5 permit application and the results of the work done by BCRET, USGS, and the NPS. Furthermore, it cannot be disputed that waste discharges to Waters of the State will continue to occur unless the permit is denied.

Water quality monitoring downstream of the facility shows an increase in nutrient concentrations as well as other contaminants, including, but not limited to chlorides, total suspended solids and total coliform bacteria. (Mott, 2016). There is evidence that shows it is more probable than not that a portion of these contaminants are from waste generated at C&H and disposed of at the waste application sites. The contribution of nutrients and harmful bacteria from C&H is causing or contributing to water quality degradation in Big Creek and the Buffalo National River. By causing or contributing to the degradation of water quality in both Big Creek and the Buffalo River, C&H is violating state and federal anti-degradation provisions. See, APCEC Reg. 2, Chapter 2: the Clean Water Act § 303 (33 U.S.C. § 1313) and 40 CFR § 131.12.

The watersheds that adjoin the Buffalo National River watershed to the north and the west are designated as Nutrient Surplus Areas and/or contain impaired stream reaches. According to the Arkansas Natural Resources Commission:

> "A Nutrient Surplus Area (NSA) is an area that has been designated by the Arkansas General Assembly as having such high concentrations of one or more nutrients that continued unrestricted application of the nutrient could negatively impact soil fertility and waters of the state."
> (http://www.anrc.arkansas.gov/divisions/conservation/nutrient-management-program/nutrition-management-planning)

Despite decades of efforts to reverse the effects of over application, conditions do not appear to be improving in these NSAs.
(https://www.adeq.state.ar.us/water/planning/integrated/303d/list.aspx; Scott et al., 2016). The cause of the water quality impairment and public concerns are well documented and linked to agricultural activities, including CAFOs (Winthrop Rockefeller Foundation, 2008; http://arkansas-water-center.uark.edu/, Haggard et al., 2017). Dr. Andrew Sharpley

explains that prior to World War II, nutrients were mainly recycled on the farms where they were produced. In the last 75-years, a major shift has been occurring regarding the transportation of nutrient-rich agricultural feed products to areas of the nation where animal agriculture and CAFOs dominate (Sharpley, 1993). These same areas now experience water quality declines, and in some cases, water quality impairment due to the large volumes of wastes that have been generated and disposed of in these areas.

Ozark Highlands National Ambient Water Quality Monitoring Program and related studies conducted by the USGS (Adamski et al., 1995; Petersen et al., 1998; Petersen and Femmer, 2002; White et al., 2004; Petersen et al., 2014), have further demonstrated the link between agricultural land use and water quality declines. The USGS body of work contains voluminous data, scientific interpretations and compelling evidence showing clear correlations of increased nitrates with increased percent pasture, the relationship between nutrient loads and storm hydrographs, stream habitat and aquatic community changes as a result of agricultural source loading, and significant increases in nutrient loads exported from agricultural developed watersheds (http://pubs.usgs.gov/sir/2014/5170/; http://pubs.usgs.gov/sir/2011/5172/; http://pubs.usgs.gov/sir/2010/5119/; http://pubs.usgs.gov/sir/2006/5250/; http://pubs.usgs.gov/sir/2008/5174/; http://pubs.usgs.gov/sir/2006/5175/).

ADEQ has developed Total Maximum Daily Loads (TMDLs) for some of the impaired streams in northwest Arkansas. (https://www.adeq.state.ar.us/water/planning/integrated/tmdl/) Agriculture is often the single largest source of nutrients and bacteria causing stream impairments. (https://www.adeq.state.ar.us/water/planning/integrated/303d/list.aspx). TMDL tools and processes could have been used by ADEQ to better inform this permit decision. Prior to granting the initial authorization to C&H Hog Farms (C&H), ADEQ should have inventoried existing agriculture activities in the Big Creek basin and collected a meaningful baseline of existing water quality, especially during times of storm induced runoff when 80 to 90 percent of the agricultural waste is transported to Buffalo National River (https://bigcreekresearch.org/project_reports/docs/Review%20Panel%20Report%20-%20May%2019%202014.pdf; Mott, 1990; Steele and Mott, 1998, Galloway and Green, 2004).

Source inventory information and water quality data would have allowed ADEQ to develop a water quality model for the Big Creek basin. C&H waste application volumes could have been added to the water quality model, and the results could have been quantitatively evaluated, and forecasts made concerning water quality responses at various locations and scales (McCarty et al., 2016). However, this was not done. This complicates the task of researchers, including BCRET, to determine the impacts C&H is having on water quality.

The graphs labeled as 4.3.4 and 4.3.8 are copied from a recently completed report by the Watershed Conservation Resource Center, 2017, and confirm previous observations of the relationship between land use and nitrate levels at Buffalo National River (Mott, 1997; Mott and Laurans, 2004). The Watershed Conservation Resource Center analysis shows increases in nitrate over time in both the Buffalo River and its tributaries. These results correlate with agricultural land-use conversion from forest to pasture. This information is not new as these relationships were described in reports 20-years ago (Mott, 1997). As the agency whose mission is to "protect, enhance and restore the natural environment for the well-being of Arkansans," (www.adeq.state.ar.us) ADEQ has the duty to demonstrate that permitting a facility land applying 69,470 pounds of nitrogen per year (Hancock et al., 2016) will not contribute to additional elevation of nitrate concentrations in the Buffalo River. It has not done this.

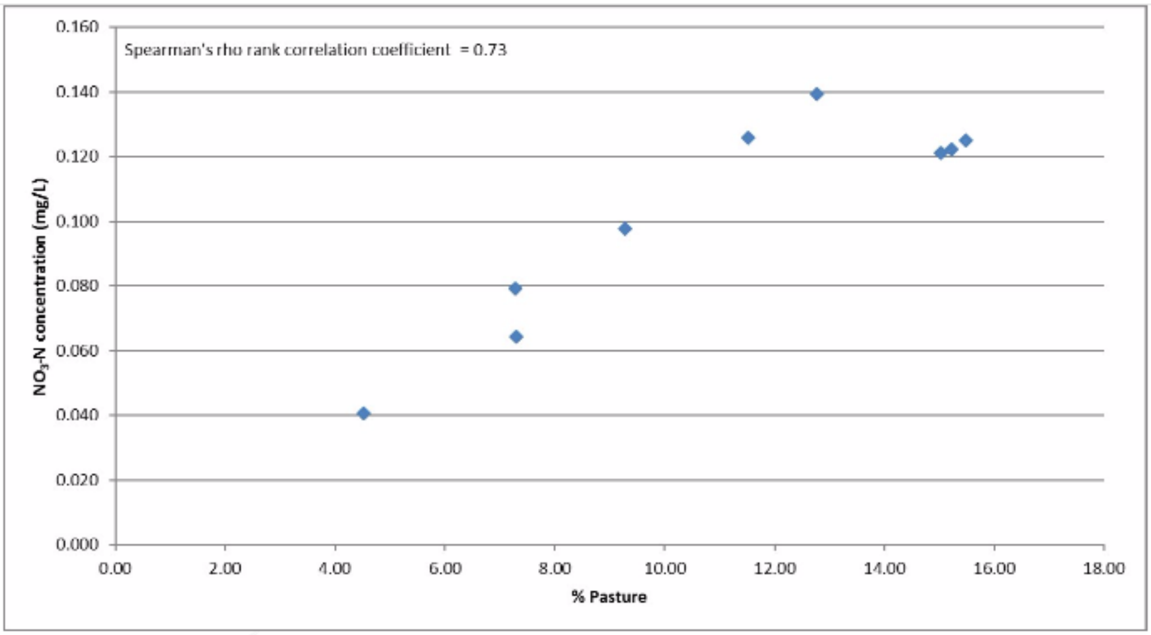


Figure 4.3.4 Relation between mean NO_3-N concentration and percent pasture of watersheds of Buffalo River corridor sites sampled between 1985-2011 during storm-flow and base-flow conditions for Buffalo River corridor

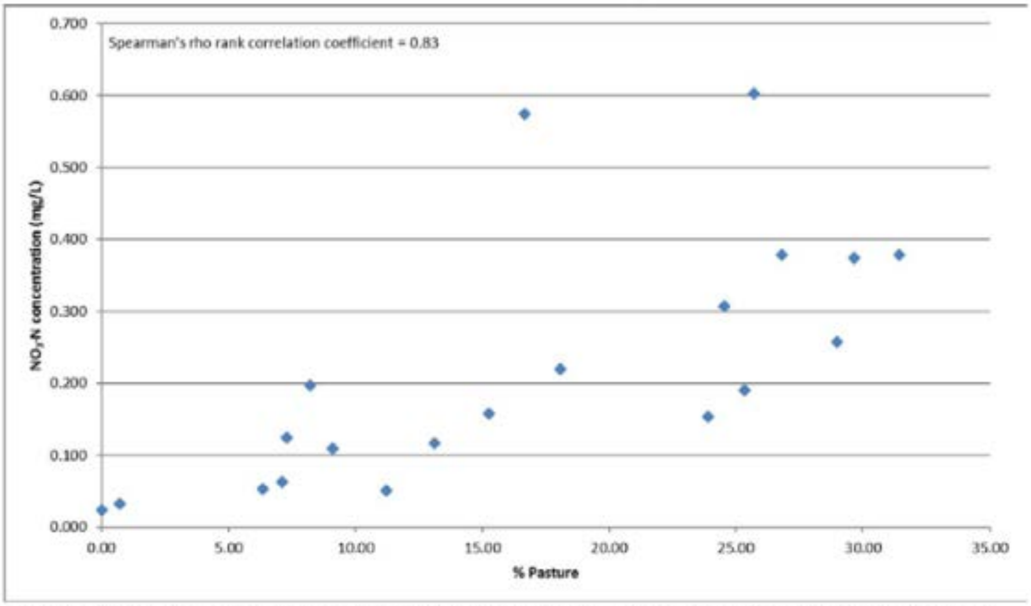


Figure 4.3.8 Relation between mean NO_3-N concentration and percent pasture for Buffalo River tributary sites sampled between 1985-2011 during storm-flow and base-flow conditions.

ADEQ has long been aware of the nexus between water quality and nutrient issues and has stated:

> "The greatest threat to surface and ground water quality in northwest Arkansas is nonpoint source pollution from confined animal operations. Northwest Arkansas has the greatest percentage of broiler houses, hog farms, and dairies than any other area of the State. In conjunction with having some of the highest production rates in the United States, northwest Arkansas is also listed as one of the most vulnerable areas of the State to potential ground water pollution (Arkansas Soil and Water Conservation Commission, 1994)."
>
> "Practically all of the waste generated from these animal production facilities is land applied and, as a result, nitrate levels measured from this region are atypically high (Arkansas Department of Pollution Control and Ecology, 1993)."

Due to the widespread and significant water quality impacts in northwest Arkansas, ADEQ had a duty to conduct a rigorous water quality assessment previous to permitting this large CAFO. Given the State and National significance of Buffalo National River, its Outstanding National Resource status, and the vast body of science that shows the impacts of CAFO waste runoff on water quality, ADEQ also has a duty to model the water quality changes that are and will occur, under all hydrologic conditions. Because source inventories, baseline water quality, and modeling has not been conducted, ADEQ does not know the linkages between dissolved oxygen (D.O.) minima levels at Big Creek at Carver, or what is the source of the *E. coli* numeric standard criteria exceedances observed in the BCRET data, or if the nuisance algae blooms in Buffalo National River were or were not contributed to by C&H. ADEQ should deny this permit until it can develop an unbiased, peer reviewed, water quality model, and use it to test its assumptions that C&H is retaining all of its nutrients, chlorides, trace metals, solids and bacteria from the applied swine waste load.

Buffalo National River is recognized as an Outstanding National Resource Water under provisions of the Clean Water Act. The anti-degradation policy prohibits degradation of water bodies to the point where they no longer meet their most restrictive designated use. CFR 40 § 131.12 states:

> ***(3) Where high quality waters constitute an outstanding National resource, such as waters of National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance, that water quality shall be maintained and protected.***

Anti-degradation regulations help to ensure the following: "(1) all waters continue to support their designated uses; (2) waters with higher quality than the minimum are protected, unless there are important benefits associated with carefully considered actions that could cause additional degradation; and (3) **highly valued, high-quality waters are not degraded at all**" (USEPA, undated).

Under ADEQ Regulation No. 2 the Buffalo River is listed as an Outstanding Resource Water with two designated uses: Extraordinary Resource Water (ERW) and Natural and Scenic Waterway (NSW). Where high quality waters constitute an ORW, those uses and **water quality** for which the outstanding waterbody was designated **shall be protected by** (1) water quality controls, (2) maintenance of natural flow regime, (3) protection of instream habitat, and (4) **encouragement of land management practices protective of the watershed.**

Based on the work of Mott, 1990; Steele and Mott, 1998; Galloway and Green, 2004; White et al., 2004, it is understood that nutrients and bacteria will be delivered from the C&H waste application fields to Buffalo National River primarily during periods of storm generated runoff. The EPA (https://www.epa.gov/sites/production/files/2016-05/documents/tech_notes_8_dec_2013_load.pdf) estimates that 80 to 90 percent of nonpoint pollution loads are delivered to rivers in the 10 to 20 percent of the time surface runoff is occurring. Another complicating factor in the Big Creek basin, the fifth largest tributary to the Buffalo River, is the karst subsurface drainage system, which in some situations can deliver bacteria and nutrients to surface streams nearly as rapidly as through surface runoff (Brahana et al., 2016).

ADEQ is making its decision to issue this permit without analyzing storm runoff water quality conditions at BCRET's upstream or downstream monitoring sites near Mt. Judea, or the USGS monitoring site at Carver. As a result, ADEQ is not assessing the most significant concern presented by this decision, and is unable to answer questions about the water quality impact of field runoff from the waste application sites operated by C&H. Evidence is presented here regarding runoff of nitrate that is measurably impacting the water quality of the Buffalo River. This data has been obtained from the USGS continually recording Hach® Nitratax sensor located at Big Creek at Carver, ½ mile upstream from the confluence with the Buffalo River (https://waterdata.usgs.gov/ar/nwis/uv?site_no=07055814).

In most aquifers, water travels at the rate of feet per year. In karst aquifers, ground water velocities achieve feet per second. Infiltrating rainwater moves rapidly towards a discharge point at springs or directly within adjacent surface streams (Brahana et al., 2016). Based on a detailed analysis (Mott, 2016), the upper karst aquifer near Mt. Judea has elevated nitrate concentrations. In this setting during significant rain events, storm runoff is merging with the land applied waste, and carrying some component of this waste to surface streams, either through sheet flow or discrete conduits such as gullies, ditches or rivulets. Flow in karst conduits is also responding to the rain, and groundwater with elevated levels of nitrate is discharging at greater volumes to surface streams. These combined elevated sources of nutrients and bacteria are then carried downstream toward Buffalo National River.

It is possible to estimate the travel time for a peak of nitrate concentration generated upstream of the USGS Mt. Judea stream gage to the USGS Big Creek at Carver gage using an equation given in a link provided by the USGS https://pubs.usgs.gov/sir/2004/5064/SIR2004-5064.pdf. The distance from the USGS Mt. Judea gage to the USGS Big Creek at Carver gage is approximately 4-miles (Figure 2). Travel time for the arrival of a peak nitrate concentration generated from the area of C&H's waste application fields to the Big Creek at Carver gage can be forecast by inserting the required values in the equation in the document referenced above. Values used were an average discharge of 150 cfs, a stream slope of 0.00118 ft/ft, and a drainage area of 89.9 miles. The equation yielded an average velocity for the nitrate peak of 1.07 ft/s, and calculated a gage to gage travel time of 5.5 hours.

Figure 1 shows the storm hydrograph response from a rain event with sufficient volume, intensity, and duration to generate surface runoff and karst conduit flushing in the Big Creek basin. This event was not a major flood or runoff event. The horizontal axis minimum starts at 00:00 hours on Oct. 12, 2016. Surface runoff began passing the Big Creek at Carver gage at 17:00 hours and stream discharge rises. Figure 1 also shows nitrate concentration every 15 minutes. Nitrate increased from 0.035 mg/L pre-storm runoff to 0.065 mg/L (about twice as high) during the first 4 hours of runoff. The first 4 hours represent runoff from the mostly forested lower portion of the Big Creek basin (bigcreekresearch.org, Figure 2). After the first 4 hours the nitrate concentration began to increase and peaked 6 hours after runoff started (Lag 1).

The discharge curve in Figure 1 shows three periods of peak rainfall generated three peaks in the hydrograph. The time between when the discharge began to rise in response to surface runoff, and the arrival of the peak nitrate concentration (lag time), ranges from 5.5 to 7 hours, and is a reasonable approximation of the 5.5 hours estimated by the travel time equation. Nitrate concentration peaks at 1.97 mg/L (about 56 times higher than the pre-storm nitrate value). Travel time lag analysis provides evidence that the source of the peak nitrate is the developed portion of the Big Creek basin where C&H and its waste application fields are located as little as 0.7 miles above the USGS Mt. Judea gaging station. This is a simplified analysis intended to portray a glimpse of the critical information contained in storm runoff data. Better evidence would be attained if a tracer was injected into the flow of Big Creek at the Mt. Judea gage when surface runoff first begins passing this location, and its arrival time physically detected at the Big Creek at Carver gage while simultaneously collecting water quality samples to be analyzed for all parameters of concern.

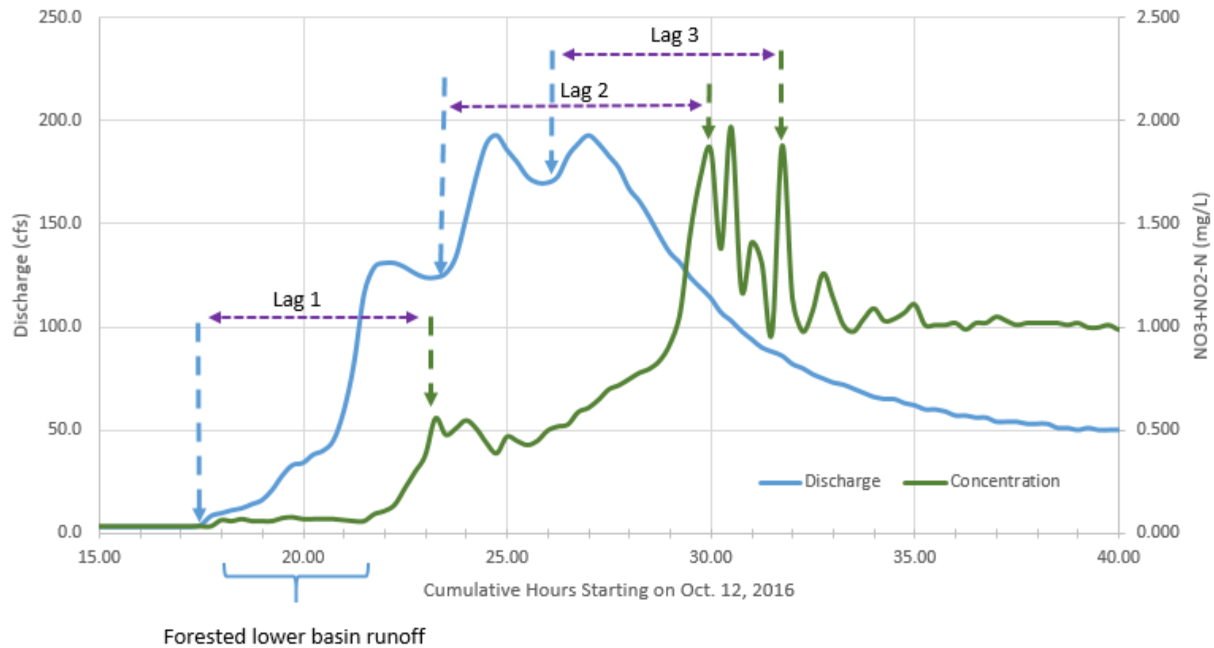


Figure 1: Response of discharge and nitrate concentrations to an October 12 and 13th, 2016 storm event at the USGS gage and sampling site at Big Creek at Carver (cfs = cubic feet per second, mg/L = milligrams per liter).

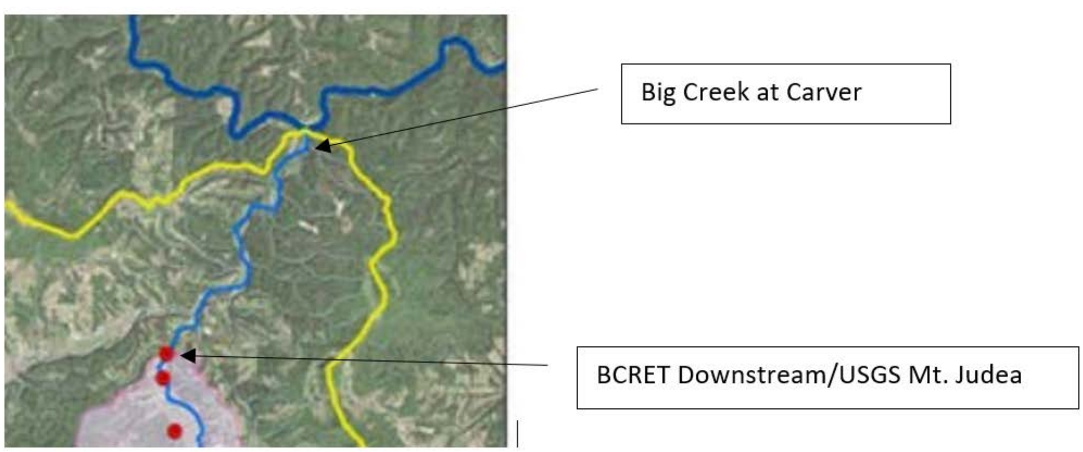


Figure 2: Aerial photo of lower Big Creek (bigcreekresearch.org)

Routine water quality monitoring programs that grab a sample on a predetermined schedule are likely to miss short-duration peak concentrations, and conclude the water quality is little affected by agricultural sources. The storm event data shows that the existing water quality in the Buffalo River will be measurably increased in nitrate by the surface runoff and groundwater moving out of the Big Creek basin. This example is not unique, and storm event concentration spiking can be shown for storm after storm with the USGS data (Figure 3).

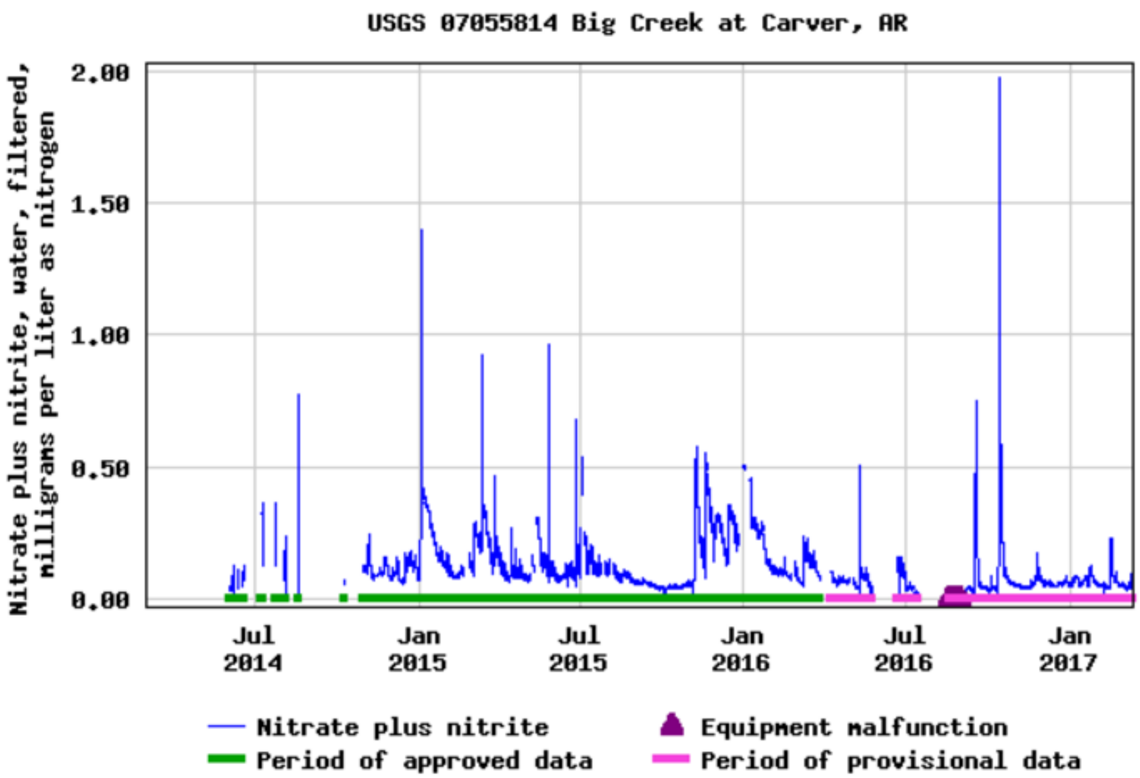


Figure 3: Nitrate concentrations at Big Creek for the period of USGS data collection.

Quantifying the total mass of a substance being transported down Big Creek and loaded into the Buffalo River is critical to analyzing C&H's impact on the water quality of Buffalo National River (Haggard et al., 2003; https://bigcreekresearch.org/project_reports/docs/Review%20Panel%20Report%20-%20May%2019%202014.pdf). Loads can be expressed in many forms, but typically they are represented as pounds per day or tons per year. For nutrients, the load is most useful when examining how aquatic systems will respond to nutrient stimulation, and the potential for nuisance algae development. For streams draining agriculturally developed basins, loads are typically orders of magnitude greater on days with storm runoff than on base flow days. (McCarty et al., 2016; Shujiang et al., 2008; Lohman and Jones, 1998; Scott et al., 2016, Steele and Mott, 1998).

Before a storm load can be calculated, the interval of storm flow must be isolated within the hydrograph. Inflection point analysis employing asymptotic lines matched to the falling side of the hydrograph and the base-flow tail was used in hydrograph separation (dashed lines in Figure 4). Where these lines intersect is a good approximation of when surface runoff has stopped dominating the hydrograph, and subsequent stream discharge is composed primarily of discharging ground water (https://www.slideshare.net/DirkKassenaarMScPEng/characterizing-change-in-baseflow-interactions-with-urbanization-through-eventbased-hydrograph-separation-and-analysis).

In the case of the October 12 - 13, 2016 storm event, the storm hydrograph spans 19 hours. To calculate the load, the concentration at time x is multiplied by the discharge at time x to derive an instantaneous flux, or a load of nitrate in milligrams carried past the sampling station each second. Because discharge and nitrate data are collected by the USGS every 15 minutes, the flux is multiplied by the time interval and converted, in this example, to express a load in pounds per 15 minutes. These 15 minute loads are then summed over the 19 hours of the storm runoff hydrograph to derive a total storm load. The nitrate load for this storm was calculated to be 310 pounds of NO3+NO2 as N.

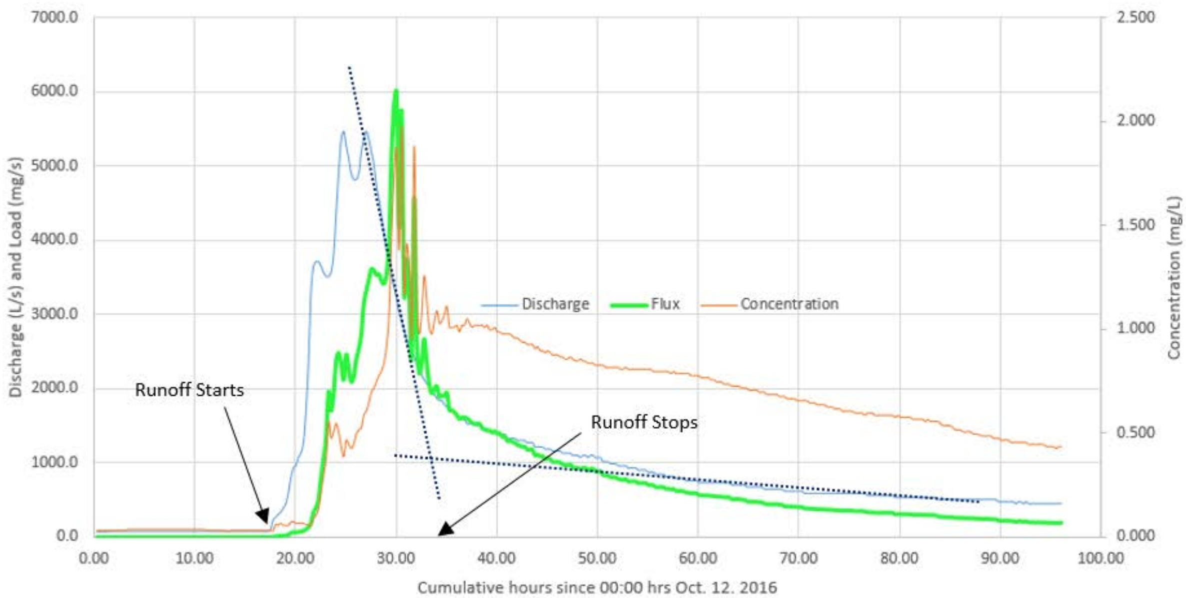


Figure 4: Behavior of discharge, concentration, and flux loads in response to an October 12 - 13, 2016 storm event at Big Creek at Carver (L/s = liters per second, mg/s = milligrams per second, and mg/L = milligrams per liter).

During the 24-hours prior to storm runoff initiation, the load was 0.5134 pounds per day. This storm loaded the equivalent of 607 pre-storm days of nitrate into the Buffalo River. C&H produces an estimated 92,611 pounds of nitrogen per year (DeHaan, Grabs & Associates, 2012). The USGS discharge and nitrate concentrations are readily accessed at, https://waterdata.usgs.gov/ar/nwis/uv?site_no=07055814.

Figure 5: Storm runoff from Field 5a, a total of 40 C &H waste spreading fields comprising 630 acres are discharging to Big Creek during periods of runoff (bigcreekresearch.org).

Figure 6 shows median nutrient values in field runoff and at Big Creek stream sampling sites. Field runoff median values are higher in nutrients than the receiving stream, with the exception of nitrate at Big Creek downstream, which is receiving a constant elevated level of nitrate via groundwater contributions (big creekresearch.org; Mott, 2016). Note that nitrate is coming off the waste application fields at concentrations similar to the median concentration at BCRET's downstream sampling site. Also note that much of the total nitrogen leaving the fields would not be detected with the nitrate probe at Big Creek at Carver. Therefore, the total nitrogen load, once calculated by USGS, will be much larger than the nitrate spike used in this example.

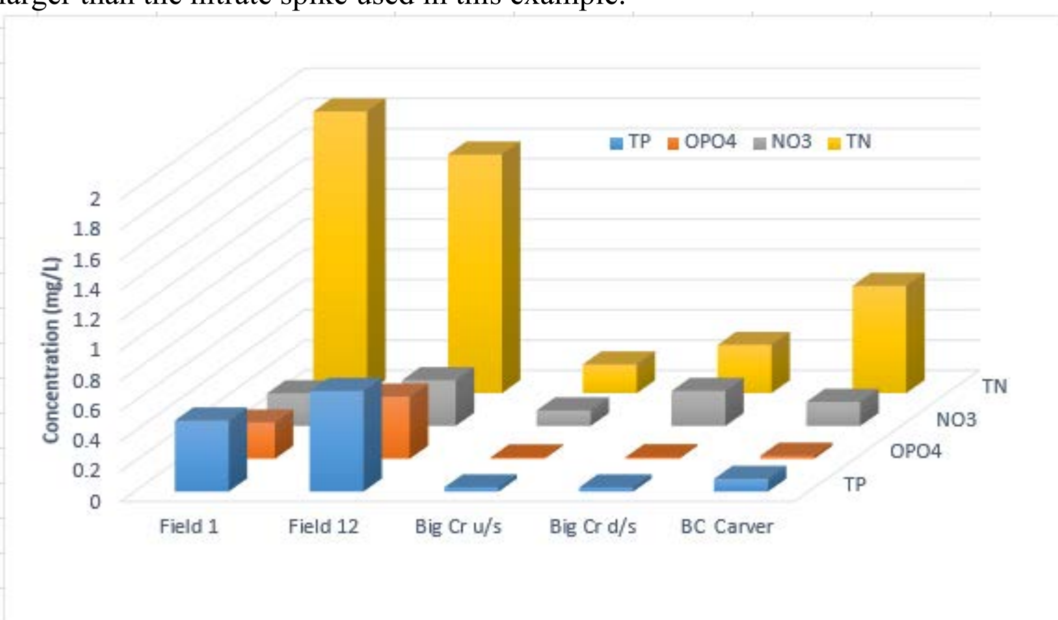


Figure 6: Median nutrient concentrations in C & H Hog Farms field runoff and at Big Creek sampling stations.

Another observation in the flume data is that 60 percent of the total phosphorus coming off the waste application fields is in the plant available dissolved form, while in the surface streams the DP/TP ratio is closer to 30 percent. This means during each rainstorm runoff episode, especially during summer thunderstorms, dissolved phosphorus is being supplied to the Buffalo River's aquatic plant community.

Bacteria levels are also observed exceeding state numeric criteria in Big Creek at both BCRET sampling stations (bigcreekresearch.org; Mott, 2016). The sampling station on Big Creek at Carver (Figure 7), and in the Buffalo River below the confluence with Big Creek (Figure 7) can also show high bacteria levels (Mott, 2016).

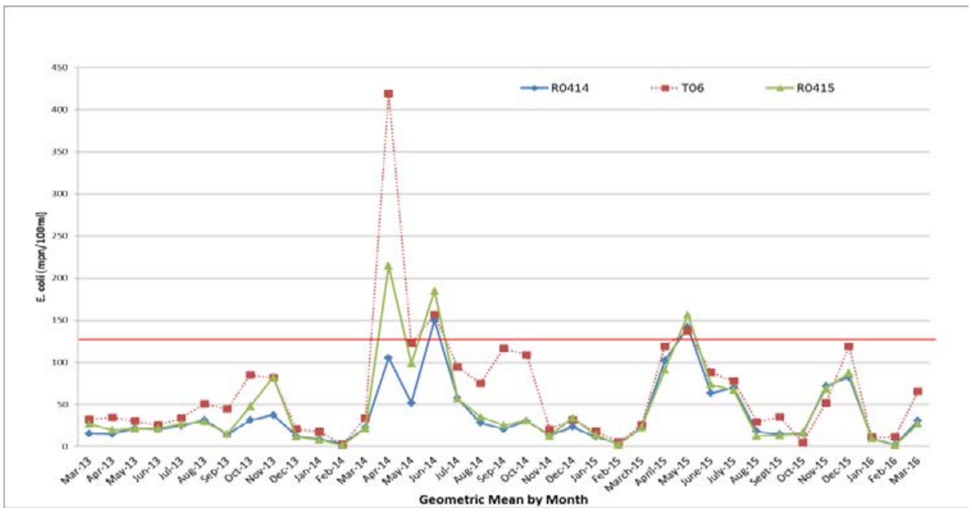


Figure 7: Geometric mean (5 samples) E. coli values at Big Creek at Carver (T06), the Buffalo National River above its confluence with Big Creek (R0414), and the Buffalo National River downstream from its confluence with Big Creek (R0415).

ADEQ has not explained the source of these high bacteria levels or addressed the issues identified by BCRET, USGS, or NPS monitoring.

In summary, we believe the available evidence demonstrates C&H is contributing measurably to water quality degradation of the Buffalo River in violation of the ONR status and associated anti-degradation policy. While nitrate was the only nutrient parameter reviewed due to limited storm flow data availability, the results indicate a compelling need for ADEQ to understand how storm runoff is impacting water quality in order to make an informed decision. Because ADEQ has failed to conduct a meaningful analysis of the high flow data, it lacks the ability to characterize water quality impacts to Buffalo National River attributed to the continued operations of C&H.

Because BCRET is not collecting water quality samples in a way that allows a systematic assessment of storm runoff, the BCRET data is most applicable to analyzing base-flow concentrations. BCRET is not gathering discharge data at the upstream site. Because of this oversight, instantaneous flux, storm flow, base flow and annual load calculations and comparisons between sites are either compromised or not possible. BCRET has not systematically evaluated high flow data collected with the ISCO automated samplers, or presented peer reviewed interpretations of the ISCO data to decision makers

Nutrients and bacteria are delivered to Big Creek during both base and storm flows, although the base flow load contribution is typically smaller in agricultural settings. BCRET data shows elevated nitrate and total nitrogen concentrations at the downstream sampling site (bigcreekresearch.org). This result is expected in agriculturally developed basins on karst terrain (Steele et al., 1990; Scott et al., 2016; Mott et al., 2000; Petersen et al., 1998; Petersen et al., 2014; Adamski, 1997) and this finding likely pre-dated C&H to some extent. However, the extent to which C&H has caused or contributed to elevated nitrate levels is difficult to quantify in the absence of baseline data. A recent analysis of nitrate and total nitrogen trends shows these parameters increasing downstream of C&H since initiation of C&H swine waste spreading (Mott, 2016).

Nutrients can affect water quality in many ways, including reduction of dissolved oxygen levels https://www.uaex.edu/publications/PDF/FSA-9517.pdf. ADEQ is aware that the USGS continuous dissolved oxygen (D.O.) monitoring probe at the Big Creek at Carver site records D.O. minima values below state standards during summer/fall low-flow conditions (Figure 8). It is likely that nutrients from C&H are contributing to the eutrophication of the stream reach between the BCRET downstream station and the Big Creek at Carver site near the confluence with the Buffalo River (Mott, 2016; https://pubs.usgs.gov/fs/fs11803/; Sharpley et al., 2006; https://www.pca.state.mn.us/sites/default/files/wq-iw3-22.pdf). ADEQ has not analyzed this relationship following EPA guidance. ADEQ has not sought or presented an alternative explanation for these low D.O values (https://www3.epa.gov/caddis/ssr_do_int.html).

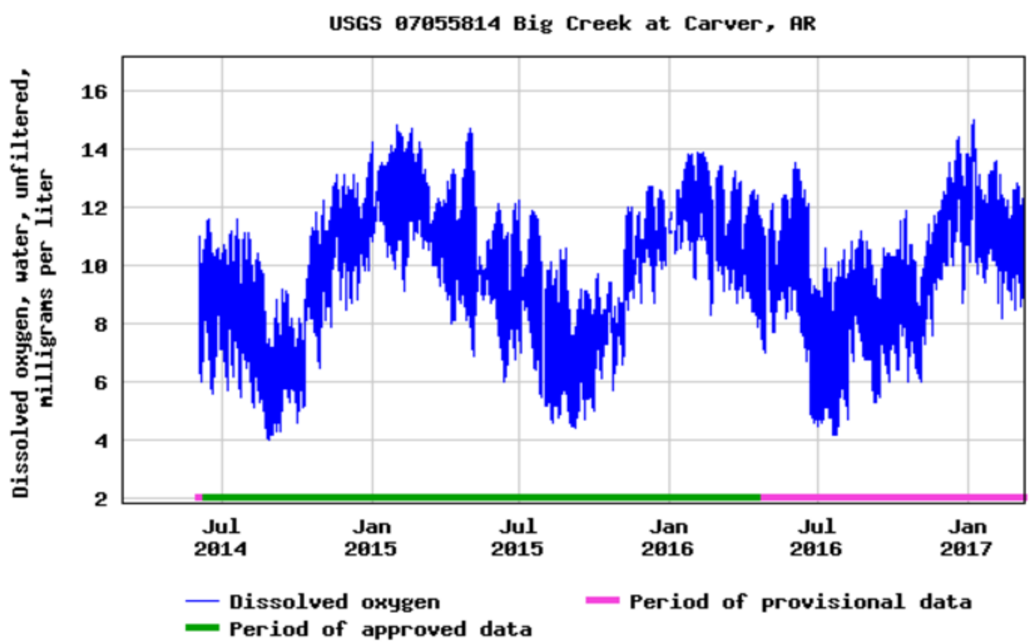


Figure 8: Dissolved oxygen record at Big Creek at Carver for the period of record (source, USGS, NWIS).

Although several parameters are elevated at statistically significant levels downstream from C&H when comparing the upstream BCRET testing site to the BCRET downstream testing site, the most concerning is an elevation of nitrate and total nitrogen concentrations (Mott, 2016). Median nitrate concentrations are over twice as high at the BCRET downstream site as compared to the upstream sampling site. Total nitrogen median concentration is 70 percent higher at the downstream site. Nitrate/total nitrogen ratios are also higher at the downstream site *Id*.

Nitrate levels are more elevated in late summer and early fall and result from ground water elevated in nitrate discharging from the karst aquifer into Big Creek above the downstream sampling site. *Id.* Base flow concentrations of nitrate and total nitrogen increased from one summer low-flow period to the next at the downstream site, but not at the upstream site. *Id.* According to the results of numerous studies, nitrate derived from CAFOs and other agriculturally generated wastes readily migrates to groundwater in karst settings (see the vast body of research cited in NRCS, 2012). Nitrate is little attenuated in karst aquifers and discharges to surface streams through springs and gaining reaches (Musgrove et al., 2016; Vesper et al., 2003, NRCS, 2012).

Nutrients infiltrate groundwater at C&H through leaking lagoons and from waste application fields (DeHaan, Grabs & Associates, 2012; NRCS, 2012; https://www.uaex.edu/publications/PDF/FSA-9517.pdf; Tesoriero et al., 2013; Shujing et al., 2008; Musgrove et al., 2016; Vesper et al., 2013; Adamski, 1997; Aley, 1982). As a result of geologic factors, the groundwater nitrate load resurges above the BCRET downstream sampling site, and is subsequently transported the 4-miles toward the Big Creek at Carver gaging station. Within this 4 mile reach, during base flow conditions assimilation and dilution (and possibly loss of flow to the karst strata), processes appear to measurably reduce soluble nitrate concentrations. Nitrate concentrations were typically much lower at the Big Creek at Carver site than at the BCRET downstream sampling station (Mott, 2016).

The dissolved oxygen (D.O.) record (Figure 8) at the Big Creek at Carver site shows the effects of eutrophication caused by this constant supply of agriculturally derived nutrients. In recent summers during warm weather and low-flow conditions, the diurnally fluctuating dissolved oxygen values dip below ADEQ Regulation #2 numeric standard of six milligrams per liter at the Big Creek at Carver site (https://waterdata.usgs.gov/ar/nwis/uv?site_no=07055814).

A plausible explanation for these observations is that algae production, driven by increased nutrient concentrations and subsequent die-off, is resulting in low dissolved oxygen levels (Mott, 2016). ADEQ is aware of the D.O. minima observations, but hasn't offered an explanation regarding water quality violations. Nor has ADEQ conducted any assessments of possible impacts to aquatic communities in the effected reach. Other complicating factors include the possibility that stream flow in the reach between the gages is being pirated to the karst units below the Boone Limestone. This flow could move directly to the Buffalo River in a karst distributary process (Mott, 2016; Taylor and Greene, 2008). Increasing nitrate values as observed by Watershed Conservation Resource Center (2017) in the Buffalo River at Woolum and Mitch Hill Spring could be associated with karst interactions between the Big Creek Valley and the Buffalo National River (Mott, 2016; Moix and Galloway, 2014). Karst hydrologic processes in the area have not been assessed by ADEQ or BCRET.

Phosphorus is another nutrient of concern with total phosphorus significantly elevated at the BCRET downstream site. The current magnitude of increase in phosphorus is less than for nitrogen in the base-flow data at this time due to issues associated with "legacy phosphorus" (Sharpley et. al., 2013). According to Dr. Sharpley, "outmigration of phosphorus from a basin is a slow process, but once it begins it is very hard to reverse and lasts a long time." (Sharpley et al., 2006). This statement does not apply to storm flow conditions when phosphorus outmigration is accelerated. (https://www.epa.gov/nutrientpollution/sources-and-solutions-agriculture; https://pubs.ext.vt.edu/424/424-029/424-029_pdf.pdf). Outmigration of phosphorus begins with the first storm event following the application of high phosphorous swine waste on waste application fields. Coupled with surface runoff, this first storm event, and each subsequent one, can yield large loads of dissolved and total phosphorus to receiving streams (Figure 6). It has been determined that 33 percent of soluble phosphorus found in swine manure applied to test plots was transported in runoff after two simulated storms (Smith et al., 2000).

Stream ecosystems can be stimulated by phosphorus inputs before reaching "legacy phosphorus" conditions. Phosphorus is the primary limiting nutrient in the Buffalo River watershed (Meyer and Rippey, 1976). Under natural conditions, aquatic plant growth is limited by very low phosphorus concentrations in the Buffalo River and its tributaries. Nitrogen and potassium, the two other essential plant nutrients, are typically more plentiful and do not limit aquatic plant metabolism.

When phosphorus is added to phosphorus limited aquatic systems, the dissolved portion will stimulate plant growth and be removed from the water column and incorporated into plant tissue. The labile and organic phosphorus bind to the surface of particles in the stream bed. These compounds can subsequently be converted to the dissolved form in an aquatic environment, and further stimulate plant growth. If enough dissolved phosphorus is consistently added to a stream by storm events, discharging ground water, and dissolution from stream deposits, phosphorus will no longer be the primary factor limiting plant growth (http://edis.ifas.ufl.edu/sg118). At this point, base flow water samples will show elevated phosphorus as well as the storm flow samples (http://pubs.acs.org/doi/abs/10.1021/es403160a; https://www.ncbi.nlm.nih.gov/pubmed/24216410; https://water.usgs.gov/edu/phosphorus.html; https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/rca/?cid=nrcs143_014203).

The ultimate sources of elevated phosphorus in streams draining agricultural basins are phosphorus in land applied waste and phosphorus enriched soils that have received excessive nutrients for many years. Over time, elevating soil phosphorus increases phosphorus in ground water and stream deposits. If it increases enough, it is no longer the primary limiting factor in plant growth. Plants will not immediately absorb dissolved phosphorus, and it can then be consistently measured at elevated levels in water samples, especially in winter when plant growth is limited by light and temperature. However, this increasing phosphorus will be stimulating aquatic plant growth and eutrophication processes years before Sharpley's legacy phosphorus concept becomes manifest in base flow water sampling results. At that time, even if efforts to control (or eliminate) the phosphorus in land application practices are applied, the "legacy phosphorus" in the soils and stream deposits will result in elevated phosphorus levels in water samples, and it is "very hard to reverse and lasts a long time." (Sharpley et al., 2006).

ADEQ appears to be satisfied waiting up to ten-years for these base flow legacy phosphorus signatures to appear in the data. This is an unacceptable management and monitoring approach and is inconsistent with ADEQ's stated mission "to protect, enhance, and restore the natural environment for the well-being of all Arkansans" (https://www.adeq.state.ar.us/) and the goals of the Beautiful Buffalo River Action Committee to "jump start" improvements in water quality in the Buffalo River watershed. (https://www.adeq.state.ar.us/water/bbri/bbrac/). In truth, it is exactly the opposite.

Another problem relating to phosphorus buildup concerns seven waste management sites (Fields 3, 5, 6, 7, 9, and 12) that C&H's original NOI indicate are "occasionally flooded" by Big Creek. The fields currently have phosphorus levels above optimum according to C&H's Reg. 5 permit application and the runoff and erosion caused by a flood could remove several inches of soil and transport it rapidly to the Buffalo River. Depending on how recent waste applications occurred, other contaminants including nitrogen and pathogens would be discharged along with the phosphorus. There may be additional waste management sites that have a flooding potential since some of the fields added to the original seventeen are along Big Creek or the Left Fork of Big Creek.

E. coli data from BCRET also shows the potential for bacteria standard violations in Big Creek (Mott, 2016). A review of BCRET data shows little sampling of *E. coli* concentrations during storm flow conditions, as holding times are not met when using the ISCO samplers. We are unable to find *E.coli* data regarding the waste storage ponds, and cannot determine if this indicator species survives in the lagoon environment. There is nothing to show that ADEQ has investigated the source of water quality impairment as evidenced by *E. coli* data exceeding State numeric criteria, and ADEQ has not made a determination of exceedance, even though bacteria levels are a concern for the public and the Arkansas Department of Health (Arkansas Department of Health, 2013).

Since ADEQ does not have the information it needs to make informed determination regarding the extent this facility is causing stream impairment the permit should be denied. Approving this permit for C&H will allow it to continue to contribute to the degraded water quality conditions observed in Big Creek and the area's karst aquifers. Unless the steps outlined above are taken, ADEQ will have failed to satisfy its obligations to protect Big Creek and Buffalo National River from further degradation as required by law. Completion of a nonpoint source inventory and development of a water quality model to estimate contributions of nutrients and bacteria from these inventoried sources, including C&H, is long overdue.

Karst hydrogeologic studies have been conducted in the Buffalo River basin and provide useful information relative to this permit decision (Aley, 1982; Aley and Aley, 1989; Aley,1999; Aley and Aley, 2000; Brahana et al., 2016; Mott et al., 2000). This work was not cited as a source for preparing permit 5264-W by ADEQ or by Hancock et al., 2016, though it directly relates to the karst ground water concerns in the area. The two main sources of potential ground water contamination are (1) infiltration and discrete recharge from the waste application fields, and (2) seepage from the waste holding ponds. (NRCS, 2012; DeHaan, Grabs & Associates, 2012; Aley and Aley, 1982; Tesoriero et al., 2013; Shujing et al., 2008; Nolan et al., 1998; Almasri and Kaluarachchi, 2007; https://bigcreekresearch.org/project_reports/docs/Review%20Panel%20Report%20-%20May%2019%202014.pdf).

At nearly 50-percent of the acreage available for land application, alluvial material (stream deposits) covers the Boone Formation. Stream deposits draining the Boston Mountains commonly contain higher proportions of sand (https://soilseries.sc.egov.usda.gov/OSD_Docs/R/RAZORT.html). Sand is relatively inefficient at capturing phosphorus (NRCS, 2012). Under these stream deposits, dissolution and erosion processes have formed a "cutter and pinnacle" bedrock surface typical of karst, and the water table is relatively close (5 - 6.5 feet) to the surface (Halihan and Fields, 2015). The higher elevation fields are also located on the Boone Formation and can contain a high gravel fraction which increases permeability and has little adsorptive capacity (https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/arkansas/AR101/0/newton.pdf). Electrical resistivity survey results showed "The potential for rapid transport pathways in the underlying bedrock as joints or potential karst features were observed as conductive electrical features in a resistive background." (Halihan and Fields, 2015).

Nitrate dissolves and moves with water and does not readily adsorb onto, or absorb into, soil particles (NRCS, 2012; https://www.uaex.edu/publications/PDF/FSA-9517.pdf). According to the NRCS, even when application rates target plant consumption levels, nitrogen is the most difficult nutrient to manage because of the many pathways it can follow to get into ground and surface waters (NRCS, 2012). BCRET data shows a negative correlation between nitrates and stream flow at the downstream sampling site (Mott, 2016). This inverse relationship to discharge indicates groundwater is elevated in nitrate, as is the aquifer discharging to Big Creek (Tesoriero et al., 2013; Shujing et al., 2008). The C&H house well, trench, and spring monitored by BCRET show similar elevated nitrate levels (Mott, 2016). It would be informative if BCRET would conduct a statistically valid trend analysis of nitrate and total nitrogen concentrations at their sampling sites to determine if these values are increasing in the aquifer.

ADEQ should evaluate the elevated nitrate concentrations in the karst aquifer, and the potential for C&H to further increase nitrate levels in groundwater. Nitrate discharging with ground water to Big Creek is likely contributing to the eutrophication and low D.O. values at Big Creek at Carver (https://water.usgs.gov/edu/nitrogen.html; https://pubs.usgs.gov/fs/2003/fs091-03/; https://archive.epa.gov/water/archive/web/html/vms57.html; http://www.arkleg.state.ar.us/assembly/2017/Meeting%20Attachments/470/I14350/3%20

29%2016%20BITTING%20%20Nat%20Park%20Svs%20-%20Big%20Creek.pdf). Groundwater is also mobilized during storm events and contributes to the storm flow loads exported to Buffalo National River, as previously addressed. In these interconnected karst aquifers, groundwater flow could also be migrating to unknown discharge points in adjoining watersheds (Mott et al., 2000; Mott, 2016)). Since there is elevated nitrate at the BCRET downstream sampling site, ADEQ should deny this permit.

An extensive body of literature exists describing the process of eutrophication in aquatic systems, and its effects on dissolved oxygen, aquatic ecosystems and aesthetics (Lohman and Jones, 1998; https://www.epa.gov/nutrientpollution/harmful-algal-blooms; https://www.epa.gov/nutrientpollution/problem;). Once transported to surface streams, nutrients stimulate increased plant production and are a primary driver of nuisance algae blooms. Of the various factors that control the development of algae blooms, nutrient stimulation is the primary factor influenced by human activities. The Buffalo River is more susceptible to nuisance algae blooms than many other Ozark streams due to its unique flow and temperature regimes, hydrogeology, and channel dimensions (Watershed Conservation Resource Center, 2016; Panfil and Jacobson, 2001; McKinney, 1997; Mott, 2016).

During some summers, the Buffalo River can become aesthetically degraded due to nuisance aquatic plant stimulation with nutrients, -- a/k/a “algae blooms” (Meyer and Rippey, 1976). Aquatic plant over-production can lead to dissolved oxygen depletion as observed at the Big Creek at Carver sampling site. Stimulation of primary production also leads to changes in aquatic communities. Permitting a facility that adds measurable increases of nutrients to Buffalo River will result in increased nuisance algae production and related affects.

While nutrient loading is happening with every storm, the worst case scenario involves a summer thunderstorm developing over the Big Creek basin generating a surface runoff load of mostly soluble, plant available, nutrients (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/crops/?cid=nrcs143_014202; http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Document-4676/BAE-1521web.pdf). It is not unusual for the Buffalo River to remain at base flow while a tributary carries its load of runoff generated nutrients, bacteria, and sediments out of the Boston Mountains, Springfield, or Salem Plateaus. The incoming nutrient slug will “tail out” in the Buffalo River, and stimulate the growth and abundance of aquatic plants. Agricultural development of the Buffalo River basin has already resulted in measurable increases in nitrate (Watershed Conservation Resource Center, 2017), and this large CAFO is adding to that trend. Because the Buffalo River is an ONRW, granting this permit causes or contributes to a violation of the anti-degradation regulations, and the nuisance species clause of Regulation No. 2.

Nuisance algae blooms have social and economic consequences. They degrade the visitor experience, which harms the area’s tourism business. If enough algae blooms are encountered, tourists and locals alike will lose the perception of the Buffalo River as being a pure and unpolluted stream. APC&EC has not set numeric nutrient criteria for waterbodies in Arkansas, but does have narrative criteria. This criteria is subjective and not well defined, and can be argued as being "in the eye of the beholder" (Figure 9).

Figure 9: An example of a nuisance algae bloom in the Buffalo National River downstream of C&H during the fall of 2016 (source: Carol Bitting).

The Agricultural Waste Management Field Handbook (AWMFH) states:

> "Manure and other waste associated with livestock production can be important sources of aesthetic degradation. For example, they can be the source of objectionable deposits, floating scum, bad odors, and nutrients that promote growth of nuisance aquatic life. Local regulations are often aimed at maintenance of aesthetic quality of watercourses. To maintain aesthetic water quality, all water should be free from substances that produce undesirable or nuisance aquatic life."

ADPC&E Regulation No. 2 General Standards are applicable to all waters at all times unless a waterbody is specifically excluded. These standards state that man-made pollution cannot produce undesirable aquatic biota or result in the dominance of nuisance species. The standards also discuss the use of biological integrity assessments to determine if a waterbody's ecological condition has declined relative to a reference waterbody or a list of key species. To our knowledge ADEQ has not conducted such an assessment and cannot demonstrate through water quality modeling, supported by robust water quality data and load calculations, that C&H is not the source of nutrient pollution to the Buffalo River.

Field	2012	2014	2015
1	83	45	95
2	72	67	108
3	42	79	89
4	50	46	75
7	178	94	89
8	46	80	82
9	52	53	82
10	69	31	72
11	57	27	62
12	19	72	88
13	48	23	86
14	52	15	75
15	15	29	72
16	48	50	68
17	50	21	86
Average	58.7	48.8	81.9

Table 1: Soil test phosphorus results from C&H waste spreading fields.

The research of many agronomists and hydrologists, including Dr. Andrew Sharpley, shows phosphorus (P) buildup in soils leads to eutrophication of streams resulting from a "legacy" of improper/uninformed P management (Sharpley et al., 1999; Sharpley et al., 2013; Scott et al., 2016; Haggard et al., 2017; Mittlestet et al., 2016; Haygarth et al., 2014; Meads et al., 2010; Michalak et al., 2013). Sharpley (2016) prescribes key elements to managing agricultural phosphorus in a manner that minimizes the water quality impacts of legacy phosphorus. The first recommendation is to apply fertilizer at the right rate: "Fertilizer P rates are usually established by crop need and modified by the amount already in the soil, as determined by established soil P test methods."

Soil tests results and University of Arkansas phosphorus application recommendations show that long-term over application of P is occurring on almost 90% of the currently used C&H waste disposal fields. Guidance from the University of Arkansas states that fields are considered to be above the optimum agronomic level for P when values exceed 50 pounds per acre (Espinoza et al., 2007). Mott, 2016, used soil test results to calculate the amount of phosphorus existing on the 17 waste application fields based on the original NMP (DeHaan, Grabs & Associates, 2012). Calculations revealed nearly 25 tons of excess phosphorus existed in the 17 C&H waste application fields prior to the start of swine waste application. Subsequent review of soil test results from these 17 fields are presented in Table 1, and show average phosphorus levels increased by 40 percent in only two-years.

In the current NMP (Hancock et al., 2016) soil test results were provided for 40 fields as shown in Table 2. Out of 630 acres permitted, only 174 acres (28%) required a total of 5,000 pounds of P based on the maximum recommended rate for plant uptake. All other fields were recommended to receive zero pounds of phosphorus to fulfill crop needs. Furthermore, when the acres are looked at in total, these 40 fields contain an above optimum surplus of 50,090 pounds of legacy phosphorus already existing on the landscape. The NMP calculations indicate an additional 33,325 pounds of phosphorus will be added to these fields annually (Hancock et al., 2016). This analysis shows Dr. Sharpley's "Right Rate" recommendation is not being followed at C&H.

Field # NMP	Acres NMP	Existing P (lb/ac)	Recommend P_2O_5 (lb/field)	lbs above optimum P (>50 lb P/ac)
1	8.4	190	0	1176
2	6	216	0	996
3	15.2	178	0	1946
4	7.2	150	0	720
5	9.7	126	0	737
6	5.6	232	0	1019
6A	7.9	222	0	1359
7	64.3	178	0	8230
7A	28.3	76	1530	736
8	7.2	164	0	821
8A	1.4	144	0	132
9	25.2	164	0	2873
9A	10.3	134	0	865
10	14.1	144	0	1325
10A	16.4	200	0	2460
11	14.2	124	0	1051
12	11.4	176	0	1436
13	11.6	172	0	1415
13A	30.7	150	0	3070
13B	8.6	122	0	619
14	8.1	150	0	810
15	22.5	144	0	2115
15A	10.4	36	800	-146
15B	15	132	0	1230
16	15.2	136	0	1307
17	31.9	172	0	3892
18	22.6	84	1665	768
19	10.3	132	0	845
20	21.6	126	0	1642
21	20.3	24	840	-528
21A	15.6	42	1920	-125
21B	6	76	225	156
22	35.5	76	1470	923
23	28.1	112	0	1742
24	8	90	540	320
32	10	114	0	640
33	4	104	0	216
34	13.5	112	0	837
35	18.4	80	1170	552
36	9.3	40	1320	-93
Totals	630	as P_2O_5	11,480 lb	
		as P	**5,010 lb**	**50,090 lb**

Table 2: Soil test results and related calculations from NMP (Hancock et al., 2016).

Another recommendation of Dr. Sharpley is to utilize nutrients from the "right source:" "Fertilizer nutrients can be formulated to match crop needs; however, manures have more P than N compared to crop needs. For instance, the ratio of N:P in manure (2 to 4:1) is three to four times lower than that taken up by major grain and hay crops (8:1). As a result, applications of manure to meet crop N needs, apply three to four times more P than annual crop needs. Repeatedly applying manure at rates to provide sufficient N, will increase soil P levels and the risk of P runoff."

Pond 1				Pond 2			
Date	N	P_2O_5	N:P Ratio	Date	N	P_2O_5	N:P Ratio
9/24/2013	12.6	10.54	2.72	9/24/2013			
4/10/2014	22.4	18.1	2.81	4/10/2014	11.6	3	8.79
4/17/2015	20.1	4.8	9.52	4/17/2015	15.2	7.9	4.37

Table 3: Nutrient results and ratios from samples collected in C&H waste ponds (lbs/1,000 gal).

Manure pond test results (Table 3) show nitrogen to phosphorus ratios averaged 3:1 in pond 1 and 7:1 in pond 2. The maximum N:P ratio was 11:1 while the minimum was 2:1. This wide variability in pond sample results indicates waste application fields are receiving waste loads with significanly variable nutrient contents. For example, the pond 1 phosphorus result from January 5, 2016 was 6.7 times greater than the April 17, 2015 result. Yet the April 17, 2015 P result was used in the developing the NMP, and is significantly lower than the average. Using this lower value could guide phosphorus management at C&H for an undetermined time period because there is no requirement in Regulation No. 5 or the draft permit to update the NMP.

The NMP does not meet the "Right Source" requirement because the nutrient source provides more phosphorus than the crop needs. Given the variable nutrient levels of pond samples, actual nutrients provided to individual fields could differ significantly both spatially and temporally. Fields are also not likely to be receiving nutrients over the long-term as specified in the NMP, because projections were made on the basis of one sample from a highly variable sample set. Part of the reason for the variable results could relate to poor mixing and stratification within the ponds. Table 4 shows the stratification of nutrients in the ponds (bigcreekresearch.org). Both N and P increase with depth, with pond 1 showing very high P concentrations in the accumulating sludge, as predicted. The waste sample used to develop the NMP significantly underestimates the amount of phosphorus in Pond 1. N:P ratios approaching 0.5:1 are found in the accumulating sludge (bigcreek research.org).

	Pond 1				Pond 2			
	Top 6"	Bottom	Profile	NMP	Top 6"	Bottom	Profile	NMP
Total N (mg/L)	1692	5078	2640	2410	1213	2890	1043	1820
Total P (mg/L)	180	5070	1316	253	114	458	279	417
solids %	0.8	11.9	3.8	3.4	0.5	4.3	2.3	2.4

Table 4: Nutrient concentrations and percent solids at differing depths within waste ponds and in comparison to values used in the NMP.

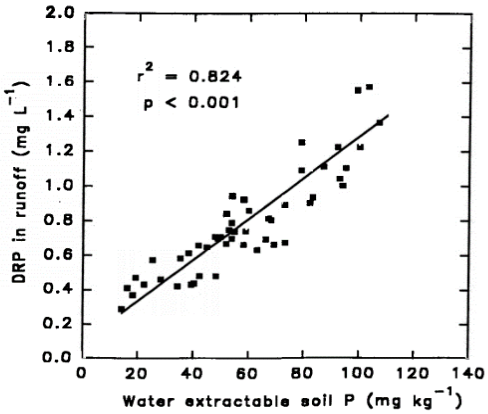


Figure 10: Relationship between water extractible P in Captina surface soil and dissolved reactive P in runoff.

The NMP lists the crop production/pasture use as rotational grazing. With rotational grazing most nutrients are retained within the harvested field and watershed. The distribution of nutrients within soils has been shown to be spatially variable with elevated P concentrations associated with cattle feeding and loafing areas. Cattle can also migrate into unfenced areas near streams and sinkholes and transport nutrients to areas designated as buffers in the permit. Appendix 1 below (taken from BCRET's 4th Quarter 2016 Report) shows changes in P concentrations in gridded soil samples. In most areas P values have increased significantly in the top 4 inches of the soil column. Agronomists have shown that increased P values in the top 4 inches of soil directly relates to increased dissolved P in storm runoff as shown in the examples in Figure 10 and 11.
https://pubag.nal.usda.gov/pubag/downloadPDF.xhtml?id=60&content=PDF
https://www.bigcreekresearch.org/docs/ARS%20Ag%20P%20%20Eutrophication.pdf

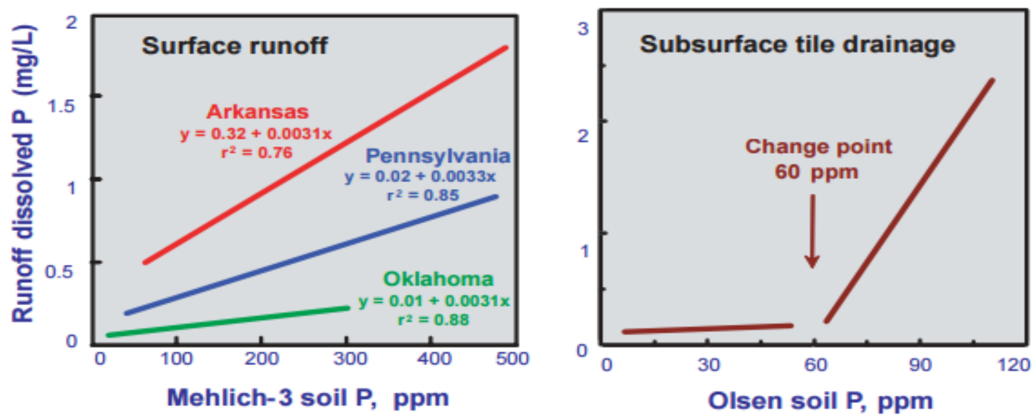


Figure 11: Effect of soil P on dissolved P concentration in runoff from several pasture watersheds and subsurface tile drainage.

Figure 11 also shows that for soils above 60 ppm P, e.g. most C&H waste application fields, migration of phosphorus to ground water increases sharply. BCRET's Appendix 1 below shows phosphorus levels are also generally increasing at deeper depths within the soil profile. As discussed in other comments, waste application field soils are often not well suited to phosphorus retention and the underlying karst ground water transport mechanisms make this area very susceptible to storm runoff and infiltration, and legacy phosphorus build up in soils.

The soil tests and soil mapping clearly show the buildup of legacy phosphorus in soils. The AWMFH predicts this and warns against it (Chapter 11 Waste Utilization, 651.1102 Land application):

"Nutrient management is an essential component of an agricultural waste management system. Plans should be based on soil tests, crop yields, manure nutrient analyses, and environmental concerns of the farm enterprise. The plan must account for the nutrients available in the waste, the crop's requirement for the nutrients, and timing and method of application. It should be formulated to minimize the potential offsite losses of nutrients by runoff, leaching, and volatilization."

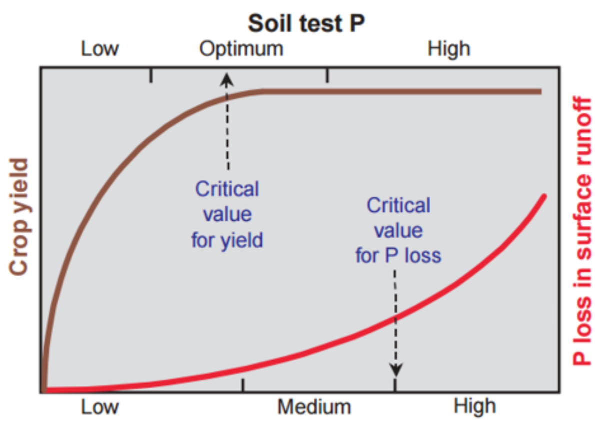


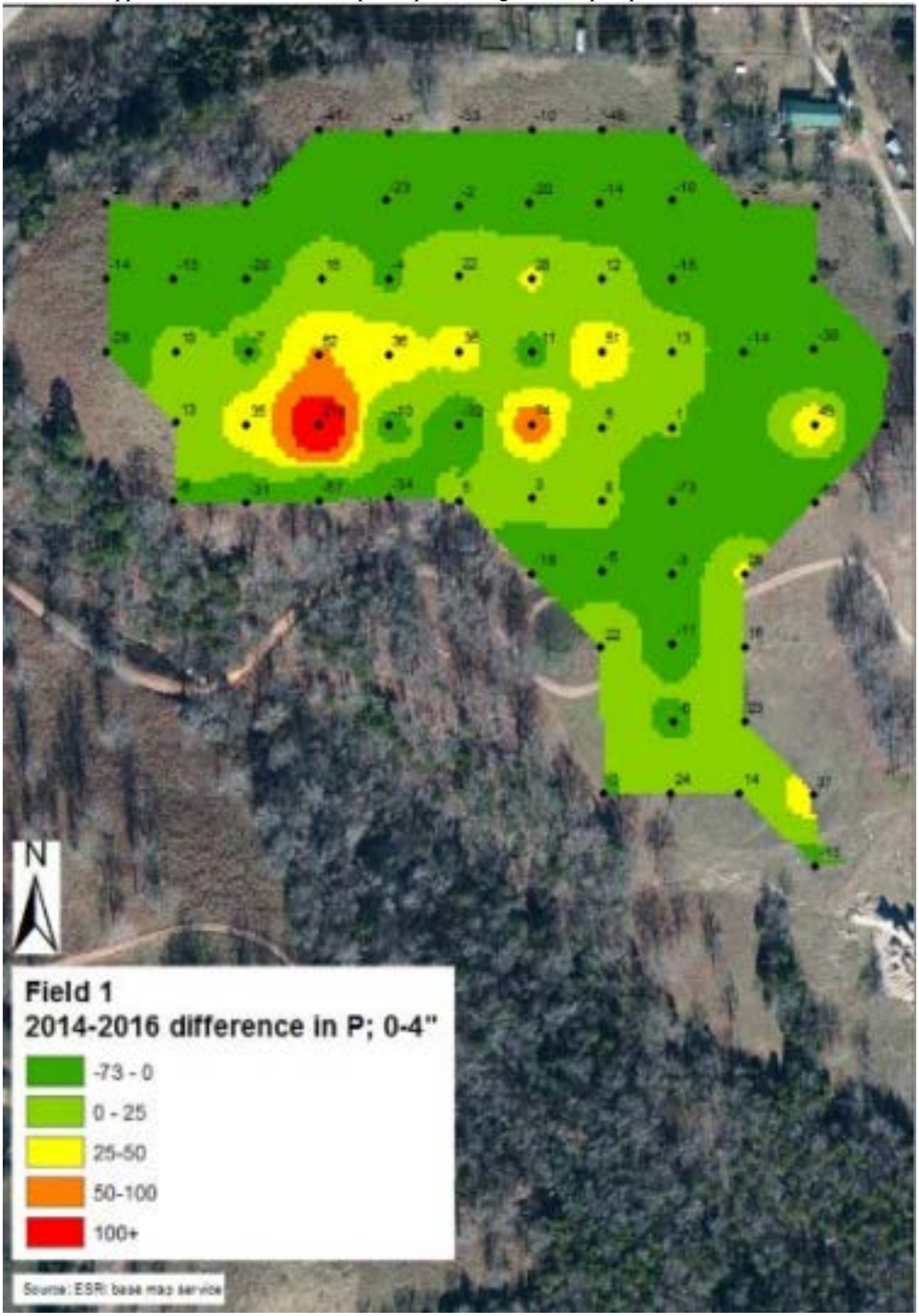
Figure 12: P loss in surface runoff and crop yield as related to soil test P and phosphorus indices such as the API.

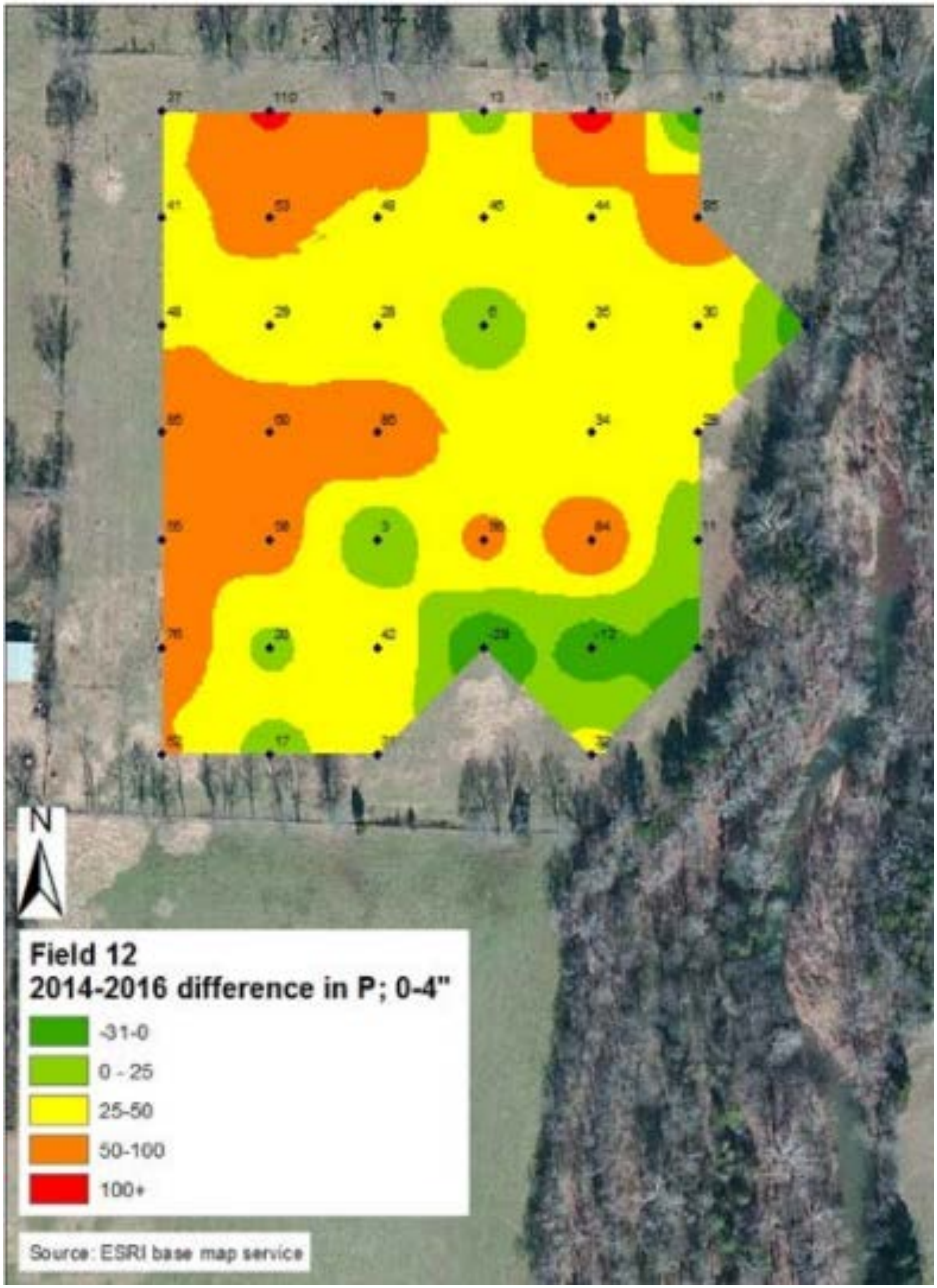
Figures 10 - 12 show a comparison of P loss in surface runoff at various levels of soil phosphorus concentrations. The results show that fields with low soil phosphorus values provide little phosphorus in storm runoff. Application of phosphorus to achieve maximum crop yield increases the amount of phosphorus in runoff by at least twice as much. Allowing phosphorus application at moderate levels under guidance such as the API results in significantly greater phosphorus losses in runoff.

https://www.bigcreekresearch.org/docs/ARS%20Ag%20P%20%20Eutrophication.pdf
Other comments presented herein describe the existing water quality impacts of excessive nutrient application such as storm event runoff, legacy phosphorus buildup in soils, and legacy nitrate buildup in ground water. Increasing nutrients in aquatic systems is the primary anthropogenic driver of the nuisance algae blooms observed at Buffalo National River. Nuisance algae blooms degrade the visitor experience, and are the number one water quality related complaint submitted by park visitors (Mott and Laurans, 2004). Increasing nutrients in streams also results in changes to aquatic community structure and function, favoring species that directly harvest the more abundant periphyton and other aquatic plants (Petersen and Femmer, 2002; Petersen et al., 2014).

https://www.bigcreekresearch.org/docs/ARS%20Ag%20P%20%20Eutrophication.pdf

BCRET's Appendix 1: Gridded soil sample maps showing elevated phosphorus over time at C&H.




N
Field 12
2014-2016 difference in P; 0-4"
-31-0
0 - 25
25-50
50-100
100+
Source: ESRI base map service

In 2014, a panel of experts reviewed the operational and monitoring activities taking place at C&H and analyzed BCRET's study design and implementation (https://bigcreekresearch.org/project_reports/docs/Review%20Panel%20Report%20-%20May%2019%202014.pdf). In their Summary of Findings the panel stated "The complexity of the landscape and the farming operation presents a challenging task for the Team." They began their review by noting (as we do above) that conclusively demonstrating the impact of C&H on water quality is made difficult by "the fact that limited data on water quality are available prior to the onset of the farming operations. Additionally, within the Big Creek watershed there are a number of other ongoing land management and land use activities that can impact water quality."

The panel immediately recognized the significance of monitoring storm events and stated "extreme events are often the driver of hydrologic responses to environmental stressors and **we recommend that more effort be directed at sample collection during high-flow events**." The panel also "recognized three major potential threats to water quality associated with C&H. These include: 1) leakage from the two onsite waste storage ponds, 2) contamination of surface and subsurface water due to land application of the wastes, and 3) potential long-term buildup of soil nutrient levels (primarily soil phosphorus) due to application in excess of crop needs and removal."

The following is a list of specific recommendations made by the expert panel, actions BCRET has taken in response to the panel's concerns, and an assessment of remaining concerns:

Recommendation #1: A short-term, detailed water balance study should be conducted to determine the actual seepage rate of the storage ponds.

> **BCRET Response**: A water balance study has not been undertaken. Exact pond seepage rates/volumes remain unquantified.

Recommendation #2: Water quality samples should continue to be collected from the house well on a routine basis. In addition, the Panel recommends that the detailed well driller's log be obtained and that a slug test, pump test, or both be conducted on this well to determine characteristics of the aquifer from which water is drawn.

> **BCRET Response**: Water samples continue to be collected from the well but it was not apparent that aquifer testing was conducted. Well sample results showed problems with bacteria contamination and nitrate values are higher than in surface water samples.

Recommendation #3: A detailed walking survey of the slope down gradient from the waste ponds should be conducted to identify potential seeps and springs from perched aquifers. If perched aquifers are noted based on the driller's log or by the identification of hillside seeps, one or more shallow monitoring wells should be installed to the depth of the perched aquifer within as short a distance as feasible from the storage ponds. If springs or seeps are noted on the hillside, these should be monitored on a routine basis to establish baselines and trends in water quality.

> **BCRET Response:** No monitoring wells were installed. Because BCRET installed trenches below the pond, it might be assumed that seeps were found below the ponds during prolonged dry weather indicating perched water, but this could not be confirmed. In karst environments, trenches are often an ineffective way to assess pond seepage as a result of "discrete recharge zones" and internally drained geohydrologic properties (Aley, 1982). Contaminants could be migrating vertically through solutionally enlarged fractures, such as those identified in the Harbor borehole, to the subsurface drainage network, and then discharge to springs and or surface streams. Some trench results indicate high nitrate values. BCRET has not provided a peer reviewed report describing their trench study methods and results.

Recommendation #4: An inventory of the entire reach of Big Creek between the upstream and downstream sampling points with georeferenced notes made on any significant changes in water flow due to tributaries or major springs. This inventory should include karst features located within the contributing area.

> **BCRET Response**: A karst inventory could not be confirmed, however the work of Halihan and Fields (2014) clearly shows the mature karst just below the waste application fields and near the ponds, and the fractures and conduits normally associated with karst terrain, and directly supports the AWMFH concerns for siting CAFOs in such terrain.

Recommendation #5: A detailed land use map that identifies all land uses within the contributing area of the watershed. This should include surveys of farmers to gauge land management practices, with particular emphasis on animal stocking practices, fertilization, and manure applications.

> **BCRET Response**: A land use analysis has been conducted for the contributing watersheds to support the BCRET study objectives (bigcreekresearch.org). The analysis used GIS and remote sensing acquired sources. Unfortunately, the watershed boundary assumptions may be in error in this karst settings. A detailed inventory and survey of farmers as suggested by the panel is more appropriate to developing a stand-alone water quality model as we recommended in other comments.

Recommendation #6: A seepage survey to include stream profile measurements and estimations of discharge. The stream survey should be repeated under high (if feasible), medium, and low flow conditions to capture the potential variability in groundwater recharge and discharge to the riparian zone, valley alluvium, and karst features (if present).

> **BCRET Response**: Seepage surveys have not been conducted. Sometimes referred to as a gain and loss flow study, seepage surveys are a critical recommendation. Karst influence on surface flow is pronounced in Big Creek as this stream channel is

often dry where it passes the C&H's waste application fields and waste storage ponds during base flow conditions. A seepage survey in this karst setting would yield quantifiable and reproducible results concerning ground water/surface water interactions. Seepage survey design should incorporate water quality measurements and sample collection. By the time Big Creek reaches the upstream sampling site it has flowed across the Boone Formation for two miles. It is likely significant stream flow has already been lost to the subsurface drainage network before it reaches the upstream sampling site. This is confirmed by the times in the BCRET sampling record when the upstream site is dry while the downstream site is still flowing.

At the downstream site, it is likely karst hydrology is having the opposite effects on stream flow. The downstream site is located near the base of the Boone Formation. In the Big Creek valley, the lower Boone contains a relatively high quantity of chert (Braden and Ausbrooks, 2003). Chert is composed mainly of silica, and therefore is insoluble. Chert also interacts in complicated ways with the soluble limestone in which it is inter-bedded to affect hydrologic ground water flow processes (Brahana et al., 2016). At the downstream sampling site, it is likely these chert layers form an aquitard of undefined spatial distribution, disrupting the subsurface drainage network and forcing flow back into Big Creek's surface channel. Instead of losing flow as happens at the upstream site, the downstream sampling site is likely capturing water from other basins, such as Dry Creek east of Mt. Judea, for example (bigcreekresearch.org).

Recommendation # 7: Develop rating curves between water level and discharge at both the upstream and downstream sites.

BCRET Response: A USGS gage and rating curve has been installed at the downstream sampling site. The upstream sampling site lacks a rating curve and discharge measurements. This recommendation reflects the importance of being able to match water quality results to stream discharge and calculate loads or flow-weighted concentrations. Rating curves allow stream stage to be converted to stream discharge. The use of the watershed area ratio to estimate flow and loads at the upstream site is likely not applicable because the flow relationship between the two sites is not linear due to karst surface water/groundwater interactions affecting surface flow. Without discharge at the upstream site, verification of the accuracy of the watershed ratio method, or development of nonlinear relationships between flow at the upstream and downstream sites, is not possible.

Recommendation #8: Conduct traces with multiple dyes. The first set of traces should be qualitative to identify the potential connections between points of recharge and discharge. Once established, quantitative traces should be conducted with both conservative and non-conservative dyes to establish travel times and dispersion characteristics. Results of the traces, for example from the sinkhole in Field #1 to the spring downslope, may help revise the area for manure application.

BCRET Response: Dye tracing studies have not been conducted by BCRET. BCRET has used GIS techniques to delineate the watersheds contributing to their monitoring sites. These estimates are likely in error because this simplistic view of watersheds often does not apply to karst basins with extensively developed subsurface drainage networks (Aley, 1982; Aley and Aley, 1989; Aley, 1999; Aley and Aley, 2000; Mott et al., 2000). This is especially applicable to the BCRET downstream sampling site. The actual recharge area for the upstream and downstream sampling sites, and Left Fork of Big Creek, should be delineated using common dye tracing techniques. BCRET has not delineated the recharge area for the spring they are monitoring.

Recommendation #9: The Dry Creek watershed includes an estimated 1/3 of the proposed land area approved for manure application from C&H Farms. An automated sampling and gauging station should be installed as close to the confluence with Big Creek.

BCRET Response: Between November, 2014, and May, 2015, Dry Creek was sampled seven times. The small sample set from a limited time period makes the data of little value in assessing Dry Creek's contribution to Big Creek.

Recommendation #10: The Panel recognizes the need to monitor surface runoff and recommends that more emphasis be placed on a sampling protocol to better capture flow-weighted samples during runoff events.

BCRET Response: The BCRET sampling strategy does not appear to have changed to increase emphasis on surface runoff sampling. There is limited surface runoff data from three flumes. Only two of the fields draining to the flumes receive swine waste. C&H has refused to supply waste application results by date to BCRET limiting interpretations of the results.

Recommendation #11: Use commonly available geophysical techniques to characterize the subsurface conditions that could potentially contribute to preferential flow of water and contaminants from fields receiving swine waste applications. If these procedures document significant subsurface features that can affect water flow, subsurface investigations (i.e., drilling) should be conducted to confirm these observations.

BCRET Response: Ground penetrating radar and electrical resistivity methods have been employed by BCRET collaborators. Follow-up investigations of karst features using borehole investigations at the waste application fields showed many profiles dominated by sand and gravel. One borehole was drilled near the waste storage ponds, this borehole confirmed the presence of a karst preferential flow path (a solutionally enlarged fracture). The electrical resistivity surveys identified concerns related to preferential flow paths in the subsurface karst. Identified concerns based on karst hydrology were not used by the permit planner (Hancock et al., 2016) or the draft permit approver to appropriately design or condition waste storage and application as required by the AWMFH (NRCS, 2012).

Recommendation #12: If buildup of soil phosphorous levels is noted, the results of the manure solids and liquid separation trials that are being conducted as part of the project may offer an opportunity to better match waste applications to specific crop and soil fertility needs. In general, the manure solids will have a lower N:P ratio than the liquid fraction. Ideally, the dryer solid fraction could be applied to fields where soil P levels are low or transported out of the watershed altogether. In light of C&H Farm's use of additives to enhance the function of the waste storage ponds, a regular sampling of storage ponds is important to understand the effects of the additives and to determine variability in nutrient concentrations.

> **BCRET Response**: BCRET's efforts to study ways to ameliorate high P levels in the waste stream have been abandoned. BCRET has noted significant stratification of nutrients in waste holding ponds. Buildup of phosphorus levels in soils has been noted by BCRET in recent years (bigcreekresearch.org). ADEQ studies of CAFO facilities in the Buffalo River watershed in the 1990s and early 2000s identified sludge build up and disposal as the most significant concern at Regulation No. 5 permitted facilities (ADEQ, 2002; Mott, 2016). The current NMP and permit do not address sludge buildup or waste stream treatment, or the need to refine NMP calculations based on "as applied" testing results.

Recommendation #13: Source tracking of nutrients and bacteria. While this is time consuming and can be prohibitively expensive to conduct on a routine basis, if elevated contaminant levels are noted at the downstream site relative to the upstream monitoring locations, source tracking using isotopic or PCR methods may provide additional information needed to establish whether activities associated with C&H are a contributing factor.

> **BCRET Response**: No evidence was found that any source tracking methods have been employed by BCRET. BCRET data shows statistically significant increases in several parameters at the downstream site (Mott, 2016).

Recommendation #14: Supplemental chemical parameters. The study of watershed hydrology and geochemistry is regularly enhanced by combining a multi-parameter approach. For example, the use of multiple water quality parameters may provide additional information on flow paths, residence times, and sources that may otherwise be difficult to interpret on limited sources of data. Therefore, the Panel recommends that the Team consider, if practical, the following additional analytes: - Principal ions – Alkalinity – Appropriate trace metals – Environmental isotopes (including C/N ratios) – Ammonia, Nitrite, and Nitrate fractions of total N – Emerging contaminants (caffeine, hormones, antibiotics, etc.).

> **BCRET Response**: BCRET added several parameters to their sampling regime based on the review team's recommendations. However, some obvious parameters are still lacking such as dissolved oxygen and quantification of discharge concurrent with sample collection at the upstream site. The base flow database BCRET has

developed is substantial and lab reports reflect high standards of quality. Unfortunately, the other short comings of the study design and execution limit the intended use of the base flow data to interpret the impacts of C&H Hog Farms.

Recommendation #15: Storm event sampling. Wide-ranging studies of watershed processes and contaminant transport demonstrate the importance of storm events. In this particular investigation, the transport of waste offsite may be strongly correlated to periods of overland flow on application fields. While the Panel is encouraged to see instrumentation specifically designed to capture this overland flow, it would be beneficial to capture more than a single composite sample, particularly for long lasting storms.

BCRET Response: BCRET has not modified their sampling strategy to focus on critical storm event runoff sample collection. ADEQ is proceeding with their decision on this permit in the absence of critical storm loading information or a peer reviewed analysis of the limited storm event results. The Big Creek sampling strategy employed by BCRET primarily utilizes an upstream of C&H activities and below C&H activities (upstream/downstream) approach. Their stated purpose of this monitoring is to assess potential declines in water quality occurring in the intervening reach where the production facility, swine excrement holding ponds, and swine excrement land application fields are located (bigcreekresearch.org). Samples are collected on a set weekly basis independent of hydrograph considerations. In agricultural basins, it is well known that nonpoint source contamination is rainfall generated, and transport to surface streams is primarily in conjunction with storm hydrographs, as the review panel noted.

In a report prepared for the EPA looking at studies from across the country (https://www.bae.ncsu.edu/programs/extension/wqg/issues/loadestimation.pdf) the relationship between parameter concentrations and storm loading is discussed.

> "Especially for particulate pollutants of non-point origin, the flux varies drastically over time, with fluxes during snowmelt and storm runoff events often several orders of magnitude greater than those during low flow periods. It is not uncommon for 80 to 90% or more of the annual load to be delivered during the 10% of the time with the highest fluxes, as is illustrated in Table 1. Clearly it is critical to sample during these periods, if an accurate load estimate is to be obtained."

Table 1. Delivery of pollutants in Lake Erie tributaries, during selected periods of time with the highest fluxes. Data from Baker (1988).

Parameter	Percent of time	Percent of annual load delivered				
		Raisin	Maumee	Sandusky	Rock	Cuyahoga
Suspended solids	0.5	17.8	17.3	24.3	42.7	28.3
	1.0	26.9	27.1	36.4	59.5	38.1
	10.0	79.6	81.6	87.7	97.6	81.5
	20.0	91.2	93.9	95.4	99.0	90.9
Total Phosphorus	0.5	14.8	9.8	14.8	30.9	13.2
	1.0	23.9	17.2	22.8	47.2	18.0
	10.0	67.9	67.5	77.3	93.9	51.3
	20.0	81.3	85.6	90.2	97.2	64.8
Nitrate + Nitrite	0.5	5.3	5.0	6.9	17.9	3.0
	1.0	9.5	8.7	12.3	28.8	5.2
	10.0	54.2	52.2	56.7	81.0	25.9
	20.0	76.4	75.4	77.2	91.4	40.5

Table 5 compares base flow median instantaneous loads (flux) at BCRET's downstream sampling site compared to flux during a period of storm flow at the same site. The results show analyzing storm flow loads as recommended by the expert panel, EPA, USGS, and other researchers is very applicable to the study of C&H Hog Farms. It is critically important to accurately quantify the storm loads. BCRET collects approximately 80 percent of its stream samples from periods of base flow water quality, and 20 percent of its samples are collected from storm runoff periods (bigcreekresearch.org). BCRET prepares quarterly update reports based on these data and presents this information on their website (bigcreekresearch.org), but there is no analysis of loads presented. Not only is it critical to sample during times of storm runoff, the data collection and analysis must be conducted in a specific manner to calculate accurate, scientifically accepted, loads (Haggard et al., 2003; https://toxics.usgs.gov/pubs/of-2007-1080/methods.html; https://pubs.usgs.gov/tm/2005/tm4A5/pdf/508final.pdf; https://pubs.er.usgs.gov/publication/sir20115172).

	Ortho-P mg/s	TP mg/s	NO3 mg/s	TN mg/s	TSS mg/s
Median Base-flow flux	5.43744	15.40608	151.7952	165.1056	1019.52
May 11, 2015 flux	1870	31970	4283	67560	16739244
Increase (times)	344	2,076	28	409	16,411

Table 5: Comparison of median base-flow flux values to storm flow flux values at BCRET downstream sampling site (Ortho-P = orthophosphorus; TP = total phosphorus; NO3 = nitrate+nitrite-N; TN - total nitrogen; TSS = total suspended solids; mg/s = milligrams per second).

After nearly four years of monitoring, BCRET has not subjected its data or interpretations of such data to independent peer review. ADEQ has not asked BCRET to prepare such an analysis prior to making its permit decision. We submit that subjecting the BCRET study to peer review would reveal that:

- If BCRET anticipates developing load calculations for the downstream sampling site in the future, it is unclear how loads will be compared in this upstream/downstream study?
- BCRET and USGS should coordinate sampling and prioritize storm event data collection and analysis with the goal of quantifying the offsite impacts of C&H on the water quality of Big Creek, Buffalo National River, and the karst aquifer.
- Does BCRET plan to compare their load estimates at the downstream site to the USGS loads at Carver? How will these loads be comparable if USGS uses different sampling techniques and load development procedures?
- BCRET is not planning to sample storm-event runoff in Big Creek at intervals throughout the rising and falling limbs of a storm hydrograph(s) to allow for integration analysis.
- BCRET flags storm and base flow samples in their database, these flags sometimes contradict behavior of the USGS hydrograph at the Mt. Judea gage.
- BCRET data may show increasing nitrates in base flow over time, this result has not been detected or reported by BCRET in their quarterly reports. BCRET should use more commonly accepted and refined water quality assessment techniques and peer review processes to interpret data and state conclusions.
- *E. coli* concentrations are not measured from storm samples collected with ISCO samplers.

The findings and recommendations of the expert review panel show the water quality monitoring approach being employed by BCRET is missing important aspects of a carefully designed study tailored to "the complexity of the landscape and the farming operation." BCRET has not adequately responded to the recommendations made by the expert review panel (and others) to focus on Big Creek and karst aquifer monitoring, especially during storm flow periods, nor has it conducted a proper scientific assessment of the facility's impact through accepted scientific peer review processes. Without this information, it is impossible for ADEQ to make an informed decision regarding the level of water quality impacts to Big Creek, Buffalo National River, and the karst aquifer caused by C&H.

In a letter to ADEQ, the Arkansas Department of Health expressed its concern for potential pathogen risk for park visitors stating "…we have concerns that water borne pathogens – including E-coli and Cryptosporidium - from the proposed land application sites may pose a risk for full-body contact on the BNR, a popular recreational destination" (Arkansas Department of Health, 2013). The excreta from warm-blooded animals have countless micro-organisms, including bacteria, viruses, parasites, and fungi. Some of the organisms are pathogenic (disease causing), and many of the diseases carried by animals are transmittable to humans (NRCS, 2012).

Many states, including Arkansas, use fecal coliform and/or *Escherichia coli* (E. coli) bacteria as indicators of pollution from warm-blooded animals, including humans. The EPA reports that a direct relationship between the density of *E. coli* in water and the occurrence of swimming-associated gastroenteritis has been established, resulting in numeric criteria defining recreational water standards (EPA, 2012; NRCS, 2012). There is no estimate of bacteria production or attenuation in the NMP as there is for nutrients (DeHaan, Grabs & Associates, 2012).

E. coli counts range from near zero to over 20,000 in Big Creek at the BCRET monitoring sites. ADEQ has not assessed the source of the high *E. coli* levels and potential exceedances of State water quality criteria in Big Creek (Mott, 2016). ADEQ has not reviewed the potential for C& H to further contribute to the bacteria levels and bacteria loading in Big Creek. As pointed out by the review panel, source tracking methods could be employed as a means of assessing the source of the high bacteria counts in Big Creek. ADEQ should determine the source of the high bacteria readings and quantify bacteria levels during storm runoff conditions.

Section 5.402 of Reg. 5 states:

> (A) Designs and waste management plans <u>shall be in accordance with</u> this Chapter and the following USDA Natural Resource Conservation Service technical publications:
>
> - Field Office Technical Guide, as amended
> - Agricultural Waste Management Field Handbook, as amended. (Emphasis added).

The requirement is mandatory. Merriam-Webster defines "in accordance with" as "in a way that agrees with or follows something." The design of this CAFO and its agricultural waste management system (AWMS) must follow or agree with the AWMFH. However, the Regulation No. 5 application submitted by C&H ignores the conservation planning processes and provisions of the AWMFH. Rather, it permits a facility designed and operated under a permitting scheme (NPDES ARG59000) that does not require conformance with the AWMFH. Data collection, assessments, and hard choices required by the AWMFH to protect areas recognized as particularly susceptible to adverse impacts caused by CAFOs (as this site is) have not been undertaken at C&H. ADEQ has issued a draft permit to an inadequately designed facility based on an incomplete permit application (that is one that doesn't meet the requirements of Regulation 5). The final decision must be to deny the permit because it is not "in accordance" with the AWMFH.

Specific requirements of the AWMFH and the major shortcoming of the current AWMS, permit application, and draft permit are addressed in detail in this comment and include:

- A detailed planning and analysis of the AWMS has not been conducted. If the information submitted with the permit application is to be considered C&H's AWMS plan, it lacks many important considerations defined in the AWMFH.
- A NRCS Conservation Plan is required and has not been developed.
- A "complete systems approach" was not followed and this led to numerous incorrect decisions including the ongoing disposal of excess phosphorus in soils.
- The AWMS must be designed with maintenance or improvement of surface and ground water quality as a priority.
- Alternative construction and operation scenarios have not been developed for the AWMS. Specific measures to reduce contaminated runoff have not been assessed.
- The required site evaluation criteria have not been collected or analyzed, including the many sources of data and information that have become available since operation commenced.
- Appropriate experts such as geologists, water quality specialists, and NRCS staff, were not utilized in planning and construction.
- The original NOI and construction planning documents did not include a recognition or assessment of the area's karst geology or its karst aquifer. The result is a facility design not compatible with the AWMFH.
- The use of waste storage ponds with synthetic or clay liners is not allowed in karst settings in recognition of numerous commonly acknowledged risks.
- The disposal of nutrients from the swine wastes to waste application fields at rates that exceed plant uptake and soil test based recommendations is not justified for sensitive areas such as karst near Buffalo National River.
- The permit application did not assess primary and secondary waste treatment options.
- Because water quality degradation and soil phosphorus loading is identified in the available data, the planning process must incorporate NRCS recommended approaches to reduce waste impacts on the environment.

The AWMFH requires the planner to complete a site evaluation as part of the waste management plan and consult with the decisionmaker regarding findings. Section 651.0200 states:

> "Planning an agricultural waste management system (AWMS) involves the same process used for any type of natural resource management system, such as an erosion control system. Each system includes a group or series of practices planned, designed, and installed to meet a need. However, different resource concerns, management requirements, practices, environmental effects, and economic effects must be considered.
>
> Planning an AWMS requires the collaboration and combined efforts of a team of people. The decisionmaker for the property involved, NRCS specialists and conservationists, county agricultural extension agents, and other professionals often make up the team. Specialists include engineers, geologists, soil scientists, and agronomists."

The firm that prepared the original Notice of Intent (NOI) did not assemble the team of professionals required. It did not involve a geologist or geohydrologist, a water quality specialist, or NRCS specialists. In fact, the original NOI developers were located in North Dakota, and did not even mention the site's karst geology or its proximity to the Buffalo River. Failure to consider these important factors leads one to question wehter the original NOI planners ever stepped foot on the C&H site? C&H failed to submit a complete site evaluation with its original NOI, nor has it submitted one with its current permit application.

Section 651.0201 "Planning for Protection of Natural Resources" states:

> "The major objective of the NRCS in planning an AWMS is to collaborate with the producer to achieve wise use of natural resources. The NRCS must assure that the decisionmaker recognizes the nature, extent, and importance of natural resource conservation.
>
> …
>
> Consideration of soil, water, air, plant, animal, and energy resources and the interrelationships in the planning process has increased the complexity for decisionmakers. **Implemented as a system, practices and appropriate interactions of practices must be in place to fully address the resource concern."** (Emphasis added).

This section makes it clear that to conform with the AWMFH, the NRCS must direct the planning process and must follow the internal planning requirements and inform the decisionmaker regarding the full environmental consequences of any decision to implement an AWMS. For a large CAFO producing a large volume of waste, and disposing of that waste in a sensitive setting, such as karst geology near Buffalo National River, coordinated planning documents are required. These documents include:

- Conservation Plan; and
- Agriculture Waste Management System Plan

Section 651.0201 of the AWMFH describes planning for protection of natural resources and states:

> "Maintaining or improving the quality of surface and groundwater generally is critical in the planning of an AWMS. Potential groundwater contaminants from agricultural operations include nutrients such as nitrates; salts; waste pesticides; pathogens, generally bacteria; and pharmaceuticals. Potential surface water contaminants from agricultural operations are nutrients, usually nitrates or other agriculture chemicals in solution; phosphorus and other agricultural chemicals attached to soil particles; organic matter; and bacteria.

> Water, both clean and contaminated, must be considered in an AWMS. The usual objective in planning an AWMS is to exclude unneeded clean water and capture polluted water for storage or treatment for subsequent use when conditions are appropriate."

Section 651.0202 of the AWMFH describes the conservation planning process and states:

> "The NRCS nine steps of planning include:
>
> Step 1 Identify the problem.
>
> Step 2 Determine the objectives.
>
> Step 3 Inventory the resources.
>
> Step 4 Analyze the resource data.
>
> Step 5 Formulate alternative solutions.
>
> Step 6 Evaluate alternative solutions.
>
> Step 7 Client determines a course of action.
>
> Step 8 Client implements the plan.
>
> Step 9 Evaluation of the results of the plan.
>
> Although the steps are listed in order, the process is often nonlinear (fig. 2–3).
>
> To thoroughly and efficiently plan an AWMS, each planning step must be considered.
>
> An AWMS plan can and **should be part of the overall conservation plan for a farm**. The overall plan identifies the concerns and opportunities related to all the soil, water, air, plant, animal, energy, and human resources. Often, it will briefly address the issues related to animal waste (such as type and number of livestock, and location, type and construction dates for any manure storage facilities), and leave many of the specific details to be covered by the AWMS plan. **It is especially important the conservation plan assesses the potential for nutrients to be transported offsite through runoff (where nutrients attached to soil particles that erode), by leaching through the soil profile to** groundwater and by volatization into air. If a potential problem is identified, the plan should include appropriate conservation practices and management activities. (emphasis added).
>
> …

Following is a description of the planner's activities and responsibilities in each planning step as it relates to an AWMS.

(a) Identify the problem

Decisionmakers need to know what problems, potential problems, and Federal, State, and local laws and regulations affect their operation. This information can help them recognize the need to develop an AWMS that will protect the resource base.

(b) Determine the objectives

…

A decisionmaker's objective to bring the operation into compliance with laws and regulations may result in an AWMS that is not as extensive as one where the objective is to minimize the effect on the environment and enhance public acceptance of the system.

(c) Inventory the resources

Inventory or collecting appropriate natural resource, economic, and social information about the planning area …the planner must assure that the resource inventory data are complete to the extent that they can be used to develop AWMS alternatives.

Planning an AWMS requires gathering a great deal of information. A partial list of items that must be inventoried or evaluated follows. These items are described in more detail in their specific chapter.

> **(3) Site location**
>
> …
>
> The location of lakes, streams, wells, and other receiving water should be noted and actions designed to minimize the negative effect of an AWMS on the water. In addition, land application of agricultural wastes should not be made during periods when flooding normally occurs unless the waste is injected or tilled to mix and combine with soil immediately.
>
> **(5) Land availability**
>
> **Adequate amounts of agricultural land are needed for application of nutrients and other constituents in agricultural wastes to assure crop utilization and protection** (emphasis added).

(6) Soil

Soils must be evaluated to determine if they are appropriate for AWMS components and activities, such as land application, construction, mortality disposal, and associated traffic, soil physical and chemical characteristics, nutrient levels, water table level, depth to bedrock, and other soils features are included in the evaluation.

…

(9) Geology

The geology of a site plays an important part in selecting an appropriate AWMS. For this reason, the geology of the area in which the AWMS will be located must be evaluated. The groundwater table, variations in depth to bedrock or in soil depth, potential for sinkholes, and fractured or cavernous rock often eliminate use of some types of AWMS components. Geologic information, including depth to the water table and geologic reports, should be reviewed for any given site. Onsite geologic investigations with the assistance of a qualified geologist should be given a high priority, especially where storage or treatment components are involved (emphasis added).

(10) Crops

…

To achieve appropriate use and avoid offsite pollution, the planner and decisionmaker must determine the best time for land application. A tentative schedule for land application of waste should be prepared during planning to determine if the system that has been selected will work.

(17) Water quality

…

The sensitivity of lakes, streams, or groundwater aquifers to contaminants in the agricultural waste should be evaluated and made part of the decision process of whether to allow discharge. Receiving water sensitivity must also be considered when establishing the intensity of management and level of efficiency needed to avoid or minimize accidental spills and to **assure that the designated water use is protected** (emphasis added).

(d) Analyze the resource data

In step 4 of the planning process, the resource data collected in the previous planning step is analyzed. The inventory data are cataloged into one of the six functions and then interpreted, analyzed, and evaluated in preparation for developing alternatives.

(e) Formulate alternative solutions

Step 5 of the planning process, formulate alternative solutions, is used to develop alternative AWMSs based on the analysis of the inventory data as cataloged into one of the six functions of an AWMS.

(f) Evaluate alternative solutions

Alternative solutions need to be evaluated to determine if they meet the objectives, solve the problem, and are socially, culturally, and economically acceptable.

(g) Client determines a course of action

…

The decisionmaker must select one system from among the alternatives developed by the planner; however, the planner needs to guide the decisionmaker by presenting cost effective, environmentally sound, and socially acceptable alternatives. If the preceding planning elements are properly carried out, the decisionmaker will have all of the information available, including the private and public objectives, on which to make the needed decision.

Numerous worksheets and guides are presented in various sections of this handbook to aid in documenting information used in planning. Resource information and data that need to be documented provide a basis for the decisions that are made.

651.0203 AWMS plan

An AWMS plan is prepared as an integral part of and in concert with conservation plans. It is prepared in consultation with the producer and is formulated to expressly guide the producer in the installation, operation, and maintenance of the AWMS (emphasis added).

(a) Purpose of the plan

The purpose of the AWMS plan is to provide the producer with all the information necessary to manage agricultural wastes in a manner to protect the air, soil, water, plant, animal, and energy resources. The plan may be necessary to comply with State regulation or law.

(b) Contents of the plan

The AWMS plan should include:

- a description of all system components or practices planned
- the sequence and schedule of component installation
- the operation and maintenance requirements including a time schedule
- engineering design and layout information on location, size, and amounts
- nutrient management plans, including an accounting of the nutrients available, crops and fields where applied, and amount and timing of application
- biosecurity measures and CAM response plan
- information showing the relationship between the AWMS and the other management systems.

The plan is to guide the actions of the producer in a way that provides for protection of all natural resources. It must have adequate information to accomplish this purpose." (Emphasis added).

These are but a few of the requirements imposed by the AWFMH in conducting the required planning process. However, the Draft Permit does not include a NRCS Conservation Plan and shows minimal onsite investigations, far less that that required by the AWMFH. The primary concern associated with the ongoing waste management activities at C&H is nutrient disposal at the waste application sites.

The AWMFH devotes an entire chapter (Chapter 11) to responsible "waste utilization" and contrasts waste utilization with the ongoing waste disposal being conducted at C&H:

651.1100 Introduction

Water and air quality protection requires proper management of organic waste from agricultural operations. Recycling of agricultural waste materials by land application for plant uptake and crop production is a traditional and proven waste utilization technique. Properly done, recycling by land application and crop uptake is an environmentally sound method of waste management.

This chapter describes "how manure can be applied to land to use nutrients for crop production while minimizing negative water quality impacts."

651.1102 Land application

(a) **The conservation plan**

Land application of agricultural waste for crop production requires careful planning. Conservation plans developed for animal-feeding operations should include a plan for agricultural waste management needs and must address the overall nutrient management requirements for the farm or ranch operation. … The goal of the manure management portion of the conservation plan should be to recycle nutrients in the manure as fertilizer in amounts that can be used by the crop without degrading the environment.

The nutrients in the manure to be land applied must be accounted for in the nutrient management plan for the farming operation.

Later, there is a discussion of management considerations:

***(iv) Management considerations*—Waste must be applied in a manner that**

- **Prevents runoff or excessive deep percolation of the wastewater,**
- **Applies nutrients in amounts that do not exceed the needs of the crop."** (emphasis added)

C&H is violating these important management considerations by applying phosphorus to soils where soil tests show optimum or above optimum levels of phosphorus. The completion of the mandated conservation plan would have identified this concern and required development of appropriate AWMS alternatives.

Section 651.1105 Nutrient management states:

"A variety of factors must be considered in designing nutrient management programs. Production and environmental goals need to be balanced, and these goals might not always be compatible. Crop nutrient requirements should be met, and soil limiting features must be considered.

…

Nutrient management applications must be planned for a limiting nutrient, which is usually either nitrogen or phosphorus. **The ratio of phosphorus to nitrogen in manure is not the ratio needed by the crop. Applying manure to meet crop nitrogen needs of the crop will usually result in excess application of phosphorus needs of the crop.** This is not often a problem if the soil has the ability to retain excess phosphorus for future crop use. However, once the soil has sufficient phosphorus, there is no production gained by adding more and as the phosphorus content of the soil increases so also the risk of the phosphorus leaving the field and reaching a sensitive water resource also increases.

…

A nutrient management plan must consider all likely pathways of manure nutrient transformation and transport…Plans should be based on soil tests, crop yields, manure nutrient analyses, and environmental concerns of the farm enterprise. The plan must account for the nutrients available in the manure, the crop residues, and the soil residues, the crop's requirement for the nutrients, and timing and method

> of application. **The plan should be formulated to minimize the potential offsite losses of nutrients by runoff, leaching, and volatilization**. (emphasis added)
>
> **(c) Nutrient requirements**
>
> Manure can provide part, all, or even excessive amounts of the nutrients required for plant production. The amount of nutrients required by plants must be determined as part of the nutrient management program.
>
> …
>
> Two strategies can be used for manure utilization: management for maximum nutrient efficiency, and management for maximum application rate of manure.
>
> **Strategy 1 —Management for maximum nutrient efficiency.** This strategy best realizes the value of the nutrients in the manure. The rate of application is based on the nutrient available at the highest level to meet the crop's needs. This element is often phosphorus. The manure rate is calculated to meet the requirement of phosphorus, and additional amounts of nitrogen and potassium are added from other sources (generally commercial fertilizers). This rate is most conservative and requires the greater supplement of fertilizer, but applies nutrients in the quantities that do not exceed the recommended rates for the crop.
>
> **Strategy 2—Management for maximum application rate of manure.** This is the strategy employed when the land available for application is limited, and it fails to fully realize the value of the nutrients in the manure. The most abundant element in the manure, generally nitrogen, is used to the greatest extent possible. The manure rate is calculated to meet the nitrogen need of the crop. Often the crop is chosen to maximize the nitrogen uptake. This maximizes the application rate of manure, but will overapply phosphorus and potassium for the crop's requirement. **Over the long term, this will lead to an undesirable accumulation of phosphorus in the soil. Once a phosphorus threshold is reached, another strategy will need to be employed and manure will need to be applied elsewhere.** (emphasis added)

Given the risks of developing a legacy phosphorus issue in the Buffalo River watershed, and the potential long-term environmental consequences, the AWMFH clearly recommends the use of Strategy 1. However, this obviously more resource responsible approach has not even been considered as an alternative to the AWMS at C&H, most likely because no alternatives have been explored since the required planning process has not been followed. Soil test phosphorus is increasing in the waste spreading fields, and total phosphorus is significantly higher downstream of the waste spreading fields and in storm runoff leaving the waste spreading fields, as discussed in detail elsewhere in these comments. This could and should have been avoided through adherence to the AWMS planning, design, and operational requirements of the AWMFH. At pp. 11-28-29, the AWMFH (210–VI–AWMFH, Amend. ___, September 2013) states:

"In some situations the amount of land available is not adequate to use the total quantities of nutrients in the waste. Alternatives should be explored to use the excess manure produced. Some possibilities are additional land acquisition, agreement to apply on neighboring farms, decrease in animal numbers, composting and off-farm sales, and treatment to increase the nutrient losses in environmentally safe ways.

...

If no solution is apparent, a more detailed planning effort should be considered to formulate another alternative for the agricultural waste management system."

Chapter 5, **Role of Soils in Manure Management**, (210–VI–AWMFH, Amend. 61, August 2012) states "A well-planned agricultural waste management system (AWMS) that uses manure as a land improving resource considers landscape features and the physical, chemical, and biological properties of soils." It goes on to state that "Soil data should be collected early in the planning process."

The "physical, chemical, and biological properties of soils" include:

(a) Available water capacity;
(b) Bulk density;
(c) Cation-exchange capacity;
(d) Depth to bedrock or cemented pan (e.g. Bedrock or a cemented pan, less than 40 inches limits plant growth and root presentation and reduces soil waste adsorptive capacity. Limits to application of waste are moderate at a depth of 20 to 40 inches and severe at less than 20 inches;
(e) Depth to high water table;
(f) Flooding;
(g) Fraction greater than 3 inches in diameter—rock fragments, stones, and boulders;
(h) Intake rate;
(i) Permeability rate;
(j) Soil pH;
(k) Ponding;
(l) Salinity;
(m) Slope (Slope greater than 15 percent is shown by C&H but slope between 8 and 15 percent should be shown since this requires an application limitation beyond that of the PI; and
(n) Sodium adsorption ratio (SAR) (relative to calcium and magnesium).

Note: Table 5-3 in Chapter 5 lists many of the soil data characteristics above versus the degree of limitation that they put on application of waste.

Chapter 6 **Role of Plants in Manure Management** states:

“The objectives of a complete system approach to manure management are to:

- recycle nutrients in quantities that benefit plants,
- builds levels of soil organic matter,
- limit nutrient or harmful contaminant movement to surface and ground water”

<u>**Chapter 7**</u> “**Geologic and Groundwater Considerations**” lists additional requirements. On page 7-1 it states “An appropriately conducted onsite investigation is <u>essential</u> to identify and evaluate geologic conditions, engineering constraints, and behavior of earth materials.” Factors that must be considered, investigated, and measured for the contaminant source, i.e. the waste application field surface include:

> (a) Attenuation potential of soil (page 7-15) (this includes (1) clay content, (2) depth of soil to bedrock, (3) vertical distance to groundwater supply and horizontal distances to wells and springs);
> (b) Groundwater flow direction (page 7-16);
> (c) Permeability of aquifer material (page 7-16);
> (d) Hydraulic conductivity (page 7-16);
> (e) Hydraulic head (page 7-16);
> (f) Hydraulic gradient (page 7-18);
> (g) Hydrogeologic setting (page 7-18);
> (h) Land topography (page 7-18);
> (i) Proximity to designated use aquifers, recharge areas, and well head protection areas (page 7-18);
> (j) Type of aquifer (page 7-18); and
> (k) Vadose zone material (page 7-18)

Table 7-2 (p. 7-10) lists the engineering geology components that may need to be investigated for various waste management components. For land application areas it lists “topography”. Topography includes karst and since the Arkansas Geological Survey Map for the Mt. Judea area shows Boone Formation underlying the C&H waste application fields, karst is undoubtedly present as the top layer of the bedrock. As outlined above in Chapter 5(d), the depth to bedrock should be determined for each waste application field as well as for the pond area. The “Topography” section on page 7-14 states the importance of mapping the karst terrain. For the waste application fields this may require test pits and/or ground penetrating radar and the services of a geologist. The karst as the top layer of the bedrock in areas of shallow soil may rule out some waste application fields or areas of some waste application fields for use.

Chapter 2 Planning Considerations also discusses the need to properly evaluate the waste storage component of the AWMS. Section 651.0204 “Waste impoundment planning considerations” states:

> “Waste impoundments include earthen waste storage ponds and waste treatment lagoons. See chapter 10 of this handbook for the design detail of these AWMS

components. **The planning of waste impoundments must consider the potential consequences if they fail.** Safeguards or measures to reduce the potential for failure or the consequences of failure should be considered as warranted.

Not all waste impoundments are planned to have an embankment. **Those that do must consider the risk to life and property should the embankment fail.** (emphasis added)

The two major categories considered are:

- embankment breach or accidental release
- liner failure

At page 2-14 it states:

Significant consequences in the event of sudden embankment breach or accidental release may occur, particularly if there is impact to a surface waterbody. The primary consequence to a surface waterbody is contamination with microorganisms, organic matter, and nutrients. This contamination may kill aquatic life and make the water unsuitable for its intended use.

…

Regardless of the impact, it must be recognized that releasing wastewater in any amount or concentration into a surface waterbody is seldom socially acceptable. For this reason, precautionary measures should be considered in planning and design to minimize the risk or consequences of embankment breach or accidental release if a hydraulic analysis indicates that a surface waterbody may be impacted. This would be even more important from a social acceptability aspect if the affected waterbody is off-farm.

…

Features, safeguards, or management measures to minimize the risk of embankment failure or accidental release or to minimize or mitigate impact of this type of failure should be considered if one or more of the categories listed in table 2–1 may be significantly impacted …

…

A substantive evaluation of the impact of sudden breach or accidental release from waste impoundments should be made on all waste impoundments. Waste impoundments planned with embankments where significant direct property damage may occur should be evaluated with an appropriate breach routing procedure, such as that in NRCS Technical Release No. 66, Simplified Dam Breach Routing Procedure.

Table 2–1 "Potential impact categories from breach of embankment or accidental release" states:

- Surface waterbodies—perennial streams, lakes, wetlands, and estuaries
- Critical habitat
- Farmstead or other areas of habitation
- Off-farm property

…

Development of an emergency action plan should be considered for waste impoundments where there is potential for significant impact from breach or accidental release. In addition, consideration should be given to actions to minimize damage from breach. Actions would include wellhead protection, dikes, and diversion channels. These actions should be taken to augment, not replace the measures to reduce the risk of breach."

At C&H, storage pond embankment failure has not been addressed, a breach routing procedure has not been completed, and an emergency action plan has not been developed. Once again the lack of planning at C&H leaves significant requirements of the AWMFH unaddressed. Section 651.0204 (b) of the AWMFH also discusses the potential hazard of liner failure for waste impoundments and states:

"Waste impoundments present a risk of contaminating underlying groundwater aquifers and surface water that may be fed by these aquifers because of the nutrients and microorganisms contained in the wastewater. To minimize this risk, NRCS practice standards require that waste impoundments be located in soils of acceptable permeability or be lined. Despite this, risk remains because of the possibility of poor performance of these measures in preventing the movement of contaminants to the groundwater. Any of a number of causes could lead to nonperformance of liners. These causes would include such things as not being homogenous with lenses of more permeable material, being constructed with inadequate compaction, having desiccation cracks develop following impoundment emptying, and being damaged during agitation. Flexible membrane liners may fail by such things as cracks, tears, seam separation, or loosened connections. Concrete liners may leak if they crack or joint seals fail. The acceptability of the risk depends on the importance of the underlying aquifer, location and type of aquifer, and geologic site conditions that may be unforgiving to poor performance.

The seepage protection planned for a waste impoundment should correspond to the risk involved. **A thorough geologic investigation is essential as a prerequisite to planning seepage control for a waste impoundment. Special**

consideration should be given to seepage control in any one of the following conditions:

- any underlying aquifer is at a shallow depth and not confined
- the vadose zone is rock
- the aquifer is a domestic water supply or ecologically vital water supply
- **the site is located in an area of carbonate rock** (limestone or dolomite)." (Emphasis added).

At C&H, all of the requirements for "special consideration" are present. Waste holding ponds are not appropriate and should never have been approved. Adding synthetic liners will not cure this problem. Almost all of the site characteristics conflict with the siting provisions of the AWMFH and thus conflict with Regulation 5. The AWMFH discusses how the planner is to analyze the relationship of the waste storage system to the site-specific environmental conditions and how to proceed when selecting an appropriate waste storage solution. This is ignored by the permit applicant and approver.

Chapter 7 Geologic and Groundwater Considerations section 651.0701 states:

"Although karst topography (fig. 7–2) is well known as a problem because of its wide, interconnected fractures and open conduits, almost any near-surface rock type will have fractures that can be problematic unless treated in design.

The planners of agricultural waste management practices should be familiar with the principles of groundwater. NRCS references that include information on groundwater are Title 210, National Engineering Handbook (NEH), Section 16, Drainage of Agricultural Lands, Part 631, Chapter 30, Groundwater Hydrology and Geology, Chapter 31, Groundwater Investigations; Chapter 32, Well Design and Spring Development, and Chapter 33, Groundwater Recharge, and Part 650, Engineering Field Handbook (EFH), Chapter 12, Springs and Wells and Chapter 14, Water Management (Drainage).

When designing any agricultural waste management component, it is important to know:

- what type(s) of aquifers are present and at what depth
- the use classification of the aquifer, if any"

Section 651.0702 Engineering geology considerations in planning states:

"This section provides guidance in determining what engineering geology considerations may need to be investigated for various waste management components (table 7–2). The significance of each consideration is briefly described with some guidance given on how to recognize it in the field. Most issues serve as signals or red flags that, if found, justify requesting assistance of a geologist or other technical specialist.

> **Sinkholes or caves in karst topography** or underground mines **may disqualify a site for a waste storage pond or treatment lagoon.** Sinkholes can also be caused by dissolving salt domes in coastal areas. The physical hazard of ground collapse and the potential for groundwater contamination through the large voids are severe limitations…
> 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."** (Emphasis added).

Section 651.0704 describes the detailed AWMS planning and design process utilizing the site investigation factors listed previously:

> "The purpose of a preliminary site investigation is to establish feasibility for planning purposes. A preliminary site investigation also helps determine what is needed in a detailed investigation. A site investigation should be done only after local regulations and permit requirements are known. The intensity of a field investigation is based on several factors including:
>
> - quality of information that can be collected and studied beforehand
> - previous experience with conditions at similar sites
> - complexity of the AWMS or site
>
> The purpose of a detailed geologic investigation is to determine geologic conditions at a site that will affect or be affected by design, construction, and operation of an AWMS component. Determining the intensity of detailed investigation is the joint responsibility of the designer and the person who has engineering job approval authority. **Complex geology may require a geologist.** Detailed investigations require application of individual judgment, use of pertinent technical references and state-of-the-art procedures, and timely consultation with other appropriate technical disciplines. Geologic characteristics are determined through digging or boring, logging the types and characteristics of the materials, and securing and testing representative samples. An onsite investigation should always be conducted at a proposed waste impoundment location. State and local laws should be followed in all cases." (Emphasis added).

Upon completion of the preliminary and detailed site analysis above, the information is to be used to examine the critical requirements of Chapter 8 *Siting Agricultural Waste Management Systems*. The AWMFH goes into significant detail and provides clear guidance on the appropriate approach to siting waste storage components. The design of an AWMS must consider measures to improve and protect water quality. Chapter 9 of the AWMFH further discuses important considerations for Agricultural Waste Management Systems and states in 651.0900:

> "An agricultural waste management system (AWMS) is a planned system in which all necessary components are installed and managed to control and use byproducts of agricultural production **in a manner that sustains or enhances** the quality of air, water, soil, plant, animal and energy resources." (Emphasis added).

Section 651.0901 directs the planner to develop the AWMS through a "total systems approach" and includes an introduction to waste stream treatment stating:

> "Treatment is any function designed to reduce the pollution potential or modify the physical characteristics of the waste, such as moisture and TS content, to facilitate more efficient and effective handling. Manure treatment is comprised of physical, biological, and chemical unit processes. **It also includes activities that are sometimes considered pretreatment, such as the separation of solids.** The plan should include an analysis of the characteristics of the waste before treatment; a determination of the desired characteristics of the waste following treatment; the selection of the type, estimated size, location, and the installation cost of the treatment facility; and the management cost of the treatment process." (Emphasis added).

C&H and ADEQ have provided no evidence that they have considered treatment of the swine waste in any manner previous to discharging the waste to storage ponds, or prior to allowing the disposal of this environmentally damaging waste stream to waste application fields. This waste stream is sprayed into the Buffalo River watershed in raw form where it seeps into aquifers and runs off to surface streams.

Chapter 10 of the AWMFH brings all the inventory, analysis, planning, conservation, environmental protection, and farm operator considerations to bear on the agricultural waste management system component design. This discussion describes preferred waste storage alternatives based on a risk assessment of the planning information developed in the previous AWMFH prescribed planning steps and states:

> "A successful manure management system must address production, operation, regulatory guidelines, and environmental considerations…Operating a livestock facility creates an environmental risk for pollution. Climatic conditions and operating procedures can lead to an accidental discharge into surface waters. Foundation problems can result in seepage into subsurface waters. Location of a facility is an extremely important consideration during the planning process to minimize exposure to vulnerability and risk.
>
> Earthen storage is frequently the least expensive type of storage; however, certain restrictions, such as limited space availability, high precipitation, water table, permeable soils, or shallow bedrock, can limit the types of storage considered. **Table 10–4 provides guidance on siting, investigation, and design considerations.**

Pond liners are used in many cases to compensate for site conditions or improve operation of the pond. Concrete, geomembrane, and clay linings reduce permeability and can make an otherwise unsuitable site acceptable. **Table 10–4 provides criteria on selection between types of liners."** (Emphasis added).

Table 10–4 Criteria for siting, investigation, and design of liquid manure storage facilities

Risk→ / Vulnerability ↓	**Very high** <1,500 ft from public drinking water supply wells; **OR** <100 ft from any domestic well or Class 1 stream	**High** Does not meet Very High Risk criteria; **AND** Recharge areas for Sole Source aquifers; **OR** 100 to 600 ft from unconfined domestic water supply well (or where degree of aquifer confinement is unknown) or Class 1 stream	**Moderate** Does not meet High Risk criteria; **AND** 600 to 1,000 ft from unconfined domestic well (or where degree of aquifer confinement is unknown) or Class 1 stream; **OR** <600 ft from unconfined nondomestic water supply well (or where degree of aquifer confinement is unknown) or Class 2 stream	**Slight** Does not meet Moderate Risk criteria; **AND** >1,000 ft from unconfined domestic well (or where degree of aquifer confinement is unknown) or Class 1 stream; **AND** >600 ft from unconfined nondomestic water supply well (or where degree of aquifer confinement is unknown) or Class 2 stream
Very high Large voids (e.g., karst, lava tubes, mine shafts); **OR** Highest anticipated ground water elevation within 5 ft of invert; **OR** <600 ft from improperly abandoned well*	**Evaluate other storage alternatives** * (or properly seal well and reevaluate vulnerability)	**Evaluate other storage alternatives** * (or properly seal well and reevaluate vulnerability)		
High Does not meet Very High Vulnerability criteria: **AND** Bedrock (assumed fractured) within 2 ft of invert; **OR** Coarse soils/parent material (Permeability Group I soils as defined in AWMFH, always including GP, GW, SP, SW); **OR** Highest anticipated groundwater elevation is between 5 to 20 ft below invert; **OR** 600 to 1,000 ft from improperly abandoned well*		**Synthetic liner required** * (or properly seal well and reevaluate vulnerability) No additional site characterization required	**Liner required** * (or properly seal well and reevaluate vulnerability) Specific discharge $\leq 1\times10^{-6}$ cm^3/cm^2/s No manure sealing credit Earthen liner design includes sampling and testing of liner material (Classification, Standard Proctor compaction, Permeability)	**Liner required** * (or properly seal well and reevaluate vulnerability). Specific Discharge $\leq 1\times10^{-6}$ cm^3/cm^2/s No manure sealing credit Earthen liner design includes sampling and classification testing of liner material Published permeability data and construction method specifications may be used
Moderate Does not meet High Vulnerability criteria; **AND** Medium soils/parent material (Permeability Group II soils as defined in AWMFH, usually including CL-ML, GM, SM, ML); **OR** Flocculated or blocky clays (typically associated with high Ca);	**Evaluate other alternatives or synthetic liner as**	**Further evaluate need for liner** Specific discharge $\leq 1\times10^{-6}$ cm^3/m^2/s No manure sealing credit Earthen liner/no liner design includes sampling and testing of liner/in-place material (Classification, Standard Proctor compaction/in-place density, Remolded/ Undisturbed sample Permeability)	**Further evaluate need for liner** Specific discharge $\leq 1\times10^{-6}$ cm^3/cm^2/s No manure sealing credit Earthen liner/no liner design includes sampling and testing of liner/in-place material (Classification, Standard Proctor compaction/ in-place density,	**Further evaluate need for liner** Specific discharge $\leq 1\times10^{-6}$ cm^3/cm^2/s No manure sealing credit Earthen liner/no liner design includes sampling and classification testing of liner/

(210–VI–AWMFH, amend. 31, August 2009)

Table 10-4 categorizes C&H as an AWMS that meets the "very high vulnerability" criteria and requires the planner to "Evaluate Other Storage Alternatives" because of the karst geology and associated ground water contamination, leakage, and collapse potential. The "Other Storage Alternatives" include all alternatives with the exception of storage ponds with synthetic or clay liners. The preferred alternative is some type of storage tank:

> "Liquid manure can be stored in aboveground (fig. 10- 22) or belowground (fig. 10–23) tanks. Liquid manure storage tanks are usually composed of concrete or glass-lined steel… A variety of manufactured, modular, and cast-in-place tanks are available from commercial suppliers…Cast-in-place, reinforced concrete, the principal material used in belowground tanks, can be used in aboveground tanks, as well."

The AWMFH states flexible membrane liners are unsuitable for karst settings due their limited ability to reduce the collapse risk and the inherent "puncturability" of the liner. ADEQ inspectors have voiced concerns with the current clay liner, one of which is the large and sharp exposed chert fragments (Morris, 2013):

> "Puncturability is the ability of foundation materials to puncture a flexible membrane liner or steel tank. Angular rock particles greater than 3 inches in diameter may cause denting or puncturing in contact with a tank. Angular

> particles greater than 0.5 inch can puncture plastic and synthetic rubber membranes. Sharp irregularities in the bedrock surface itself also can cause punctures. Large angular particles can occur naturally or be created by excavation and construction activity."

The choice of a waste storage system must also consider potential waste treatment options. The planner is to develop waste treatment options based on "a total system design" which properly accounts for the karst environment, soil and waste nutrient levels, and environmental sensitivity. Section 651.1005 states:

> "In many situations, manure treatment is necessary before final utilization. Adequate treatment reduces pollution potential of the manure through biological, physical, and chemical processes using such components as lagoons, oxidation ditches, composting, and constructed wetlands. These types of components reduce nutrients, reduce pathogen counts, and reduce total solids. Composting also reduces the volume of the material. Treatment may also include solids separation, drying, and dilution that prepare the material for facilitating another function. By their nature, treatment facilities require a higher level of management than that of storage facilities."

The AWMFH also discusses how to plan and design a facility to reduce the problems associated with sludge and solids build up in the waste storage system. Sludge management was noted as one of the most significant operational and environmental concerns in the ADEQ CAFO studies undertaken in the Buffalo River watershed in the late 1990s and early 2000s:

> "Primary treatment includes the physical processes such as solids-liquids separation, moisture adjustment, and dilution. Although not required, primary treatment is often followed by secondary treatment prior to storage or land application.
>
> Separators also facilitate handling of manure. Separation facilities should be planned and designed in accordance with NRCS Conservation Practice Standard 632, Solid/Liquid Waste Separation Facility…Several kinds of mechanical separators can be used to remove by-products from manure (fig. 10–24).
>
> Secondary treatment includes biological and chemical treatment such as composting, lagoons, oxidation ditches, and vegetative treatment areas. This additional treatment step reduces the pollution potential prior to land application by reducing the nutrient contents of the material."

Section 651.0304 (a) of the AWMFH further describes what should be done in the event that an improperly designed and operated AWMS is resulting in off-site impacts to water quality and the natural environment:

"The following examples illustrate how animal waste or the particular constituents within the waste (nutrients, bacteria) can be limited in a watershed or at waste application sites, assuming a water quality problem has been identified and the source is a livestock operation. Measures to be used are:

- Remove all animals from the watershed.
- Reduce the number of animals.
- Use cropping systems that require more nutrients throughout the year.
- Apply wastes in split applications throughout the growing season, thereby making smaller amounts of manure available each time.
- Apply wastes over more acres at recommended rates. (Nutrient application rates far exceeding agronomic recommendations can result if, for convenience sake, wastes are applied to only the fields nearest the confinement facility.)
- Incorporate the manure, thus limiting the availability of particular constituents. P and NH4 will become bound within the soil profile and be less available for detachment.
- Collect and transport wastes to fields in other watersheds or bag the material for sale elsewhere."

The draft permit does not satisfy the requirements of the AWFMH for C&H's location. The fact that the location drives the selection of the most protective design elements of the AWMFH is ignored. Because C&H is having a measurable impact on aquifers, surface water, and Buffalo National River, the primary concern of ADEQ should not be the issuance of a new permit to C&H, rather ADEQ should be focused on eliminating the ongoing water quality degradation resulting from this facility in accordance with the AWMFH.

The NOI submitted by C&H on June 25, 2012 for coverage under the general NPDES permit, ARG590001, described C&H as a "2,500 head farrowing farm." It also stated that the barns would have a "maximum capacity of 6,503 head of swine weighing an average 150 lbs." (Section C: "*Design Report*," p. C-1) The breakdown was:

3 Boars @ 450 lbs.
2,100 Gestation Sows @ 375 lbs
400 Lactating Sows @ 425 lbs
4,000 Nursery Pigs @ 10 lbs

Section C2: "*Design Calculations*," p. C-3.

It appears the 4,000 "Nursery Pigs" was estimated by assuming that a nursing litter would be 10 piglets per sow being weaned. The weaning process requires 23 to 24 days (www.nationalhogfarmer.com/health-diseases/0615-producing-quality-pigs.) The 4,000 estimate is an average but this number will be relatively constant because as sows give birth to new litters, litters are weaned and then shipped off-site.

Reg. 5.901(D) states that "A permit renewal, permit modification, or new permit issued pursuant to Reg. 5.901(C) shall not increase the number of swine permitted at a facility." However, the "Application Packet" submitted by C & H on April 6, 2016 in support of its request for a Reg. 5 permit, states it now has:

6 Boars @ 450 lbs
2,252 Gestating Sows @ 425 lbs
420 Lactating Sows@ 400 lbs
750 Nursing Pigs @ 14 lbs.

C & H Hog Farms, Inc., "*Application for Regulation 5 Permit, Engineering Plans and Review*," p. 6.

In contrast to its 2012 NOI, in its Reg. 5 permit application C & H defines "Nursery Pigs" as pigs that have completed the weaning process. The "750" is arrived at as the average of 1,500 weaned pigs on the farm before the weekly shipment and the zero number on the farm just after the shipment. *Id.* at pp. 5-6. This ignores pigs in the weaning process that weigh from 3 to 5 pounds at birth and 14 pounds or more when weaned. (www.nationalhogfarmer.com/health-diseases/0615-producing-quality-pigs.) The weaning period is from 23 to 24 days. (*Id.*) In order to ship 1,500 pigs at a given time, there must be over 4,000 pigs being weaned at the time of the shipment.

If C & H's Reg. 5 permit application had used the same method for determining the number of "Nursery pigs" as in the original NOI, the numbers would currently be:

6 Boars @ 450 lbs
2,252 Gestating Sows @ 425 lbs
420 Lactating Sows @ 400 lbs
4,200 Nursing Pigs @ 10 lbs

Thus, the original approved NOI is being violated since there are now approximately 6,878 pigs on the farm instead of the original 6,503. If approved, the new Regulation 5 permit would violate Reg. 5.901(D).

Comparisons of pounds of swine and waste permitted in the original NOI and the current Reg. 5 daft permit and application further confirm these estimates. In the NOI (DeHaan, Grabs & Associates, 2012), C&H was permitted to raise 998,850 pounds of swine producing 1.5 million gallons of waste. The current permit lists 1,138,000 pounds of swine (Hancock et al., 2016) producing 1.9 million gallons of waste (Permit No. 5264-W Statement of Basis, p. 3).

In addition, the waste calculations in the permit application are incorrect. Along with the boars and sows, waste volumes should have been based on 4,200 pigs weighing 10 pounds instead of 750 pigs weighing 14 pounds. This means the volume of waste will be significantly greater. The draft permit should be denied because it violates Reg. 5.901(D).

The authors of an Agricultural Research Services report examining agricultural phosphorus (P) and eutrophication state: "P loss can lead to significant off-site economic impacts, which in some cases occurs many miles from P sources. By the time these water-quality impacts are manifest, remedial strategies are difficult and expensive to implement; they cross political and regional boundaries; and because of P loading, improvement in water quality will take a long time (Sharpley et al., 1999)."

Eutrophication problems associated with stimulation of aquatic vegetation with nutrients, especially phosphorus, are well documented (Sharpley et al., 1999). If the Buffalo National River becomes perceived as nuisance algae dominated in low flow conditions, or as receiving *E. coli* and pathogens from waste runoff, visitation and economic stimulus will decline. One of the primary draws of the Buffalo National River is the perception that it remains a "pure" waterway. Many believe it to be a safe and beautiful place for all seasons and all recreational activities. Visitors of many generations gather on the banks, and the economic benefits from tourism are on an upward trend (National Park Service, 2014). ADEQ should work with the Arkansas Department of Parks and Tourism and the National Park Service, and their staff economists, to evaluate the potential loss in tourism revenue that could result from a large source of contaminants.

ADEQ imposed a moratorium for Regulation No. 5 permits in the Buffalo River watershed in 1992 (1992 Moratorium). This moratorium specifically mandated the completion of site specific studies, and the use of those studies to inform regulatory changes to protect the watershed prior to the moratorium being lifted. C&H was designed and is managed in a similar manner to the previous swine CAFOs studied by ADEQ from 1994 – 2002, but the operation functions on a much larger scale. Not only did ADEQ fail to complete the requirements of the previous moratorium, the agency never provided public notice that the 1992 moratorium was to be lifted. ADEQ did not disclose the modifications and corrections it made, if any, based on the results of its own studies and investigations. Because lifting this moratorium would have been a major environmental decision with potential to impact the Buffalo National River, and the outstanding national resource designation by the State of Arkansas, public notice and analysis of this decision was warranted.

The Buffalo River watershed was off-limits to new CAFO permits for 20-years prior to granting C&H coverage under the general permit. Had the public been adequately informed of the decision to grant C&H coverage under a state-wide general NPDES permit, concerned citizens and responsible agency representatives would have voiced strong opposition, especially if made aware that the CAFO threatened the Buffalo National River. By not announcing that it was lifting the moratorium, ADEQ effectively circumvented public participation in protecting and maintaining the water quality of the Buffalo National River. ADEQ should deny this permit because it has yet to fulfill the mandates of the moratorium. ADEQ has not yet gone through the public notice and public comment process, nor has the agency explained to concerned citizens of the state of Arkansas how it addressed the requirements of the moratorium. The goal of this effort as stated in the moratorium was to adjust the regulatory, mitigation, and evaluation requirements of Regulation No. 5 permits issued in the Buffalo River watershed. Until ADEQ addresses the concerns identified in its own studies, ADEQ is in violation of the 1992 moratorium.

Design and management of swine farm waste streams was a noted problem in ADEQ's investigations of permitted swine operations in the Buffalo River watershed circa 1992 (Arkansas Soil and Water Conservation Commission, 1994). In ADEQ's words "the current system by which confined animal operations are designed, permitted, and regulated is failing to curtail discharges from the waste storage and disposal systems." ADEQ staff recommended a moratorium on CAFOs to allow them time to assess operational and regulatory means to improve swine waste management. ADEQ Director Randall Mathis signed the moratorium on October 12, 1992.

ADEQ studies revealed accumulated solids in the bottom of the waste storage ponds represented a seemingly intractable problem under existing waste pond construction and management scenarios permitted through Regulation No. 5. The solids, or sludge, was very high in nutrients, especially phosphorus. The nutrient management plan under which these CAFOs were permitted had not accounted for these elevated nutrients (Van Epps et al., 1998). Removal of the sludge also proved problematic. Expense of agitation and waste application exceeded financial capability of producers. Because the nutrient management plan had not accounted for sludge build up, field soil testing of nutrient levels revealed there was not enough acreage available to dispose of the accumulated swine waste sludge due to the anomalously high phosphorus content.

Sludge management is a critical need based on previous work and associated research (Formica et al., 2001; ADPCE, 1993; ADEQ, 2002; https://www.bae.ncsu.edu/topic/animal-waste-mgmt/program/lagoon/sludge-mgmt-closure.pdf). Dr. Sharpley has performed some limited experiments on sludge removal from C&H's waste stream (bigcreekresearch.org), but has stated there is no encouragement or incentive for application of sludge management at C&H, and the experiments have terminated.

The results of these studies, and the issues and concerns they raise, have not been used by ADEQ in conditioning permit 5264-W. C&H was designed, and is managed in a similar manner to the previous swine CAFOs studied by ADEQ from 1994 – 2002. However C&H is much larger in scale, and in turn, this CAFO generates more nutrient rich waste and sludge. (ADEQ, 2002; DeHaan, Grabs & Associates, 2012). The only reference to sludge management in the current NMP states:

> "As needed, to maintain available volumes, both ponds will be agitated during pumping to remove solids." (Hancock et al., 2016)

The NMP portrays sludge management as an issue related only to storage volume. The NMP developers have not accounted for the high phosphorus characteristics of this sludge. A separate analysis of the nutrient concentrations in this sludge, or forecast of the rate of build-up, is not provided in the NMP. The NMP does not describe the equipment to be used for agitation, or the methods by which sludge volume loss is to be quantified.

The NMP does not assess the risk agitation could pose to the clay liner and there is no reporting checkoff sheet required by ADEQ to confirm that agitation of the waste was performed. It is unknown if the sludge has ever been "agitated" at C&H. If it has been agitated, it is unknown to what extent sludge agitation was successful. Knowing the chemistry of the sludge compared to the chemistry of the liquid and the forecast nutrient concentrations used to develop the waste application rates in the NMP would also be considered highly beneficial. The NMP and the permit do not address the primary concern of the previous ADEQ CAFO study. Sludge management was concluded to be an intractable problem under existing waste stream management approaches, and showed a high potential to overwhelm soil and water quality protection efforts (ADEQ, 2002).

ADEQ should deny this permit until completing the process it started in 1992. If ADEQ decides to allow swine CAFOs in the Buffalo River watershed, it should evaluate permit conditions, including appropriate operational practices, mitigation requirements, monitoring, and regulatory adjustments to determine what permit conditions are appropriate for a large source of nutrients and bacteria in the Buffalo River watershed. This process should be conducted under public scrutiny and use appropriate scientifically peer reviewed studies to ensure conditions intended to safeguard natural resources are included in the final permit.

Although the C&H permit application mentions a few steps that will be taken for odor control at the barns and waste ponds, nothing is stated as to what measures will be put in place for odor and emissions control during field applications.

An in depth study in North Carolina looking at ammonia emissions on swine farms found that approximately 30 percent of the emissions came from the barns, 20 percent from the waste ponds, and, if normal air spraying were employed, 50 percent from field application.
(http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.517.6355&rep=rep1&type=pdf). This occurs when normal spraying methods are used such employed by C&H, i.e. Vac Tankers with splash plates and spraying from elevated nozzles from spray irrigation pipes.

Spraying waste in this manner gives several negative results. Ammonia is volatilized resulting in the loss of nitrogen as a fertilizer and perhaps more importantly the gaseous ammonia as well as other components of the waste such as hydrogen sulfide and fine liquid droplets containing entrained pathogens are now in the atmosphere. There will not only be an odor issue but a health issue as well.

Thus odor control for field application as required by Reg. 5 and Code 590 should be employed. The AWMFH, Chapter 12, states that significant reduction in reducing odor, other emissions, and ammonia volatilization can be obtained if either band spreading or shallow injection is used. Band spreading is laying down the liquid in a thin film on the surface. Injection is, as the name implies, injecting the waste a few inches into the ground. The AWFMH lists a number of ways that this can be done without damage to vegetation growing in a field. A Vac Tanker, when rigged out with proper accessories, will have a substantial advantage over spraying for protection of the environment and human health. Odor (and emissions) control should be required for the waste application fields.

Based on the available data, C&H is contaminating surface and groundwater with pollutants from swine wastes. The data from an ongoing three-year study being conducted by the Big Creek Research and Extension Team (BCRET) of the University of Arkansas cannot be used to assert that there is no evidence of environmental impacts from C&H. While the study design is compromised and the approaches and methods have major limitations, nevertheless, the available data provide clear evidence that this CAFO is contaminating Big Creek (tributary to the Buffalo National River) and other surface waters with pollutants such as nitrate, suspended solids, and the harmful fecal bacterium *Escherichia coli*. Nitrate can travel substantial distances and, therefore, likely is contaminating the Buffalo National River as well.

These findings were expected; they are similar to findings of impacts from other CAFOs on surrounding natural resources (Burkholder et al. 2007 and references therein). C&H utilizes a waste management system characterized by waste holding ponds (in this instance located in a karst environment) at or near the groundwater table that allow solids to settle, with waste liquids applied to nearby waste application fields. This type of waste management system has been shown to cause unavoidable water, soil, and air pollution (see U.S. EPA 1998, 2013a; Evans et al. 1984; Westerman et al. 1985; Payne et al. 1988; Ritter and Chirnside 1990; Dewi et al. 1994; Huffman and Westerman 1995; Burkholder et al. 1997; Mallin et al. 1997; Stone et al. 1998; Ham and DeSutter 2000; Mallin 2000; Krapac et al. 2002; Spellman and Whiting 2007; and Rothenberger et al. 2009). Yet, ADEQ has publicly stated that the BCRET study has found no pollution from this CAFO.

In addition, the Harbor Drilling Study, a limited investigation of the geologic materials underlying C&H, demonstrates that this CAFO is surrounded by karst geology. This is consistent with the available evidence that indicates it is underlain by karst. Karst areas have features that allow contamination to move easily through multiple pathways to cause widespread surface- and groundwater quality impacts (United States Environmental Protection Agency [U.S. EPA] 2002). Thus, areas with karst geology are especially sensitive to water pollution. A dye study conducted in the area showed in detail the interconnectedness of Big Creek and the Buffalo National River basins (Van Brahana et al. 2014). The data indicate that contamination from C&H into shallow groundwater can easily spread throughout the Big Creek area and into the Buffalo National River. Even though the Harbor report shows evidence of karst geology underlying C&H CAFO, that study is apparently being used by ADEQ to assert, wrongly, that the area where C&H is located is not karst.

However, the core samples from the Harbor Drilling Study definitely show that karst is present. In Exhibit C of Harbor's final report, Tai T. Hubbard, the Senior Geologist of Hydrogelogy Inc. assessed the subsurface geology below the manure ponds. Through chemical analyses and examination of the core samples he determined that the limestone bedrock between 13.8 feet and 28 feet below ground level had the characteristics of epikarst and that, as expected there was Boone Formation limestone bedrock between 28 feet and the drilling termination depth of 120 feet, some of it with fractures. "Epikarst" or "epikarst zone" is defined as a relatively thick (the thickness may vary significantly, but 15 to 30 meters thick is a good generalization) portion of bedrock that extends from the base of the soil zone and is characterized by extreme fracturing and enhanced dissolution. ("A Lexicon of Cave and Karst Terminology with Special to Environmental Karst Hydrology, " EPA/600/R-02/003, 2002, EPA: Washington, DC.) The bottoms of the waste storage ponds are at essentially the same level where the epikarst begins. This supports our earlier comment that the waste ponds should be replaced with tanks . It would be an unacceptable situation for synthetic liners to sit atop epikarst. Tearing and rupturing would almost certainly occur.

The most recent state permit under Regulation 6 (under the national pollution discharge elimination system, NPDES) for C&H expired in October 2016. The company has applied for a new permit from ADEQ but, this time, under Regulation 5 as a "no discharge" operation. C&H is already permitted to apply the equivalent amount of untreated sewage effluent (~2.6 to 2.8 million gallons of manure, process water, and litter; ADEQ Annual Report Forms for C&H) as would be contributed by a population of about 25,000 people (derived from U.S. EPA 2004) to adjacent fields that lie very close to receiving surface waters. ADEQ gave tentative approval for the permit in February 2017. If approved, the new permit would allow C&H to operate permanently in the Buffalo National River watershed as a "no discharge" facility. This permit would allow ongoing major pollution from C&H to surrounding natural resources in perpetuity. Moreover, the state has already approved a separate area known as EC Farms to spread up to 6.4 million gallons of waste from C&H onto 30 different land parcels (total area more than 500 acres) within the Buffalo National River watershed (see ADEQ Permitting Section at http://www.adeq.state.ar.us/home/pdssql/pds.aspx#dis). Based on the analysis below, this CAFO is contaminating Waters of the State with swine waste pollutants, meaning that it is discharging pollutants. It *should not* be classified as "no-discharge," based on U.S. EPA (2004).

The BCRET study (BCRET 2014a-d, 2015a-d, 2016a-d) and other available data (Nix 2016) shows that C&H is indeed discharging pollutants from swine wastes into Waters of the State. A review of the information related to karst in the drilling study (Harbor Environmental and Safety 2016) reflects the karst hydrogeology underlying C&H, making the area much more sensitive to pollutant contamination and dispersal.

The control stream and field sites, which are supposed to be minimally affected by pollution and are critical for data interpretations, are receiving substantial swine and/or poultry waste pollution. C&H and BCRET study site are shown in Figures 13 and 14, taken from BCRET quarterly reports. Note that Big Creek flows from south to north. Figure 13 is the only map published in all of the BCRET quarterly progress reports which shows the locations of the 17 fields in C&H, 15 of which are used for swine waste application. This CAFO extends for approximately three river miles along the stream. Note that the downstream site is "buffered" or somewhat protected from swine wastes considering that fields #5 and #6, which do not receive swine waste applications, are nearest to and just upstream from the downstream station. In contrast, the field numbers circled in red (#15, #16, and #17) are near the so-called "upstream" station and, given the karst character of the area, could easily be contaminating it. The "upstream" station is in quotes because the BCRET data show that its waters are degraded and thus is not an acceptable "upstream control."

The Big Creek "upstream control" - The BCRET study of possible surface water quality impacts from this CAFO on Big Creek entirely rests on comparison of the one "upstream" station and the one downstream station. The combination of a seriously compromised "upstream control" station and a downstream station that is buffered from swine waste pollution skews the findings by artificially "minimizing" any upstream vs. downstream differences in surface water quality. See Tables 6 and 7 below for information on swine waste (mostly liquid effluent or "slurry") applications to fields in 2014 (Table 6) and in December 2013-October 2014 near the compromised "upstream control" station (Table 7). Appropriate upstream controls are important in that they make or break the scientific validity of studies such as this (Bartram and Balance 1996, Maybeck et al. 1996a,b). The BCRET study lacks adequate, uncompromised controls.

In May/June 2015, an additional monitoring station was belatedly established in a tributary of Big Creek, Left Fork Creek. The watershed (about 38 square miles in area, ~25% larger than the Big Creek watershed) of Left Fork Creek does not have a CAFO, but the area in urban development is about double that in the Big Creek watershed. The BCRET data from several stations on Left Fork Creek indicate that *E. coli* levels frequently are much higher than recommended for human health protection, especially after storm events. Of 27 samples taken in May-October of 2014-2016, 26% of them exceeded state regulatory limits for primary contact regulation (single samples, 410 colonies per 100 mL; Arkansas Pollution control and Ecology Commission 2011), with *E. coli* levels as high as 3,100 colonies per 100 mL. Without additional detailed, quantitative information, attempts by the BCRET to use the Left Fork as another "control" site are highly questionable.

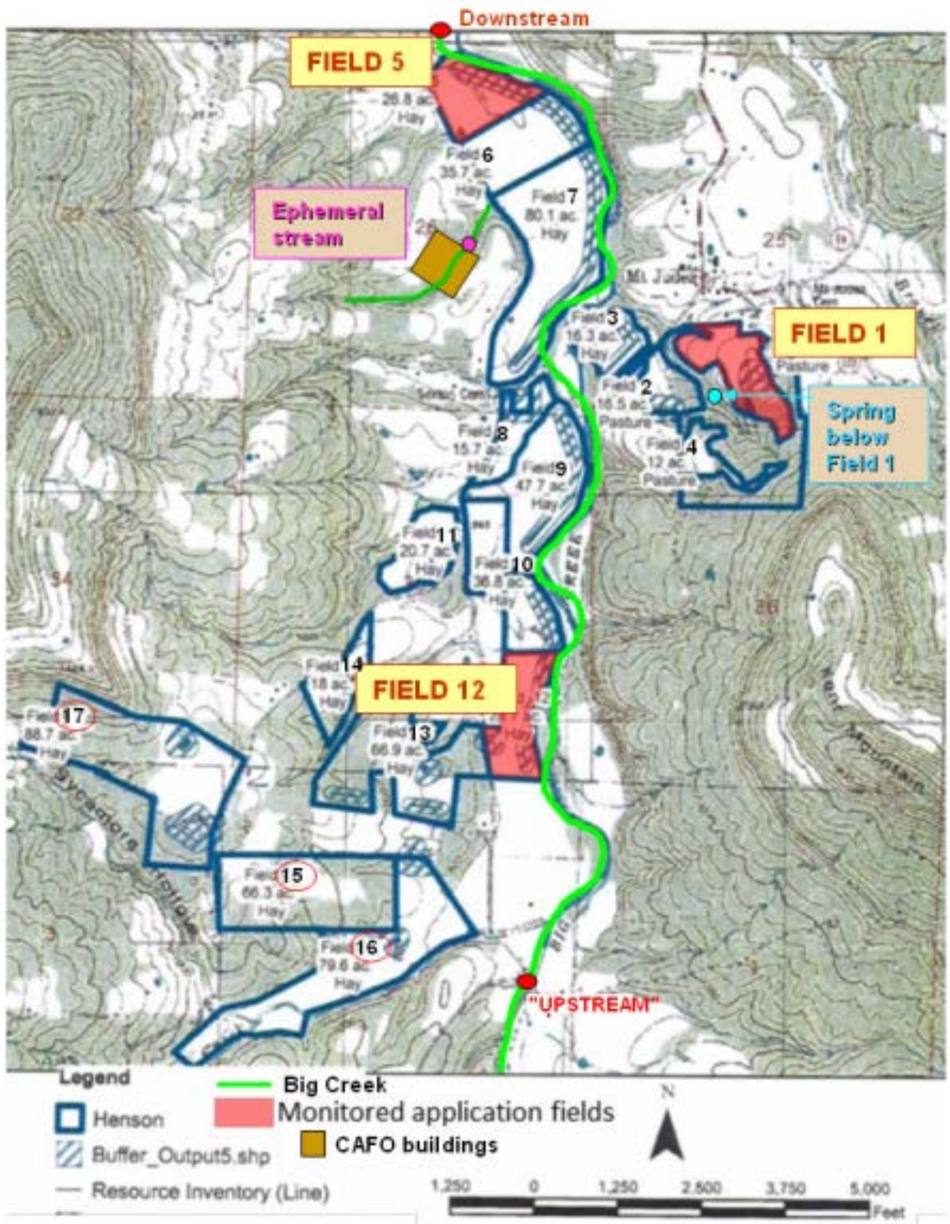


Figure 13. **Map indicating features of C&H, and of the BCRET study design which, perhaps inadvertently, minimizes detection of surface water impacts of C&H:** This map is modified from the first BCRET quarterly progress report (October 1 to December 31, 2013, p.13) to show more clearly the locations of the main stream in the immediate area, Big Creek, and various other features. The map incorrectly depicts the location of field #5 (see BCRET addendum at http://arkansasagnews.uark.edu/bigcreekreport.quarter1addendum.pdf , and see the correct location of field #5 below in *Figure 14*). This CAFO extends for approximately three river miles along the stream.

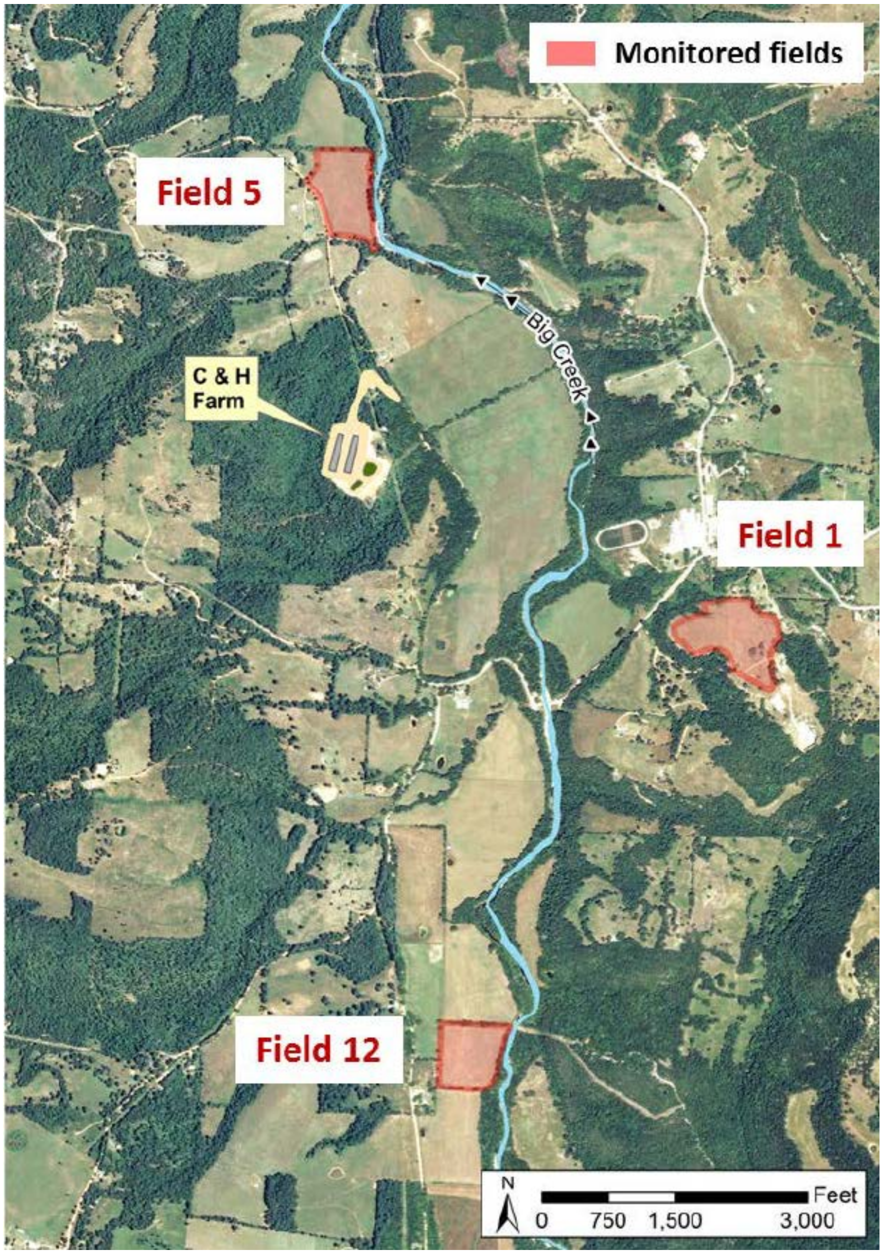


Figure 14. **Map from a BCRET addendum** to the October 1 to December 31, 2013 quarterly progress report, showing the correct location of monitored Field #5. Note that this field designation was later changed to Field #5a so that there would not be two fields numbered 5. Field #5A is just north of Field #5, and Field #5A is not one of C&H's leased fields.

***Table 6.* Characteristics of 15 of the 17 C&H CAFO fields**, taken from the ADEQ Annual Report Form for C&H CAFO operations that were permitted under NPDES General Permit ARG590000 through October 2016. The swine "slurry" (mostly liquid effluent, along with a small percentage of solids) applied to 15 fields at C&H in a 4-month period (March – June) of 2014 (WHP – waste holding pond). The fields are very close to, or immediately along, Big Creek. The BCRET progress reports are founded upon an inadequate study design, including lack of appropriate stations and lack of appropriate analyses to detect C&H CAFO-related water resource impacts (see text). Note that the acreages given differ from those reported in *Table 7* below.

Field	Area (acres)	Field Use	Application (Mar-Jun 2014, from WHP #1)	Conservation Practice(s)
H1	7.30	Continuously Grazed >0.75 An.Units	6,530 gallons/acre	None in place
H2	6.00	Continuously Grazed >0.75 An.Units	4,060 gallons/acre	None in place
H3	15.20	Rotational Grazing	5,590 gallons/acre	None in place
H4	6.80	Continuously Grazed >0.75 An.Units	4,760 gallons/acre	None in place
H7	64.30	Rotational Grazing	5,020 gallons/acre	None in place
H8	8.60	Rotational Grazing	13,150 gallons/acre	None in place
H9	35.50	Rotational Grazing	6,750 gallons/acre	None in place
H10	29.30	Rotational Grazing	14,760 gallons/acre	None in place
H11	14.20	Continuously Grazed >0.75 An.Units	5,690 gallons/acre	None in place
H12	10.90	Rotational Grazing	5,880 gallons/acre	None in place
H13	50.90	Rotational Grazing	6,530 gallons/acre	None in place
H14	7.30	Rotational Grazing	6,530 gallons/acre	None in place
H15	32.20	Rotational Grazing	6,530 gallons/acre	None in place
H16	15.20	Rotational Grazing	6,530 gallons/acre	None in place
H17	31.90	Rotational Grazing	6,530 gallons/acre	None in place

The field "control" - A total of 2,614,059 to 2,786,908 gallons of swine wastes (manure, process water, and litter) were produced at C&H in the first two years of operation (ADEQ Annual Report Forms, 2013 and 2014, for C&H CAFO operations under NPDES General Permit ARG590000). Two of the 15 fields receiving swine waste applications from C&H, fields #1 and #12, are being monitored by the BCRET. A third monitored field, field #5 (or #5a), does not receive C&H CAFO wastes but it cannot be considered a "control" because the polluted surface runoff data for that field indicate that it is compromised.

***Table 7.* Timing and rate of swine effluent slurry applied by C&H to fields #15, #16, and # 17 near the compromised, degraded "upstream control" station**, in the karst area where the CAFO is located, during December 2013 through October 2014. Compiled from the January 1 to March 31, 2015 BCRET quarterly progress report (pp. 33-35).

Date applied	Field #	Volume applied	Area applied	Average rate applied
		gallons	acres	gallons/acre
12/27/2013	15	3,000	1	3000
12/30/2013	15	6,000	2	3000
12/31/2013	15	24,000	9	2667
1/16/2014	15	18,000	7	2571
1/20/2014	15	36,000	13	2769
3/31/2014	15	42,000	14	3000
4/1/2014	15	45,000	15	3000
6/16/14	15	25,400	9	2822
6/17/14	15	16,800	6	2800
6/18/14	15	16,800	6	2800
6/19/14	15	11,200	4	2800
7/14/10	15	90,000	29	3103
7/28/14	15	8,200	3	2733
10/17/14	15	57,500	20	2875
10/18/14	15	34,500	12	2875
6/19/14	16	56,000	9	6222
1/07/14	17	25,000	9	2778
1/16/2014	17	6,000	2	3000
4/1/2014	17	30,000	10	3000
4/1/2014	17	3,000	10	300
4/18/2014	17	30,000	5	6000
4/22/14	17	21,000	7	3000
4/25/14	17	36,000	12	3000
6/07/14	17	22,400	8	2800
7/14/14	17	16,800	6	2800
7/22/14	17	11,800	4	2950
10/19/14	17	18,000	6	3000
10/20/14	17	46,000	16	2875
10/21/14	17	28,750	10	2875

Field #15 - 33,000 gallons of raw swine effluent slurry in December 2013

Field #15 - 401,400 gallons of raw swine effluent slurry during 6 months of 2014

Field #16 - 56,000 gallons of raw swine effluent in June 2014

Field #17 - 294,750 gallons of raw swine effluent slurry during 5 months of 2014

The monitored fields are not representative of average impacts being sustained by application of swine wastes. The BCRET progress reports describe the monitored fields as "representative" of the 15 fields to which swine effluent is being applied, "encompassing a range in landscape position, topography, and soil fertility levels." As Table 8 shows, however, ***the monitored fields are not representative of average impacts being sustained, and in fact minimize the impacts being sustained*** in soils, surface runoff quality, or groundwater quality from land.

The "application area" in Table 8 refers to the cumulative total number of acres to which swine effluent was applied in a given field, and "volume" refers to the total volume of effluent applied to the field. From this table, the **mean volume of swine effluent or slurry** applied per field among the 15 fields was **160,023 gallons** during December 15, 2013 to January 15, 2015. *The two fields selected for monitoring received 46,000-48,000 gallons*, or only about one-third of the average volume of swine effluent applied per field. Monitored field characteristics are strongly dependent on the *frequency* of effluent applications, *as well as the total amount* of effluent applied. The average number of waste applications was 4.3 over that period. The two fields selected for monitoring received only 1-2 applications.

Thus, the BCRET team's assertion that the monitored fields were "representative" for characterizing the impacts of swine effluent on receiving lands, surface runoff, and groundwater is false. Also note that, as explained in the legend for Table 8 below, the two fields with red arrows (#15, #17), close to the highly compromised "upstream" station, received 13 to 15 applications and more total effluent than any other field except fields #7 and #13. Another field close to the "upstream" station, #16, received the highest average rate of swine waste applied per acre. As another example of the lack of "representative" character of the two fields selected for monitoring, unmonitored field #13, immediately west of monitored field #12, received ten-fold more applications of swine effluent and about 10 times more total effluent than field #12. The BCRET has informed the general public that the three fields being monitored are the only fields that it has received permission to monitor from the private landowners leasing the fields to C&H. This is clearly a major, serious problem in the study design because the fields are far from "representative" regarding the relatively small amount of swine waste they receive, and the fact that only two of the three monitored fields (#1 and #12) receive C&H CAFO swine wastes:

Field #5a (called Field #5 in the first BCRET quarterly progress report dated October 1 to December 31, 2013) is the third field being monitored by the BCRET team. *However, as mentioned above* (see Figure 14 legend), *swine effluent from C&H is not applied to it*; the quarterly progress report states that nutrient runoff and leaching from all three fields (#1, #5a, and #12) captures whatever field management is being done by the land owners, including swine effluent application (fields #1 and #12 only) as well as grazing and mineral fertilizer application. The water quality degradation in fields #1 and #12 can be ascribed mostly or at least partially to swine effluent application from C&H, whereas the source(s) of water quality degradation in the surface runoff from field #5a cannot be related to swine effluent application. Also as explained above, field #5 cannot be considered as a "control" because the degraded surface runoff from that field shows that it is highly compromised.

***Table 8.* The total amount of slurry applied to each of 15 fields between 12/15/2013 and 1/15/2015 by C&H**. Modified from the January to March 2015 BCRET quarterly progress report (p.36). Red squares and ovals indicate the two fields monitored by the BCRET, and the small number of swine effluent applications (1-2) in each. Arrows indicate fields #15 and #17, near the highly compromised, degraded "upstream control" station and farthest from the downstream station. Fields #15 and #17 received approximately 6 to 9 times more waste than monitored fields #1 and #12, and about 10 times more waste applications. And, note that field #16, also near the "upstream control," had the highest average rate of swine waste applied per acre.

Field number	Field area	Application area	Number of apps	Volume	Average rate applied	Average inches applied
		acres		gallons	gallons/acre	inches
1	28.5	13.0	2	46,000	3,538	0.13
2	16.5	6.0	1	22,600	3,767	0.14
3	16.8	27.0	3	118,100	4,374	0.16
4	12.0	8.5	3	28,800	3,388	0.12
7	80.1	123.0	4	396,200	3,221	0.12
8	15.7	9.0	1	25,000	2,778	0.10
9	47.7	35.0	2	103,800	2,966	0.11
10	36.8	64.0	5	249,200	3,894	0.14
11	20.7	17.0	1	51,000	3,000	0.11
12	28.7	9.9	1	48,000	4,848	0.18
13	66.9	151.0	11	453,550	3,004	0.11
14	18.0	23.0	2	73,000	3,174	0.12
15	66.3	150.0	15	434,400	2,896	0.11
16	79.6	9.0	1	56,000	6,222	0.23
17	88.7	105.0	13	294,750	2,807	0.10

A very small number of sites (6-7) is included for sampling surface water quality, and are supposed to be representative of surface water quality in a CAFO with 17 fields for realized or potential swine waste application that sprawls along Big Creek for ~3 river miles – including *only one site* downstream from the CAFO on Big Creek itself, and no sites on the Buffalo National River. Thus, the sites are sparse for use in providing an overall assessment of the impacts of this CAFO on water quality. The "one upstream versus one downstream station" approach used by the BCRET team to evaluate whether the CAFO is polluting Big Creek, is confounded by the fact that the "upstream control" is compromised (above), and also because the CAFO is in a karst area.

The only spring being sampled is adjacent to field #1. Yet, water quality data show that this spring was frequently degraded in 2013, *before* the CAFO began application of swine wastes to field #1 (March-June 2014), in total suspended solids (TSS, e.g. 21.2 mg/L), nitrate-N (~2.5 to 3.3 mg/L), total coliform bacteria, and *E. coli* densities. The BCRET progress reports do not once mention this serious problem. Thus, the area has been described as containing numerous springs, yet only this spring is being sampled, and its water quality was clearly compromised prior to use of adjacent fields for swine effluent application. Nevertheless, when field #1 received swine wastes, runoff from the field was extremely degraded (see below). The runoff from fields #1, and from other nearby fields such as fields #2, #3, and #4, would be expected to have contributed to contamination of this spring.

The study does not include diel sampling of dissolved oxygen (DO), despite the fact that the high biochemical oxygen demand of swine wastes is known to cause severe oxygen deficits in contaminated receiving surface waters. Reports (e.g., by Dr. Van Brahana et al. 2014) describe a decrease in DO concentrations in Big Creek below C&H in both summer and winter. Swine CAFO pollution is well known to drive the DO in receiving streams down to levels that can stress or kill beneficial aquatic life (Burkholder et al. 1997, 2007; Mallin 2000, and references therein). Dissolved oxygen is of fundamental importance to the biota of the Big Creek and Buffalo National River ecosystems; its measurement is straightforward using well accepted techniques (e.g. Reed et al. 2010); and it should have been included in the BCRET study. It has been wrongly argued that nitrate, which is being measured, can serve as a "surrogate" for DO – that nitrate levels would indicate conditions that could decrease DO levels. That assertion has no scientific basis. High nitrate concentrations and high amounts of oxygen-demanding organic materials are being added to surface waters by swine waste pollution (below). Respiration of decomposing microbes causes a high oxygen demand that drives down the oxygen concentrations, and the high ammonia levels in swine wastes also cause oxygen demand (Mallin 2000, Mallin et al. 2006). As the ammonia is oxidized by DO from the overlying air during waste/runoff travel overland, it is transformed to nitrate. The nitrate concentration does not indicate conditions that could decrease DO levels in the water. It indicates nothing about whether the DO concentration was adequate to prevent stress, suffocation, and death of beneficial aquatic life.

The study lacks use of tracking methods which, together with the poor study design and compromised "controls," prevent rigorous evaluation of impacts from C&H. As previously explained, in various portions of the datasets shown in the BCRET quarterly progress reports, the one "upstream" location in Big Creek commonly has higher concentrations or comparable concentrations of some parameters than the station "downstream" from C&H. According to the reports, the project team has failed to ensure that its selection of an "upstream control" station location is not so compromised by local pollution or land disturbance that C&H influence in the stream cannot be detected. Thus, the pollution from upstream needs to be isolated from the pollution being contributed by the C&H operation, which can be done using various techniques such as microbial source tracking (e.g. Heaney et al. 2015, and references therein) and nitrogen/oxygen stable isotopes (e.g. Michener and Lajtha 2007, Eppich et al. 2012, Pastén-Zapata et al. 2014, and references therein). There is a critical need for use of these techniques in the BCRET study. A false "conclusion" that could easily result from the inadequate BCRET study design would be, "Nothing above 'upstream background' could be detected in terms of water quality impacts from the C&H operation." The BCRET project team thus far has elected *not* to use source tracking or stable isotope techniques which are *essential* to verify the CAFO impacts, given the seriously inadequate study design.

Based on the "upstream vs. downstream" evaluation criteria being followed by the BCRET, there is a significant impact of C&H in contaminating Big Creek with nitrate pollution at levels that would stress and kill sensitive aquatic life. The nitrate levels reported at the "downstream" station sometimes exceed levels known to stress or kill sensitive aquatic life (Camargo and Alonso 2005). In a presentation (August 11, 2015, University of Arkansas), Dr. A. Sharpley, the BCRET team leader, acknowledged that statistical analysis had shown that nitrate levels were significantly higher downstream than "upstream." Peer-reviewed science repeatedly has demonstrated that high levels of ammonia in swine wastes are oxidized to nitrate as the wastes move away from the site of origin, resulting in high levels of nitrate pollution to receiving waters (e.g. Evans et al. 1984; Stone et al. 1995, 1998; Ham and DeSutter 2000; Mallin 2000; Krapac et al. 2002). The data show that C&H is a major source of nitrate located immediately upstream from the "downstream" sampling site.

Sensitive stream biota have been shown to be adversely impacted by low dissolved oxygen caused by swine CAFOs, and also adversely affected by the disease-causing microbes, high nutrient levels, high suspended solids, and other pollutants added by CAFOs (U.S. EPA 1998, Mallin 2000). Beneficial macroinvertebrates have been adversely affected by nitrate concentrations as low as 0.23 mg/L nitrate-N (Camargo et al. 2005, Camargo and Alonso 2006). Endocrine functioning in vertebrates such as reptiles, amphibians, and fish has been damaged, as well (Guillette and Edwards 2005). Moreover, nitrate is well known to be capable of traveling long distances (up to 200 miles or more), much farther than the approximately 5-mile distance from this CAFO to the confluence of Big Creek with the Buffalo National River (Mallin et al. 1993, Houser and Richardson 2010). Thus, nitrate impacts from this CAFO should be assessed in the larger river as well as the other surface waters.

The excessive ammonia-N concentrations in Waters of the State affected by C&H, as noted in Tables 9 and 10, are much higher than levels reported to stress and kill sensitive aquatic life (Camargo and Alonso 2006), and in violation of levels required to sustain sensitive biota as recommended by the U.S. EPA (2013ba). Thus, ammonia impacts from this CAFO on sensitive aquatic life should be evaluated as well.

The data also show frequent, high contamination of other surface waters by C&H. Evidence of frequent, high contamination and degradation of surface waters by C&H is illustrated in the following examples. For comparison:

- *Total phosphorus* (TP) *and nitrate-nitrogen* (NO_3^-N, here also including nitrite-N or NO_2^-N, as they typically are measured together) – Surface flowing waters in the area should have approximately 5.6 µg of total phosphorus/L (or 0.056 mg TP/L) and 30 µg nitrate-N/L (or 0.03 mg NO_3^-N/L) or less as a minimally impacted ("reference" or unpolluted) condition (U.S. EPA 2000 – level III nutrient sub-ecoregion 38). Median concentrations over a ~decadal period in the Buffalo National river near Big Creek during surface runoff events were 21 µg TP/L (0.021 mg TP/L and 140 µg NO_3^-N/L (0.14 mg nitrate-N/L) (White et al. 2004).

- *Total suspended solids* (TSS), *dissolved phosphorus* (DP), and *ammonia-N* (NH_3N) – Median concentrations over a ~decadal period in the Buffalo National River near Big Creek during surface runoff events were 30 mg TSS/L, 10 µg DP/L (or 0.01 mg DP/L), and 20 µg NH_3N/L (White et al. 2004).

- *Dissolved organic carbon* (DOC) – is typically less than 7 mg/L in streams draining small forested watersheds during stormflow, or streams draining agricultural cropland watersheds (e.g. Hinton et al. 1998, Hood et al. 2006, Warner et al. 2009, Biden 2013, and references therein).

- *Total coliform bacteria* – in potable waters, no more than 5.0% of samples should be positive for 1 or more total coliform bacteria within one month; or, for systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month (U.S. EPA; see http://water.epa.gov/drink/contaminants/basicinformation/pathogens.cfm). Note that total coliform bacteria are no longer recommended as an indicator for recreational waters (U.S. EPA; see http://water.epa.gov/type/rsl/monitoring/vms511.cfm). In the 1950s studies conducted by the U.S. Public Health Service reported adverse human health effects when total coliform density was ~2,300 per 100 mL (Stevenson 1953).

- *Escherichia coli* – According to the ADEQ, the following limits apply (taken from the BCRET January to March 31, 2015 quarterly progress report, p.56):

> Primary Contact Maximum allowable is 126 colonies/100 mL as a geometric mean; (May-Sept) maximum for a single-sample is 298 colonies/100 mL (Extraordinary Resource Waters [ERWs], Ecologically Sensitive Waterbodies [ESWs], and Natural and Scenic Waterways [NSWs]), or 410 colonies/100 mL (all other streams).

***Table 9.* Water quality of a culvert described by the BCRET as an ephemeral stream** draining the subwatershed containing a portion of C&H (the production houses, waste holding ponds, the well adjacent to the waste holding ponds, and surface runoff from field #1). Compiled from the following BCRET quarterly progress reports: April 1 to June 30, 2014; July 1 to September 30, 2014; October 1 to December 31, 2014; and January 1 to March 31, 2015. Numbers highlighted (red outlines, with arrows for most extreme values) are examples of excessive levels.

Date & time sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E_coli	Total coliform
	mg/L							MPN/100 mL	
Culvert									
3/18/2014	0.009	0.028	0.05	0.64	0.63	1.0	0.7	19.3	365.4
3/26/2014	0.007	0.028	0.00	0.61	0.62	11.0	1.2	260.2	>2419.2
3/29/2014	0.004	0.042	0.00	0.69	0.81	3.3	4.9	ND	ND
4/2/2014	0.009	0.020	0.00	0.48	0.54	2.1	1.1	44.3	517.2
4/4/2014	0.026	0.262	0.46	0.85	2.36	908.8	6.5	ND	ND
4/8/2014	0.011	0.022	0.04	0.47	0.53	2.5	2.7	70.8	770.1
4/13/2014	0.003	0.016	0.00	0.46	0.49	4.7	1.8	8.5	195.6
4/13/2014	0.007	0.032	0.03	0.48	0.56	1.9	2.0	547.5	4320.0
4/22/2014	0.004	0.012	0.00	0.45	0.50	1.0	0.0	47.9	>2419.2
5/1/2014	0.005	0.010	0.00	0.448	0.50	1.5	0.6	90.5	4790.0
5/12/2014	0.010	0.290	0.61	0.939	2.33	847.6	4.7	N.D.	N.D.
5/13/2014	0.007	0.060	0.12	0.509	0.70	5.1	2.6	307.6	10760.0
5/19/2014	0.008	0.020	0.08	0.522	0.55	0.8	0.3	204.6	5940
5/28/2014	0.011	0.020	0.10	0.799	0.85	1.7	0.2	517.2	14830.0
6/22/2014	0.005	0.090	0.68	4.562	7.16	2096.3	4.09	N.D.	N.D.
6/27/2014	0.017	0.022	0.00	0.550	0.60	1.7	0.83	N.D.	N.D.
7/8/2014	0.023	0.054	0.37	0.759	2.89	1252.1	6.96	N.D.	N.D.
7/16/2014	0.006	0.032	0.06	0.601	0.67	16.8	0.56	N.D.	N.D.
7/23/2014	0.016	1.018	0.98	0.875	2.69	2642.0	5.09	N.D.	N.D.
7/31/2014	0.017	0.042	0.20	1.204	1.23	4.9	1.03	1732.9	30760.0
10/13/2014	0.004	0.068	0.08	0.996	1.37	11.2	3.28	N.D.	N.D.
12/15/2014	0.021	0.040	0.04	1.161	1.11	8.2	1.11	N.S.	N.S.
12/22/2014	0.011	0.026	<0.03	0.416	0.58	6.3	1.54	770.1	3550.0
1/8/2015	0.008	0.022	<0.03	0.448	0.59	2.4	1.73	25.6	1203.3
1/15/2015	0.007	0.028	<0.03	0.469	0.55	1.9	0.55	7.4	1413.6
1/21/2015	0.005	0.016	<0.03	0.370	0.46	1.0	2.34	155.3	2419.2
2/26/2015	0.006	0.022	<0.03	0.530	0.57	1.3	1.38	16.1	4790.0
3/3/2015	0.006	0.020	<0.03	0.477	0.52	ND	1.84	N.S.	N.S.

***Table 10.* Water quality in an ephemeral stream** sampled in the BCRET study near the animal holding units of C&H (quarterly progress report dated April 1 to June 30, 2015, pp. 44-45; and see *Figure 13* of these Comments). Numbers highlighted (red outlines, with arrows for most extreme values) are excessive levels.

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
	mg/L							MPN/100 mL	
Ephemeral stream									
1/8/2015	0.008	0.022	<0.03	0.448	0.59	2.4	1.73	25.6	1203.3
1/15/2015	0.007	0.028	<0.03	0.469	0.55	1.9	0.55	7.4	1413.6
1/21/2015	0.005	0.016	<0.03	0.370	0.46	1.0	2.34	155.3	2419.2
2/26/2015	0.006	0.022	<0.03	0.530	0.57	1.3	1.38	16.1	4790.0
3/3/2015	0.006	0.020	<0.03	0.477	0.52	ND	1.84	N.S.	N.S.
3/11//2015	0.006	0.022	0.04	0.567	0.60	0.5	2.20	6.3	410.0
3/19/2015	0.007	0.018	0.01	0.529	0.63	1.0	4.31	14.6	866.4
3/25/2015	0.007	0.014	0.02	0.462	0.53	1.1	0.64	8.6	344.8
4/2/2015	0.006	0.032	0.02	0.467	0.46	1.8	4.41	5.2	547.5
4/15/2015	0.005	0.026	0.03	0.472	0.56	0.8	1.26	305.0	2430.0
4/23/2015	0.008	0.026	0.03	0.520	0.56	2.0	1.78	12.0	3270.0
4/29/2015	0.012	0.018	0.02	0.569	0.61	3.5	1.98	14.3	4080.0
5/7/2015	0.013	0.066	0.02	0.628	0.71	3.2	16.41	71.7	7170.0
5/8/2015	0.005	0.254	0.41	2.287	3.23	127.1	6.45	5200.0	241920
5/11/2015	0.008	0.146	0.15	0.941	1.80	22.0	8.09	N.S.	N.S.
5/14/2015	0.010	0.022	0.01	0.527	0.50	1.7	0.73	41.3	1986.3
5/18/2015	0.007	0.028	0.03	0.525	0.55	0.7	1.18	90.7	7630.0

The geometric mean is calculated from 5 or more samples collected within 30 days at evenly spaced time intervals. No more than 25% of samples from a group of 8 or more samples per contact season may exceed these limits (Arkansas Pollution Control and Ecology Commission 2011, p.5-5).

*** *Ephemeral Streams*** – A culvert sampled by the BCRET was described as an "ephemeral stream" (April 1 to June 30, 2014 quarterly progress report, pp. 30 and 63) (see Table 9). It is atypical because it drains the subwatershed containing a portion of C&H. It may drain other pollution source(s) as well, but the CAFO is a source mentioned by the BCRET. Data are also included in the BCRET quarterly progress report dated April 1 to June 30, 2015 for an ephemeral stream that drains the area containing the animal holding units ("barns") of C&H (Table 10; and see Figure 13).

Ephemeral streams, which flow for only part of an annual cycle, are generally small and represent the majority of river miles in the U.S. (U.S. EPA; see http://water.epa.gov/type/rsl/streams.cfm). The U.S. EPA (above website) described them as "the very foundation of our nation's great rivers." They play a significant role in the hydrological and ecological integrity of river ecosystems, and provide critical habitat for certain important fauna (McDonough et al. 2011).

Based on the data in Tables 9 and 10, the two sites examined by the BCRET are extremely degraded. The data for the "culvert" ephemeral stream show very high total suspended solids, extreme values ranging from more than 900 to more than 2,400 mg TSS/L (Table 9). Considering that 30 mg TSS/L has been characteristic of surface waters in this area during storm/ runoff events. Consistently at both stations, nitrate-N is excessive (Tables 9 and 10). The culvert station also has several excessive ammonia-N, total nitrogen (TN), *Escherichia coli*, and total coliform levels. The second site, described in Table 10, also had consistently high levels of nitrate and frequent high levels of total coliform bacteria, up to 241,920 MPN/100 mL.

**** Surface runoff from fields #1 and #12*** was highly contaminated during and after swine effluent application, and would have been expected to contribute to the contamination of nearby waters –

As mentioned, the spring below field #1, part of C&H, was degraded in water quality when it was sampled in 2013 prior to the C&H swine effluent application. Nevertheless, during and following the period of swine effluent application in 2014, runoff from field #1 (and from field #12, based on sparse data) revealed excessive levels of some pollutants (DP, TP, NH_4^+N, NO_3^-N, TSS, and DOC) which would be expected to have contributed to the poor water quality of receiving waters such as the spring (Table 11; note that fecal bacteria were not measured in these important runoff samples).

Thus, regardless of the source of degraded spring water in 2013, during 2014 surface runoff from the fields containing C&H swine effluent was clearly contaminated with various pollutants during the effluent application period and for some time thereafter, and would have contributed to degradation of nearby waters such as the spring. Contaminated subsurface flow from field #1 likely also contributed to the degraded water quality of nearby shallow groundwaters.

The data also indicate frequent, high contamination of other surface waters and groundwater by C&H. Data from the BCRET study on a trench (Figure 15) and a well indicate that groundwater quality is being adversely affected by this CAFO. Water quality in the north and south ends of a long trench ("Interceptor Trench 1 [South], Interceptor Trench 2 [North]") near the swine waste holding ponds which, the BCRET team stated (July – Sept. 2014 quarterly progress report, p.2), was installed to monitor potential leakage. The trench samples are confusingly labeled as indicated above, implying that there are two trenches when instead there is one trench that is being sampled at each end. The trench location is shown in Figure 15 below; the holding ponds are shown and described in Figure 16. The water quality data for the trench are summarized in Table 12. Such findings are supported by various peer-reviewed studies in the science literature (e.g. Huffman and Westerman 1995, Westerman et al. 1995, Ham and DeSutter 2000).

***Table 11.* Surface runoff from two fields to which C&H CAFO swine wastes had been applied** in the BCRET study, according to Table 8 in these Comments. Compiled from three BCRET quarterly progress reports: July 1 to September 30, 2014; October 1 to December 31, 2014; and April 1 to June 30, 2015. Note how sparse the data are for surface runoff from field #12 (n = 2 dates over a 1.5-year span). Nevertheless, those data (examples in red outlines, with arrows for excessively high levels) show excessive DP, TP, NH_4^+N, NO_3^-N, and TSS; 1 of the 2 samples also contained excessive DOC. Also note that fecal bacteria were not sampled in surface runoff from the two fields being monitored that are receiving applications of C&H CAFO swine wastes.

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
Field 1									
5/8/2014	0.079	0.312	0.17	0.209	1.63	125.9	9.6	N.D.	N.D.
5/12/2014	0.190	0.366	0.10	0.126	1.33	42.1	10.2	N.D.	N.D.
5/28/2014	0.235	0.310	N.D.	N.D.	N.D.	56.1	164.7	N.D.	N.D.
6/20/2014	0.228	0.498	0.18	0.114	2.39	23.2	20.15	N.D.	N.D.
6/25/2014	1.166	1.374	0.10	0.333	1.18	12.3	7.80	N.D.	N.D.
7/23/2014	0.648	0.794	0.16	0.388	1.65	5.6	8.84	N.D.	N.D.
10/13/2014	0.529	0.746	0.98	0.698	2.89	65.7	9.46	N.D.	N.D.
3/26/2015	0.143	0.346	0.41	0.216	2.68	65.5	15.65	N.S.	N.S.
5/8/2015	0.525	0.714	0.16	0.475	2.19	16.9	13.28	N.S.	N.S.
5/11/2015	0.251	0.386	0.09	0.055	0.86	44.4	6.31	N.S.	N.S.
5/18/2015	0.208	0.512	0.54	0.410	3.59	53.7	26.12	N.S.	N.S.
Field 12									
5/8/2015	0.675	0.956	0.14	0.303	1.82	57.0	16.00	N.S.	N.S.
5/11/2015	0.194	0.364	0.09	0.135	0.83	36.7	7.03	N.S.	N.S.

Water quality in the north and south ends of a long trench ("Interceptor Trench 1 [South], Interceptor Trench 2 [North]") near the swine waste holding ponds which, the BCRET team stated (July – Sept. 2014 quarterly progress report, p.2), was installed to monitor potential leakage. The trench samples are confusingly labeled as indicated above, implying that there are two trenches when instead there is one trench that is being sampled at each end.

Figure 15. Photos showing (left) the site of the seepage monitoring trench near the swine waste holding ponds, and (right) the "north" and "south" sample collection points. From the July 1 to September 30, 2014 BCRET quarterly progress report

The trench location is shown in Figure 15 above; the holding ponds are shown and described in Figure 16. The water quality data for the trench are summarized in Table 12 below. Such findings are supported by various peer-reviewed studies in the science literature (e.g. Huffman and Westerman 1995, Westerman et al. 1995, Ham and DeSutter 2000).

Figure 16. **More magnified view of the large swine waste "manure" or "slurry" holding ponds** as described by the BCRET. The yellow outer boundary was described as denoting the drainage area (59,457 square feet) into the waste holding ponds. The red inner boundary was described as denoting the top of the free board for holding pond 1 (16,999 square feet) and the larger holding pond, holding pond 2 (34,618 square feet). The volumes of waste holding ponds 1 and 2 were given as 616,395 gallons and 1,723,009 gallons. From the BCRET quarterly progress report dated October 1 to December 31, 2014, pp. 35-36.

Table 12. **Data for surface water quality in a long trench** that was designed to capture any leakage from swine waste holding ponds at C&H. The data for Interceptor Trench 1 (South) are compiled from three BCRET quarterly progress reports dated October 1 to December 31, 2014; January 1 to March 31, 2015; and April 1 to June 30, 2015. The data for Interceptor Trench 2 (North – next page) are compiled from two BCRET quarterly progress reports dated October 1 to December 31, 2014; and April 1 to June 30, 2015. Numbers highlighted (examples in red outlines) are excessive levels indicating pollution from C&H waste holding pond. Note that the project team implausibly has alluded to wildlife such as a bobcat as having contributed the total coliforms, but the consistently high nitrate instead indicates leakage from the waste holding pond.

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
Interceptor Trench 1 (South)									
9/3/2014	0.004	0.003	0.04	0.937	1.22	3.7	0.68	N.D.	N.D.
9/11/2014	0.001	0.018	0.03	1.580	1.86	1.0	0.54	1.0	57,940
10/13/2014	<0.002	0.024	<0.03	1.251	1.46	71.4	0.83	15,650.0	61,310
11/5/2014	0.004	0.012	0.02	1.54	1.67	0.9	0.37	N.D.	N.D.
11/12/2014	0.004	0.012	0.02	1.54	1.67	0.9	0.37	N.D.	N.D.
12/22/2014	0.005	0.018	<0.03	0.881	0.83	6.1	1.09	1.0	630.0
1/8/2015	0.005	0.022	<0.03	0.769	0.75	4.7	0.88	1.0	13130.0
1/14/2015	0.007	0.028	<0.03	0.469	0.55	1.9	0.55	7.4	1413.6
2/26/2015	0.004	0.028	<0.03	0.712	0.76	46.0	0.60	1.0	41063.0
3/3/2015	0.003	0.024	<0.03	0.867	0.89	N.D.	0.95	N.S.	N.S.
3/11/2015	0.003	0.014	0.07	0.989	0.97	0.3	2.00	<1.0	2419.2
3/19/2015	0.003	0.012	0.01	0.849	0.93	<6.58	3.11	1.0	275.5
3/25/2015	0.003	0.008	<0.03	0.838	0.88	0.2	0.59	<1.0	410.6
3/26/2015	0.004	0.026	0.02	0.904	1.00	15.4	0.69	<1.0	1553.1
4/2/2015	0.003	0.028	0.02	0.865	0.87	0.3	3.34	1.1	308.6
4/9/2015	0.006	0.018	<0.03	0.790	0.83	0.8	2.99	<1.0	187.2
4/15/2015	0.003	0.020	<0.03	0.857	0.93	1.3	4.29	<1.0	3180.0
4/23/2015	0.003	0.034	<0.03	0.877	0.97	1.2	1.18	3.1	2690.0
5/11/2015	0.003	0.060	0.02	0.916	0.97	27.6	1.78	N.S.	N.S.

Table 12, cont'd.

Date sample collected	Dissolved P	Total P	Ammonia-N	Nitrate-N	Total N	Total suspended solids	Dissolved Organic C	E. coli	Total coliform
Interceptor Trench 2 (North)									
9/11/2014	<0.002	0.010	0.03	2.033	2.31	3.2	0.70	81.3	27,550
10/13/2014	0.001	0.116	0.33	1.714	2.73	11.1	4.14	920.8	241,920
11/5/2014	0.004	0.032	0.03	3.375	3.65	33.1	0.87	N.D.	N.D.
11/12/2014	0.004	0.032	0.03	3.375	3.65	33.1	0.87	N.D.	N.D.
3/11//2015	0.003	0.056	0.04	1.443	1.59	1.2	3.51	<1.0	2419.2
3/19/2015	0.004	0.062	0.09	1.036	1.42	1.9	5.12	5.2	2419.2
3/26/2015	0.004	0.126	0.13	0.873	1.44	22.2	4.63	105.4	6950.0
5/11/2015	0.003	0.042	0.05	0.553	0.76	8.8	3.44	N.S.	N.S.
5/14/2015	0.005	0.042	0.02	0.904	0.94	29.9	1.20	81.6	1732.9
5/18/2015	0.002	0.020	<0.03	0.897	0.93	0.3	1.28	32.3	1732.9

The data from monitoring of a groundwater well ("house well") adjacent to the CAFO buildings show that the well water would be unsafe for human or animal consumption unless treated, as indicated by 1 or more total coliform bacteria or *Escherichia coli* bacteria detected (U.S. EPA; see http://water.epa.gov/drink/contaminants/basicinformation/pathogens.cfm). The water also has commonly contained substantial densities of coliform bacteria, including *Escherichia coli* (see the April 1 to June 30, 2015 BCRET quarterly progress report). The BCRET reports offer no information about the potential for sources other than C&H that could contribute to the contamination of the well water. It also is not known whether the groundwater source for the well was contaminated before the waste holding ponds were installed. The close proximity of the well to the animal holding units and the swine waste holding ponds, considered together with the data showing high leakage of the waste holding ponds, indicate that C&H is a major contaminant source. Nevertheless, it is uncertain as to whether the data can be used to provide information about impacts of this CAFO because no information about the actual sampling procedure is provided in the BCRET reports. The reports should have stipulated whether the well samples were taken from the wellhead; if not, the data may not be useable.

The above examples mostly were taken from BCRET reports from 2013 through September 2015. The BCRET reports for the last quarter of 2015 through 2016 (BCRET 2015, 2016a-d) show very similar patterns as the data as those described above: Nitrate commonly was significantly higher at the downstream station in comparison to the upstream station, despite the fact that the upstream station was compromised (see section B-I above). Total coliform bacteria and *E. coli* were also commonly higher downstream than at the upstream station. And, as expected since this CAFO is a major source of pollution to surface waters, the ephemeral stream and trench stations within the CAFO area typically had much higher pollutant levels (nitrate, TSS, fecal bacteria) than the upstream or downstream sites. Analyses conducted by water quality specialist Dr. Nix (Nix 2016) also indicated that nitrate pollution from C&H is contaminating Big Creek.

Interpretations of the data by the BCRET reveal a lack of scientific understanding about how/when swine wastes contaminate adjacent waters. BCRET incorrectly maintains that absent consistent or prolonged trends in nutrient or bacteria levels, the CAFO is not causing significant impacts (e.g. BCRET 2014d, p.2). This statement is incorrect. Studies show that the concentrations of a given pollutant from a CAFO that is added to receiving surface waters and groundwaters should not be expected to be consistent; that is the nature of water pollution from CAFOs (Westerman et al. 1985, Huffman and Westerman 1995, Stone et al. 1998, U.S. EPA 1998, Ham and DeSutter 2000, Huffman 2004). Parameter levels vary depending on location with respect to swine waste practices at the CAFO, storm/runoff conditions, and soil characteristics (U.S. EPA 1998, 2013b – pp. 22-24). Extreme spikes in pollutant levels commonly occur during storm/runoff events (e.g. Mallin et al. 2014); they may or may not be detected depending on the sampling location and frequency relative to the runoff. BCRET's position that pollutant levels "must be consistently elevated" for the CAFO to cause impacts has resulted in ADEQ either ignoring or downplaying ongoing water quality impacts.

Inadequate use of statistics has been reflected in data interpretations by the BCRET. Compounding the incorrect belief that there must be consistent trends in water quality degradation is BCRET's inadequate or incorrect use of statistics. BCRET expects average pollutant concentrations to be significantly higher downstream from the CAFO under all conditions. It fails to separately consider data taken during or immediately after storm events. This conceals the adverse impacts of this CAFO. These results appear to be relied on by ADEQ to mistakenly conclude that there are no adverse impacts from this CAFO on nearby surface waters.

The proper use of a statistical analysis is described in a peer-reviewed, published study that tracked water contamination by nitrate and *Escherichia coli* (Knierim et al. 2015):

> Non-parametric statistical procedures were applied in SigmaPlot v. 12.5 to characterize data and determine significant relations at an α of 0.05. Coefficients of determination (r^2) between estimated discharge…and *E. coli* were compared for untransformed and log–log transformed data. A non-parametric t test (Mann–Whitney Rank Sum Test) was used to determine if *E. coli* concentrations were significantly different **between base-flow periods and storm events** [emphasis added]. For the 2007 to 2013 period, storm hydrographs were analyzed graphically for a change in slope on the receding limb, which can correspond to a change from storm-event flow (i.e., quick flow) to base flow (Brodie and Hostetler 2005). Base-flow *E. coli* samples were **additionally analyzed for seasonality** [emphasis added] using a non-parametric analysis of variance (Kruskal–Wallis One Way ANOVA on ranks) to determine if concentration was significantly different among spring (March, April, May), summer (June, July,

> August), fall (September, October, November), and winter (December, January, February) periods….

No such analyses have been reported by BCRET. All seasons, flow regimes and weather conditions have been combined, thereby obscuring statistically significant differences in CAFO pollutants at a given site.

The Harbor Drilling Study was completed on 21-23 September 2016 by Harbor Environmental and Safety in an attempt to address major public concerns after a BCRET member noted a possible major fracture and movement of waste near the waste holding ponds. The drilling study analyzed the data from only one drill site upslope from the waste ponds, whereas multiple drill holes, including holes down-slope from waste ponds, would be needed for a rigorous evaluation of whether karst is present in a given area and whether the waste ponds were contaminating groundwater.

Karst landscape has direct hydraulic connections between surface water and groundwater (Brahana et al. 2014). Karst topography is formed by dissolution of underlying carbonate rocks (limestone and dolomite), and/or other soluble rocks such as gypsum (Alpha et al. 2013). Karst soil or bedrock is permeable because air and water can move through them easily, making karst systems "very vulnerable to groundwater pollution…." (Alpha et al. 2013). Limestone (calcium carbonate) is known to strongly adsorb phosphorus (Stumm and Morgan 1996, Wetzel 2001); thus, recent work indicates that on an annual basis, up to ~70% of the total phosphorus (TP) flux (movement into/through the karst material) and ~90% of the soluble reactive phosphorus flux (highly bioavailable P) is retained by the karst material (Jarvie et al. 2014). However, as Jarvie et al. (2014) also noted, subsequent P remobilization and release from the karst material may serve as a long-term source of P to surface waters.

The Harbor Drilling Study was limited for evaluation of karst and the presence/ absence of swine waste pollutants in C&H area for two basic reasons:

- It was based entirely on one drill hole as stated above. *Karst areas are known to be spatially variable over short distances* (Mellander et al. 2012, Knierim et al. 2015). The northwestern Arkansas area is part of one of the major karst terrains in the U.S., *and* karst features are often poorly developed because of a thick mantle of residual chert fragments and insoluble clays (Adamski et al. 1995, Criss et al. 2009).

- *The investigation was conducted during a dry period.* There had been no rain for the previous four days, and only 0.34 inch of rain over the previous ten days (National Weather Service data). It is well known that variability in pollutant concentrations over both space and time in karst is "due to groundwater flow path heterogeneity, **storm-event antecedent conditions** [emphasis added], seasonality of temperature and **precipitation** [emphasis added, and]…nitrate and bacteria can pool at the epikarst boundary and flushed out once storm-event water creates a hydraulic connection between the soil and epikarst zones…"(Knierim et al. 2015 and references therein; also see Mellander et al. 2012 and references therein).

A third point concerns evidence from the Harbor Environmental and Safety (2016) report. There is a brief description indicating that the grouting of the bore hole required much more grout than had been planned, suggesting that larger fractures were present in various zones, and that the area is karst. This finding also suggests that the area is susceptible to groundwater (and surface water) contamination from waste ponds leaks, and with application of liquid swine wastes to fields. It is accepted that waste ponds with clay liners commonly leak substantial pollutants into shallow groundwater (e.g., Huffman and Westerman 1995, Ham and De Sutter 2000). Swine CAFOs (both the land application practices and waste pond leakage) additionally pose a significant threat to well water via contamination by other harmful substances and pathogenic microbes (e.g. Stone et al. 1998, Krapac et al. 2002).

Mr. Tai Hubbard, P.G., of Hydrogeology, Inc., was hired by ADEQ to evaluate the study. He found it to be inadequate because only one drill hole was analyzed, and noted other serious limitations in the study design, methods, and data interpretation as well. In Appendix C to the report Mr. Hubbard states:

> Other questions concern the apparent void detected at a depth that closely corresponds to the depths of the pond floors. The void was detected during drilling and again when difficulty was encountered while sealing up the hole above a depth of 25 feet below the ground. Water for lubricating the drilling process was lost at this depth and the final grouting of the shaft required almost 50% more in cement than what the driller had calculated. The report provided little discussion regarding this seemingly significant karst feature [emphasis added]. The report and the cores show that karst is indicated throughout most of the 120 ft. range of the drilled shaft….*this facility and its waste ponds are clearly sitting atop karst* [emphasis added].

The U.S. Geological Survey has published information about the general area which supports karst underlying C&H (Hudson et al. 2001, 2011). Both documents describes pervasive occurrence of karst features. Other peer-reviewed publications such as Knierim et al. (2015) have noted that abundant chert, which has been found in C&H site, is characteristic of the general karst area of northwestern Arkansas. An electrical resistivity imaging (ERI) analysis of fields 5a and 12 at the CAFO was conducted by scientists from Oklahoma State University. The ERI surveys have confirmed soil thickness, extent, and depth of epikarst features and bedrock material. *The average epikarst thickness underlying the two fields was highly variable*, ranging from 6 to 75 feet. *A large doline feature was detected, which is a closed topographic depression in karst areas,* caused by dissolution or collapse of underlying rock or soil within the weathered bedrock underlying one, but not all three fields (Fields and Halihan 2015).

ADEQ appears to interpret the results of the Harbor Drilling Study as adequate support to conclude that although C&H is surrounded by karst geology, there is no karst underlying the CAFO. The report *did not* reach that conclusion. Rather, it states that karst features were not encountered in the zone from 70 to 90 feet below the ground surface (p. 7). Attachment C to the report states, "The highly weathered limestone bedrock and unconsolidated clay intervals observed between 13.8 and 28.0 feet below the ground surface appeared to have the characteristics of epikarst." This depth would correspond to at or just below the bottom of the waste holding ponds; thus, the pond leakage would move directly into the epikarst layer. The U.S. EPA (2002) defines epikarst or epikarst zone as a relatively thick portion of bedrock that extends from the base of the soil zone and is characterized by extreme fracturing and enhanced dissolution. Significant water storage and transport occur in the epikarst zone.

For all the reasons set forth herein as well as other comments submitted in opposition to the draft permit, the permit should be denied.

C&H Hog Farms, Inc. Draft Regulation 5 Permit
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