IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF OKLAHOMA

STATE OF OKLAHOMA, ex rel. GENTNER DRUMMOND, in his capacity as Attorney General of the State of Oklahoma and OKLAHOMA SECRETARY OF ENERGY AND ENVIRONMENT KEN McQUEEN, in his capacity as the TRUSTEE FOR NATURAL RESOURCES FOR THE STATE OF OKLAHOMA,*

Plaintiffs,

v.

Case No. 05-CV-329-GKF-SH

TYSON FOODS, INC.,
TYSON POULTRY, INC.,
TYSON CHICKEN, INC.,
COBB-VANTRESS, INC.,
CAL-MAINE FOODS, INC.,
CARGILL, INC.,
CARGILL TURKEY PRODUCTION, LLC,
GEORGE'S, INC.,
GEORGE'S FARMS, INC.,
PETERSON FARMS, INC., and
SIMMONS FOODS, INC.,

Defendants.

FINDINGS OF FACT AND CONCLUSIONS OF LAW

DATED: January 18, 2023

* Pursuant to Fed. R. Civ. P. 25(d), Oklahoma's current Attorney General and current Secretary of Energy and Environment are substituted as relators.

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FINDINGS OF FACT AND CONCLUSIONS OF LAW

The Illinois River runs 145 miles from East to West through the Ozarks of Northwest Arkansas and Northeast Oklahoma. In the 1970s, the Oklahoma Legislature found the Illinois River and its tributaries "possess[ed] such unique natural scenic beauty, water, fish, wildlife and outdoor recreational values of present and future benefit to the people of the state" that it designated most of the Illinois River and two of its tributaries as Scenic Rivers. 82 Okla. Stat. § 896.5. As late as the 1960s, its waters were crystal clear. But that is no longer the case. The river is polluted with phosphorus, with adverse consequences that include low dissolved oxygen; abundant filamentous green algae; blue-green algae in Lake Tenkiller near the river's terminus; greatly decreased transparency; and significant detrimental impacts on the numbers and species of fish. The State has established that hundreds of thousands of tons of poultry litter generated by defendants' chickens and turkeys are spread onto the lands of the Illinois River Watershed (IRW) each year. The State further established that a significant cause of the excess phosphorus in the waters of the IRW is the land application of litter from defendants' poultry.

I. Overview and History of the Case

The State of Oklahoma brought this case against eleven defendants: Tyson Foods, Inc.; Tyson Poultry, Inc.; Tyson Chicken, Inc.; Cobb-Vantress, Inc.; Cal-Maine Foods, Inc.; Cargill, Inc.; Cargill Turkey Production, LLC; George's, Inc.; George's Farms, Inc.; Peterson Farms, Inc.; and Simmons Foods, Inc.[1] The State alleges that the defendants have polluted and continue to

[1] Tyson Foods, Inc., Tyson Chicken, Inc., and Tyson Poultry, Inc. are Delaware corporations headquartered in Springdale, Arkansas, with operations in the IRW. [Doc. 1238 at 3, ¶¶6-7; Ct. Ex. 4, Hudson Dep., at 28:24-29:2]. Cobb-Vantress, Inc. is a Delaware corporation headquartered in Siloam Springs, Arkansas, with operations in the IRW. [Doc. 1238 at 4, ¶9]. Cal-Maine Foods, Inc. is a Delaware corporation headquartered in Jackson, Mississippi. Cal-Maine, which is in the business of producing shell eggs for market, has not had any production in the IRW since January 2005. [TR at 4412:7-10; OK Ex. 6082]. Cargill, Inc. is a Delaware corporation with its principal place of business in Minnesota. [Doc.

pollute the waters of the IRW with phosphorus and bacteria from the waste generated from defendants' poultry and applied to lands in the IRW. [Doc. 2641, p. 2 (Pretrial Order)].

The State asserted ten causes of action in its First Amended Complaint: 1) cost recovery under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA); 2) natural resource damages under CERCLA; 3) a Solid Waste Disposal Act (SWDA) citizen suit; 4) state law nuisance (including nuisance *per se*); 5) federal common law nuisance; 6) trespass; 7) violation of 27A Okla. Stat. § 2-6-105 and 2 Okla. Stat. § 2-18.1; 8) violation of 2 Okla. Stat. § 10-9.7 and Oklahoma Administrative Code (OAC) § 35:17-5-5; 9) violation of OAC § 35:17-3-14; and 10) unjust enrichment/restitution/disgorgement. [Doc. 18].

Defendants filed motions to dismiss various counts of the First Amended Complaint, as well as answers denying the remainder of the State's allegations. [*See* Docs. 64-67, 75]. While those motions were pending, the State of Arkansas petitioned the United States Supreme Court seeking leave to file a bill of complaint to enjoin the lawsuit. Following the Supreme Court's denial of the petition, the State of Arkansas moved to intervene in this action. That motion was denied. [Doc. 1141].

1240 at 5, Cargill Answer to Sec. Am. Compl.]. Cargill transferred its turkey business in the IRW to Cargill Turkey Production, LLC, a wholly-owned subsidiary, in 2004, and currently has no contracts with any poultry growers in the IRW. [TR at 4849:13-15 (Alsup)]. Cargill Turkey Production, LLC ("CTP") is a Delaware corporation. [Doc. 1241, CTP Answer to Sec. Am. Compl., at 5]. CTP processes turkey under the brand name Honeysuckle White, among others. [TR at 4896:5-10]. George's, Inc. is an Arkansas corporation that contracts with 27 independent growers in the IRW, three of which are located in Oklahoma and 24 of which are located in Arkansas. [TR at 3026:6-9 (M. Henderson)]. George's also owns one farm in the Arkansas portion of the IRW, and it operates nine other farms, which it leases but does not own, that are located in the Arkansas portion of the IRW. [TR at 3024:16-3026:5 (M. Henderson)]. George's Farms, Inc., is a wholly owned subsidiary of George's, Inc. Peterson Farms, Inc. is an Arkansas corporation. [TR at 4841:14-4842:3 (Houtchens)]. All of Peterson's operational assets were located in Decatur, Arkansas, which is outside the boundaries of the IRW. [TR at 4841:14-4842:3 (Houtchens)]. Peterson has no continuing relationship with poultry operations in the IRW, having sold its broiler production business to Simmons Foods in July 2008. Most of its contract growers in the IRW signed contracts with Simmons Foods [OK Ex. 0827 at 2; TR at 4786:1-4787:13 (Houtchens)]. Simmons Foods, Inc. is a family owned and operated Arkansas corporation with its headquarters in Siloam Springs, Arkansas. [TR at 4119:9-15; 4119:25-4120:8; 4121:23-25].

Meanwhile, defendants filed two third-party complaints naming over one hundred sixty individuals, entities and municipalities for contribution and indemnity due to their activities causing the release of phosphorous and hazardous substances into the Illinois River. [Doc. 80, 82]. The State moved to sever or stay the proceedings with respect to the third-party complaints and the court granted the motion.

At hearings on the motions to dismiss, the court dismissed the State's claim under 27A Okla. Stat. § 2-6-105 to the extent the State sought to affix liability for conduct occurring in Arkansas. [Docs. 1187, 1206]. The court also dismissed the trespass claim, but granted leave to re-plead. The State then filed a Second Amended Complaint [Doc. 1215] re-pleading the trespass claim. Defendants filed a motion to dismiss the re-pled claim, and the court denied the motion.

The State then filed a motion for preliminary injunction under the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. § 6972(a)(1)(B), asserting that fecal bacteria from the disposal of poultry waste generated by defendants' birds was causing an imminent and substantial endangerment to human health. Following an eight-day evidentiary hearing, the court denied the motion, finding in part:

> The evidence produced to this Court reflects that fecal bacteria in the waters of the IRW come from a number of sources, including cattle manure and human waste from growing numbers of human septic systems in that area's karst topography. The record reflects levels of fecal bacteria at similar levels in rivers and streams throughout the State of Oklahoma, including waterways in whose watersheds the record does not evidence similar application of poultry waste. At this [stage of] the action, the State has failed to meet the applicable standard of showing that the bacteria levels in the IRW can be traced to the application of poultry litter.

Oklahoma v. Tyson Foods, Inc., 2008 WL 4453098, at *4 (N.D. Okla. Sept. 29, 2008). The State appealed to the Tenth Circuit, and the Circuit affirmed the order denying preliminary injunctive relief. *Oklahoma v. Tyson Foods, Inc.,* 565 F.3d 769 (10th Cir. 2009).

Defendant poultry companies moved to dismiss the State's claims for damages on the ground that the Cherokee Nation was a required party that had not been joined. The State argued that the Nation was not a required party but had negotiated an agreement in which the Nation purportedly assigned the State its interests in the litigation. The court ruled that the agreement was invalid and granted the defendants' motion, restricting the State to injunctive and other equitable relief. In doing so, the court dismissed the State's CERCLA claims, its claim for unjust enrichment and its claims for damages under Oklahoma's laws of nuisance and trespass, and under the federal common law of nuisance. *Oklahoma v. Tyson Foods, Inc.*, 258 F.R.D. 472 (N.D. Okla. 2009).

Nineteen days before trial, the Cherokee Nation sought to intervene. This court denied the motion as untimely. The Cherokee Nation appealed, and the Tenth Circuit affirmed. *Oklahoma v. Tyson Foods, Inc.*, 619 F.3d 1223 (10th Cir. 2010).

The State seeks equitable relief against the defendant poultry companies on the following claims set forth in the Final Pretrial Order:

1. violation of RCRA, 42 U.S.C. § 6972;
2. state law public nuisance and state law nuisance *per se*;
3. federal common law nuisance;
4. trespass; and
5. violations of 27A Okla. Stat. § 2-6-105 (Pollution of state air, land or waters – Order to cease) and 2 Okla. Stat. § 2-18.1 (Pollution of air, land, or waters – Order to cease – Administrative penalty).

[Doc. 2641, Pretrial Order at 2]. With respect to the RCRA, nuisance, trespass and 2 Okla. Stat. § 2-18.1 claims, the State seeks injunctive/equitable relief, including but not limited to abatement, remediation, and costs associated with quantifying the amount of remediation. With respect to the

27A Okla. Stat. § 2-6-105 claim, the State seeks both injunctive relief and civil penalties, as well as attorney fees and costs associated with the recovery of civil penalties.

Defendants have asserted numerous affirmative defenses, including that the State lacks standing to pursue the claims at issue; that the claims are preempted by federal law and the Arkansas River Basin Compact; and that the relief sought violates defendants' due process rights as well as the Commerce Clause of the Constitution and principles of comity and federalism. They assert the claims are barred by the doctrines of license and consent; that they are not liable for acts of their poultry growers; and that they—at all times relevant to this action, have obeyed all laws and regulations. [Doc. 2641, Pretrial Order at 3-4].

The parties tried the case to the court for 52 days over the course of five months, resulting in a trial transcript of 11,889 pages and 8,392 pages of admitted exhibits. After the State rested, the defendants moved for judgment on partial findings under Federal Rule of Civil Procedure 52(c). The court heard extensive argument on these motions from all parties over the course of three days, then granted defendants' motions in part and denied them in part. *See Oklahoma v. Tyson Foods, Inc.*, 2010 WL 653032 (N.D. Okla. Feb. 17, 2010). First, the court granted the motions with respect to the State's nuisance *per se* claim. Under Oklahoma law, a nuisance *per se* is "an act, occupation or structure which is a nuisance at all times and under any circumstances, regardless of location or surroundings." *Sharp v. 251st St. Landfill, Inc.*, 810 P.2d 1270, 1276 n.6 (Okla. 1991), *overruled on other grounds by DuLaney v. Okla. State Dep't of Health*, 868 P.2d 676, 678-79 (Okla. 1993). In this case, the State failed to demonstrate that the land application of poultry litter in the IRW is "a nuisance at all times and under any circumstances, regardless of location or surroundings." Expert testimony established that poultry litter may properly be used as a fertilizer within the IRW under certain circumstances and with certain limitations, and the State itself permits land application of poultry litter under those circumstances. *Tyson Foods, Inc.*, 2010 WL 653032, at *3-5. Second, the court granted the motions with respect to the State's claim of bacterial pollution because the State's evidence was insufficient to prove: (a) that land application of poultry litter has caused bacterial pollution of the IRW's waters; or (b) that bacteria from poultry litter poses a risk to human health or the environment in the IRW. However, the court expressly excluded from that ruling the State's allegations and evidence relating to blue-green algae (sometimes referred to as cyanobacteria). *Id.* at *6-7. Third, the court granted defendants' motions with respect to the State's RCRA claim because, if properly applied, poultry litter can be beneficially used as a fertilizer and soil amendment, because poultry litter has a market value, and because the State had failed to prove that poultry litter was applied within the IRW for the sole purpose of discarding it. *Id.* at *8-11 The court denied the defendants' Rule 52(c) motions in all other respects.

Pursuant to Fed. R. Civ. P. 52(a)(1), the court enters the following Findings of Fact and Conclusions of Law with respect to the State's remaining claims.

II. Findings of Fact

A. Geology and Soils of the IRW

1. The IRW, which is comprised of slightly over one million acres, straddles northeastern Oklahoma and northwestern Arkansas. [OK Ex. 3351 at OSU0005147]. Slightly more than half of the watershed—approximately 576,030 acres—is located in Oklahoma. [*Id.*]. The IRW is located within the western flank of the Ozark uplift, a large structural dome that centers in southeastern Missouri. [TR at 1594:23-1595:2 (Fisher); OK Ex. 3351 at OSU0005148]. The Springfield Plateau, which occupies the northern two-thirds of the IRW, consists of gently undulating to steeply rolling topography. [OK Ex. 3351 at OSU0005148]. The Boston Mountains, the highest

of the plateaus in the Ozarks, form the southern portion of the IRW. Local relief in some places exceeds 1,500 feet, and the southern portion is characterized by greater slopes and overall ruggedness. [OK Ex. 3351 at OSU0005155]. There is very little flat land in the IRW. [TR at 1598:3-7 (Fisher)].

2. This topography determines the hydrology of the IRW. [TR 1594:2-3 (Fisher)]. Waters that fall in the IRW travel, in general, from the northeast to the southwest. [TR at 1594:17-22 (Fisher)]. The major drainage features of the IRW include the Illinois River, which arises in the eastern part of the IRW and flows into Lake Tenkiller in the southwestern part of the IRW; Caney Creek, which arises near the Oklahoma-Arkansas border near Stilwell, Oklahoma, and flows east to west into the Illinois River near Lake Tenkiller; Barren Fork (a.k.a. Baron Fork) River, which arises in Arkansas and flows generally east to west into the Illinois River near Lake Tenkiller; and Flint Creek, which arises in the northeastern portion of the IRW and flows into the Illinois River in Oklahoma near the Oklahoma-Arkansas border. [TR at 1601:24-1602:3; 1603:2-8; 1603:21-1604.21 (Fisher); OK Ex. 2519]. Lake Tenkiller, a run-of-the-river reservoir, was created in 1954 by the impoundment of the Illinois River. [TR at 1678:25-1679:1, 2136:24-2136:25 (Fisher)]. As a watershed, the IRW is a single, interconnected hydrologic unit. [TR at 5954:18-5957:3 (Chaubey)].

3. The primary surface drainage channels in the IRW are a result of the underlying geological structure—faults in the underlying limestone that are the consequence of the Ozark uplift. [TR at 1604:25-1605:11 (Fisher)]. The primary pathways for groundwater flow are along smaller fractures and joints and along bedding planes in the underlying limestone. [TR at 1605:12-21 (Fisher)]. Since limestones are fairly brittle, the underlying geology in the IRW is broken "much like a china cup." [TR at 1605:14-16 (Fisher)]. Because of the fractured limestone,

rainfall percolates readily through the soil and into groundwater. Moreover, because of the limestone fractures and karst topography (formed by the dissolution of soluble rocks such as limestone and characterized by underground drainage systems), groundwater moves relatively rapidly in the IRW. [TR at 1604:25-1606:11 (Fisher); OK Ex. 3312]. As a result of these underground conduits, surface water and groundwater in the IRW are "fairly closely linked." [TR at 1606:14-21 (Fisher)].

4. Under base flow conditions (times when there has not been significant precipitation), rivers and streams in the IRW are fed primarily from alluvial groundwater. [TR at 5528:8-12; 5530:4-10; 5369:2-3 (Olsen)]. The alluvium—the soil area adjacent and contiguous to the rivers and streams—is recharged by surface water in rivers and streams during high flow events; once the river or stream level drops, the water from the recharged alluvium drains back into the river or stream. [TR at 5778:11-18 (Engel); TR at 2071:1-16 (Fisher)].

5. The IRW is a region of "mantled karst"—fractured limestone overlain by a mantle of weathered material. [TR at 1608:11-25 (Fisher)]. This mantled karst is a critical geological feature that plays a major role in the hydrology of the IRW. The limestone is calcium carbonate and very soluble. [OK Ex. 3351 at OSU0005155]. Groundwater has formed networks of underground drainage channels in the limestone. Over time, bedding planes, joints and faults in the limestone have been enlarged by dissolution of the limestone, and sinkholes, caves and fissures are common. [OK Ex. 3351 at OSU0005155; TR at 1608:18-25; 1619: 23-1620:13 (Fisher); OK Ex. 6923-STOK0033387; TR at 944:15-20 (Fite)]. A substantial amount of water can, and does, pass through the mantled karst. [TR at 1620:3-5 (Fisher)].

6. The weathered mantle overlying the limestone is a residual soil formed by in-place weathering and dissolution of the limestone. [TR at 1609:8-10 (Fisher)]. It is a rocky cobble,

generally with chert gravels and boulders in it, covered by a very thin layer of organic soil. [TR at 1609:10-15 (Fisher); OK Ex. 6923 at STOK0039169, STOK0047621].

7. The soils in the Oklahoma portion of the IRW are "marginal, at best," so it's difficult to grow row crops. [TR at 920:2-6 (Fite)]. The record reflects that bermuda grass and fescue are the most common crops. In their natural state, the soils of the IRW are not high in nutrients. [TR at 1527:4-7 (Phillips)].

8. The record reflects that the natural background level of phosphorus in the soils of the IRW (soil test phosphorous, or "STP") is less than 65 lbs/acre.

B. Historical Aesthetic Quality of IRW Waters

9. The beauty of the waters of the IRW has long been recognized. For example, an 1867 report described the Illinois River as "a wide, clear, rapid, pebbly, ever-running stream," and stated, "[i]t is impossible in this brief Report to recount the riches, resources, and loveliness of this river. . ." [OK Ex. 3100]. An 1870 report to the President from the Secretary of the Interior's Board of Indian Commissioners described the Illinois River as "one of the prettiest rivers on the continent, sparkling with crystal waters." [OK Ex. 3121 at OK0003528.] A 1952 report stated:

> Any description of the Illinois River should properly be filled with glowing adjectives and loaded with phrases of superlative beauty. For the "Illinois" is a clear, spring-fed stream, flowing through the oak and hickory clad Ozark hills in a succession of sparkling riffles and long, quiet pools, that inspires cries of "Eureka!!" when first viewed by people from the short grass country.

[OK Ex. 3089]. An April 16, 1961, article described the Illinois River as "a sparkling spring-fed masterpiece of nature" with "a succession of alternating deep pools and swift shallows flowing over beds of gravel." [OK Ex. 3116 at OK0003578]. A 1992 report stated, "[t]he Illinois River is cherished for its beauty." [OK Ex. 3351 at OSU005174]. A 1999 report described the river as "unquestionably one of Oklahoma's outstanding natural resources." [DJX0147-0004]. Similarly, witnesses for the State testified about the historical clarity of the Illinois River. [TR at 669:12-672:2 (Fite in the early 1960's); TR 610:2-11 (Hilsher in the mid-1970's); 978:11-980:11 (Phillips)]. Lake Tenkiller, too, was once known for its clear water and beauty. [OK Ex. 3106 at OK0003576 (1956); OK Ex. 3113 at p. 458; OK Ex. 5593A at p. 537; TR at 978:24-979:12 (Phillips)].

C. Land Uses in the IRW

10. The IRW is predominantly a rural watershed. [TR at 1623:25 (Fisher); OK Ex. 2491]. According to the United States Geological Survey ("USGS"), "[t]he basin is dominated by about equal proportions of agricultural (pasture and cropland) and forest land uses and is interspersed with minor amounts of commercial and residential land uses." [OK Ex. 5862 at p. 4]. The IRW is comprised of 45 percent grassland, 44 percent forest land, two percent cropland, one percent orchards and vineyards, six percent urban areas, and two percent "other land use," including confined animal feeding operations (CAFOs), roads and railroads and water. [OK Ex. 3351 at OSU0005156].

11. The easternmost portion of the IRW is the site of one of the fastest-growing urban areas in the United States (Fayetteville-Springdale-Rogers, Arkansas). [OK Ex. 5862 at p. 4; TR at 10091:2-11 (Grip)]. The human population of the IRW at the time of trial was approximately 340,000. [TR at 1624:14-18 (Fisher)]. In 2000, it was approximately 280,000. [TR at 1624:14-15 (Fisher)]. Most of the population growth has occurred in urban areas. [TR at 1538:24-1539:4 (Phillips)]. Most of the waste from the urban population growth is treated at wastewater treatment plants ("WWTPs"). [TR at 1539:5-8 (Phillips)].

12. A significant amount of the IRW's pastureland, located primarily in the upstream portion of the IRW in Arkansas, is used for cattle production. [OK Ex. 5862 at 4]. The application of

poultry waste as fertilizer on those pasturelands has enabled those lands to grow the grass necessary to support the cattle industry. [TR at 951:20-25 (Fite); TR at 9603:9-14 (Smith)].

13. Recent rapid population growth in Northwest Arkansas has resulted in attendant residential and commercial construction, as well as deforestation. [TR at 10085:19-10091:11; 10092:15-10093:6 (Grip); TR at 8882:25-8883:7 (Connolly); DJX3494; DJX3676].

14. The IRW is inhabited by other domestic animals and wildlife, including horses, sheep, swine, deer, ducks, geese and wild turkeys. Defendants point to these other animals as contributors to the total amount of phosphorus contained in animal manure deposited in the IRW. [TR at 9850:10-9852:21 (Clay)]. However, the relative amount of waste from these other animals, as compared to the systematic application of poultry waste onto the lands of the IRW, is small.

15. The Illinois River and Lake Tenkiller are used for recreation, including floating (canoeing, tubing, kayaking, and rafting), swimming, fishing, camping, hunting, scuba diving, mountain biking, and foliage tours. [TR at 324:10-24; 326:4-327:1 (Tolbert); TR at 959:17-960:14 (Fite)].

16. The IRW contains at least seven WWTPs. [TR at 511:7-18 (Tolbert)]. These plants have discharge permits which permit them to discharge effluent containing phosphorus directly into the streams of the IRW, which ultimately drain to Lake Tenkiller. [TR at 511:7-512:6 (Tolbert)].

17. The waters of the IRW are also used for drinking water. [TR at 339:1-340:18 (Tolbert)]. Eighteen utilities in the Oklahoma portion of the IRW treat water drawn from the Illinois River or Lake Tenkiller and distribute drinking water to local populations. [TR at 11021:2-23 (McGuire); OK Ex. 5202].

D. Regulation of the Waters of the IRW

18. 27A Okla. Stat. § 2-6-102 sets out the State's public policy regarding water pollution:

> Whereas the pollution of the waters of this state constitutes a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life, and impairs domestic, agricultural, industrial, recreational and other legitimate beneficial uses of water, and whereas the problem of water pollution of this state is closely related to the problem of water pollution in adjoining states, it is hereby declared to be the public policy of this state to conserve the waters of the state and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses; to provide that no waste or pollutant be discharged into any waters of the state or otherwise placed in a location likely to affect such waters without first being given the degree of treatment or taking such other measures as necessary to protect the legitimate beneficial uses of such waters; to provide for the prevention, abatement and control of new or existing water pollution; and to cooperate with other agencies of this state, agencies of other states and the federal government in carrying out these objectives.

19. 27A Okla. Stat. § 2-6-105(A) provides: "It shall be unlawful for any person to cause pollution of any waters of the state or to place or cause to be placed any wastes in a location where they are likely to cause pollution of any air, land or waters of the state. Any such action is hereby declared to be a public nuisance."

20. With respect to poultry waste, the law states: "Poultry waste handling, treatment, management and removal shall: (a) not create an environmental or a public health hazard, (b) not result in the contamination of the waters of the state . . . ." 2 Okla. Stat. § 10-9.7(B)(4)(a) and (b).

21. The State asserts "an interest in the beds of navigable rivers to their high water mark, as well as all waters running in definite streams," and also claims that it "holds all natural resources, including the biota, land, air and waters located within the political boundaries of Oklahoma in

trust on behalf of and for the benefit of the public." [TR at 309:18-310:20 (Tolbert); Doc. 1215, Sec. Am. Compl. ¶5].[2]

22. The principal agencies having jurisdiction over environmental matters in the Oklahoma Portion of the IRW include the Oklahoma Department of Environmental Quality ("ODEQ"), the Oklahoma Water Resources Board ("OWRB"), Oklahoma Department of Agriculture, Food and Forestry ("ODAFF"), Oklahoma Conservation Commission ("OCC"), Oklahoma Department of Wildlife Conservation ("ODWC") and the Oklahoma Scenic Rivers Commission ("OSRC"). [*See* 27A Okla. Stat. § 1-3-101; TR at 304:15-305:8 (Tolbert)]. The activities of these agencies are coordinated through the Oklahoma Secretary of the Environment. [*Id.*].

23. Additionally, the Arkansas-Oklahoma Arkansas River Compact Commission ("Compact Commission"), was formed in 1970 to administer the appropriation of water in the Arkansas River basin. [TR at 644:14-19 (Fite)]. The Compact Commission has no regulatory authority; its primary role is water quantity, not water quality. [TR at 307:20-22 (Tolbert); 82 Okla. Stat. § 1421; TR at 307:25-308:9 (Tolbert); TR at 9464:23-9465:10 (Smith)].

24. The Oklahoma Legislature has designated portions of streams and rivers in the IRW in Oklahoma, specifically the Illinois River, the Barren Fork and Flint Creek, as "Scenic Rivers." [82 Okla. Stat. § 1452; TR at 312:5-25; 313:21-314:2; 315:6-17 (Tolbert); 3186:1-16; 3187:6-12; 3188:5-19 (Strong)], and as "outstanding resource waters" [TR at 3186:1-3187:12; 3188:5-19 (Strong)].

1. Water Quality Standards

25. The OWRB sets water quality standards for the waters of the state, including the water in the IRW. [*See* 82 Okla. Stat. §§ 1085.2(16), 1085.30(A)(1); TR at 323:15-25 (Tolbert)]. Water

[2] The Cherokee Nation also claims ownership of much of the waters of the IRW. [*See, e.g.,* 63 Cherokee Nation Code § 201 ("Waters of the Nation"); Doc. 2362, Opinion and Order].

quality standards are provisions of law that identify beneficial uses of the waters and govern how clean that water is supposed to be. [TR at 321:16-20 (Tolbert); TR at 3180:6-12 (Strong)]. Beneficial uses are assigned on the basis of what those water bodies should be able to support (*e.g.*, a public water supply, agriculture, fish and wildlife propagation, recreation). [TR at 3180:13-20 (Strong); Okla. Admin. Code § 785:45-1-2)]. "Beneficial uses are protected through the restrictions imposed by the antidegradation policy, narrative criteria and numerical standards." [*See* Okla. Admin. Code § 785:45-5-2(a)].

26. Water quality standards differ for every body of water in the state based on scientific surveys. [TR at 321:21-23 (Tolbert); TR at 3180:21-3181:4; 3183:7-19 (Strong)]. The standards identify the beneficial uses of the water at issue, the criteria needed to protect those uses, and the prohibitions against antidegradation. [TR at 321:23-322:7 (Tolbert)].

27. Water quality standards apply to pollution from both point and non-point sources. [TR at 322:8-12 (Tolbert)]. A water body that does not meet water quality standards is described as "impaired." [TR at 322:-13-16 (Tolbert)].

28. The State's water quality standards are promulgated as regulations in the Oklahoma Administrative Code. [Okla. Admin. Code § 785:45; OK Ex. 5108; TR at 3178:11-16 (Strong)]. The designated beneficial uses and antidegradation protections set for particular bodies of waters are found in Appendix A to title 785, chapter 45 of the Oklahoma Administrative Code. [TR at 3184:5-10 (Strong)].

29. The criteria are both numerical (*e.g.,* a concentration level in the water) and narrative (*e.g.,* a qualitative description of the condition of water quality). [TR at 3182:8-3183:6 (Strong); Okla. Admin. Code § 785:45-1-2]. Where there is a conflict between a narrative criterion and a numerical criterion, the more stringent criterion controls. [Okla. Admin. Code § 785:45-5-4(d);

TR at 3188:25-3189:3 (Strong)]. Additionally, as the term suggests, antidegradation standards prohibit degradation of water quality in the waters of the state. [TR at 3183:20-23 (Strong).

30. The State's water quality standards contain a general narrative criterion with respect to nutrients which is applicable to all beneficial uses. It provides that "[n]utrients from point source discharges or other sources shall not cause excessive growth of periphyton, phytoplankton, or aquatic macrophyte communities which impairs any existing or designated beneficial use." [Okla. Admin. Code § 785:45-5-9(d); TR at 3449:8-25 (Strong)].

31. The narrative and numerical water quality standards for aesthetics beneficial use are found at Okla. Admin. Code § 785:45-5-19. [TR at 3189:9-20 (Strong)]. The narrative standard provides that "[t]o be aesthetically enjoyable, the surface waters of the state must be free from floating materials and suspended substances that produce objectionable color and turbidity," and that "[t]he water must also be free from noxious odors and taste, from materials that settle to form objectionable deposits, and discharges that produce undesirable effects or are a nuisance to aquatic life." [Okla. Admin. Code § 785:45-5-19(a) and (b); TR at 3190:6-22 (Strong)]. The numerical standard provides that "[t]he thirty (30) day geometric mean total phosphorus concentration in waters designated 'Scenic River' in Appendix A of this Chapter shall not exceed 0.037 mg/L." [Okla. Admin. Code § 785:45-5-19(c)(2); TR at 3189:21-3190:5 (Strong)]. The numerical standard for total phosphorus became effective on July 1, 2002. [TR at 3190:23-25 (Strong)].

32. The narrative and numerical water quality standards for the fish and wildlife propagation (cool water aquatic community) beneficial use are found at Okla. Admin. Code § 785:45-5-12. [TR at 3443:18-22 (Strong)]. The narrative biological standard provides that "[a]quatic life in all waterbodies with the beneficial use designation of Fish and Wildlife Propagation (excluding waters designated 'Trout, put-and-take') shall not exhibit degraded conditions as indicated by one

or both of the following: (i) comparative regional reference data from a station of reasonably similar watershed size or flow, habitat type and Fish and Wildlife beneficial use subcategory designation or (ii) by comparison with historical data from the waterbody being evaluated." [Okla. Admin. Code § 785:45-5-12(f)(5)(A); TR at 3450:25-3451:18 (Strong)]. The standard further provides that "[c]ompliance with the biological criteria to protect Fish and Wildlife Propagation set forth in this paragraph shall be based upon measures including, but not limited to, diversity, similarity, community structure, species tolerance, trophic structure, dominant species, indices of biotic integrity (IBI's), indices of well being (IWB's), or other measures." [Okla. Admin. Code § 785:45-5-12(f)(5)(B); TR at 33451:19-25 (Strong)]. The numerical standard for dissolved oxygen provides that "[e]xcept for naturally occurring conditions, the dissolved oxygen criteria are as set forth in Table 1 of Appendix G." [Okla. Admin. Code § 785:45-5-12(f)(1)(C).] Appendix G provides that for early life stages (March 1 through May 31) the dissolved oxygen criterion is 7 mg/L at seasonal temperatures of 22 degrees centigrade; for other life stages in summer conditions (June 1 through October 15) the dissolved oxygen criterion is 6 mg/L at seasonal temperatures of 29 degrees centigrade; and for other life stages in winter conditions (October 16 through February 28) the dissolved oxygen criterion is 6 mg/L at seasonal temperatures of 18 degrees centigrade. [Okla. Admin. Code § 785:45 (App. G); TR at 3444:17-3445:2 (Strong)].

33. The narrative and numerical quality standards for public and private water supply beneficial use are found at Okla. Admin. Code § 785:45-5-10. [TR at 3445:9-14 (Strong)]. The numerical standard for chlorophyll-a provides,

> The long term average concentration of chlorophyll-a at a depth of 0.5 meters below the surface shall not exceed 0.010 mg/L in Wister Lake, Tenkiller Ferry Reservoir, nor any waterbody designated SWS [sensitive water supply] in

> Appendix A of this Chapter. Wherever such criterion is exceeded, numerical phosphorus or nitrogen criteria or both may be promulgated.

[Okla. Admin. Code § 785:45-5-10(7); TR at 3445:18-3446:10 (Strong)].

34. The state's water quality standards for the IRW have been submitted to and approved by the Environmental Protection Agency ("EPA"), and as such have become federal law. [TR at 372:2-10 (Tolbert)].

35. The OWRB has adopted a 0.037 mg/L aesthetics criterion for total phosphorus concentration in designed Scenic Rivers. [Okla. Admin. Code § 785:45-5-19(c)(3)]. At the time of trial, the State had not compelled wastewater treatment plants to reduce their phosphorus discharge levels to meet the 0.037mg/L criterion. Instead, wastewater treatment plants were merely required to meet a 1.0 mg/L phosphorus standard, which is nearly 30 times higher than the 0.037 mg/L goal. [TR at 884:22-885:14 (Fite)].

2. Antidegradation Standards

36. Oklahoma's water quality standards specifically provide that "[n]o water quality degradation which will interfere with the attainment or maintenance of an existing or designated beneficial use shall be allowed." [Okla. Admin. Code § 785:45-3-2(d); TR at 3452:8-20 (Strong)].

37. Oklahoma's water quality standards establish a more stringent antidegradation requirement for Scenic Rivers, Outstanding Resource Waters and waters located within the watersheds of Scenic Rivers by providing that "[n]o degradation of water quality shall be allowed in these waters." [Okla. Admin. Code § 785:45-3-2(a); TR at 3452:21-3453:18 (Strong)].

38. Oklahoma's water quality standards also establish a more stringent antidegradation requirement for High Quality Waters which are waters of the state that "possess existing water quality which exceeds those levels necessary to support propagation of fishes, shellfish, wildlife,

and creation in and on the water" by providing that "[t]hese high quality waters shall be maintained and protected." [Okla. Admin. Code § 785:45-3-2(b); TR at 3456:3-18 (Strong)].

39. The implementation policies for these antidegradation standards include a prohibition on any new point source discharges of designated pollutants, including phosphorus, or any increased load of designated pollutants, including phosphorus, from any existing point source discharger in Outstanding Resource Waters, Scenic Rivers, and waterbodies within the watersheds of Scenic Rivers after June 25, 1992. [Okla. Admin. Code § 785:45-5-25(a) and (c)(1); TR at 3455:3-16 (Strong)].

40. Similarly, these implementation policies include a prohibition on any new point source discharges of designated pollutants, including phosphorus, or any increased load of designated pollutants, including phosphorus, from any existing point source discharge in High Quality Waters except in limited circumstances (which have not occurred in the IRW). [Okla. Admin. Code § 785:45-5-25(c)(3); TR at 3458:1-15 (Strong)].

3. Designated Beneficial Uses of Waters in the IRW

41. The beneficial uses designated for Lake Tenkiller are public and private water supply, cool water aquatic community, agriculture, primary body contact recreation and aesthetics. [Okla. Admin. Code § 785:45 (App. A); TR at 3184:16-20 (Strong)]. Additionally, Baron Fork has been designated as both an "outstanding resource water" and a scenic river. [Okla. Admin. Code § 785:45 (App. A); TR at 3186:7-16 (Strong)]. The beneficial uses designated for Baron Fork from Highway 59 to the Arkansas state line are public and private water supply, cool water aquatic community, agriculture, primary body contact recreation and aesthetics. [Okla. Admin. Code § 785:45 (App. A); TR at 3186:17-25 (Strong)]. Baron Fork has also been designated as an

"outstanding resource water" and as being located in a "nutrient limited watershed." [Okla. Admin. Code § 785:45-5-29(B)(19); TR at 3187:1-5 (Strong)].

42. The beneficial uses designated for the upper Illinois River upstream from the Baron Fork confluence to the Arkansas state line are public and private water supply, cool water aquatic community, agriculture, primary body contact recreation and aesthetics. [Okla. Admin. Code § 785:45 (App. A); TR at 3186:6-12, 3187:22-3188:1 (Strong)]. It has also been designated an "outstanding resource water," a scenic river, and as being located within a "nutrient limited watershed." [Okla. Admin. Code § 785:45 (App. A); § 785:45-5-29(b)(19); TR at 3186:6-12 (Strong)]. Further, the Illinois River is a "high use waterbody." [TR at 3441:25-3442:7 (Strong)].

43. The beneficial uses designated for Flint Creek from its mouth to the state line are public and private water supply, cool water aquatic community, agriculture, primary body contact recreation and aesthetics. [Okla. Admin. Code, § 785:45 (Appendix A); TR at 3188:5-9 (Strong)]. Flint Creek has also been designated an "outstanding resource water," a scenic river and as being located within a "nutrient limited watershed." [Okla. Admin. Code, § 785:45 (Appendix A); Okla. Admin. Code, § 785:45-5-29(b)(19); TR at 3188:10-16 (Strong)].

4. Total Maximum Daily Load

44. Total maximum daily load ("TMDL") is defined as:

> The sum of the individual WLAs [Wasteload Allocations] for point sources and LAs [Load Allocations] for nonpoint sources and natural background. If a receiving water has only one point source discharger, the TMDL is the sum of that point source WLA plus the LAs for any nonpoint sources of pollution and natural background sources, tributaries, or adjacent segments. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. If Best Management Practices (BMPs) or other nonpoint source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TMDL process provides for nonpoint source control tradeoffs.

40 C.F.R. § 130.2(i).[3]

45. A TMDL is a planning tool used to determine the greatest amount of loading that a water body can receive without violating water quality standards (*i.e.,* a load capacity), and to apportion that loading capacity between loads from point and nonpoint sources. [TR at 3608:14-17 (Strong); Court's Ex. 13 at p. 12 (Thompson Dep.)]. A TMDL is not self-executing. *See* CL ##86-91.

46. Oklahoma drafted a TMDL for the Oklahoma portion of the IRW, but that draft had not been finalized at the time of trial. [TR at 1396:1-13 (Phillips); TR at 3704:9-14 (Strong)].

47. Stephen Thompson, Executive Director of the ODEQ, testified that a completed TMDL for the IRW will result in a determination that phosphorus loads from point sources and nonpoint sources need to be reduced. [TR at 10769:12-25 (Thompson)]. Point sources in the Oklahoma portion of the IRW include the cities of Tahlequah, Westville and Stilwell; ODEQ is legally required to implement any loading reductions required by a TMDL in these cities' point source NPDES permits. [TR at 10770:1-26 (Thompson)]. However, ODEQ has no authority to mandate reductions in poultry litter-based loads required by a TMDL, and can only make recommendations. [TR at 10771:18-25 (Thompson)]. Further, although phosphorus loading also

[3] Wasteload allocation means:

> The portion of a receiving water's loading capacity that is allocated to one of its existing or future point sources of pollution. WLAs constitute a type of water quality-based effluent limitation.

40 C.F.R. § 130.2(h). Load allocation means:

> The portion of a receiving water's loading capacity that is attributed either to one of its existing or future nonpoint sources of pollution or to natural background sources. Load allocations are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Wherever possible, natural and nonpoint source loads should be distinguished.

40 C.F.R. § 130.2(g).

originates in the Arkansas portion of the IRW, no agency of the State of Oklahoma has authority to enforce nonpoint source loading reductions required by a TMDL in the State of Arkansas. [TR at 10776:17-10777:6 (Thompson)].

48. Thompson testified the ODEQ is concerned the sampling methodology used to determine the TMDL will result in an unfair allocation in load reductions between point sources and nonpoint sources. [TR at 10769:7-11; 10772:23-10773:25; 10782:14-22 (Thompson)]. Both the former and current Water Quality Division Chiefs worked with the OWRB to resolve the issue, but at the time of trial, no resolution had been reached. [TR at 10776:9-16 (Thompson)]. Thompson did not know when OWRB would make its decision, and he testified that if the issue is not resolved, ODEQ would have to proceed to generate a TMDL. [TR at 10787:9-15; 10785:13-19 (Thompson)].

49. In October 2009, the EPA proposed development of a model of the IRW incorporating all relevant segments and nutrient sources in both Arkansas and Oklahoma. [DJX8090; TR at 10794:20-10795:15 (Thompson)]. The EPA's stated purpose was "to provide a technically sound basis upon which regulatory and non-regulatory decisions can be confidently based." It stated, "[w]e expect this modeling effort may lead to the development of one or more Total Maximum Daily Load (TMDLs) for the Illinois Basin." [DJX8090]. The EPA proposed a June 2012 deadline for having TMDLs established. [*Id.*] Both the ODEQ and the Arkansas Department of Environmental Quality are participating in the effort. [TR at 10806:22-10807:6 (Thompson); 9544:3-11 (Smith)]. The modeling project (which the EPA expects may lead to the development of one or more TMDLs for the Illinois Basin) was completed in April of 2018.

50. Arkansas regulators believe that the 0.037 mg/L phosphorus scenic river criterion is "unachievable." [TR at 9519:8-9520:12; 9542:6-16 (Smith)]. Therefore, pursuant to a Joint

Statement of Principles entered into in 2003 by the States of Oklahoma and Arkansas, Oklahoma committed to "re-evaluate [the] .037 milligram per liter criterion for total phosphorus in Oklahoma's scenic rivers by 2012, based on the best scientific information available at that time." [TR at 3700:13-21 (Strong); TR at 10797:23-10799:24 (Thompson); OK Ex. 5928].[4]

51. The State of Oklahoma has not adopted a numeric criterion for total phosphorus in the numerous streams, creeks and rivers in the Oklahoma portion of the IRW not designated as Scenic Rivers. [TR at 3602:1-12 (Strong); TR at 7308:1-19 (Stevenson)].

E. Phosphorus in the IRW

52. Much of the evidence in this case refers generally to the various phosphorus compounds at issue as "phosphorus" or the single letter, "P." This shorthand does not refer to elemental phosphorous ("P" on the periodic table). Elemental phosphorous "is not found naturally in the environment," but rather is "created in a laboratory and is used for things like fireworks." [TR at 8894:3-10 (Connolly)]. For convenience, these findings and conclusions will occasionally adopt the common shorthand of referring to phosphorus compounds simply as "phosphorus."

53. Broadly speaking, phosphorus can be divided into four categories: particulate organic phosphorus, particulate inorganic phosphorus, dissolved organic phosphorus and dissolved inorganic phosphorus. [TR at 8894:20-8898:7 (Connolly)]. Soluble reactive phosphorus, or

[4] Oklahoma and Arkansas have entered into a Second Statement of Joint Principles and Actions, pursuant to which Oklahoma committed to remove the date to achieve full compliance with the 0.037 mg/L Numeric Phosphorus Standard set forth in OAC 785:45-5-19 and 785:45-5-25(d), and the States commissioned a three-year Joint Phosphorus Criteria Study. [Doc. 2920, Ex. A]. The goal of the study was to determine "the Total Phosphorus threshold response level, in milligrams per liter (mg/L), at which any statistically significant shift occurs in algal species composition or algal biomass production resulting in undesirable aesthetic or water quality conditions in the Designated Scenic River," the purpose of which is "to provide reliable and objective data and analysis that will then form the basis for the parties and EPA to make informed decisions about the scientific merit of any proposed revisions to the phosphorus criteria for the Designated Scenic Rivers." [*Id.* at 2-4].

"SRP" is mostly dissolved inorganic phosphorus, but includes a small amount of dissolved organic phosphorus, and is available for algal growth. [TR at 8896:17-8897:1 (Connolly)].

F. State Regulation of Poultry Litter

54. Both Oklahoma and Arkansas regulate the land application of poultry litter in the IRW.

1. Oklahoma

55. Oklahoma regulates poultry feeding operations and litter application through the Oklahoma Registered Poultry Feeding Operations Act ("ORPFOA"), 2 Okla. Stat. § 10.9:9.1-9.12, and the Oklahoma Poultry Waste Applicators Certification Act ("OACA"), 2 Okla. Stat. § 10.9:9.16-9.24, both of which were enacted in 1998.

56. Under the ORPFOA, all poultry feeding operations are required to register with the State Board of Agriculture. [2 Okla. Stat. § 10-9.3]. Additionally, the ORPFOA requires that all poultry feeding operations shall:

- utilize Best Management Practices, 2 Okla. Stat. § 10-9.7(A);
- have an Animal Waste Management Plan ("AWMP") and comply with the application rates and instruction set forth therein; Okla. Admin. Code § 35:17-5-3(b); and
- perform annual testing of the poultry litter and the soil to which it may be applied. 2 Okla. Stat. § 10-9.7(E); Okla. Admin. Code § 35:17-5-5(a)(3).

57. The State Department of Agriculture is charged with administration and enforcement of the OACA. [2 Okla. Stat. § 10-9.20]. The department has the authority to suspend, cancel, deny or revoke applicator certificates. [2 Okla. Stat. § 10-9.21].

58. The Oklahoma Department of Agriculture, Food and Forestry ("ODAFF") has promulgated regulations for both ORPFOA and OACA. [*See* Okla. Admin. Code § 35:17-5-1, *et seq.* (ORPFOA regulations), and Okla. Admin. Code § 35:17-7-1, *et seq.*]. The purpose of the regulations is to assist in ensuring the beneficial use of poultry waste while preventing adverse

effects to waters of the State. [Okla. Admin. Code § 35:17-5-1; TR at 463:14-18 (Tolbert)]. The ODAFF regulations set forth the factors that control the amount, location and manner in which poultry litter may be applied to any particular field. [TR at 467:1-470:4 (Tolbert)].

59. AWMPs are field-specific plans setting forth the time, location, and amount of poultry litter that may be applied to a parcel of land. [*See, e.g.,* DJX1, DJX3480; OK Ex. 4061; TR at 2899:15-2900:5 (Gunter)]. An AWMP must set forth "land application rates of poultry waste . . . based on the available nitrogen and phosphorus content of the poultry waste and . . . provide controls for runoff and erosion as appropriate for site conditions" based on "a soil test and current [USDA Natural Resources Conservation Service (NRCS)] phosphorous standards." 2 Okla. Stat. § 10-9.7(C)(5); Okla. Admin. Code § 35:17-5-3(b)(6), (7).

60. AWMPs must also incorporate Best Management Practices ("BMPs") including all those set forth in the ORPFOA and accompanying regulations. [*See* 2 Okla. Stat. § 10-9.7(A); TR at 464:17-465:6; (Tolbert)]. For example, an AWMP will include instructions regarding how the grower is "going to handle and utilize the poultry waste," including storage. [TR at 2900:14-15 (Gunter)]. At the time of trial, about 20 percent of growers had not yet received an AWMP, although they had all applied for one. An AWMP contains prohibitions against application in certain circumstances, including "when the ground is saturated or during rainfall events or when it's frozen." [TR at 2900:17-19 (Gunter)]. It prohibits application to locations within 100 feet of a perennial stream, within 50 feet of an intermittent stream and to fields with a slope greater than 15 percent or soils less than 10 inches in depth. [TR at 484:2-485:8 (Tolbert)].

61. Oklahoma regulations authorize the drafting and issuance of AWMPs on behalf of the State "by the USDA NRCS or an entity approved by the State Department of Agriculture." [Okla. Admin. Code § 35:17-5-3(b)(3)]. Currently, AWMPs are drafted by soil scientists under contract

with ODAFF, each of whom possesses training and expertise in this field. [TR at 2906:25-2907:11, 2909:11-16 (Gunter)].

62. Each AWMP is supposed to be tailored to the characteristics of the specific parcel of land to which the AWMP relates. [TR at 464:17-465:6 (Tolbert)]. Each plan "incorporates everything from the statutes and the rules, but it also may incorporate particular issues that are associated with that individual's property, like is it a bordering stream or something to that effect." [TR at 2899:15-2900:5 (Gunter)].

63. The ORPFOA requires AWMPs to include BMPs and provisions mandating that there be "no discharge of poultry waste to the waters of the state" and no "contamination of the waters of the state." [2 Okla. Stat. § 10-9.7(B)]. Under ORPFOA, "[t]he procedures documented in the [AWMP] must ensure," that "poultry waste shall only be applied to suitable land at appropriate times and rates," and "[d]ischarge or runoff of waste from the application site is prohibited." [2 Okla. Stat. § 10-9.7(C)(6)(c)].

64. Similarly, ODAFF's "Animal Waste Management Plan Requirements" mandate that "[s]torage and land application of poultry waste shall not cause a discharge or runoff of significant pollutants to the waters of the state." [Okla. Admin. Code § 35:17-5-5(c)].

65. The OACA requires that anyone who applies poultry litter—whether as a commercial or private applicator—must first obtain an applicator's certificate from the State Board of Agriculture. [*See* 2 Okla. Stat. § 10-9.17(A); Okla. Admin. Code §§ 35:17-7-3(a), 4(a)]. The OACA also requires litter application, whether by a private or commercial applicator, to "comply at all times with the provisions set forth in . . . [t]he Animal Waste Management Plan, if application is conducted on land operated by a registered poultry operation." [2 Okla. Stat. § 10-

9.19]. All other applications in a nutrient-limited watershed must comply with a Conservation Plan. [*Id.*]

66. The ORPFOA requires all poultry feeding growers and all certified applicators to receive nine hours of education on "poultry waste handling" in the first year and two hours of continuing education every year until the operator has received a total of 19 hours training; thereafter, operators are required to receive two hours of continuing education every three years. [*See* Okla. Admin. Code § 35:17-5-11.] The training is generally provided through the Oklahoma State University Extension Service and usually includes participation by ODAFF officials in the educational programs and training videos. [TR at 2917:23-2919:12 (Gunter); DJX1185 (OSU Extension Service handouts); DJX1191-A (training video excerpt)].

a. Phosphorus Standards in Oklahoma

67. The ORPFOA incorporates the standards set forth in the U.S. Department of Agriculture's Natural Resources Conservation Service's ("NRCS") Code 590, which are the "current [NCRS] phosphorus standards." [2 Okla. Stat. § 10-9.7(C)(5); Okla. Admin. Code § 35:17-5-3(b)(6), (7); *see* DJX3916 (Oklahoma-NRCS Code 590); TR at 472:3-25 (Tolbert)].

68. NRCS Code 590 is "the primary document that the State of Oklahoma relies on for putting [AWMPs] together." [TR at 2910:16-2911:2 (Gunter)]. Indeed, the legislature has mandated a specific Code 590 for use in Oklahoma (herein "Oklahoma NRCS Code 590"). [TR at 472:3-25 (Tolbert); DJX3916 (NCRS, OK Code 590)]. The purpose of Oklahoma NRCS Code 590 is, among other things, (1) "to minimize agricultural nonpoint source pollution of surface and ground water resources" and (2) to "properly utilize manure or organic by-products as a plant nutrient source." [DJX3916 at1].

69. Oklahoma law requires Oklahoma-NRCS Code 590 standards to be incorporated into individual growers' AWMPs, and growers are required to follow these standards. [2 Okla. Stat. § 10-9.7(C)(5); Okla. Admin. Code § 35:17-5-3(b)(6), (7); TR at 2911:12-24 (Gunter)].

70. Oklahoma NRCS Code 590 incorporates an agronomic rate for nitrogen as the limiting nutrient, but does not incorporate an agronomic rate for phosphorus. [TR at 531:13-532:6 (Tolbert); DJX3916 at 4]. The agronomic rate is the soil test value of the measured constituent at which there is 100 percent adequacy to grow the yield potential for a particular crop. [TR at 5003:23-5004:21 (Johnson)].

71. Oklahoma NRCS Code 590 sets maximum limits on litter application that are dependent on whether the land at issue is in a "Nutrient Limited" or "Non-Nutrient Limited" Watershed. [DJX3916 at 21]. In nutrient limited watersheds, litter may not be applied to any land with an STP (soil test phosphorus) level greater than 300. [*Id.*] The State first designated the Oklahoma portion of the IRW as "Nutrient Limited" effective July 1, 2006. [TR at 2910:7-12 (Gunter)]. Prior to that time, the non-nutrient limited Code 590 standards applied to the IRW, including the STP cap of 400 pounds per acre. [DJX3916 at 21; TR at 3657:11-25 (Strong)].

72. The maximum land application rate of 300 lbs/acre STP in a nutrient limited watershed set forth in Code 590 is not scientifically based. [TR at 3688:24-3689:5 (Strong); 5088:5-8 (Johnson)].

73. As mentioned in paragraph 7, above, the principal pasture grasses grown in the IRW are fescue and bermuda. [TR at 9864:23-9865:1 (Clay)]. At an STP of 40 lbs/acre, there is a 95 percent sufficiency of the phosphorus requirement for growth of these grasses, while at an STP of 65 lbs/acre, there is a 100 percent sufficiency. [OK Ex. 3169; OK Ex. 3168].

74. "Science-based fertilizer recommendations used by Oklahoma State University, based on decades of field and laboratory research, show a STP value of 65 is adequate for production of most crops." [OK Ex. 3145 at p. 2; TR at 5001:9-12 (Johnson)].

75. The Oklahoma Cooperative Extension Service states that "nutrient utilization standards that are protective of the environment would require that animal manure applications do not result in soil test phosphorus levels that exceed 120." [OK Ex. 3145 at p. 2].

76. A field-average soil test of 120 lbs/acre (based on 15 to 20 cores per field) can be used to ensure that 95 percent of the area of a field has sufficient phosphorus with soil test levels of 65+lbs/acre to prevent any localized deficiencies due to soil variability. [OK Ex. 3145 at p. 2; TR at 5020:19-5022:6 (Johnson)]. Nutrient utilization standards that are protective of the environment require that animal manure applications do not result in soil test phosphorus levels that exceed 120. [OK Ex. 3145 at p. 2 (Oklahoma Cooperative Extension Service Publication entitled "Managing Phosphorus from Animal Manure"].

77. Significantly, however, there would be no noticeable difference in crop response between a field-average soil test of 120 lbs/acre and a field-average soil test of 65 lbs/acre. [TR at 5174:3-16; 5022:2-6 (Johnson)]. Put another way, at land application rates in excess of agronomic need for phosphorus, there is no crop benefit. [TR at 5174:4-8; 5022:7-9 (Johnson)]. Indeed, the State's expert, Dr. Gordon Johnson,[5] characterized additional land application of phosphorus from poultry waste at levels above 120 STP as "waste disposal." [TR at 5022:19-5023:9 (Johnson)].

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[5] Dr. Johnson received his Ph.D. in soil science with a specialty in chemistry and biology in 1969 from the University of Nebraska at Lincoln. [TR at 4986:10-16 (Johnson)]. He was a professor of soil science at Oklahoma State University from 1977 until he retired as Regents Professor in 2004. [TR at 4985:18-20 (Johnson)]. Before that, he was a professor in the Department of Agriculture, Chemistry and Soils at the University of Arizona from 1969-1977, where he taught and conducted research in nutrient management. [TR at 4986:18-24 (Johnson)]. In 1977, he was hired by OSU as a state specialist in nutrient management

78. The "protective rate"[6] for commercial fertilizer in Arkansas regulations that became effective January 1, 2010, recommends no additional phosphorus for soils having STP values greater than 100 lbs/acre (the Arkansas agronomic critical value). [DJX8133 (New ANRC Rules, Appendix B)].

79. Elevated STP levels increase the amount of dissolved phosphorus in runoff. [TR at 5028:3-10 (Johnson); TR at 9209:1-6 (Connolly); OK Ex. 3312 at ADEQ-226; OK Ex. 3145 at 2249-2].

80. Field-specific restrictions on the land application of poultry waste are a field management tool, not a watershed management tool. [TR at 9597:1-5; 9597:9-14 (Smith)]. AWMPs and NMPs are "absolutely site specific" and are not written with a view to protecting the watershed as a whole, but rather to attempt to reduce phosphorus running off from a specific field. [TR at 6654:9-17 (Engel)]. As defendants' expert, Dr. Timothy Sullivan,[7] recognized, one of the issues with nonpoint source pollution is that there can be what amounts to "death by a thousand cuts." [TR at 10932:16-22 (Sullivan)]. Put another way, over an entire watershed, individually small but environmentally consequential releases of phosphorus combine to create the overall pollution of a waterbody.

81. Based upon the evidence presented at trial, the court finds by a preponderance that land application of poultry litter in the IRW that results in soil test phosphorus levels in excess of

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in the cooperative extension service and as the director of the soil, water and forage testing laboratory. [TR at 4987:2-6 (Johnson)].

[6] "Protective rate" is defined as "the application rate for commercial fertilizers approved by the Commission for designated Nutrients that provides for proper Crop utilization and prevention of significant impact to Waters within the State." [DJX8133 (New ANRC Rules, Title XXII, § 2201.4(X))].

[7] Dr. Sullivan has a Ph.D. in biological sciences from Oregon State University and conducted post-doctoral research in Norway on hydrology flow paths in watersheds. [TR at 10565:15-25, 10568:25-10569:14]. He is president of E & S Environmental Chemistry, Inc., a consulting firm which conducts work on human activities and water quality, and on environmental restoration and watershed assessments. [TR at 10565:7-12, 10571:20-10572:20].

120 lbs/acres results in continued and unnecessary pollution of the IRW by phosphorus from poultry waste. However, the agronomic critical level for phosphorus in the IRW is 65 lbs/acre STP, and the land application of poultry litter in the IRW in excess of this agronomic critical level is not protective of the environment and likely results in continued phosphorus pollution.

82. Oklahoma, through the ODAFF, currently has the statutory authority to alter land application rates in the Oklahoma portion of the IRW. [TR at 487:5-8 (Tolbert); TR at 2914:21-2915:17; 2948:25-2950:18 (Gunter); 3564:22-3566:17 (Strong); 2 Okla. Stat. § 10-9].

83. Neither the legislature, nor ODAFF, nor any other state agency has formally advocated for the adoption of more stringent standards to limit or prohibit the land application of poultry litter to the Oklahoma IRW. [TR at 532:7-23 (Tolbert)]. In fact, the State adopted the current standard after the governor's animal waste task force specifically considered and voted against recommending lower STP ceilings. [TR at 3585:1-3588:20 (Strong); DJX2616].

84. At the time of trial, the Office of the Oklahoma Secretary of the Environment had not formally petitioned the legislature or ODAFF to lower the land application rates governing the application of poultry litter in the Oklahoma portion of the IRW. [TR at 476:16-477:2, 488:12-17 (Tolbert)]. ODAFF's Deputy General Counsel testified that ODAFF had not received a formal request from any state agency to make such a change, although she admitted that ODAFF could act unilaterally, as it does not need a formal request to amend its own regulations. [TR at 2915:3-6, 2915:18-2916:8 (Gunter)].

85. During the pendency of this lawsuit, the State continued to draft, approve and issue AWMPs to growers in the IRW. [TR at 475:2-6 (Tolbert); 3579:5-9 (Strong)].

86. The Attorney General and Secretary of Energy and Environment, as relators, seek an injunction against land applications of poultry litter that are made in accordance with site-specific

State authorizations. The State's position in this litigation reflects a disagreement with current State law and regulations.

87. For example, Secretary Tolbert testified that he "disagree[s] with the law as it currently stands today," in particular the standards set forth in Code 590. [TR at 489:8-15]. The Deputy General Counsel for the Oklahoma Department of Agriculture, Teena Gunter, admitted that through this lawsuit the State seeks a result "more restrictive than the present existing Code 590 and existing Animal Waste Management Plans as set out by [ODAFF's] rules and regulations and by the legislature." [TR at 2980:14-23]. Shanon Phillips, director of the Water Quality Division of the Oklahoma Conservation Commission, testified that her "preferred outcome" from this litigation is, in part, to achieve a reduction in the land application of poultry litter in the IRW through the imposition of land application rates more restrictive than those currently provided for by Oklahoma law. [TR at 1504:15-1507:1]. The State's expert, Dr. Johnson, acknowledged that he did not consider the role of AWMPs drafted pursuant to the current legal standards because he believes that "the laws of Arkansas and Oklahoma should be changed and replaced with [his] absolute 120 STP criteria." [TR at 5171:3-8].

b. Compliance

88. Numerous Oklahoma poultry growers and/or certified applicators testified they rely on AWMPs to ensure they are complying with Oklahoma law. [TR at 3857:14-20; 3859:7-18; 3860:1-9 (Pigeon); TR at 3944:13-16 (Collins); TR at 4100:20-4101:6; 4116:19-4117:9 (Anderson); TR at 4605:6-18 (Saunders); TR at 4483:22-25, 4517:6-19 (Reed)].

89. Representatives of each defendant testified their companies rely on local, state and federal regulations and state inspectors to ensure that contract growers were implementing sound environmental practices. [TR at 3316:20-3317:6 (Keller, former Tyson employee); TR at

4143:16-4144:16; 4146:12-17 (Simmons, Simmons representative); TR at 4308:3-4309:4 (McClure, George's representative); TR at 4450:23-4451:7 (Storm, Cal-Maine representative); TR at 4732:5-4733:3, 4734:14-4735:5; 4735:16-4736:9, 4771:21-4773:4, 4777:19-4778:7 (Maupin, Cargill employee); TR at 4797:12-24; 4809:23-4810:13; 4831:15-23; 4832:13-19; 4834:7-4835:9, 4839:5-25, 4843:8-18 (Houtchens, Peterson representative); Ct. Ex. 7 (Butler Dep.) at 78:07-78:15 (Cobb-Vantress representative)].

90. Under Oklahoma law, the ODAFF may (1) assess penalties and points to growers who fail "to utilize or comply with Best Management Practices or the [AWMP] and [where] the failure results in actual harm to natural resources of the state," Okla. Admin. Code § 35:17-5-10.1(2)(H); and (2) assess penalties and points for the "[f]ailure . . . to utilize or comply with Best Management Practices or the [AWMP] and [where] the failure results in potential harm to natural resources of the state." [Okla. Admin. Code § 35:17-5-10.1(2)(I)]. The ORPFOA also provides that "[v]iolations involving the greatest harm to the natural resources of the state, ground or surface water quantity or quality, public health or the environment shall receive the most points and shall be considered significant violations." [2 Okla. Stat. § 10-9.12(B)(1)(a)]. The ORPFOA also provides for criminal penalties for violations of the litter application laws. [*See* Okla. Stat. § 10-9.11].

91. Regardless of points, the State Board of Agriculture is authorized to designate any poultry feeding operation as a concentrated animal feeding operation (CAFO) if "it is determined to be a significant contributor of pollution to the waters of the state." [2 Okla. Stat. § 20-44(A)(3) and (C); 2 Okla. Stat. § 10-9.9(A)]. Under Oklahoma's CAFO Act, an animal feeding operation designated as a CAFO is subject to greater scrutiny, stricter requirements, and more in-depth record-keeping requirements. [2 Okla. Admin. Code § 20-40, *et seq.*].

92. ODAFF has only two poultry inspectors who work in the IRW and are responsible for inspection of the operations for a total of 77 IRW growers in Oklahoma. [TR at 2923:12-2924:7 (Gunter)]. The inspectors conduct annual inspections of all farms at which litter applications occur and investigate complaints received about the farms assigned to them. [TR at 2924:8-2925:18 (Gunter)].

93. The representatives of the State who testified at trial had not been notified of any violations of the Act or regulations. [*See* Ct. Ex. 15 (Peach Dep.) at 38:19-24, 39:1-4, 75:2-4, 75:6-10, 75:12-14, 75:16-76:2, 76:3-10, 92:25-93:4, 93:6; TR at 476:12-15, 478:2-5, 490:20-24 (Tolbert); TR at 2696:15-23 (Fisher); TR at 4843:19-4844:4 (Houtchens); TR at 4977:9-4978:13 (Alsup)].

94. The growers and applicators appearing as witnesses at trial (all of whom were selected and called by the State) testified uniformly that they comply with the litter application rates and requirements set forth in their AWMPs. [TR at 3852:18-3853:3, 3864:20-3865:6 (Pigeon); 3937:21-24, 3939:1-3 (Collins); 4097:22-4098:8, 4103:11-25 (B. Anderson); 4493:8-11, 4508:4-25 (Reed); TR at 4588:20-25, 4595:19-23 (Saunders)].

95. Based on the evidence adduced at trial, the Court finds that the defendants themselves comply with state and federal regulations—including litter application rates and instructions set forth in AWMPs or NMPs[8]—on company-owned or operated farms. [TR at 3088:25-3089:9 (M. Henderson); TR at 3317:11-3318:8 (Keller)].

96. Plaintiff's expert, Dr. J. Berton Fisher,[9] testified that the State hired a dozen Tulsa detectives to conduct surveillance of litter hauling and spreading activities in the IRW; the

[8] Nutrient Management Plans, discussed below.
[9] Dr. Fisher holds a Ph.D. in earth sciences from Case Western University. [TR at 1560:11-16]. He has experience with issues of fate and transport of environmental constituents and contaminants. [TR at

surveillance did not result in any evidence of violations of the ORPFOA. [TR at 1654:15-19, 2696:15-23 (Fisher)].

97. ODAFF grower files introduced at trial showed a handful of violations, most of which involved deficiencies in record keeping and reporting or issues that were corrected by the grower in consultation with the agency. [*See, e.g.,* TR at 4977:9-4979:16 (Alsup); TR at 4595:19-4596:6 (Saunders); OK Ex. 2875B; TR at 3865:8-3872:15 (Pigeon); OK Ex. 2875D].

98. There is no record evidence that any of the issues identified in the paragraph above caused any pollution or injury to the waters of the Sate. [TR at 3578:12-18 (Strong)]. The current and former Secretaries of the Environment confirmed that there have been no "significant violations" of the ORPFOA. [TR at 477:16-478:5 (Tolbert); TR at 3579:20-3581:4 (Strong)]. The ODAFF Deputy General Counsel also confirmed that she was unaware of any "significant violation." [TR at 2968:9-2969:15 (Gunter)]. No poultry operation in the IRW has been designated a CAFO because of a significant violation finding. [TR at 2931:10-2932:21 (Gunter)]. No criminal prosecution has been brought for an ORPFOA violation. [TR at 476:12-15 (Tolbert); TR at 2968:9-2969:15 (Gunter)]. The ODEQ has never made a finding that the spreading of poultry waste on any lands within the IRW presents an imminent and substantial endangerment to human health. [Ct. Ex. 13 (Stephen Thompson Dep.) at 34:19-25].

2. Arkansas Laws and Regulations Governing Land Application of Litter

99. The Arkansas Soil Nutrient Application and Poultry Litter Utilization Act was enacted by the Arkansas Legislature in 2003. [*See* Ark. Code. Ann. § 15-20-1101, *et seq.*]. However, as amended in 2005, the act provided that "[a]pplication of poultry litter to soils or to associated crops within a nutrient surplus area shall be done in accordance with a nutrient management plan

1561:13-1575:15]. He is the founder of Lithochimea, Inc., an environmental consulting firm. [TR at 1574:10-14].

or poultry litter management plan after January 1, 2007." [Ark. Code. Ann. § 15-20-1106(f)]. Thus, it was not until January 2, 2007, that poultry growers were required by Arkansas law to comply with nutrient management plans. In addition, while the Arkansas Natural Resources Commission ("ANRC") promulgated certain "Rules Governing the Arkansas Soil Nutrient and Poultry Litter Application and Management Program," those rules did not become effective until January 1, 2006. [OK Ex. 5914 (Former ANRC Rules, Tit. XXII, § 2201.1(B))]. In any event, at no time prior to the enactment of the 2003 legislation did Arkansas place any restriction on the amount of poultry waste that could be applied on a field. [TR at 9515:2-8; 9598:17-23 (Smith)].

100. Following enactment of the legislation in 2003, the ANRC provided for a "protective rate" to be used as an interim measure. [TR at 9514:7-23 (Smith)]. The "protective rate" set limits on application of poultry litter or commercial fertilizer in nutrient-limited areas where land owners had not yet obtained nutrient management plans for their land. [OK Ex. 5914 (Former ANRC Rules, Title XXII, § 2202.3(a))]. The "protective rate" for poultry litter application expired January 1, 2007. [OK Ex. 5914, Former ANRC Rules, Title XXII, § 2202.3(A)(1)]. Although the protective rate has expired, Earl Smith, the chief of the water management division of the ANRC, cannot be sure that all farmers have nutrient management plans. [TR at 9596:10-22 (Smith)].

101. The ANRC Rules Governing the Arkansas Soil Nutrient and Poultry Little Application and Management Program also provide for a "Phosphorus Index" to be referenced in all nutrient management plans and to "govern the terms and conditions under with Nutrients may be land-applied." [*See* ANRC Rules, Title XXII, § 2201.4(B)]. ANRC revised the rules effective January 1, 2010, to replace the original Phosphorus Index (developed in 2001) with a new Phosphorus Index (developed in 2009). [DJX8133 (New ANRC Rules, Title XXII, § 2201.4(B); OK Ex. 5914

(Former ANRC Rules, Title XXII, § 2201)]. The revised Rules also delete all mention of the protective rate as it once pertained to the land application of poultry litter. [DJX8133 (New ANRC Rules, Title XXII, § 2202.3, Appendix B); OK Ex. 5914 (Former ANRC Rules, Title XXII, § 2202.3, App. B)].

102. The protective rate under the former ANRC Rules did not recommend land application of commercial fertilizer on fields that have an STP value of more than 100 lbs/acre. [OK Ex. 5914 (Former ANRC Rules, Title XXII, Appendix B (Table 3))]. In contrast, the protective rate allowed application of three tons of poultry waste if the STP was between 1-100 lbs/acre, and 1.5 tons of poultry waste if the STP was between 1000 and 1100 lbs/acre. [OK Ex. 5914, (Former ANRC Rules, Title XXII, Appendix B (Table 1)); TR at 5018:18-5019:10 (Johnson)]. In other words, this protective rate allowed land application of waste up to 11 times the Arkansas agronomic critical level of 100 STP. [TR at 5019:25-5020:3; 5006:3-6 (Johnson)].

103. A phosphorus index is a nutrient management tool that operates on the principle of relative risk rather than absolute risk of nonpoint source pollution from phosphorus. [TR at 5088:13-17, 5190:20-5191:10 (Johnson)]. A phosphorus index does not scientifically determine how much nonpoint source pollution from phosphorus will reach streams from individual sites and waste applications. [TR at 5088:12-23 (Johnson)]. Nor does a phosphorus index identify the actual risk associated with how much phosphorus will make it all the way to a stream. [TR at 5088:24-5089:3 (Johnson)]. A phosphorus index thus allows land application of poultry waste in excess of the agronomic critical level and contributes to the elevation of STPs in areas where it is used. [TR at 5089:4-10 (Johnson)].

104. The Arkansas phosphorus index applies to individual farms or fields; it is not applied at the watershed level. [TR at 9597:1-5, 9597:9-14].

105. Significantly, the Arkansas protective rate was by and large more restrictive than the Arkansas phosphorus index. [TR at 9515:8 -12, 9599:7-14 (Smith)]. Monty Henderson, former president of defendant George's, testified that he became concerned the Phosphorus Index was not restrictive enough after attending a February 16, 2006, BMPS, Inc. board meeting. [TR at 3121:22-3122:12 (Henderson)]. Minutes from that meeting (which was attended by representatives of the Tyson Defendants, the George's Defendants, the Cargill Defendants and defendants Simmons and Peterson) provide a summary of discussion concerning the Arkansas Phosphorus Index:

> Contract growers in the Nutrient Surplus watersheds are following new Arkansas regulations and getting plans using the Arkansas phosphorus index, *which allows them to put out more litter per acre than they had in the past.* Most contract growers will continue to be allowed to apply litter to their land under the new regulations. Therefore, there's little pressure on the producers in Arkansas to export their litter.

[OK Ex. 3041 (emphasis added)]. Several years before this board meeting, Preston Keller, then Director of Environmental Agriculture for defendant Tyson Foods, Inc., voiced his concerns about the new index, stating in a June 18, 2002 email:

> The phosphorus index that Arkansas developed is a very good management tool. Their application rates are somewhat questionable. Example: A farmer's field with zero to five percent slope, good forage coverage and soil test of *800 pounds per acre* of P could apply two tons per acre of manure. A little high, in my opinion. Are we helping the farmers or not?

[OK Ex. 3187].

106. Smith admitted that Arkansas phosphorus index has not stopped nonpoint source pollution from poultry waste. [TR at 9597:15-25 (Smith)].

G. Uses of the Waters of the IRW

107. As previously noted, the waters of the IRW in Oklahoma have been designated for multiple beneficial uses, including recreation and aesthetics, drinking water, and fish and wildlife propagation. [OK Ex. 5862 at p. 3].

108. Recreational activity has taken place occurring in the Illinois River corridor as long as people have been there. [TR at 4336:20-4337:10; 4339:3-4342:12 (Caneday); OK Ex. 3116; OK Ex. 3113]. Dr. Lowell Caneday described the Illinois River, Flint Creek and the Baron Fork as the "premier float streams in Oklahoma" and testified they are the longest stretch of unimpounded water in float streams in Oklahoma. [TR at 4346:19-4347:1 (Caneday)].

109. With respect to the Illinois River, Ed Fite (former administrator of the Oklahoma Scenic Rivers Commission and current Vice President, Scenic Rivers Operations at Grand River Dam Authority) estimated that close to 500,000 individuals visit annually. [TR at 796:1-3; DJX0147 at 0057]. Approximately 105,000 registered floaters floated the Illinois River in 2007. [OK Ex. 505; TR 4348:2-8 (Caneday)]. Fite estimated that of the 400,000-500,000 people who visit the IRW for recreation annually, approximately 150,000 to 180,000 are potential floaters and the remaining numbers would be swimmers, fishermen, hunters, campers, day users, equestrian tours, mountain bike rides, motorcycle poker runs, foliage tours, church baptisms and retreats, groups, and camps. [TR 959:13-960:14 (Fite)].

110. The smaller streams of the IRW are also used for recreational purposes. [TR at 7190:18-23 (Stevenson)].

111. A total of 2.6 million people visited Lake Tenkiller in 2007. [OK Ex. 498; TR at 4359:25-4360:9 (Caneday)]. This number included approximately 375,000 campers and 2.3 million day visitors. [OK Ex. 495; OK Ex. 496; TR at 4355:12-18; 4356:21-4357:3 (Caneday)].

There were just under 350,000 boaters (including water skiers and scuba divers) on Lake Tenkiller in 2007. [OK Ex. 497; TR at 4358:8-4359:1 (Caneday)].

112. Economic contributions from recreational activities on the waters of the IRW are significant. Tourists and other visitors spend between $11 million to $16.5 million per year in the basin. [OK Ex. 5862 at p. 3; DJX0147 at pp. iv, 32-33].

113. The recreation-based economy of the area relies on maintenance of aesthetically pleasing water quality in IRW streams and rivers and Lake Tenkiller. [OK Ex. 5862 at p. 3; OK Ex. 3285 at p. 34].

114. The waters of the IRW are also used for drinking water. [TR at 339:1-4 (Tolbert)]. Approximately 18 public water systems draw water from the Oklahoma portion of the IRW. [TR at 6086:18-6087:9 (Teaf); OK Ex. 5202]. Many of those systems draw water from Lake Tenkiller. [TR at 339:18-25 (Tolbert); OK Ex. 5202].

115. The rivers and streams of the IRW have historically been the habitat to a broad range of fish, including smallmouth, largemouth, Kentucky spotted, rock and brownie bass; green perch, crappie and channel cats. [OK Ex. 3116]. Lake Tenkiller has historically been stocked with cool water fish, including smallmouth bass, walleye and striped bass, although neither walleye nor striped bass have fared well. [TR at 7767:2-21; 7781:18-7782:5 (Welch)].

H. Condition of the Waters of the IRW in Oklahoma

1. Rivers and Streams

a. High Phosphorus Levels and Algae

116. The State's expert, Dr. Jan Stevenson, developed and directed an IRW stream sampling program conducted in the summer of 2006, spring of 2007 and summer of 2007. [TR at 6986:7-

7000:10 (Stevenson)].[10] The summer 2006 sampling program focused largely on measuring habitat condition, land use, nutrient concentration, algal biomass, diatom species composition and benthic invertebrates. [TR at 6988:1-6993:1 (Stevenson); OK Ex. 4508]. The spring 2007 sampling program focused largely on filamentous green algae and benthic invertebrate responses to it. [TR at 6993:2-6996:19 (Stevenson); OK Ex. 4468]. The summer 2007 sampling program focused largely on nutrient concentrations and fish assemblages. [TR at 6996:20-7000:10 (Stevenson); OK Ex. 4477]. Each sampling program investigated phosphorus concentrations in the streams. [TR at 7012:2-13 (Stevenson)].

117. Dr. Stevenson testified that algae occur in two major habitats in aquatic ecosystems: benthic algae are attached to the bottom of the water body, and planktonic algae float in the water column. [TR at 6964:19-6965:4 (Stevenson)].

118. The two primary nutrients for algal growth are nitrogen and phosphorus. [TR at 7000:25-7001:2 (Stevenson)]. In most freshwater ecosystems, phosphorus is the limiting nutrient. [TR at 7001:22-23 (Stevenson)]. "Limiting" refers to Liebig's law of the minimum, that is, the nutrient which is in lowest relative supply constrains the growth of algae. [TR at 7001:5-9 (Stevenson); 7376:20-25 (Cooke); 983:11-16 (Phillips)].

119. Algae have a nitrogen to phosphorus atomic ratio of 16 to 1 in their tissues; in other words, they have 16 atoms of nitrogen for each atom of phosphorus. [TR at 7001:9-12

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[10] Dr. Stevenson holds a Ph.D. in natural resources and the environment from the University of Michigan. [TR at 6962:9-20]. His Ph.D. research focused on benthic algae. [TR at 6965:5-7]. Dr. Stevenson is a professor at Michigan State University. [TR at 6965:23-6966:2]. He served from 2007-2008 as the president of the North American Benthological Society. [TR at 6971:21-6972:2]. He has published more than 100 articles in peer-reviewed journals. [TR at 6971:1-20; 6973:8-6974:8; 6976:21-25]. In addition, Dr. Stevenson is the author of the section of the EPA bioassessment protocols addressing methods that should be used by federal and state agencies to assess algae in streams. [TR at 6975:16-6976:10]. He has significant professional experience in studying nutrient and algal impacts on streams. [TR at 6972:14-6978:10]. Dr. Stevenson was retained by the State as an expert. [TR at 6978:11-13].

(Stevenson)]. If nitrogen to phosphorus ratios are greater than 16 to 1, then nitrogen is in "luxury supply," i.e., there is excess nitrogen in the environment, and phosphorus is the limiting nutrient. If the nitrogen to phosphorus ratio is less than 16 to 1, then phosphorus is in luxury supply and nitrogen tends to be limiting. [TR at 7001:13-21 (Stevenson)]. The nitrogen to phosphorus ratios in the Illinois River are almost always well above 16 to 1. [TR at 7001:23-25 (Stevenson)]. Therefore, phosphorus is the limiting nutrient in the Illinois River. [TR at 7001:25-7002:2 (Stevenson)].

120. The water column of an aquatic ecosystem typically contains three different fractions of phosphorus: dissolved inorganic phosphorus (also referred to as PO_4, phosphate or soluble reactive phosphorus), dissolved organic phosphorus and particulate phosphorus. [TR at 7003:24-7004:5 (Stevenson)].

121. All three forms of phosphorus are available for algae to use in the aquatic ecosystem. [TR at 7004:16-19 (Stevenson)]. Dissolved inorganic phosphorus—the primary form of phosphorus available for algae growth—can be taken up immediately by algae across some membranes. [TR at 7004:20-7005:2 (Stevenson); 8900:7-13 (Connolly)]. Most algae cannot take up dissolved organic phosphorus directly. Rather, such algae secrete an enzyme called phosphatase that cleaves the phosphate group off the organic phosphorus molecule. [TR at 7005:3-11 (Stevenson)]. Thus, when inorganic phosphate becomes depleted in the water column, algae will start breaking down dissolved organic phosphorus for use. [TR at 7005:12-18 (Stevenson)]. Particulate phosphorus is composed of fractions of dead organic matter or algal cells themselves which are floating in the water column and get entangled in the benthic algae. [TR at 7005:20-25 (Stevenson)]. Bacteria then breaks the particulate phosphorus down into inorganic phosphorus for use by the algae. [TR at 7005:20-7006:3 (Stevenson)]. Particulate

phosphorus can often be an important source of phosphorus, particularly with respect to sustaining thick algal mats. [TR at 7006:3-6 (Stevenson)]. Additionally, particulate phosphate can be consumed by other organisms (meiofauna and aquatic invertebrates), broken down and partially digested, then excreted into the benthic habitat, where it can be entangled in the benthic algae. [TR at 7006:7-21 (Stevenson)].

122. Because all three forms of phosphorus are available for algae to use in the aquatic ecosystem, Dr. Stevenson considered them all important in his investigation in characterizing phosphorus availability. [TR at 7007:25-7008:5 (Stevenson)]. He used total phosphorus as the best indicator of phosphorus availability in the water. [TR at 7008:6-9 (Stevenson)]. Dr. Stevenson testified the EPA and his colleagues concur with this approach. [TR at 7008:10-18 (Stevenson)]. The defendants' expert, Dr. Connolly, agreed that the EPA focused "[a]t a gross scale" on total phosphorus as a benchmark for water quality. [TR at 9366:16-19 (Stevenson)].

123. The summer 2006 sampling program revealed total phosphorus concentrations ranging from 0.008 mg/L to 0.648 mg/L, with a median concentration of 0.076 mg/L, and 25th and 75th quartiles of 0.037 mg/L and 0.118 mg/L, respectively. [TR at 7013:3-7014:10 (Stevenson)]. The spring 2007 sampling program revealed total phosphorus concentrations ranging from 0.007 mg/L to 1.254 mg/L, with a median concentration of 0.057 mg/L, and 25th and 75th quartiles of 0.026 mg/L and 0.113 mg/L, respectively. [TR at 7014:13-18 (Stevenson)]. The summer 2007 sampling program revealed total phosphorus concentrations ranging from 0.007 mg/L to 0.945 mg/L, with a median concentration of 0.067 mg/L, and 25th and 75th quartiles of 0.029 mg/L and 0.142 mg/L, respectively. [TR at 7015:1-5 (Stevenson)].

124. Similarly, defendants' retained expert, Dr. Connolly, found that phosphorus concentrations in the Illinois River are in the range of 0.100 mg/L. [TR at 9320:13-15 (Connolly)].

125. Dr. Stevenson testified that the phosphorus concentration in the rivers and streams of the IRW is high compared to phosphorus concentrations in streams in similar geologies and climates in the United States. In a study of streams in Kentucky and Michigan, and another study of streams in Pennsylvania, West Virginia, Virginia and Maryland, phosphorus concentrations in background natural conditions were about .01 mg/L. [TR at 7016:14-7017:10 (Stevenson)]. Two to three percent of the streams in those areas had phosphorus concentrations greater than .1 mg/L. [TR at 7017:11-16 (Stevenson)]. In the IRW, in contrast, more than 25 percent of the streams had phosphorous concentrations higher than .1 mg/L. Dr. Stevenson testified that "the phosphorus concentrations in the Illinois River Watershed are higher than anyplace that I've seen . . . in similar geologic settings." [TR at 7017:19-22 (Stevenson)].

126. During the spring and summer of 2007, the five sampling stations on the Flint and Illinois River that are within the scenic river zone had total phosphorus concentrations in excess of the .037 mg/L limit for scenic rivers. [TR at 7015:6-19 (Stevenson)]. Looking across the board at the results of all three sampling programs, 75 percent of the streams sampled in the summer of 2006 had phosphorus concentrations in excess of the .037 mg/L scenic river standard and in the spring and summer of 2007, 64 percent and 62 percent, respectively, of all streams sampled had concentrations in excess of .037 mg/L. [TR at 7016:4-13 (Stevenson)].

127. Dr. Stevenson's conclusions concerning the scope and severity of phosphorus pollution in the IRW are corroborated by the findings of the USGS. In a 2006 report, the USGS found that

the rivers and streams of the IRW have higher total phosphorus concentrations in comparison to other relatively undeveloped watersheds in the United States:

> Estimated mean flow-weighted phosphorus concentrations at the stations in the basin were more than 10 times greater than the median flow-weighted concentrations (0.022 mg/L) and were consistently greater than the 75th percentile of flow-weighted phosphorus concentrations in relatively undeveloped basins of the United States (0.037 mg/L). In addition, flow-weighted phosphorus concentrations in 2000-2002 at all Illinois River stations and at Flint Creek were approximately equal to or greater than the 75th percentile of all National Water-Quality Assessment program stations in the United States (0.29 mg/L).

[OK Ex. 5862 at p. 20 (internal citations omitted)].

128. The State's 2008 Water Quality Assessment Integrated Report ("Integrated Report") prepared by ODEQ and submitted to the EPA pursuant to sections 303(d) and 305(b) of the Clean Water Act, which listed impaired waters of the State, also supports Dr. Stevenson's conclusion concerning phosphorus loading of the waters of the IRW. [OK Ex. 6008, App. C]. The Integrated Report, which was approved by the EPA, lists seven segments of rivers or streams of the IRW in Oklahoma with aesthetic impairment caused by total phosphorus:

- a 7.68-mile segment of the Illinois River, segment code OK121700030010_00;
- a 31.68-mile segment of the Illinois River, segment code OK121700030080_00;
- a 15.65-mile segment of the Illinois River, segment code OK121700030280_00;
- a 5.18-mile segment of the Illinois River, segment code OK12170030350_00;
- a 23.30-mile segment of the Illinois River, segment code OK121700050010_00;
- a 1.60-mile segment of Flint Creek, segment code OK121700030290_00; and
- a 7.75-mile segment of Flint Creek, segment code OK121700060010_00.

[OK Ex. 6008, App. C at C-15, C-16; TR at 3493:15-3496:12, 3498:12-3500:8 (Strong)].

129. The 2007 Beneficial Use Monitoring Report ("BUMP") for the Illinois River, Baron Fork Creek and Flint Creek also confirms that these water bodies are not meeting water quality

standards. The aesthetics beneficial use is impaired for total phosphorus and total phosphorus is being exceeded for each of these bodies. [OK Ex. 5594].

130. The court finds that phosphorus concentrations in streams and rivers of the IRW in Oklahoma are elevated beyond natural or background levels in violation of Oklahoma's antidegradation standards for these waters. Those standards prohibit degradation of water quality in the IRW. *See* Okla. Admin. Code § 785:45-3-2(a). The court further finds that phosphorus concentrations in the Illinois River, Flint Creek and Baron Fork Creek exceed the total phosphorus criterion applicable to scenic rivers, and the aesthetics beneficial use is impaired for total phosphorus in violation of Oklahoma water quality standards. *See* Okla. Admin. Code § 785:45-5-19(c)(2).

b. Phosphorus-Induced Algae Biomass and its Consequences

131. The State's experts testified about ways in which increases in algae biomass impact the waters of the IRW.

(1) Aesthetics

132. Algae biomass in the water column is determined with reference to the cell volume of chlorophyll per unit volume of water, while algae biomass on the stream bottom is determined with reference to the weight of algae per unit area. [TR at 7022:4-14 (Stevenson)].

133. Three basic types of algae are found in the Illinois River streams: cyanobacteria (also referred to as "blue-green algae"), cyanobacteria diatoms (gold and brown algae), and filamentous green algae. [TR at 7022:16-7023:5 (Stevenson); OK Ex. 4449].

134. The EPA recommends using filamentous green algae cover as an indicator of impaired use for a stream. [TR at 7033:25-7034:5 (Stevenson)].

135. At background or natural total phosphorus concentrations, filamentous green algae cover is typically 5 to 10 percent. [TR at 7019:11-16 (Stevenson)]. When total phosphorus concentrations increase, there is a dramatic increase in filamentous green algae. [TR at 7019:17-19 (Stevenson)]. Dr. Stevenson considers filamentous green algae cover of 20 percent to be nuisance level. [TR at 7020:6-12 (Stevenson)]. Dr. Connolly testified that studies from various agencies and researchers conclude that between 20 to 30 percent algae coverage is a nuisance. [TR at 9316:9-19 (Connolly)].

136. Filamentous green algae cover on IRW stream sites sampled in spring 2007 ranged from 0 to 91 percent, with a median of 20 percent. [TR at 7038:6-25 (Stevenson)]. That is to say, using 20 percent as the benchmark for nuisance, half of the streams sampled had nuisance levels of algae. Further, 25 percent of the IRW stream sites had greater than 50 percent filamentous green algae cover. [TR at 7039:22-7040:1 (Stevenson)]. Thus, using 30 percent as the benchmark for nuisance level, some 35 percent of the stream sites sampled in the IRW had nuisance levels of algae. [TR at 9319:5-15 (Connolly)].

137. There is a strong relationship between phosphorus concentrations in streams and algal biomass in those streams. [TR at 7062:6-15 (Stevenson)]. Dr. Stevenson testified the total phosphorus threshold for dramatic benthic algae growth in IRW streams is at concentrations of 0.027mg/L. [TR at 7070:4-17 (Stevenson)]. Streams with phosphorus concentrations up to the low .02s of mg/L typically had algal biomass averaging 4 to 5 percent of the stream bottom. [TR at 7070:18-22 (Stevenson)]. Once phosphorus concentration increased above .027 mg/L, the average cover of filamentous green algae on the bottom of streams jumped to 36 percent. [TR at 7070:23-7071:7 (Stevenson); OK Ex. 4473].

138. Dr. Stevenson concluded that 83 percent of the third order rivers and streams of the IRW were injured for aesthetics due to having total phosphorous concentrations of 0.027 mg/L or higher. [TR at 7159:5-8 (Stevenson)].[11]

139. Dr. Stevenson's finding of significant benthic algae coverage of IRW rivers and streams is confirmed by the testimony of other witnesses. The testimony before this Court established that the rocks on the bottom of the Illinois River are covered with green and brown algae. [TR at 610:17-612:6 (Hilsher)]. Similarly, Ed Fite testified that, in April, May and the summer months of 2006, he observed algae, scum and unclear water on stream segments in IRW sub-basins that do not receive discharges from wastewater treatment plants. [TR at 694:2-20 (Fite)].

140. The USGS has likewise concluded that "[e]levated phosphorus concentrations promote algae growth in streams" and "[p]hosphorus levels in streams in the basin have resulted in the growth of excess algae, which have degraded the aesthetic benefits of water bodies in the basin, especially in the Illinois River and Lake Tenkiller." [OK Ex. 5862 at p. 3].

(2) Dissolved Oxygen Concentrations

141. Increases in phosphorus concentrations stimulate increases in algae biomass, and increases in algae biomass generate low dissolved oxygen conditions. [TR at 7091:8-13 (Stevenson)].

142. Algae are photosynthetic organisms. During the day, they use light and carbon dioxide in the process of photosynthesis to create sugars, and they give off oxygen, which oxygenates the water. At night, algae do not photosynthesize. So, at night, algae use—but do not produce—oxygen. [TR at 7020:23-7021:12 (Stevenson)]. Thus, oxygen concentrations in streams

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[11] Although Dr. Stevenson attempted to measure algal biomass in water columns by measuring chlorophyll concentrations, he was unable to do so because a laboratory incorrectly analyzed the chlorophyll-a samples he submitted. [TR at 7060:7-7061:1 (Stevenson)].

fluctuate—going up in the day with photosynthesis, and going down at night with respiration. [TR at 7086:7-10 (Stevenson)]. As a result, large masses of algae in a stream cause dramatic decreases in dissolved oxygen concentration at night. [TR at 7021:13-15 (Stevenson)].

143. Low dissolved oxygen stresses fish, reduces their reproductive capacities, and negatively affects their health. It eliminates dissolved oxygen sensitive species from their habitats. [TR at 7086:11-7087:19 (Stevenson)].

144. High nutrient concentrations generate high algal biomasses, which support large amounts of bacteria; and the high algal biomasses and bacteria can consume enough oxygen at night that dissolved concentrations can go below critical levels. Fish and "invertebrate assemblages" can be impaired, and fish-kills can result. [TR at 7087:6-18 (Stevenson)].

145. Oklahoma's water quality standards address dissolved oxygen levels. [*See* Okla. Admin. Stat. § 785:45 (App. G)]. The standard for dissolved oxygen levels in cool water streams from June 1 through October 15 is 6 mg/L. [*Id.*]

146. The summer 2006 sampling results revealed that 30 out of 69 stream samples had dissolved oxygen levels of less than 5 mg/L. [TR at 7089:8-15 (Stevenson)].

147. Dr. Stevenson also investigated a fish kill in April 2006 near Round Hollow on the Illinois River. Crews documented the high and low oxygen concentrations and took photographs at the site of the kill [TR at 7092:14-24 (Stevenson)]. His investigation revealed large amounts of algae biomass and dissolved oxygen levels of between 1 mg/L to 2.5 mg/L. [OK Ex. 4451 (photographs); TR at 7092:25-7093:17 (Stevenson)]. Dr. Stevenson concluded that low dissolved oxygen was the likely cause of the fish kill. [TR at 7096:4-12 (Stevenson)].

148. The State's 2008 Integrated Report corroborates Dr. Stevenson's conclusion that low dissolved oxygen levels are impairing fish and wildlife propagation in cool water aquatic

communities on the rivers and streams of the IRW in Oklahoma. [OK Ex. 6008 at App. C; TR at 3492:8-14, 3492:22-25; 3493:15-3496:12; 3498:12-3500:8 (Strong)].

(3) pH

149. Dr. Stevenson testified that pH levels are one of the most important environmental variables affecting biodiversity in rivers and streams; changes in pH levels can adversely affect fish, invertebrates and algae in rivers and streams. [TR at 7101:4-20 (Stevenson)].

150. When algae photosynthesize, they consume carbon dioxide, which causes a shift in the carbonate equilibrium in the water, thereby alkalizing the water. [TR at 7102:1-7 (Stevenson)]. Background levels of pH in streams of the IRW are 8 to 8.5. [TR at 7104:6-9 (Stevenson)].

151. Sampling data revealed that with increased algae biomass in IRW streams there was also an increase in high pH values. [TR at 7103:16-24 (Stevenson)]. Dr. Stevenson testified that the frequency of pH values found that were above 9 are not natural and are related to high algal biomasses. [TR at 7104:10-13 (Stevenson)].

152. Oklahoma's water quality standards address pH, requiring that it should be between 6.5 and 9, unless it naturally occurs outside that range. [TR at 7102:8-15 (Stevenson)].

(4) Aquatic Habitat

153. The natural condition of an IRW stream is bare rock. When large masses of filamentous green algae attach to the rock, it disrupts the natural habitat for fish, invertebrates and other algae that live among the rocks. [TR at 7026:4-16 (Stevenson)]. As discussed above, increased algae can also disrupt the aquatic habitat by causing changes in dissolved oxygen levels and pH. [*See* FF ##141-152].

154. Dr. Stevenson concluded the changes in natural condition of the rivers and streams of the IRW have caused a 20 percent reduction in the number of fish species in those rivers and streams.

[TR at 7132:8-7133:9 (Stevenson)]. Actual numbers of fish belonging to carnivorous species have been reduced by 70 percent. [TR at 7133:10-7134:1 (Stevenson)].

155. Significant detrimental impacts on fish numbers and species diversity occur in waters such as those in the IRW when total phosphorus concentrations reach or exceed 0.060 mg/L. [TR at 7139:7-18 (Stevenson)]. Using that phosphorus threshold criteria, about 47 percent of the third order rivers and streams in the IRW have been injured by a reduction in fish biodiversity. [TR at 7159:11-17 (Stevenson)]

(5) Water Quality

156. The State's expert, Dr. Christopher Teaf,[12] testified that disinfection byproducts (DBPs) are chemicals formed during the disinfection of drinking water, typically conducted by chlorination processes which kill the bacteria. [TR at 6078:11-17 (Teaf)]. Various factors influence the amount of DBPs created during the disinfection of drinking water, including the amount of organic carbon in the raw water, pH level, water temperature, chlorine contact time and whether the water has been pretreated before chlorination. [TR at 6079:8-21 (Teaf)]. Eutrophication—a process that introduces higher levels of organic carbon into the raw water—causes higher levels of DBPs. [TR at 6079:22-6080:5 (Teaf)].

157. DBPs are a human health concern because of their carcinogenic qualities and also because they present developmental and reproductive risks such as embryotoxity. [TR at 6085:3-20; 6100:9-6101:11 (Teaf); 7462:20-22 (Cooke)].

[12] Dr. Teaf holds a Ph.D. in toxicology from the University of Arkansas. [TR at 6039:6-12]. He is board certified by the Academy of Toxicological Sciences. [TR at 6046:13-16]. He has been on the faculty at Florida State University for 30 years, is a faculty member at the Center for Biomedical and Toxicological Research at the university, and since 1983, has served as the associate director of the center. [TR at 6040:1-10, 6040:22-26]. Dr. Teaf has a toxicology and risk assessment consulting firm, Hazardous Substance and Waste Management Research. [TR at 6044:8-6045:6].

158. Until 2012, DBPs were regulated by the Stage 1 DBP Rule, which set the maximum contaminant level ("MCL") at 80 micrograms per liter for trihalomethanes and 60 micrograms per liter for haloacetic acids. [TR at 11124:23-11125:12 (Gibb)]. The Stage 1 DBP Rule was determined by the EPA to be inadequate to protect human health. [TR at 6083:10-12 (Teaf)]. Therefore, in 2006, the EPA promulgated the Stage 2 DBP Rule [TR at 6083:12-13 (Teaf)], which Oklahoma adopted effective in 2012. [TR at 6083:6-15; 6097:21-25 (Teaf)].

159. The Stage 2 DBP Rule includes a maximum contaminant level goal ("MCLG") for DBPs. [TR at 6092:11-21 (Teaf)]. The MCLG is a health-based standard related to the potential for causing cancer, after which cost and feasibility must be applied to determine what the maximum containment level will be. In addition to the MCLG, there is a separate risk-based screening level criterion. [TR at 6092:23-6093:15 (Teaf)]. While the risk-based screening level criterion is not part of the Stage 2 DBP Rule, it is used by toxicologists as a starting point for evaluating potential health risk. [TR at 6093:2-15 (Teaf)]. It represents a baseline or one-in-one million chance risk that found the starting point for screening evaluations at all potential drinking supplies. [TR at 6093:10-15].

160. Dr. Teaf evaluated the presence of DBPs in water treatment systems in the IRW. First, he evaluated the total organic carbon loading found in the State's edge-of-field samples, and found that they were higher in edge-of-field samples than in background samples. [TR at 6080:19-25 (Teaf)]. Dr. Teaf testified that the organic carbon in the water, whether it comes from algae or from direct, dissolved and particulate organic carbon, is chlorinated and forms the DBPs. [TR at 6081:15-19 (Teaf)].

161. Next, Dr. Teaf evaluated data from ODEQ reporting the values of various DBPs in the treated water produced by the water treatment plants in the IRW (*i.e.,* tap water). [TR at 6086:18-

6087:19, 6094:6 (Teaf); OK Ex. 5212].[13] He found that a little over 90 percent of the ODEQ values exceeded the risk-based screening level criterion; that 55.5 percent of the ODEQ values exceeded the risk-based screening level criterion for the DBP dibromochloromethane; that 92.5 percent of the ODEQ values exceeded the risk-based screening level criterion for the DBP bromodichloromethane; that 11.4 percent of the ODEQ values exceeded the Stage 2 Rule MCL for the DBP total trihalomethane ("TTHM"), and that 11.2 percent of the ODEQ values exceeded the Stage 2 Rule MCL for the DBP haloacetic acids ("HAA5"). [TR at 6093:22-6096:15; 6097:16-6099:9 (Teaf); OK Ex. 5212].

162. Finally, Dr. Teaf evaluated DBP data gathered by Camp Dresser & McKee from tap water distribution points in water systems in the IRW. [TR at 6101:12-6102:16 (Teaf)]. He testified that he found numerous exceedances of the risk-based screening level criterion or MCLG for various DBPs in the treated water he evaluated. [TR at 6109:9-6111:17 (Teaf); OK Ex. 5213].

163. Based upon his investigation, Dr. Teaf concluded that "the breadth both in time and in space of the detected concentrations, the magnitude of those concentrations and the significance of the substances renders this to be a significant health issue that needs to be addressed." [TR at 6117:5-20 (Teaf)].

164. Defendants' expert, Dr. Michael McGuire,[14] criticized Dr. Teaf's comparison of concentration levels of DBPs in IRW water supplies with concentration standards that were lower

[13] Dr. Teaf's chart compares concentration levels of chloroform against both MCLG standards and risk-based standards. According to Dr. McGuire, there is no MCL standard for chloroform. [TR at 11027:12-15]. Dibromochloromethane and bromodichloromethane concentrations are compared against only risk based standards. TTHM and HAAS concentrations are compared with MCL standards. [OK Ex. 5212].

[14] Dr. McGuire received a Ph.D. in environmental engineering from Drexel University. [TR at 10987:12-18 (McGuire)]. He has worked as an engineer for the Philadelphia Water Department, and with the USGS sampling watersheds and investigating urbanization of streams, as well as with Brown and Caldwell Consulting Engineers in California on wastewater, industrial waste cleanup and surveys. [TR at 10988:7-10989:21 (McGuire)]. He was a project engineer/water quality engineer for the Metropolitan Water

than either MCLs set by the EPA or regulatory requirements for water utilities in Oklahoma at the time. [OK Ex. 5212; TR at 11026:2-16 (McGuire)]. Further, the reported violations were based on single exceedances, when they should be based on running annual averages from the data produced by the water utilities. [TR at 11029:5-12 (McGuire)].

165. Dr. McGuire testified that when EPA's MCL standards were applied, there were only a total of 24 exceedances for all 18 facilities over the time period of 1997 to 2008. [TR at 11030:15-19 (McGuire)]. The exceedances occurred at only six of the 18 facilities, and 67 percent of the exceedances occurred at only three utilities. [TR at 11031:3-14 (McGuire)]. Twelve of the facilities had no exceedances. [TR at 11031:15-19 (McGuire)].

166. In light of Dr. McGuire's testimony, the court finds Dr. Teaf's analysis of DBP levels in public water supplies in the IRW to be of slight value, and accords it little weight. Thus, the court finds that the State has failed to establish that land based application of poultry litter in the IRW has resulted in exceedances in DBP levels that pose significant risks to human health.

(6) Personal Observation

167. Ed Fite, who both sides agree is one of the most knowledgeable persons about the rivers and streams of the IRW, disagrees that there have been improvements in the condition of the Illinois River or the Baron Fork, [TR at 785:1-786:7 (Fite)] and the Court finds Mr. Fite's testimony to be entirely credible.

c. Summary

168. Based upon the foregoing factual findings, the court finds that the rivers and streams of the IRW have elevated phosphorus concentration levels above natural or background levels. The

District of Southern California, where he headed the water quality laboratory. [TR at 10990:14-10991:13 (McGuire)]. He is president of Michael J. McGuire, Inc., which provides consulting services to water utilities on water quality and treatment issues. [TR at 10987:6-11 (McGuire)].

elevated phosphorus concentration levels have resulted in significant increases in the algae biomass in the rivers and streams of the IRW. The increases in algae biomass have impacted the aesthetics of the rivers and streams of the IRW.

169. The court finds that increases in algae biomass have resulted in lowered dissolved oxygen concentrations, higher pH, and other adverse effects on the aquatic habitat of the rivers and streams of the IRW, and these adverse effects have injured fish communities in the rivers and streams.

170. The court further finds that phosphorus concentrations in excess of natural or background levels have caused degradation of water quality in the rivers and streams of the IRW in Oklahoma in contravention of Oklahoma's antidegradation standards in Okla. Admin. Code § 785:45-5-19(c)(2) of Oklahoma's Water Quality Standards.

171. The court finds that phosphorus concentrations in excess of background or natural levels have caused excessive growth of periphyton, phytoplankton or aquatic macrophyte communities in the rivers and streams of the IRW which impairs the aesthetics, fish and wildlife beneficial uses in violation of Okla. Admin. Code § 785:45-5-9(d).

172. Further, the court finds that as a result of phosphorus concentrations in excess of natural or background levels in the rivers and streams of the IRW in Oklahoma, these rivers and streams contain floating materials and suspended substances that produce objectionable color and materials that settle to form objectionable deposits in contravention of Section 785:45-5-19(a) and (b).

173. The court finds the State has failed to prove that increases in the amounts of algae and organic carbon in the waters and streams of the IRW caused by land application of poultry litter

have resulted in the creation of DBPs in the IRW's public water treatment facilities and supplies that present an increased risk to human health.

2. Lake Tenkiller

a. Trophic State

174. The State's expert, Dr. G. Dennis Cooke,[15] testified that "[t]rophic state" is an estimation of the degree of biological production of a lake or reservoir. [TR at 7348:7-9 (Cooke)]. There are three types of trophic states: oligotrophic, mesotrophic and eutrophic. There are no distinct breaks between the states; rather, they represent a continuum. [TR at 7348:17-21 (Cooke)].

175. Oligotrophic reservoirs have very low inflows of phosphorus to the reservoir. [TR at 7349:20-25 (Cooke)]. As a result, such reservoirs have low phosphorus concentrations, and the water is clear and has high transparency. There is an absence of scum-forming or bloom-forming blue-green algae or cyanobacteria. Productivity of algae is very low, as is total organic carbon, and there is a lot of dissolved oxygen in the system from surface to bottom. [TR at 7349:5-11 (Cooke)]. The sediments of an oligotrophic reservoir are nutrient poor and there is little or no sediment phosphorus release. [TR at 7349:1-19 (Cooke)].

176. The next trophic state on the continuum—mesotrophy—is one in which the reservoir has more biological productivity than an oligotrophic reservoir. "Productivity" means the rate at which algae biomass is produced. [TR at 7350:1-15 (Cooke)].

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[15] Dr. Cooke received a Ph.D. from the University of Iowa Department of Zoology with a major in limnology and a minor in developmental biology, after which he was a post-doctoral fellow at the University of Georgia for two years, sponsored by the National Institute of Health and the National Aeronautics and Space Administration. [TR at 7334:2-24]. He was a professor at Kent State University from 1967-2003, where he taught and conducted research on eutrophication in lakes and reservoirs. [TR at 7335:23-7337:5]. He was the founding president of the North American Lake Management Society and associate editor of its journal. [TR 7342:1-9].

177. In the third stage of the continuum—eutrophy—the reservoir has even more biological productivity and very high amounts of algae. [TR at 7350:16-19 (Cooke)]. A eutrophic reservoir has no dissolved oxygen in the bottom waters, and possibly none even in middle zone waters. The water is not clear and transparency is low. It is characterized by abundant blue-green algae. The rate at which oxygen is consumed by bacterial growth in the eutrophic reservoir is high—a condition called "aerial hypolimnetic oxygen deficit" or "AHOD." [TR at 7350:19-7351:12 (Cooke)]. Eutrophic systems have a very low population—if any—of cool water game fish such as smallmouth bass and walleye, and may have an abundant population of warm water game fish such as largemouth bass and bluegills. [TR at 7351:13-19 (Cooke)]. The lake sediments are also greatly enriched with phosphorus. [TR at 7351:20-24 (Cooke)].

178. Dr. Cooke, a limnologist, testified that the key difference between the three stages—oligotrophic, mesotrophic and eutrophic—is their phosphorus inflow concentrations. [TR at 7351:25-7352:4 (Cooke)].

179. Eutrophication is the addition of nutrients, organic matter, and silt to lakes and reservoirs at a rate that increases biological production and sometimes leads to a decrease in volume of the system. [TR at 7347:24-7348:3 (Cooke)]. Eutrophication can be either natural or cultural. Natural eutrophication means weathering of the land, for example, when rain falls on land, it runs off into streams and, from there, into the reservoir, and takes with it some soil. It may take with it leaves and sticks and small animals. Over time, the rocks begin to dissolve, and that material enters the reservoir. [TR at 7352:5-19 (Cooke)]. The rate of natural eutrophication is measured in centuries, or possibly millennia. [TR at 7352:19-21 (Cooke)]. Cultural eutrophication involves human activities that lead to runoff in the watershed, including runoff from urban areas, streets, parking lots; the discharge of wastewater treatment plants; and agricultural activities that produce

nutrients, such as row crop agriculture or animal agriculture. [TR at 7352:22-7353:3 (Cooke)]. Cultural eutrophication, which can occur within decades, requires that nutrient materials flow into a reservoir at very high rates. [TR at 7353:4-8 (Cooke)].

180. Reservoirs differ from natural lakes in that they always have a one-way flow of water through them, with inflow from rivers and/or streams and outflow over or through a dam. [TR at 7353:19-7354:8; 1754:16-18 (Cooke)]. In contrast, lakes do not have a one-way flow of water and some lakes may not even have a visible outlet. [TR at 7354:18-20 (Cooke)]. The one-way flow characteristic is an important factor in causing eutrophy. [TR at 7354:23-25 (Cooke)].

181. Reservoirs have three zones: the riverine zone, the transition zone and the lacustrine zone. [TR at 7358:15-19 (Cooke)]. The water area where the river water enters the reservoir is called the "riverine zone." [TR at 7354:12-14 (Cooke)]. The riverine zone is loaded with nutrients, silt and/or organic matter, including algae, if it is nutrient rich. [TR at 7354:25-7355:4 (Cooke)]. As the flowing water hits the wider (and possibly deeper) part of the reservoir, the velocity of water slows down and materials such as nutrients, silt and organic matter begin to sink. [TR at 7355:4-9 (Cooke)]. In this area, known as the transition zone, there is less and less nutrient concentration. [TR at 7355:10-14 (Cooke)].

182. The plunge point in a reservoir is where the velocity of water has slowed down sufficiently that the pull of gravity is greater than the rate of water flow, so large quantities of materials fall out of the water. [TR at 7355:24-7356:5 (Cooke)]. The water itself also falls with the materials, because river water is cooler—and therefore heavier—than reservoir water. [TR at 7356:14-17 (Cooke)]. The water plunges to a depth equal to its weight, which generally is in the middle zone of the reservoir. [TR at 7356:18-20 (Cooke)].

183. The water plunging into lower waters (the "hypolimnion") of the lake is high in organic matter, algae and wastewater treatment plant discharges, all of which are food for bacteria. [TR at 7356:25-7357:10 (Cooke)]. The bacteria eating these substances use dissolved oxygen in the respiration process. [TR at 7357:10-13, 7357:18-23 (Cooke)].

184. Not only is the tongue of water flowing down the reservoir low in dissolved oxygen, but the water beneath it has little to no dissolved oxygen. [TR at 7357:14-17 (Cooke)]. Deeper levels of a reservoir are completely isolated from the atmosphere, and re-aeration cannot occur there. Nor is there sufficient light for photosynthesis to occur at that level. Therefore, when organic matter falls into deep water, the dissolved oxygen is consumed in a short time. [TR at 7358:4-9 (Cooke)].

185. The lacustrine zone is the deep open water of the reservoir, where most materials have fallen out and concentrations of phosphorus are low relative to the riverine and transition zones. [TR at 7358:20-7359:3 (Cooke)]. Less algae is produced and the water is clearer in the lacustrine zone. [TR at 7359:4-5 (Cooke)].

186. These general reservoir descriptions and processes occur in Lake Tenkiller. [TR at 7358:10-14, 7354:9-14 (Cooke)].

187. Down the length of a reservoir is a gradient of conditions that can range from extremely eutrophic in the upper reservoir to much less eutrophic by the time the water reaches the dam. [TR at 7359:6-10 (Cooke)]. Thus, while a true lake might have a "representative zone," no single area or zone of a reservoir can represent the entire reservoir due to the gradient. [TR at 7359:11-18 (Cooke)]. Dr. Cooke identified two types of reservoir gradients. One runs the length of the reservoir from the riverine zone to the lacustrine zone at the dam. [TR at 7359:19-23]. The other gradient runs from the surface to the bottom; surface waters are loaded with dissolved oxygen,

they are warm, and the sun shines in them. Bottom waters, in contrast, have no dissolved oxygen, no fish, and little life, except microbes. [TR at 7359:24-7360:4 (Cooke)].

188. Dr. Cooke testified that in order to properly evaluate the trophic status of a reservoir, one must sample along both gradients, i.e., along the length and from surface to bottom of the reservoir. [TR at 7360:17-21 (Cooke)]. Trophic state analysis of a reservoir should be done from late spring to early fall, because this is the time of year when the reservoir is most responsive to nutrients. [TR at 7370:5-24 (Cooke)].

189. Parameters used to determine the trophic condition of a lake or reservoir include chorophyll-a, secchi disc depth, total phosphorus, total nitrogen, aquatic macrophytes, organic nitrogen, turbidity, lake user surveys, and hypolimnetic oxygen depletion rates. [OK Ex. 0578 at p. 17].

190. In connection with their analysis of the trophic state of Lake Tenkiller, the State's experts undertook a sampling program to supplement extant data. [TR at 7366:15-24 (Cooke)]. They sampled Lake Tenkiller in the summers of 2005-2008, from late May until mid-September. [TR at 7366:25-7367:3; 7371:4-8 (Cooke)]. Samples were taken at four stations along the length of the reservoir. [OK Ex. 705; TR at 7368:15-7369:4 (Cooke)]. The stations were located near stations used in earlier studies by governmental agencies, so that the data would be as directly comparable to the previous studies as possible. [TR at 7369:10-20 (Cooke)].

191. For purposes of comparison, the State's experts also undertook a sampling program at Broken Bow Reservoir, which is in the same eco-region as Lake Tenkiller, but is not closely impacted by phosphorus. [TR at 7421:6-16 (Cooke)]. Like Lake Tenkiller, phosphorus is the limiting nutrient in Broken Bow Reservoir. [TR at 7381:25-7382:9 (Cooke)]. Additionally, a

body of data existed on Broken Bow Reservoir from its riverine zone to its dam, as well as data on fish populations. [TR at 7423:17-21 (Cooke)].

192. Dr. Cooke testified that the key differences between Lake Tenkiller and Broken Bow Reservoir are (1) the land uses within the respective watersheds—the IRW is approximately 45 percent forest and 45 percent pastures, with a significant number of poultry houses, while the Broken Bow Reservoir's watershed is approximately 80 percent forest, with comparatively fewer poultry houses; and (2) the "tremendous" difference in the phosphorus concentrations flowing into the respective reservoirs. [TR at 7424:12-7425:11 (Cooke)].

b. Phosphorus

193. Phosphorus concentrations in Lake Tenkiller were determined by the flow weighted concentrations of phosphorus entering the lake from the Illinois River, less what is deposited in its sediments. [TR at 7736:8-7737:2 (Welch)]. On an annual basis, the volume weighted phosphorus concentration entering Lake Tenkiller is 0.227 mg/L. [TR at 7737:7-8; 7745:23-7746:4 (Welch)]. For Lake Tenkiller, this equates to a phosphorus loading of 5.1 grams per square meter of lake surface per year. [TR at 7739:2-14; 7746:5-10 (Welch)].

194. Additionally, a fraction of the phosphorus deposited as sediment recycles back into the water column—a process called "sediment phosphorus release" or "sediment flux of phosphorus." [TR at 7742:19-22; 7744:2-7745:2; 7748:23-7751:22 (Welch)]. Dr. Eugene Welch's investigation revealed that this form of internal loading contributes approximately 23 mg/m^2 per day, a rate he characterized as "very high." [TR at 7751:20-22 (Welch)].[16]

[16] Dr. Welch, who testified as an expert for the State, received a Ph.D. in fisheries from the University of Washington. His dissertation was on the effects of nutrients on algae and dissolved oxygen in an estuary. He retired as a professor in the department of civil and environmental engineering at the University of Washington.

195. Dr. Welch testified that the natural or background phosphorus inflow concentrations for a water body such as Lake Tenkiller should be approximately 0.020 mg/L. [TR at 7748:7-15]. As of the time of trial, the phosphorus inflow concentrations for Lake Tenkiller were roughly ten times that amount. [TR at 7748:16-17]. Phosphorus loadings to Lake Tenkiller were higher than all but 2 of 39 North American lakes Dr. Welch investigated. [TR at 7748:3-6 (Welch)].

196. As previously noted, phosphorus is the limiting nutrient in Lake Tenkiller and thus controls the amount of algae production in the lake. [TR at 7375:22-24, 7381:25-7382:3 (Cooke); OK Ex. 0747]. Therefore, phosphorus is the key to eutrophication of the lake. [TR at 7374:5-12 (Cooke); 7733:15-16 (Welch)].

197. Limnologists agree that a reservoir transitions from oligotrophic to mesotrophic at phosphorus concentration levels of about 0.010 mg/L, from mesotrophic to eutrophic at phosphorus concentration levels of about 0.030 mg/L and from eutrophic to hypereutrophic at phosphorus concentrations of about 0.100 mg/L. [TR at 7386:15-7387:5 (Cooke); OK Ex. 0745].

198. Water residence times, *i.e.,* the length of time between when a drop of water enters the reservoir and when it exits the reservoir, also affect phosphorus concentrations in the reservoir. [TR at 7387:11-20; 7388:4-11 (Cooke)]. Residence times in various zones of a reservoir can vary based upon reservoir inflows. [TR at 7390:9-7393:3 (Cooke); OK Ex. 0747].

199. On the basis of their respective phosphorus concentrations, Lake Tenkiller is eutrophic, while Broken Bow Reservoir is on the borderline between oligotrophic and mesotrophic except for 1997, when the concentration of total phosphorus was in the eutrophic category. [TR at 7429:25-7430:5 (Cooke); OK Ex. 0714; OK Ex. 0747].

200. The average spring-summer inflow phosphorus concentration for Lake Tenkiller was 0.166 mg/L, while the spring-summer inflow phosphorus concentration for Broken Bow Reservoir

was 0.027 mg/L. [TR at 7431:3-10 (Cooke)]. Dr. Cooke testified this explains why Lake Tenkiller is eutrophic, while Broken Bow Reservoir is oligotrophic. [*Id.*]

c. Blue-Green Algae

201. Dr. Cooke testified that an abundance of cyanobacteria, also known as blue-green algae, is definitive for eutrophication of a reservoir. [TR at 7394:3-7 (Cooke)]. Blue-green algae floats up to the surface, forming scums or blooms on the surface of the water. [TR at 7394:9-11; 7395:3-9 (Cooke)].

202. Historical reports containing data about algae in Lake Tenkiller from 1960 through 1975 show that samples contained green algae and certain diatoms indicative of oligotrophic conditions, and only trace amounts of blue-green algae. [TR at 7396:17-7397:18 (Cooke)]. In contrast, sampling data from 2001-2007 revealed that blue-green algae was the dominant type of algae at every sampling site in the lake. [TR at 7398:12-7403:1 (Cooke); OK Ex. 0706].

203. Dr. Cooke opined that the abundance of blue-green algae in Lake Tenkiller is directly related to phosphorus concentrations, and if phosphorus concentration in the lake was reduced, blue-green algae would be reduced. [TR at 7476:2-10 (Cooke)].

d. Chlorophyll

204. In addition to examining the species of algae in Lake Tenkiller, Dr. Cooke investigated the quantity of algae in the reservoir. [TR at 7405:1-10 (Cooke)]. The traditional method by which limnologists evaluate biomass is to measure chlorophyll in the water. [TR at 7405:13-19 (Cooke); OK Ex. 754]. Scientists have adopted certain measures of chlorophyll as borderlines between the various trophic stages. Between oligotrophic to mesotrophic, the transition line is chlorophyll levels of about 0.0035 mg/L; between mesotrophic to eutrophic, the transition line is

chlorophyll levels of about 0.009 mg/L; and between eutrophic and hypereutrophic, the transition line is chlorophyll levels of about 0.025 mg/L. [TR at 7408:10-21 (Cooke); OK Ex. 754].

205. Based upon the chlorophyll levels found in the Lake Tenkiller sampling data, Dr. Cooke concluded that "presently, and since 1986, [Lake Tenkiller] is eutrophic." [TR at 7410:12-17, 7420:1-7 (Cooke)]. In contrast, based on chlorophyll data for Broken Bow Reservoir, Dr. Cooke concluded that this reference reservoir is oligotrophic to borderline mesotrophic. [TR at 7433:15-16 (Cooke); OK Ex. 715].

e. Transparency

206. Transparency is another metric for determining the trophic state of a reservoir. Transparency is determined using a device called a Secchi disk—a metal disk 10 centimeters in diameter and divided into four quarters, alternating black and white. The disk is lowered into water until it cannot be seen, then slowly brought back up until it is visible. The depth at which the disk can be seen determines the measure of transparency. [TR at 7412:13-7413:7 (Cooke)].

207. The data reflects nearly a 30 percent decrease in the transparency of the water of Lake Tenkiller between 1986 and 2007. [TR at 7419:19-7420:7 (Cooke); OK Ex. 756]. The average seasonal transparency for Lake Tenkiller typically falls in the eutrophic and hypereutrophic category except during dry years and at stations near the dam, which are in the mesotrophic category. [TR at 7437:13-20; OK Ex. 756]. In contrast, the data for Broken Bow Reservoir show transparencies in the mesotrophic category in every year except 1997, when the average seasonal transparency fell in the eutrophic category, and 2006, when transparency was in the oligotrophic category. [TR at 7437:21-7438:1 (Cooke); OK Ex. 716].

f. AHOD

208. Hypolimnetic oxygen depletion rates are another way to measure the trophic state of a water body. The aerial hypolimnetic oxygen deficit ("AHOD") rate is an indicator of the rate of oxygen removal in a reservoir as a whole. [TR at 7788:13-7789:1 (Welch)]. AHOD is measured in milligrams per square meter per day. [TR at 7789:1-6 (Welch)]. As with chlorophyll, total phosphorus, and transparency, scientists have set benchmark AHOD levels to differentiate trophic states. [TR at 7789:7-7790:1 (Welch)]. For AHOD, the boundary level between eutrophic state and hypereutrophic state in lakes is 550 mg/m²/day. [TR at 7792:2-7 (Welch); OK Ex. 726].

209. The average AHOD in Lake Tenkiller measured at about 1300 mg/m²/day. [TR at 7793:3-9 (Welch)]. Based upon this data, Dr. Welch concluded that Lake Tenkiller is hypereutrophic. [TR at 7796:19-21]. He found that Lake Tenkiller's AHOD rate was higher than all 39 North America reservoirs he evaluated. [TR at 7796:1-6 (Welch)]. AHOD rates for the Broken Bow Reservoir averaged about 530 mg/m²/day—or about 40 percent of the AHOD in Lake Tenkiller. [TR at 7796:7-14 (Welch)].

g. Dissolved Oxygen

210. A lack of dissolved oxygen in lake waters is also evidence of eutrophication. [TR at 7350:16-25 (Cooke)]. A comparison of dissolved oxygen levels at Tenkiller and Broken Bow shows that at Tenkiller, oxygen is gone by the end of July throughout the water column; Broken Bow, in contrast, has oxygen content well above four milligrams per litter for most of the summer." [TR at 7784:6-12 (Welch); OK Ex. 726].

h. Dr. Cooke's Conclusions

211. Dr. Cooke concluded:

> Tenkiller has become eutrophic. It wasn't always eutrophic. The algae data tell us very strongly that Tenkiller, . . . in 1960 . . . was oligotrophic. And the same in 1974 and 1975. By 1986, no question, Tenkiller is eutrophic, and has remained so.

[TR at 7420:7-12 (Cooke)]. He based his conclusion on ten years of chlorophyll values, ten years of transparency data, six years of phosphorus data and nine years of algae determinations. [TR at 7420:13-22 (Cooke)]. Dr. Cooke testified that "this represents possibly the largest dataset for evaluation of trophic state in North America. There may be some as good, but few, if any, better than this one." [TR at 7420:23-7421:1 (Cooke)].

212. Dr. Cooke further concluded that Lake Tenkiller's eutrophic state is being caused by the increasing phosphorus concentrations in the reservoir. [TR at 7382:14-19 (Cooke); *see also* 7732:20-7733:4 (Welch)].

i. Government Studies

213. The June 1996 "Clean Lakes" study of Lake Tenkiller conducted by the OWRB, the U.S. Army Corps of Engineers, and Oklahoma State University concluded that "[t]he present trophic status of Lake Tenkiller is classified as "eutrophic." [OK Ex. 3285 at p. 80]. The classification is based on "excessive levels of nitrogen and phosphorus concentrations in the lake, nitrogen and phosphorus loads impinging the lake, and resultant increased algal standing crop and hypolimnetic oxygen depletions." [*Id.*]

214. Additionally, the 2007 BUMP Lakes Report stated, "[i]n summary, Tenkiller Ferry Lake was classified as eutrophic, indicative of high primary productivity and nutrient levels." [OK Ex. 5593 at p. 540].

j. Defendants' Response

215. Defendants' expert, Dr. Connolly, pointed out that, using only data from the lacustrine portion of the lake, Lake Tenkiller would in most cases qualify Lake Tenkiller as mesotrophic.

[TR at 9418:3-6 (Connolly)]. However, the trophic state of a reservoir is determined by evaluating the entirety of the reservoir. [TR at 7359:11-18 (Cooke)]. And even using Dr. Connolly's approach, some portions of Lake Tenkiller are eutrophic. [TR at 9418:10-9419:17 (Connolly)].

216. Dr. Connolly also testified the trophic state of Lake Tenkiller is not unusual for lakes in Oklahoma. [TR at 9122:18-9123:10 (Connolly)]. However, he admitted that Lake Tenkiller is in a different ecosystem than most of the lakes in central and western Oklahoma, which tend to be more naturally eutrophic than Lake Tenkiller. [TR at 9423:21-9424:6 (Connolly)].

3 Consequences of Phosphorus-Induced Eutrophic Condition of Lake Tenkiller

a. Aesthetics

217. Eutrophication has caused aesthetic changes in Lake Tenkiller. [TR at 7445:15-22 (Cooke)]. Due to the abundance of algae in the lake, the water is green. [TR at 7445:25-7446:3 (Cooke)]. During the summer, at least two zones have low transparency—i.e., a meter or less on average—and most other zones have transparency of two meters or less. [TR at 7446:4-16 (Cooke)]. There are blue-green algae blooms in Lake Tenkiller, creating a scum on the surface of the water. [TR at 7449:7-20 (Cooke); OK Ex. 743; 4362:11-4363:10 (Caneday)].

218. The State's recreational expert, Dr. Lowell Caneday, testified the decrease in transparency of Lake Tenkiller "has definitely changed the recreational use of the lake." [TR at 4364:24-25 (Caneday)].[17] In the late 1980s and early 1990s, when Lowell was director of the former School of Health, Physical Education and Leisure at Oklahoma State University, the school offered scuba classes. [TR at 4363:19-4364:2 (Caneday)]. Scuba students performed check dives

[17] Dr. Caneday holds a Ph.D. in recreation, park and leisure studies from the University of Minnesota. [TR at 4328:25-4329:6 (Caneday). He is a professor of leisure studies in the School of Applied Health and Educational Psychology at Oklahoma State University. [TR at 4327:24-4328:5 (Caneday)]. He is a certified park and recreation professional ("CPRP"). [TR at 4329:14-16 (Caneday)].

at the southeast portion of Lake Tenkiller near the dam. [TR at 4364:2-10 (Caneday)]. By 1991, however, visibility in the lake was "down to less than an arm's length," and by 1993, the school stopped using the lake for its scuba classes. [TR at 4364:19 (Caneday)]. Caneday also testified that there used to be a number of scuba outfitters near Lake Tenkiller, but it is now down to only one licensed operator. [TR at 4365:5-18 (Caneday)].

219. Shanon Phillips, the Director of the Water Quality Division of the Oklahoma Conservation Commission, testified that when she was a child, adults could see their feet when they were swimming in the lake, but now "you can't see past your knees." [TR at 978:21-979:9 (Phillips)].

220. The State's 2008 Integrated Report corroborates the conclusions of the State's experts and the testimony of lay witnesses, that phosphorus is impairing the aesthetics of Lake Tenkiller. [OK Ex. 6008, App. C at p. 15; TR at 3492:8-18; 3492:22-25 (Strong)]. The report lists total phosphorus as causing aesthetic impairment to an 8,444 acre segment of Lake Tenkiller. [OK Ex. 6008, Appx. C at p. 15; TR at 3499:18-3500:8 (Strong)].

221. Similarly, the USGS has concluded that "[p]hosphorus levels in streams in the basin have resulted in the growth of excess algae, which have degraded the aesthetic benefits of water bodies in the basin, especially . . . Lake Tenkiller." [OK Ex. 5862 at pp. 3, 20].

b. Aquatic Habitat

222. Eutrophication, when coupled with the plunging effect of river water coming into Lake Tenkiller, affects dissolved oxygen levels in the reservoir. [TR at 7753:17-24 (Welch)]. Dissolved oxygen levels, in turn, have an impact on aquatic life. [TR at 7763:25-7764:2 (Welch)].

223. Over the course of the year, the water column in a reservoir naturally stratifies by temperature as the weather warms, with the warmer water above and the denser, cooler water

below. [TR at 6701:9-17 (Wells)]. During the winter, the water in Lake Tenkiller is isothermal—that is, the water is the same temperature and density from top to bottom. [TR at 6701:23-25 (Wells)]. In the spring, the surface temperature warms due to solar heating, resulting in an upper layer—the epilimnion—which is warmer and lighter than the water below. [TR at 6701:25-6702:5 (Wells)]. In the fall, the epilimnion increases in size until gradually, in October or November the lake de-stratifies and becomes isothermal again. [TR at 6702:7-12 (Wells); TR at 7364:1-6 (Cooke)].

224. Dissolved oxygen levels in Lake Tenkiller are driven by multiple factors, including re-aeration—that is, the exchange between the atmosphere and the surface water. [TR at 6708:10-16 (Wells)]. Because of stratification, the lower portions of the water column, which are not exposed to the atmosphere, do not get re-aerated. [TR at 6708:17-20 (Wells); TR at 7364:7-7365:14 (Cooke)].

225. Algae production is the major factor determining dissolved oxygen levels in Lake Tenkiller. [TR at 6709:10-21 (Wells)]. As phosphorus is the limiting nutrient in Lake Tenkiller, phosphorus concentrations determine the amount of algae growth in the lake. [TR at 6709:22-6710:5 (Wells)].

226. Most algae will settle to the bottom of the lake, where they continue to consume oxygen as they respire and decay. [TR at 6708:21-6709:3; 6709:10-17 (Wells)]. In addition, as previously discussed, plunging flow from the riverine zone of Lake Tenkiller depletes the oxygen in the cooler metalimnion. [*See* FF 182-183]. By the end of July, both the hyperlimnium and metalimnion of Lake Tenkiller become oxygen-depleted. [TR at 7761:1-7; OK Ex. 721 (Welch)]. It is common for dissolved oxygen levels to be zero milligrams per liter below the depth of the epilimnion, which is the well-mixed upper level. [TR at 6710:11-17 (Wells)]. Because of this,

Lake Tenkiller does not meet State water quality standards for a cool water fishery during the summer months. [TR at 7766:19-24 (Welch)].

227. Smallmouth bass and walleye are important fish to Lake Tenkiller. [TR at 7765:17-19 (Welch)]. Eutrophication specifically affects smallmouth bass and walleye in Lake Tenkiller because they are cool water species squeezed by the lack of suitable habitat. [TR at 7765:20-7766:8 (Welch)]. During the summer months, when water temperature increases and begins exceeding their preferred temperatures, smallmouth bass and walleye exist in a water layer that has insufficient oxygen, which impacts their activity and growth. [TR at 7765:25-7766:5; 7773:23-7774:5 (Welch)]. This is characterized as habitat "squeeze." [TR at 7766:55-8 (Welch); TR at 6728:14-17 (Wells)].

228. For approximately two-and-one-half months during the summer, there is no water in Lake Tenkiller suitable for the optimal growth of smallmouth bass. [TR at 7772:11-15 (Welch); OK Ex. 733]. For about three months in the summer there is no volume of water in Lake Tenkiller suitable for even suboptimal growth of walleye. [TR at 7775:13-19 (Welch); OK Ex. 733]. As a result, during the summer months, Lake Tenkiller does not meet Oklahoma's water quality criteria for cool water fish species. [TR at 7766:19-24 (Welch)].

229. Consequently, Lake Tenkiller is no longer stocked with smallmouth bass and walleye. [TR at 7767:8-21; 7781:18-21 (Welch)].

230. Based on catch rates, the abundance of smallmouth bass in Broken Bow Reservoir, the reference lake, is three times higher than the abundance of smallmouth bass in Lake Tenkiller. [TR at 7777:7-7778:15 (Welch); OK Ex. 730]. The abundance of walleye in Broken Bow Reservoir is two times higher than the abundance of walleye in Lake Tenkiller. [TR at 7780:3-17 (Welch); OK Ex. 730].

231. Largemouth bass in Lake Tenkiller are not affected by habitat squeeze because they are a warm water species and they prefer eutrophic waters. [TR at 7766:9-18 (Welch)]. The abundance of largemouth bass in Tenkiller is twice the abundance of largemouth bass in Broken Bow Reservoir. [TR at 7785:22-7786:5 (Welch)].

232. Dr. Welch testified, based on his analysis of data, that with respect to smallmouth bass and walleye, the quality of the fisheries in Broken Bow Reservoir, the reference reservoir, is better than the quality of the fisheries in Lake Tenkiller. [TR at 7782:6-14 (Welch)]. Thus, increased eutrophication of Lake Tenkiller's waters has caused injury to Lake Tenkiller's fisheries. [TR at 7765:17-7766:5; 7766:19-24 (Welch)].

233. Low dissolved oxygen in Lake Tenkiller also affects bottom invertebrates such as worms, midge larvae and snails. [TR at 7786-22:7787:3 (Welch)]. Dr. Welch's investigation revealed that the population density of bottom invertebrates in Lake Tenkiller is roughly one-sixth that of Broken Bow Reservoir. [TR at 7787:15-7788:12 (Welch)]. The reduced number of invertebrates living in the sediments of Lake Tenkiller is due to low levels of dissolved oxygen during the summer months. [TR at 7788:5-12 (Welch)].

234. The State's 2008 Integrated Report corroborates Dr. Cooke's and Dr. Welch's conclusion that low levels of dissolved oxygen impair fish and wildlife propagation in Lake Tenkiller. [OK Ex. 6008, App. C]. The report lists low levels of dissolved oxygen as causing impairment to fish and wildlife propagation in an 8,440 acre segment and another 5,030 acre segment. [OK Ex. 6008 at C-15; TR at 3493:15-3496:12; 3498:12-3500:9 (Strong)].

c. Water Quality

235. The State's 2008 Integrated Report lists chlorophyll as causing impairment to public and private water supply uses of a 5,030 acre segment of Lake Tenkiller. [OK Ex. 6008 at App. C-15; TR at 3492:8-14; 3492:22-25 (Strong)].

236. Eutrophic lakes are known to be a source of increased DBPs in water treatment plants. [TR at 7463:18-25 (Cooke)]. Eutrophic reservoirs contain a large quantities of organic matter from various sources, including wastewater treatment plants, runoff from urban areas, and algae from eutrophic streams. [TR at 7464:1-9 (Cooke)]. Additionally, phosphorus and algae in the reservoir itself produce organic molecules. [TR at 7464:10-13 (Cooke)]. Dr. Cooke testified that as much as two-thirds of the organic molecules that go into a drinking water plant may have come from algae. [TR at 7464:14-18 (Cooke)].

237. High pH in the raw water also contributes to DBP formation. [TR at 7464:19-7465:24]. The process of photosynthesis of algae in reservoirs removes carbon dioxide from the water, thereby raising pH levels. [TR at 7464:25-7465:10 (Cooke)].

238. Degradation of water quality directly impacts water supply users, as decreases in water quality require more treatment or alternate water supply sources. [OK Ex. 3285 at p. 34].

d. Summary

239. The court finds that Lake Tenkiller has become eutrophic, and this eutrophication is caused by phosphorus concentrations in the reservoir.

240. Further, the court finds that Lake Tenkiller's phosphorus-induced eutrophic condition is manifested in a variety of ways: an increase in amounts of algae, including blue-green algae, a decrease in water clarity and a decrease in dissolved oxygen.

241. The court finds that the decreases in water clarity in Lake Tenkiller are having an adverse impact on recreational activities and aesthetics.

242. The court also finds that decreases in dissolved oxygen in Lake Tenkiller are having an adverse impact on cool-water fish and bottom invertebrates.

243. The court finds that phosphorus concentrations in excess of natural or background levels have caused degradation of water quality in Lake Tenkiller and impairs its aesthetics, fish and wildlife, and public water supply beneficial uses in violation of Oklahoma's antidegradation standards in Okla. Admin. Code § 785:45-3-2(b) and (d).

244. The court finds that phosphorus concentrations have caused excessive growth of periphyton, phytoplankton or aquatic macrophyte communities in Lake Tenkiller, which impairs its aesthetics, fish and wildlife, and public water beneficial uses in violation of Okla. Admin. Code § 785:45-5-9(d).

245. The court finds that total phosphorus concentrations have caused impairment of the aesthetic beneficial use for 8,440 acres of Lake Tenkiller that is designated in Section 785:45 (Appendix A) of the Oklahoma Water Quality Standards.

246. The court finds that as a result of phosphorus concentrations, the waters of Lake Tenkiller are not meeting their aesthetics beneficial use due to floating materials and suspended substances that produce objectionable color and materials, which settle to form objectionable deposits in violation of Section 785:45-5-19(a) and (b) of Oklahoma's Water Quality Standards.

247. The court finds that phosphorus concentrations have caused impairment of the fish and wildlife beneficial use designated in Section 785:45 (App. A) of the Oklahoma Water Quality Standards in Lake Tenkiller by depleting dissolved oxygen in the hypolimnion and metalimnion, violating the dissolved oxygen standard in Section 785:45-5-12(f)(1)(C) and Appendix G of the

Oklahoma Water Quality Standards, and because aquatic life in Lake Tenkiller exhibit degraded conditions based on comparative reference historical data in violation of Section 785:45-5-12(f)(5)(A) of the Oklahoma Water Quality Standards.

248. The court finds that as a result of phosphorus concentrations, a 5,030 acre section of Lake Tenkiller is not meeting its public water supply beneficial use and is violating water quality standards due to chlorophyll-a levels in excess of the numerical criterion in Section 785:45-5-10(7) of the Oklahoma Water Quality Standards.

249. The court finds that phosphorus has caused, and is causing, injury to the rivers and streams of the IRW in Oklahoma, as well as the biota therein.

250. The court further finds that phosphorus has caused injury to Lake Tenkiller, as well as the biota therein.

I. Sources of High Phosphorus Loading to the Waters of the IRW

251. Nonpoint source pollution is pollution from diffuse sources, often resulting from runoff of pollutants over land surface.

252. In contrast, point source pollution comes from a specific discernible place, such as an outfall from a discharge from a wastewater treatment plant or an industrial site. [TR at 977:4-10 (Phillips)].

253. Once a specific phosphorus molecule enters the waters of the IRW, it is not possible to determine whether it is from a point or nonpoint source. [TR at 1492:5-13 (Phillips)]. However, as set forth below, it is possible to determine relative loadings of phosphorus from point and nonpoint sources.

1. Point Sources

254. Wastewater treatment plants are the primary source of point-source phosphorus loading to the waters of the IRW. [TR at 3149:22-3150:4 (Strong); TR at 9128:8-24 (Connolly)].

255. Two wastewater treatment plants in Oklahoma and five wastewater treatment plants in Arkansas discharge into the waters of the IRW. [TR at 511:7-13 (Tolbert); OK Ex. 5862 at p. 2].

256. Oklahoma and Arkansas have made concerted efforts to reduce phosphorus concentrations from wastewater treatment plant discharges in the IRW. [*See* OK Ex. 5666, Attachment C, p. 4 (Statement of Joint Principles and Actions)].

257. The wastewater treatment plants at Westville and Tahlequah have reduced the phosphorus in their point source discharges to less than 1.000 mg/L. [TR at 3168:22-3169:12 (Strong)]. In addition, some wastewater treatment plants in Arkansas have reduced the phosphorus in their point source discharged to less than 1.000 mg/L. [TR at 3169:13-23 (Strong)]. Wastewater treatment plant upgrades were largely completed by 2004. [TR at 8915:9-10 (Connolly)]. However, upgrades to the wastewater treatment plant at Siloam Springs that would reduce the phosphorus in its point source discharges to less than 1.0 mg/L had not been completed at the time of trial. [TR at 9525:11-9526:19 (Smith)].

2. Nonpoint Sources

258. Nonpoint sources contributing to phosphorus loading include poultry waste, septic systems, urban runoff, commercial fertilizer, stream bank erosion, cattle, nurseries, recreational users and golf courses. The parties dispute how much, if any, phosphorus each nonpoint source contributes.

3. Relative Loading of Phosphorus in the IRW Between Point and Nonpoint Sources

259. It is undisputed that point sources account for less than 20 percent of the total phosphorus load reaching Lake Tenkiller. [TR at 8922:8-20 (Connolly); TR at 10907:23-10908:1 (Sullivan)]. Defendants' expert, Dr. Connolly, testified that 82 percent of the phosphorus load reaching Lake Tenkiller is from nonpoint sources. [TR at 9141:15-9142:8 (Connolly)]. His opinions in this regard are consistent with the findings of many other researchers who have studied nutrient loading in the IRW.

260. The USGS has extensively studied phosphorus loading to the Illinois River and its tributaries. [*See* Ok Ex. 5861; OK Ex. 5862]. Its 2006 report makes clear that the overwhelming majority of phosphorus loading to the rivers and streams of the IRW is from nonpoint sources:

> Runoff components of the annual total [phosphorus] load for Flint Creek ranged from 68 to 84 percent from 2000 to 2004 (table 5). At the Illinois River stations, the range in the runoff component of the annual total load was 75 to 88 percent (table 5). Runoff components of the annual total load at Baron Fork ranged from 91 to 96 percent (table 5).

[OK Ex. 5862 at p. 11].

261. The USGS also found that "[p]hosphorus concentrations in the Illinois River basin were significantly greater in runoff samples than in base flow samples." [OK Ex. 5862 at p. 1]. Notably, the USGS observed that "[h]istorical water-quality data collections in the Illinois River basin has been biased towards sampling during base-flow (non-runoff) conditions," and as a result, "calculations using historic data may have underestimated true phosphorus concentrations, loads, and yields." [OK Ex. 5862 at p. 3].

262. The State's expert, Dr. Indrajeet Chaubey,[18] testified that the major source of nutrient loading in the watershed occurs during high-flow conditions. [TR at 6018:24-6019:2 (Chaubey)].

263. Defendants' expert, Dr. Connolly, agrees it is reasonable to assume that total phosphorus concentrations above background in the waters of the IRW are likely due to anthropogenic sources, and he acknowledged that at a substantial number of locations in the IRW with high phosphorus concentrations, wastewater treatment plant discharges are *not* occurring. [TR at 9217:3-9218:10; 9222:3-9224:7; 9224:22-9225:2 (Connolly)].

264. The USGS has also extensively studied phosphorus loading to Lake Tenkiller. [OK Ex. 5861; OK Ex. 5862]. Its 2006 report concludes that the overwhelming majority of phosphorus loading to Lake Tenkiller is from non-point sources:

> The estimated mean annual phosphorus load entering Lake Tenkiller ranged from about 391,000 pounds per year to 712,000 pounds per year, and from about 83 to 90 percent of the load was transported to the lake by runoff.

[OK Ex. 5862 at p. 1].

265. The USGS numbers are consistent with the calculations of defendants' expert, Dr. Connolly. [TR at 8922:8-20; 9142:5-8 (Connolly)]. The numbers are also consistent with the Clean Lakes study conducted by the OWRB, the U.S. Army Corps of Engineers and OSU. [OK Ex. 3285 at p. 55 (Table XXIV)].[19]

266. As previously discussed, there are three principal types of phosphorus in the waters of the IRW: dissolved inorganic phosphorus (also referred to as soluble reactive phosphorus),

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[18] Dr. Chaubey received a Ph.D. in biosystems engineering from Oklahoma State University and is a tenured professor at Purdue University, with appointments in the departments of agricultural and biological engineering, earth and atmospheric sciences, and ecological and environmental engineering. [TR at 5925:5-11, 5917:23-5918:21 (Chaubey)].

[19] The Clean Lakes study concluded that phosphorus loads to Lake Tenkiller were derived predominantly from non-point sources during high flows. During low flow periods, point and nonpoint source contributions were approximately equal. [OK Ex. 3285 at p. iv, p. 55 (Table XXIV)].

dissolved organic phosphorus, and particulate phosphorus. [*See* FF ##52-53; ##120-121]. All three forms are available for algae to use in the aquatic ecosystem. [*Id.*]

267. At base flow at Tahlequah, 15 percent of total phosphorus is particulate and 85 percent is dissolved. [TR at 9289:19-9290:1 (Connolly)]. Typically, 80 percent or more of total phosphorus in the waters of the IRW is soluble reactive phosphorus. [TR at 5363:19-21 (Olsen)].

268. With respect to the total phosphorus in IRW wastewater treatment discharge samples, approximately 70 percent is dissolved phosphorus and 30 percent is particulate phosphorus. [TR at 9285:19-9286:3 (Connolly)]. Roughly 80 percent of the dissolved phosphorus is soluble reactive phosphorus. [TR at 9286:4-11 (Connolly)]. Put another way, only slightly more than 50 percent of the total phosphorus from wastewater treatment plants is soluble reactive phosphorus. [TR at 9286:12-16 (Connolly)].

269. There is more dissolved phosphorus than particulate phosphorus in nonpoint source runoff. [TR at 9298:11-9299:4 (Connolly)]. And soluble reactive phosphorus comprises almost half of nonpoint source runoff from fields. [TR at 5356:17-19 (Olsen)]. As noted by Tyson, water goes downhill and groundwater gets into streams. [TR at 5969:22-5970:5].

270. Importantly, once phosphorus leaves the fields, "that soluble-reactive part is pretty conservative as it moves through the basin." [TR at 5367:8-19; 5369:11-15 (Olsen)]. Soluble reactive phosphorus is a conservative substance that is not volatized and lost. [TR at 5367:12-19 (Olsen); 6233:4-8 (Engel)]. Once phosphorus enters the streams, "it's a matter of time before it ultimately reaches some point further downstream," even if temporarily delayed. [TR at 6462:15-6463:4 (Engel)]. Thus, nonpoint sources directly contribute soluble reactive phosphorus to the waters of the IRW. [TR at 9134:24-9135:16; 9129:12-17; 9133:24-9134:8 (Connolly)]. Under natural rainfall conditions, concentrations of nonpoint source soluble reactive phosphorus

can be equal to or greater than such concentrations from wastewater treatment plants. [TR at 9412:24-9413:7 (Connolly)].

271. In tributaries of the Illinois River not impacted by wastewater treatment plant discharges, two-thirds of the total phosphorus at base flow is soluble reactive phosphorus. [TR at 11370:4-11372:10; 11374:5-13; 11381:5-10 (Engel)]. The average base flow soluble reactive phosphorus in such tributaries was 0.027 mg/L. [TR at 11371:11-20 (Engel)].

272. Nonpoint-source phosphorus ends up in the waters of the IRW in two ways. First, with rainfall, a certain amount of water infiltrates and moves through the soil, picking up some phosphorus in the process. [TR at 11372:11-21 (Engel)]. Ultimately, it may become shallow groundwater that later seeps out of the banks and re-enters the stream beds of some of the tributaries during dry days. [TR at 11372:21-25 (Engel)]. Second, during runoff events, water containing soluble reactive phosphorus refills voids left by water seepage from the banks, filling the alluvium along the streams; on dry days, the water trickles back into the streams and slowly flows to downstream locations. [TR at 11373:1-22 (Engel); *see also* 5778:11-18 (Engel); 2071:1-16 (Fisher)].

273. In sum, both point sources and nonpoint sources contribute all three types of phosphorus to the total phosphorus loading of the waters of the IRW.

4. Relative Environmental Impacts of Point Source/Nonpoint Source Phosphorus Loading

274. Defendants' expert, Dr. Connolly, does not dispute that 70 to 80 percent of the phosphorus moving into Lake Tenkiller comes from nonpoint sources. [TR at 8907:14-16 (Connolly)]. Nevertheless, he opines that point source phosphorus loading has the "dominant" impact on water quality in the IRW, and that nonpoint source phosphorus loading is not having a significant impact on water quality in the IRW. [TR at 8924:13-24; 9437:5-21 (Connolly)]. Dr.

Connolly testified, "[i]n other words, if you cut off the nonpoint sources, in my view you wouldn't dramatically improve the water quality in Lake Tenkiller or the Illinois River." [TR at 9437:18-21].

275. With respect to the rivers and streams of the IRW, Dr. Connolly bases his opinion principally on his contention that they flow too quickly for phosphorus loading from nonpoint sources to have a significant impact on water quality. [TR at 8904:19-8906:12 (Connolly)]. He testified that algal growth depends not only on the volume of soluble reactive phosphorus, but also "its fate and its availability to algae." [TR at 8904:19-8905:8 (Connolly)]. He explained:

> [T]here's a time factor here. Algae can't instantly grow so they have to see that phosphorus for a period of time to actually increase and grow off of it.
>
> One of the things that happens in a runoff event is that the water's flowing fairly quickly, and so—and the Illinois River in Oklahoma is actually a fairly high-gradient river, so under high-flow events the water's moving pretty fast. So the transit time through the river is very short, not enough time to grow algae…

[TR at 8905:8-18 (Connolly)]. Dr. Connolly admitted, however, that even in a watershed with a relatively high gradient, there are some low gradient tributaries in the system, and even during a high flow event, water will move slowly enough to allow algae growth. [TR at 8905:25-8906:8 (Connolly)].

276. With respect to Lake Tenkiller, Dr. Connolly bases his opinion principally on the contention that the phosphorus from nonpoint sources plunges into the metalimnion before algae can form. [TR at 8988:22-8996:5 (Connolly)].

277. Dr. Connolly's opinion refers to nonpoint sources versus point sources in general as to their impact on water quality; it does not differentiate between soluble reactive phosphorus and other forms of phosphorus. [TR at 9412:16-19 (Connolly)].

278. The IRW is the most studied watershed in Oklahoma. [TR at 399:18-400:5 (Tolbert) (testifying that "dozens and dozens" of federal and state agencies and universities have conducted studies of phosphorus impairment of the IRW); TR at 7420:13-7421:1 (Cooke) (testifying the data for Lake Tenkiller "represents possibly the largest dataset for evaluation of trophic state in North America")].

279. Despite this fact, Dr. Connolly is aware of no other investigator who has reached the conclusion that phosphorus from nonpoint sources has no significant impact on Lake Tenkiller. [TR at 9165:12-9166:18; 9189:22-9190:4 (Connolly) (stating that he disagrees with the Clean Lakes study's conclusion that "[n]onpoint source phosphorus loading was found to be the cause of eutrophication of Lake Tenkiller"); TR at 9197:21-9198:10 (Connolly) (disagreeing with the conclusion of the Illinois River Cooperative River Basin Resources Base Report that "[a] significant part of the water quality problems in the basin appear to be a precipitate of the large volume of poultry waste generated and disposed of in the basin each year")].

280. With respect to the rivers and streams of the IRW, Dr. Connolly admitted his conclusions regarding bioavailability of phosphorus are based on analysis of data from a single geographical point on the Illinois River at Tahlequah; he did not analyze flows elsewhere on the Illinois River or in other rivers and streams. [TR at 9131:20-9132:20; TR at 9136:15-17 (Connolly)].

281. Dr. Connolly conceded there is an opportunity for dissolved organic phosphorus and other forms of phosphorus, including particulate phosphorus, to have an impact on water quality at some locations in the IRW based on phosphorus cycling. [TR at 9137:3-8 (Connolly)]. Further, he acknowledged that even in the Illinois River, there are areas where the water slows down enough for algae to form. [TR at 9137:9-15 (Connolly); *see also* OK Ex. 3116 at OK0003578 ("The Illinois is a succession of alternating deep pools and swift shallows flowing over beds of

gravel. The average drop is 5 feet per mile and the normal speed of river flow is 13 miles per hour—much faster over shoals and in narrow channels and almost at a standstill on the mile-long deep holes.")].

282. Dr. Connolly also admitted that forms of phosphorus other than soluble reactive phosphorus have an impact on water quality in the IRW where relatively quiescent conditions allow enough residence time for conversion. [TR at 9135:24-9136:12 (Connolly)]. He acknowledged that such conditions exist both in tributaries of the Illinois River, as well as in locations on the Illinois River itself. [TR at 9136:18-9137:15 (Connolly)].

283. Dr. Connolly conceded that many locations in the IRW are not impacted by wastewater treatment plant discharges and yet have high phosphorus levels. [TR at 9217:3-9218:10; 9222:3-9224:7 (Connolly)].

284. With respect to Lake Tenkiller, Dr. Connolly initially testified that the plunging effect brings a "significant fraction" of the phosphorus coming into the lake down below the epilimnion (the surface layer of the lake where algae can grow) and so "it effectively is moving phosphorus out of the region that algae can grow into a region below where algae can grow." [TR at 8989:7-18]. Thus, he concluded that a "large part" of nonpoint source phosphorus is being stored in the sediment of the lake. [TR at 8997:23-8998:4 (Connolly)]. He opined that nonpoint sources only impact the lake through the recycle process, and in Lake Tenkiller, the recycle is fairly low and does not contribute significantly to the algal growth the next year. [TR at 8998:5-18 (Connolly)]. The high chlorophyll levels in Lake Tenkiller, in his view, are driven to a great extent by the point sources coming into the system rather than the nonpoint sources. [TR at 8998:18-21 (Connolly)]. However, on cross examination, Dr. Connolly acknowledged that not all of the phosphorus is driven below the surface layer by the plunging effect. [TR at 9421:6-9422:11 (Connolly)].

285. Further, Dr. Connolly made clear that he was not taking the position that nonpoint source soluble reactive phosphorus has *no* impact on water quality in the IRW; rather, in his opinion it had only a "minor" impact. [TR at 9129:20-9130:6 (Connolly)]. He did not undertake to quantify—and cannot quantify—the impact soluble reactive phosphorus from nonpoint sources is having, nor did he perform any calculations to determine what impact cessation of nonpoint source phosphorus contributions would have. [TR at 9130:7-17; 9447:21-23 (Connolly)].

5. Summary of Findings

286. Based upon the foregoing findings of fact, the court finds that all forms of phosphorus have an environmental impact in the IRW.

287. The court further finds that nonpoint source contributions of phosphorus loading to the rivers and streams of the IRW and to Lake Tenkiller are greater than point source contributions.

288. The court finds that nonpoint source phosphorus is a significant source of the phosphorus causing injury to the rivers and streams of the IRW and to Lake Tenkiller.

289. The State contends that land-applied poultry waste generated by defendants' poultry is a significant contributor to phosphorus loading of the waters of the IRW and that the phosphorus in these waters is causing injuries to the rivers and streams of the IRW and to Lake Tenkiller. Therefore, the court must evaluate the facts underlying the State's claims.

J. Overview of the Poultry Industry in the IRW

290. The Tyson Defendants maintain poultry operations in both the Oklahoma and Arkansas portions of the IRW. [OK Exs. 855, 954, 950, 939]. Those operations began in 1947. [TR 75:16-20 (Tyson Opening)]. Between 2000 and 2007, more than 703 million birds belonging to the Tyson Defendants were raised in the IRW. [OK Ex. 2528].

291. The Cargill Defendants also have poultry operations in both the Oklahoma and Arkansas portions of the IRW. [OK Exs. 847, 838, 6127, 6219-A]. The Cargill Defendants began poultry operations in the IRW in the mid-1960s. [TR 4659:5-9 (Maupin)]. Between 2000 and 2007, more than 23 million birds belonging to the Cargill Defendants were raised in the IRW. [OK Ex. 2528].

292. The George's Defendants oversee poultry operations in both the Oklahoma and Arkansas portions of the IRW. [OK Exs. 879, 883]. The George's Defendants began poultry operations in the IRW in the 1950s. [TR at 198:3-4 (George's Opening)]. Between 2000 and 2007, more than 105 million birds belonging to the George's Defendants were raised in the IRW. [OK Ex. 2528].

293. Defendant Simmons have poultry operations in both the Oklahoma and Arkansas portions of the IRW. [TR at 4122:1-3, 19-22 (Simmons testimony); OK Ex. 2722]. Defendant Simmons began poultry operations in the IRW in the early 1970s. [TR at 4121:17-22 (Simmons)]. Between 2000 and 2007, more than 162 million birds belonging to Defendant Simmons were raised in the IRW. [OK Ex. 2528].

294. Defendant Peterson had (but no longer has) poultry operations in both the Oklahoma and Arkansas portion of the IRW. [OK Ex. 913]. Defendant Peterson began poultry operations in the IRW in the mid-to-late-1970s or early 1980s. [TR at 4787:8-20 (Houtchens)]. Between 2000 and 2007, more than 121 million birds belonging to Defendant Peterson were raised in the IRW. [OK Ex. 2528].

295. Defendant Cal-Maine had (but no longer has) poultry operations in both the Oklahoma and Arkansas portions of the IRW. [OK Exs. 6062, 6059, 6060, 6061; 4412:4-10]. Defendant Cal-Maine began poultry operations in the IRW in 1989. [TR at 4412:4-10 (Storm)]. Defendant Cal-Maine ceased poultry operations in the IRW in roughly 2005. [*Id.*] Between 2000 and 2007,

more than 4 million birds belonging to Defendant Cal-Maine were raised in the IRW. [OK Ex. 2528].

1. Structure of the Poultry Industry in the IRW

296. The State's expert, Dr. Robert Taylor,[20] testified that in the modern poultry industry, birds are typically raised in one of two ways. First, birds may be raised by the poultry company itself at company-owned operations; second, the birds may be raised by growers under contract with a poultry company. [TR at 6767:9-14 (Taylor)]. Birds in the IRW have been and are predominantly raised by the latter method. [TR at 6767:22-6768:2 (Taylor)].

297. Defendants operate in the IRW on a vertically-integrated business model.[21] [TR at 6766:25-6767:8 (Taylor)]. Each defendant owns the birds it places with its growers; owns and/or supplies the feed consumed by its birds; provides all veterinary services required for its birds; and provides the medications required for its birds. [TR at 6770:3-6771:2 (Taylor)]. Defendants decide when they will place birds with their growers, how many birds will be placed with each grower, and when they will pick up the birds placed with the growers. [TR at 3373:13-17 (Pilkington); TR at 3753:21-3754:1 (Pigeon); TR 4072:9-11 (Anderson); TR at 4537:14-22 (Saunders); TR at 4682:18-20, 4683:1-4 (Maupin); TR at 3917:1-5 (Collins); TR at 4272:7-15 (Murphy); Ct.'s Ex. 6 at p. 7 (Wear Dep.); TR at 4426:18-20 (Storm)].

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[20] Dr. Taylor earned a Ph.D. in agricultural economics from the University of Missouri. [TR at 6759:4-9 (Taylor)]. He currently holds an endowed chair, the Alfa Eminent Scholar of Agricultural Economics and Agricultural Policy, at Auburn University. [TR at 6758:20-6759:3 (Taylor)]. He has served on the editorial board of the *American Journal of Agricultural Economics,* which is the top journal in his field, and on the editorial boards of several other journals. [TR at 6760:24-6761:12 (Taylor)]. Dr. Taylor has testified before congressional committees on issues pertaining to competition in agricultural markets. [TR at 6762:5-14 (Taylor)].

[21] Vertical integration involves a business model wherein a company takes a product from raw material production to processing, marketing, wholesaling and retailing. [TR at 6764:15-19 (Taylor)].

298. Defendants use their own trucks and catchers when they pick up their birds. [TR at 3759:10-12 (Pigeon); TR at 4686:10-12 (Maupin); TR at 3916: 16-18 (Collins); TR at 4272:16-21 (Murphy); TR at 4534:6-8 (Saunders)].

299. Defendants set minimum specifications for the houses where they place their birds; they regularly visit their growers to inspect, supervise, and give advice and recommendations. [TR at 6771:3-6772:6 (Taylor)]. They inspect the grow houses before placing their birds, and they specify and/or make recommendations regarding clean-outs and cake-outs of their growers' houses. [TR at 3376:10-3377:9, 3420:19-3421:5 (Pilkington); 3756:12-24, 3757:5-8 (Pigeon); TR at 4070:24-4071:1 (Anderson); TR at 4673:15-18, 4695:7-4696:16 (Maupin); TR at 4070:24-4071:1, 4273:10-20, 4277:4-16, 4302:13-16 (Murphy); Ct. Ex. 7 at p. 6 (Butler Dep.); TR at 4954:15-17 (Alsup); TR at 4311:23-4312:22 (McClure); TR at 4549:22-4550:3 (Saunders); TR at 4837:7-9 (Houtchens)].

300. Defendants' contracts with their growers are non-negotiable, and each defendant sets the payment schedule for the birds it places with its growers. [TR at 6775:5-8 (Taylor); TR at 3756:13-16 (Pigeon); TR at 4060:25-4061:3, 4063:4-7, 4065:5-8, 4069:22-24, 4072:3-5 (Anderson); TR at 4686:19-21, 4781:13-17 (Maupin); TR at 3114:8-12, 3115:5-7 (Henderson); TR at 4538:19-24 (Saunders); TR at 3915:11-13 (Collins); TR at 4273:7-9, 4276:24-4277:3 (Murphy); Ct.'s Ex. 6 at pp. 10-11, 14 (Wear Dep.); OK Ex. 6062, ¶5].

301. Defendants' contracts with their growers are typically short term (year-to-year or flock-to-flock). [TR at 6772:13-6774:2 (Taylor); OK Ex. 6062, ¶1; OK Ex. 4957; OK Ex. 6269-A4, ¶2; OK Ex. 3051, ¶1A].

302. The Tyson Defendants, Cargill Defendants, George's Defendants and defendant Peterson provide their growers with a grower and/or environmental handbook. [TR at 4073:2-5

(Anderson); TR at 3344:25-3345:10 (Keller); OK Exs. 6269-A4, ¶8; 6131A; TR at 4676:13-4677:10; 4697:22-4698:9; 4767:6-16; 4774:11-4775:6 (Maupin); TR at 4864:12-21 (Alsup); TR at 4310:3-14 (Murphy); TR at 4548:5-74542:21-4543:3 (Saunders)].

303. Defendants provide signage for the growing operations where their birds are raised. [TR at 3378:7-3379:8 (Pilkington); OK Ex. 6924-OKPL0007130; TR at 4051:11-12 (Anderson); TR at 4687:1-4 (Maupin); TR at 3049:18-3050:4, 3056:24-3057:2 (Henderson); OK Ex. 6923-STOK0043577; OK Ex. 6924-OKPL0012227; OK Ex. 6924-OKPL0006069; OK Ex. 6924-OKPL0006301; TR at 4464:24-4465:1 (Reed); TR at 3767:15-20 (Pigeon); TR at 4838:4-12 (Houtchens)].

304. The barriers to entry into the poultry growing business are significant. The average growing operation in the IRW has three or four grow houses. [TR at 1779:4-5 (Fisher); TR at 6777:3-6 (Taylor)]. The typical cost for a grow house and equipment is in the low to mid-$200,000 range. [TR at 6777:15-6778:2 (Taylor)]. Thus, a grower with two or three houses would need to invest between half a million to three-quarters of a million dollars in grow houses and equipment. [TR at 6778:5-6 (Taylor)]. Loans are typically 12 to15 years for grow houses and 7 years for equipment, but because house and equipment upgrades are required over the life of a grow house, the typical economic payback period on a grower's investment is 20 to 30 years. [TR at 6778:7-16 (Taylor)].

305. As noted above, only four defendant groups operate in the IRW. [*See* FF ##290-295]. There is no open market in the IRW for the sale of commercial broilers, turkeys, or eggs by a grower who does not have a contract with one of the poultry integrators. [TR at 6779:12-6780:1 (Taylor)].

306. Because defendants' contracts are typically short-term, growers have no assurance they will continue to receive birds from defendants for a long enough time to cover the 20 to 30 year economic payback period on their investment in grow houses and equipment. [TR at 6778:17-6779:3 (Taylor)].

307. Because the defendants' contracts are similar in most respects, switching from one integrator to another would not materially change a grower's circumstances. [TR at 6776:321, 6768:10-23 (Taylor)].

308. There appears to be no dispute that defendants' vertical integration business model has transferred certain market risk—including the risk of fluctuation in prices of chicks, feed, and mature birds—from the growers to the poultry integrators. [TR at 10117:17-10118:9 (Rausser)]. Nevertheless, growers must make significant long-term investments to raise birds for which there is no open market, no guarantee of long-term continued placement of birds (so that the long-term investment can be recaptured), and only a limited number of integrators with which growers can do business. [*See* FF. ##305-307]. In sum, the transfer of market risks from growers to integrators comes at a price.

309. Defendants' expert, Dr. Gordon Rausser,[22] does not dispute that defendants have potential leverage over growers, but opines that the integrators have not actually exercised that leverage, and that, in fact, exercise of that control would be counter to defendants' economic interests. [TR at 10185:25-10186:16; 10139:16-10140:1; 10125:15-10126:2 (Rausser)]. Further,

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[22] Dr. Rausser has a Ph.D. in agriculture and resources economics and mathematical statistics. [TR at 10107:21-23 (Rausser)]. He holds the position of Robert Gordon Sproul Distinguished Professor at the University of California at Berkeley. [TR at 10108:5-8 (Rausser)]. He has served as editor of the *Annual Reviews of Resource Economics* and the *American Journal of Agricultural Economics,* and as associate editor of the *Journal of the American Statistical Association* and the *Journal of Economic Dynamics and Control.* [TR at 10110:1-11 (Rausser)]. He served for two years as senior economist on the President's Council of Economic Advisors and for three years as chief economist of the Agency for International Development. [TR at 10111:1-14 (Rausser)].

various growers testified that they consider themselves to be independent. [TR at 4598:15-4599:10 (Saunders); TR at 3926:22-3927:4 (Collins)].

310. However, as set forth above, the actual structure of the integrator/grower relationship, including the growers' long term investment burden, significantly limits the growers' independence.

2. Characteristics, Concentration and Locations of Operations in the IRW

311. Broilers, breeders, layers, pullets, and turkeys are raised in the IRW; the overwhelming majority of the birds are broilers. [TR at 1779:12-1780:9 (Fisher)].

312. As previously noted, a typical operation has about four grow houses. [*See* TR at 1779:4-5 (Fisher); TR at 6777:6-7 (Taylor)]. Each grow house typically houses approximately 20,000 birds; five to six flocks per grow house are raised annually. [TR at 1781:2-15 (Fisher); TR at 3728:10-16 (Pigeon) (testifying he turns an average of five and a half flocks per year)]. Thus, at any given time, a typical broiler operation is housing 80,000 birds, and over the course of the year, 400,000 to 480,000 birds. [TR at 1781:20-1782:5 (Fisher)]. Chicks are delivered to grow houses within the first week after hatching, and the grow-out period is typically 49 days. [OK Ex. 6566b]. The target weight for broilers has gradually increased over the years from five to six pounds. [TR at 3727:21:3728:9 (Pigeon) (testifying that when he began raising broilers in 1995 the target weight was five pounds and as of 2009, the target weight was six pounds)]. Target weights for turkeys range from 16-25 pounds, and the number of flocks per year averages 3.4. [OK Ex. 6131A at CARTP100992].

313. The IRW has a high concentration of poultry feeding operations. [TR at 6765:3-11 (Taylor)]. Between 2000 and 2007, more than 1.1 billion birds belonging to defendants were raised in the IRW. [OK Ex. 2522].

314. There are approximately 1,900 active poultry houses in the IRW. [TR at 1723:24-1724:6 (Fisher)]. Of this total, approximately 425 poultry houses are located in Oklahoma and 1,455 are located in Arkansas. [OK Ex. 5665 at pp. 8, 11].

315. The locations of poultry growing operations affiliated with defendants are dictated largely by the locations of defendants' respective feed mills and processing plants. [TR 6781:11-6782:13 (Taylor); TR at 3038:4-3039:2 (Henderson); TR at 4256:8-22 (Murphy); TR at 3978:4-17, 3979:2 (Henderson); TR at 4798:3-6, 21-24 (Houtchens)].

3. Summary

316. The court finds, based on the foregoing findings of fact, that each defendant has maintained significant poultry operations in the IRW. Further, by virtue of their contracts and the vertically integrated structure of the business, each defendant maintains control over virtually all essential aspects of poultry production, including the activities of their contract growers.

K. Poultry Waste

1. Constituents of Poultry Waste

317. Poultry waste is a combination of poultry litter and poultry excrement. Poultry litter is a particulate matter that is used to absorb liquids from poultry excrement; generally, it is made of wood shavings or rice hulls, although wheat straw is sometimes used. [TR at 1802:15-19 (Fisher); TR at 3843:25-3844:5 (Pigeon)].

318. Poultry waste is a necessary byproduct of poultry growing. [TR at 4127:20-4128:1 (Simmons); TR at 3385:8-13 (Pilkington)].

319. Poultry waste is periodically removed from the grow houses through a procedure known as "cake-out" or "clean-out." A cake-out occurs between flocks and involves pulling a tractor-drawn machine through the house. The machine removes the layer of crusted, damp litter on top

of the bedding and sifts the dry litter back onto the floor. [TR at 3729:17-24 (Pigeon); TR at 3376:24-3377:1 (Pilkington)]. A clean-out is the removal of *all* litter from the poultry house. [DJX2654 at 0024].

320. Once poultry waste is removed from the grow house, it has no further role in growing poultry. [TR at 3385:14-18 (Pilkington); TR at 4077:1-7 (Anderson); Ct.'s Ex. 7 at 65 (Butler Dep.); TR at 4687:24-4688:2 (Maupin); TR at 3077:24-3078:3 (Henderson); TR at 4128:8-11 (Simmons); TR at 3903:7-10 (Collins); TR at 3903:7-10 (Collins); TR at 3735:18-22 (Pigeon); TR at 4454:19-22 (Storm)].

321. With the exception of defendant Peterson's post-1999 contracts, defendants' contracts with growers do not transfer ownership of the poultry waste to the growers. [TR at 6774:7-18 (Taylor); Ct.'s Ex. 7 at p. 4 (Butler Dep.); TR at 4687:12-23 (Maupin); OK Ex. 6269-A4; TR at 3027:2-12 (Henderson); OK Ex. 3051; TR at 4518:21-4519:7 (Bronson Stipulation); OK Ex. 6062]. Under Peterson's post-1999 contracts, which are non-negotiable, the grower owns the poultry litter.[23] Thus, growers are unable to decline ownership of and responsibility for poultry litter.

2. Constituents of Poultry Excrement

322. The constituents of poultry waste are a function of what is fed to the poultry. [TR at 1800:9-18 (Fisher)]. The two largest constituents of poultry feed are corn and soybeans. [TR at 1795:17-18 (Fisher)]. Poultry feed also contains milling and baking waste from the grains. [TR at 1795:18-19 (Fisher)]. In addition to the components of the grains, defendants might also add fats (*e.g.,* poultry fat recycled from processing); phosphorus compounds (*e.g.,* defluoridated phosphate,

[23] In a 1998 memorandum, Peterson's Director of Corporate Training, Ron Mullikan, predicted that regardless of whether the grower or the integrator owns the litter, he believed "that as time passes, we the integrator will be found liable for it and the [e]ffect it has on our environment" and "[t]his position will be driven by both environmental groups and the EPA." [OK Ex. 6378].

calcium phosphate); sodium chloride, potassium salts (*e.g.,* potassium sulfate, potassium chloride); amino acids; and trace minerals, including copper compounds. [TR at 1795:24-1796:9, 1797:1-23 (Fisher)]. Some defendants' feed contains arsenic compounds. [TR at 1798:22-1799:12 (Fisher)]. However, the Tyson Defendants discontinued adding arsenic compounds several years ago, and defendant Cal-Maine has never added arsenic compounds to its feed. [TR at 1799:16-20; 2694:20-22 (Fisher)].

323. Virtually all of this feed, as well as phosphorus supplements added to that feed, is imported into the IRW. [TR at 5838:2-5839:16 (Engel); TR at 1796:12-17 (Fisher); TR at 3428:25-3429:4, 3434:12-24 (Pilkington); TR at 4737:12-4738:2 (Maupin); TR at 3039:20-3041:2 (Henderson); TR at 4125:18-4126:14 (Simmons)].

324. Poultry waste generated by defendants' birds in the IRW contains, among other things, phosphorus, zinc, copper and arsenic. [TR at 1808:19-1809:1 (Fisher); OK Ex. 2523]. Analysis of samples of poultry waste generated by defendants' birds in the IRW showed that the average concentration of total phosphorus in the waste is 19,723.31 mg/Kg (or approximately two percent of the total weight of poultry waste on a dry weight basis); the average concentration of water soluble phosphorus is 1,699.11 mg/Kg; the average concentration of zinc is 488.47 mg/Kg; the average concentration of copper is 420.16 mg/Kg; the average concentration of arsenic is 19.75mg/Kg. [OK Ex. 2523; TR at 1812:14-1813:17 (Fisher)]. These values were similar to literature values and to the values of poultry waste samples from the neighboring Eucha-Spavinaw Watershed. [TR at 1817:6-1818:4; 1820:2-1821:10 (Fisher); OK Ex. 2524].

325. A comparison of the concentrations, as well as the concentration ratios, of phosphorus, copper, zinc and arsenic found in poultry waste with the concentrations and concentration ratios of such chemicals found in samples of cattle manure and wastewater treatment plant discharges in the

IRW, reveals that they are distinctly different from one another. [TR at 1824:20-1837:24; 1815:24-1816:13 (Fisher); OK Exs. 2518, 2525].

326. Poultry waste and cattle waste are solids and can be compared both in terms of the concentrations and the ratios of their chemical constituents. [TR at 1831:16-20 (Fisher)]. Poultry waste has substantially higher concentrations of phosphorus (on the order of 10,000 milligrams per kilogram) compared to cattle waste (which for wet waste is 5,600 milligrams per kilogram). [TR at 1829:20-1830:2 (Fisher); OK Ex. 2518]. The concentration for copper in poultry waste is over 400; in cattle waste, it is about 14. [TR at 1830:16-20 (Fisher); OK Ex. 2518]. Poultry waste has a broad range of arsenic, with Tyson samples having relatively low arsenic compared to the samples of waste from other defendants' birds, while arsenic was not detectible in cattle waste samples. [TR at 1831:3-13 (Fisher); OK Ex. 2518]. Zinc concentrations in poultry waste are much higher than in cattle waste. In poultry waste, zinc concentrations are over 400 milligrams per kilogram, but about 74 milligrams per kilogram in cattle waste. [TR at 1832:9-16 (Fisher); OK Ex. 2518]. In short, poultry waste contains high levels of phosphorus, zinc, copper, and arsenic compared to cattle waste.

327. Data regarding wastewater treatment plant waste is plotted in terms of milligrams per kilograms. [TR at 1831:14-24 (Fisher)]. Poultry waste is higher in copper compared to zinc, so there is much more copper present in the poultry waste itself than there is zinc on a mass basis, compared to either cattle waste or wastewater treatment plant waste. [TR at 1832:17-24 (Fisher); OK Ex. 2518]. In contrast, wastewater treatment plant waste is much richer in zinc (or much more depleted in copper) than poultry waste. [TR at 1833:9-16 (Fisher); OK Ex. 2518].

328. The differences between poultry waste, cattle waste and wastewater treatment plant waste assist in source identification analysis in the IRW. By looking at concentrations and

concentration ratios in environmental phases, one can identify a source for the material. [TR at 1833:25-1834:6 (Fisher)].

329. Errata Table 12, [OK Ex. 2525], prepared by Fisher, compares ratios of total zinc to total phosphorus, total copper to total phosphorus, total arsenic to total phosphorus, and total zinc to total copper, for poultry waste and unfiltered wastewater treatment plant effluent. [OK Ex. 2525; TR at 1834:25-1835:4 (Fisher)]. With respect to each type of waste, the table lists values for the maximum value observed; the third quartile value observed (meaning 25 percent of the data is greater than that); the mean or average value; the medium or middle value; the first quartile value (meaning that 25 percent of the data is less than that); and the minimum or smallest value. [OK Ex. 2525, TR at 1835:5-16 (Fisher)]. The table lists the ratios of total zinc to total phosphorus; total copper to total phosphorus, total arsenic to total phosphorus and total zinc divided by total copper. [OK Ex. 2525, TR at 1835:17-23 (Fisher)].

330. Fisher found that average total zinc to total copper ratios for poultry waste is about 1.3 to 1. In other words, on average, poultry waste had 30 percent more zinc than copper. For cattle waste, the average zinc-to-copper ratio is 6.1021, meaning there is six times as much zinc as there is copper in cattle waste. [OK Ex. 2525; TR at 1835:24-1836:16 (Fisher)]. Fisher testified this is consistent with poultry feed versus cattle feed because poultry eat feed enriched in copper as compared to zinc. [TR at 1836:16-19 (Fisher)]. Fisher testified the analysis assists in source identification because finding materials with high levels of copper to zinc, combined with high concentrations of phosphorus, identifies the source as poultry waste. [TR at 1836:20-25 (Fisher)].

331. Additionally, if a sample is taken close to the source, the ratios should be largely conserved. [TR at 1837:1-4 (Fisher)]. Fisher testified that copper salts are more soluble than zinc salts, so with transport, the ratio of total zinc to total copper can change (with the level of zinc

going up compared to copper), but there should still be "quite a bit" of zinc, copper, and phosphorus present. [TR at 1837:4-10 (Fisher)].

332. Further, if the source is poultry waste, the sample will show "a very clear and distinct relationship" between phosphorus and zinc and phosphorus and copper, as well as phosphorus and arsenic (although maybe to a lesser extent), because the concentrations of phosphorus are so high in poultry waste—19,700 to 20,000 on average—compared to cattle waste, which is around 6,000. [TR at 1837:11-17 (Fisher)].

333. The concentrations of zinc and copper are 400-plus milligrams per kilogram in poultry waste and only tens of milligrams per kilogram in cattle waste. [TR at 1837:18-21 (Fisher); OK Ex. 2525]. Fisher testified "[t]he signal from cattle waste with respect to copper and zinc will be lost quickly as it pollutes, but that from poultry waste will not[,] [a]nd cattle waste, as shown in the third column here, does not contain arsenic." [TR at 1837:21-24; OK Ex. 2525].

3. Amounts

334. The dense concentration of poultry production in the IRW leads to a dense concentration of poultry waste produced in the IRW. The parties offered various estimates of the aggregate amount of poultry waste generated by defendants' birds in the IRW. Using various methodologies, the State's experts arrived at estimates ranging from 354,000 tons per year to 528,000 tons per year. [OK Ex. 1227]. The State relied upon the most conservative of the estimates (354,000 tons per year) and defendants did not seriously challenge this amount. Broken down by defendant group, the annual waste production is as follows: 167,144 tons by the Tyson Defendants' birds; approximately 17,968 tons by the Cargill Defendants' birds; 60,101 tons by the George's Defendants' birds; approximately 66,299 tons by defendant Simmons' birds; 37,143 tons by defendant Peterson's birds; and 2,750 tons by defendant Cal-Maine's birds. [OK Ex. 2532].

335. Between 2001 and 2006, the annual poultry waste generated by defendants' birds contained an average of 8.7 million to 10 million pounds of phosphorus. [TR at 5685:19-5686:5 (Engel)]. During this period, the annual poultry waste generated by the Tyson Defendants' birds contained between 4,088,152 pounds and 4,461,513 pounds of phosphorus; the annual poultry waste generated by the Cargill Defendants' birds contained between 1,118,799 and 1,720,395 pounds of phosphorus; the annual poultry waste generated by the George's Defendants birds contained between 1,404,951 and 1,658,320 pounds of phosphorus; the annual poultry waste generated by defendant Simmons' birds contained between 768,007 and 1,575,910 pounds of phosphorus; and the annual poultry waste generated by defendant Peterson's birds contained between 543,414 and 858,725 pounds of phosphorus. [OK Ex. 1223]. From 2001 to 2005, the poultry waste generated by defendant Cal-Maine's birds contained between 71,837 and 396,398 pounds. [*Id.*]

336. Based on data provided by BMPs, Inc. and the George's Defendants, in 2003 approximately 8,877 tons (or 2.51 percent) of the poultry waste generated in the IRW was hauled out of the watershed. [OK Ex. 2535]. In 2004, the amount exported was 12,312 tons (or 3.48 percent); in 2005 the amount exported was 34,434 tons (or 9.73 percent); and in 2006 the amount exported was 69,019 tons (or 19.50 percent). [*Id.*] The overall average of waste exported from the IRW during the four-year period was 8.80 percent. [*Id.*] Defendants presented no evidence disputing these calculations.

337. Additionally, some poultry waste generated by defendants' birds outside the IRW is imported and applied to land in the IRW. [TR at 1930:10-14 (Fisher); TR at 6603:1-14 (Engel). *See also* TR at 9849:23-25 (Clay) (defendants' expert agreeing it is possible that some poultry waste may have been imported into the IRW)].

4. Summary

338. Based on the foregoing, the court finds that each of the defendants has generated and—with the exception of defendant Peterson and defendant Cal-Maine—is generating significant quantities of phosphorus-rich poultry waste in the IRW.

L. Poultry Waste Land Application

339. Poultry waste generated by birds owned by each defendant has been applied to lands within the IRW. [TR at 1929:1-10; 1930:4-9 (Fisher)].

1. Manner

340. It is a common practice to apply poultry waste generated in the IRW on land in the IRW. [TR at 3428:11-20 (Pilkington); TR at 4864:3-8 (Alsup); TR at 3057:10-20 (Henderson); TR at 4128:12-20 (Simmons); TR at 4292:12-14 (Murphy); TR at 3959:4-8 (Henderson)]. Land application of poultry waste occurs almost exclusively on grassland. [OK Ex. 3351 at OSU0005156].

341. Application is typically done by a spreader truck that broadcasts the poultry waste over the land. [TR at 359:5-13 (Tolbert)]. The poultry waste is applied topically—that is, spread on the surface without being incorporated into the soil. [TR at 1852:13-1853:3 (Fisher); TR at 959:8-12 (Fite); TR at 5184:14-16 (Johnson); TR at 4864:9-11 (Alsup); TR at 4292:15-16 (Murphy); TR at 3903:22-24 (Collins); TR at 4128:21-25 (Simmons); TR at 4803:11-4 (Houtchens); TR at 3965:20-23 (D. Henderson); TR at 3726:6-8 (Pigeon)]. Although land application of poultry waste occurs throughout the year, it is typically concentrated in late winter and spring—a time that coincides with significant rainfall in the IRW. [TR at 1960:12-17; 1961:15-1962:6 (Fisher); TR at 776:18-21 (Fite)].

2. Location

342. Poultry waste generated by birds owned by defendants has been land applied throughout the IRW. [OK Ex. 3351; TR at 1935:14-17, 1954:9-17 (Fisher); TR at 1269:8-24, 1270:14-19 (Phillips)].

343. Poultry waste applied in the IRW is generally applied in close proximity to where it is generated. [TR at 356:10-20 (Tolbert)]. Approximately 80 percent of the poultry waste that is land applied in the IRW is applied within four miles of where it is generated, and just a little less than 70 percent of that poultry waste is land applied within two miles of where it is generated. [TR at 1883:2-16, 1888:8-15 (Fisher); OK Ex. 2515].

344. By virtue of the fact that defendants' poultry operations are concentrated in the IRW [*see* FF ##290-95], that growers locate close to defendants operations, and that land application of poultry waste generally occurs in close proximity to the poultry growing operations [*see* FF #343], it follows that defendants strongly influence the distribution of poultry waste disposal in the IRW.

3. Behavior of Phosphorus in the Soil and STPs

345. Poultry waste contains organic and inorganic phosphorus. [OK Ex. 3145; TR at 4988:5-21 (Johnson)]. The inorganic phosphorus in land-applied poultry waste initially is highly soluble and available to plants, but as it reacts with the soil, it becomes less soluble and less available to plants. [OK Ex. 3145]. Phosphorus ions react with soil in one of two ways: either they are adsorbed[24] onto soil particles or they chemically combine with elements in soil such as calcium, aluminum and iron, forming solid compounds. [*Id.*]

[24] "Adsorption" is the "adhesion in an extremely thin layer of molecules (as of gases, solutes, or liquids) to the surfaces of solid bodies or liquids with which they are in contact." Merriam-Webster Online Dictionary (2013).

346. The State's expert, Dr. Gordon Johnson, testified that in very basic terms, the water-soluble phosphorus from land-applied poultry waste enters the pool of phosphorus in the soil and establishes equilibrium with the various forms of other phosphorus in the soil. [TR at 4988:23-4989:6 (Johnson)]. As plants adsorb water soluble phosphorus, the natural equilibrium in the soil between water soluble phosphorus and other forms replenishes water soluble phosphorus from the other forms. [TR at 4990:7-17 (Johnson)]. In this situation, the equilibrium moves phosphorus from a bound form to a water soluble form. [TR at 4991:11-13 (Johnson)]. Conversely, if more water soluble phosphorus comes from an external source, the equilibrium moves water soluble phosphorus to the adsorbed form. [TR at 4991:21-4992:4 (Johnson)]. The equilibrium reaction is continuous. [TR at 4992:5-8 (Johnson)]. For instance, if water soluble phosphorus leaves in runoff, the equilibrium reaction makes more water soluble phosphorus available from other phosphorus in the soil. [TR at 4996:6-13 (Johnson)].

347. "Managing Phosphorus from Animal Manure," an Oklahoma Cooperative Extension Service publication, explains:

> As adsorbed and precipitated P increases, the phosphorus in soil solution (water held in the soil matrix) also increases, due to the equilibrium between solid and dissolved forms of phosphorus. Soil solution phosphorus is subject to runoff loss during storm events. More P will be subject to loss when soil P approaches saturation or over-saturation. Saturation means that all the sorption sites on soil particles are occupied by P, and all Ca, Al, Fe and other elements capable of precipitating P are used up. Therefore, the soil P holding capacity is a function of clay and organic matter content, soil pH, and the amount of calcium carbonate and aluminum or iron oxides of a particular soil.

[OK Ex. 3145 at p. 2].

348. Soil phosphorus testing is a management practice used to predict the amount of phosphorus needed in a fertilizer or manure program for optimum yield. [*Id.*] Soil test phosphorus ("STP") relates soil phosphorus to crop response. [TR at 4992:9-24 (Johnson)].

349. Elevated STPs decline slowly. If a field has an STP of 200 and forage removes 50 pounds of phosphorus, the STP does not go back to 150. This is in part because of the chemistry in the soil, and in part because roots only absorb phosphorus from a thin layer of soil right next to them (positional availability). The soil between plant roots is not affected by the fact that a crop is growing there. [TR at 4992:25-4993:12 (Johnson)].

350. Haying forage and removing it from the field reduces STP values more quickly than grazing the field, because 90 percent of the forage phosphorus consumed by beef cattle passes through the animals and is recycled into the soil. [TR at 5042:10-15 (Johnson)].

4. Balance/Over-Application

351. When poultry waste is applied to meet the nitrogen needs of forage, more phosphorus—by a factor of about four—is applied than plants will need. [TR at 5024:24-5025:6 (Johnson)]. In this sense, poultry waste, unlike commercial fertilizer, is not a well-balanced fertilizer. [TR at 5023:17-5024:13 (Johnson)].

352. Poultry waste, as an "unmanipulated animal manure," is excluded from the definition of a "soil amendment" under Oklahoma law. [2 Okla. Stat. § 8-85.3(14); TR at 5091:11-17 (Johnson) (describing "unmanipulated animal manure" as "manure that has not been composted or pelletized or somehow manipulated to change its physical and chemical characteristics that would otherwise be the property when you had it fresh")].

353. A 1988 report by the Arkansas Department of Pollution Control & Ecology stated:

> Excess nitrogen, in the form of nitrate-nitrogen is water soluble and any excess is quickly leached out of the soil and enters the groundwater or surface water. Phosphorus, however, adsorbs to soil particles and is not readily leached from the soil. Excess values built up in the soil will be washed into surface waters whenever erosion occurs.
>
> Chicken manure has a higher phosphorus to nitrogen ratio th[a]n is utilized by plants. If the application of this material is based on its nitrogen content, an excess

> of phosphorus will build up. Informal soil tests done in the Lake Lincoln watershed in Washington [C]ounty by the SCS show excess phosphorus is present. Lake Lincoln, the water supply for Lincoln, currently has dense algae blooms and taste and odor problems in the summer, an indication of nutrient enrichment.

[OK Ex. 3312 at ADEQ 226].

354. The Oklahoma portion of the IRW has been designated a "nutrient limited watershed" by the Oklahoma Water Resources Board. [Okla. Admin. Code § 785:45-5-29]. A "nutrient limited watershed" means "a watershed or a waterbody with a designated beneficial use which is adversely affected by excess nutrients as determined by Carlson's Trophic State Index (using chlorophyll-a) of 62 or greater, or is otherwise listed as "NLW" in Appendix A of [Chapter 45 of the Oklahoma Administrative Code]." [Okla. Admin. Code § 785:45-1-2]. Similarly, the Arkansas portion of the IRW has been designated a "nutrient surplus area [] for phosphorus and nitrogen" by the Arkansas legislature. [Ark. Code § 15-20-1104(a)(1)].

355. The State's expert, Dr. Johnson, testified that the land application of poultry waste has substantially increased the STP of the soils in the IRW in the areas where it has been applied. [TR at 5093:14-23 (Johnson)].

356. Dr. Johnson opined that the IRW produces more poultry waste than can be agronomically used within the watershed. [TR at 5092:25-5093:5 (Johnson)]. His opinion was based on STP levels of fields where poultry litter had been land-applied. Defendants' expert, Dr. Rausser, criticized Johnson's conclusion because it was based only on STP levels on land on which poultry litter had been applied. Dr. Rausser opined that while poultry waste could not be agronomically used on lands on which poultry litter had been overapplied, it could be redistributed to other lands within the IRW where overapplication had not occurred. [TR at 10165:6-10167:11 (Rausser)].

357. STP levels at certain of defendants' own growing operations have been high. A 2003 soil test report for the George's Defendants' Ritter Farm located in Arkansas reflects STP values of 1213, 1689, 2166, and 1093. [OK Ex. 2790B]. A 1999 nutrient management plan for the George's Defendants' Morrison Farm, also located in Arkansas, reflects STP values of 790, 671, 948, 790, 770, 700, and 657. [OK Ex. 6287]. A 2000 document containing soil tests for the Tyson Defendants' Tyson Research Farm located in Arkansas reflects STP values of 726, 717, 506, 462, and 386. [OK Ex. 6535]. Soil tests for the Cargill Defendants' Cargill Breeder Farms located in Arkansas reflect STP values of 797 and 972. [OK Ex. 3337].

358. ODAFF records introduced at trial reflect STP values in excess of 120 for a number of fields belonging to defendants' growers. [Doc. 2873, Ex. A (summarizing STP results for growers)]. The summary chart shows more than 170 instances in which growers' fields had STP values in excess of 120 between July 1, 1997 and February 2, 2007. [*Id.*]

359. Representatives of each defendant testified their companies rely on local, state and federal regulations and state inspectors to ensure that the contract growers are implementing sound environmental practices. [TR at 3316:20-3317:6 (Keller, former Tyson employee)]; TR at 4143:16-4144:16; 4146:12-17 (Simmons, Simmons representative); TR at 4308:3-4309:4 (McClure, George's representative); TR at 4450:23-4451:7 (Storm, Cal-Maine representative); TR at 4732:5-4733:3, 5734:14-4735:5; 4735:16-4736:9, 4771:21-4773:4, 4777:19-4778:7 (Maupin, Cargill employee); TR at 4797:12-24; 4809:23-4810:13; 4831:15-23; 4832:13-19; 4834:7-4835:9, 4839:5-25, 4843:8-18 (Houtchens, Peterson representative; Ct. Ex. 7 (Butler Dep.) at 78:07-78:15 (Cobb Vantress representative)]. Company representatives testified they believe the state and federal regulators have the technology and expertise to ensure poultry litter is handled in an environmentally responsible manner. [*Id.*]

360. However, defendants do little to nothing to monitor or control their growers' disposal of poultry waste. Defendant Simmons' representative, Mark Simmons, testified that before his company contracts with a grower, it requires him to agree to follow the law, but it does not investigate whether the grower has appropriate places to dispose of poultry waste. [TR at 4192:13-23 (Simmons)]. Simmons testified, "Litter is the property of the grower, and we have asked our grower to adhere to State law. And that is what I believe is the limit of our authority." [TR at 4190:22-4191:3 (Simmons)]. The Tyson Defendants, for a period of time, required their contract growers to submit litter usage reports and maintained that information on a nutrient management spreadsheet. [TR at 3336:22-3337:16 (Keller)]. The practice was discontinued because "it was an overwhelming task for the live production managers." [TR at 3340:8-19 (Keller)]. Defendant Peterson never tracked what its growers did with the poultry waste generated by its birds and it did not direct what its growers did with the litter after they took it out of the houses. [TR at 4802:7-9 (Houtchens); TR at 3969:21-25 (Henderson)]. From 2002 to 2004, the Cargill Defendants worked on a project (the "Precision Ag" project) aimed at potentially moving poultry waste out of their Springdale complex to southeast Kansas. [TR at 4704:20-4705:3 (Maupin); OK Ex. 6168-A]. As part of the Precision Ag project, the Cargill Defendants conducted a search and comparison of STP levels in northwest Arkansas and surrounding areas. [OK Ex. 6138-A2]. A map generated by the Cargill Defendants in connection with the Precision Ag project shows that northwest Arkansas/northeast Oklahoma is an area with high STP levels. [OK Ex. 6138-A2]. Although some litter was moved on a "small scale," the project was discontinued because, at the time, it was not profitable. [TR at 4707 (Maupin)]. Currently, while the Cargill Defendants place "a large number of birds in the IRW," they do nothing to directly manage the poultry litter generated by their birds. [TR at 4756:12-20; 4757:15-24 (Maupin)]. The

George's Defendants now transport all of the poultry waste generated at its company-owned farms out of the IRW, but they do not transport out any of the waste generated on their contract growers' farms. [TR at 3058:9-22 (M. Henderson)]. The George's Defendants take no responsibility for the poultry waste land application practices of their contract growers, and do not know whether the growers actually comply with their nutrient management plans. [TR at 3026:23-3027:1; 3079:5-8 (M. Henderson)]. The Cal-Maine Defendants placed all responsibility for poultry waste disposal on their contract growers. [TR at 4421:7-11 (Storm)]. Cal-Maine has never had an environmental division or any employee in charge of environmental matters, despite being the largest egg-producing company in the country. [TR at 4454:3-12 (Storm)].

5. Summary

361. Based on the foregoing, the court finds that the majority of the poultry waste generated by each of defendants' birds has been land applied in the IRW, usually on or in close proximity to the growers' farms.

362. Land application of poultry waste has caused the soil in many areas of the IRW to have STP levels in excess of any agronomic need for phosphorus.

363. Historically, defendants have done little—if anything—to provide for or ensure appropriate handling or management of the poultry waste generated by their birds at their growers' houses. The evidence adduced at trial establishes that none of the defendants took any steps to do so.

M. Land-Applied Poultry Waste as a Source of High P Loading in the IRW

364. The State relies on 12 "lines of evidence" to prove that land-applied poultry waste is a source of high phosphorus loading in the IRW: (1) government reports; (2) evidence of the mass of poultry waste generated in the IRW; (3) evidence of phosphorus loading from nonpoint sources;

(4) mass balance analysis, (5) evidence of the geology of the IRW; (6) chemical ratio analysis; (7) pathway concentration analysis, (8) Lake Tenkiller geochronological sediment analysis; (9) poultry house density analyses; (10) modeling analysis; (11) upstream/downstream sampling; and (12) direct observation. The Court addresses two additional categories of evidence: (13) testimony by one of defendants' own experts, and (14) defendants' admissions.

1. Government Reports

365. In a 2008 report mandated by 82 Okla. Stat. § 1457(c) and titled "Coordinated Watershed Protection Strategy for Oklahoma's Impaired Scenic Rivers," the Office of the Oklahoma Secretary of the Environment reported that "[t]he single largest contributor of nonpoint source of phosphorus pollution is surplus poultry litter generated by the integrators' flocks." [OK Ex. 5662 at p. 3; *see also* OK Ex. 5664 at p. 4; OK Ex. 5665 at p. 4].

366. The Oklahoma Conservation Commission, in a May 1999 report entitled Comprehensive Basin Management Plan for the Illinois River Basin in Oklahoma, noted a decline in water quality in Illinois River Basin and stated:

> Land use analysis correlated this decline in water quality to dramatic changes in land use in the basin. Agriculture increased substantially in the basin in the form of confined animal feeding operations (CAFOs), primarily poultry operations, and forest land continues to be cleared for pasture and hay production. Overall, these land use changes resulted in a net increase in the amount of nutrients entering the watershed (primarily through animal feed) without a concomitant increase in the amount being exported from the watershed. The resulting imbalance in the nutrient import/export cycle is manifested in the water quality of the basin.

[DJX-0640 at p. iii].

367. In a report titled "The Illinois River Management Plan 1999," the Oklahoma Scenic Rivers Commission, Oklahoma State University, and the National Park Service stated:

> In recent years, there has been significant expansion of confined animal production, particularly broilers, in the Illinois River Corridor . . . . Poultry wastes are typically applied to nearby pasture land. Mismanagement of these applications can result in

> runoff of nutrients (nitrogen and phosphorus) to streams in the watershed. These occur in rainfall runoff as well as in shallow groundwater flow. *Increased nutrient loading in tributaries impacted by poultry production, as well as, downstream effects are documented.*

[DJX-0147 at p. 67 (emphasis added)].

368. The United States Geological Service ("USGS"), in its 2006 report, "Phosphorus Concentrations, Loads, and Yields in the Illinois River Basin, Arkansas and Oklahoma, 2000-2004, concluded:

> Phosphorus concentrations in the Ozark streams are typically greater in streams draining agricultural lands than in those draining forested lands (Petersen and other, 1998; 1999) because *runoff from pastures fertilized with animal manure are probably substantial sources of phosphorus to the rivers in this basin* (Arkansas Department of Environmental Quality, 2000).

[OK Ex. 5862 at p. 4 (emphasis added); *see also* OK Ex. 5861 at p. 2].

369. In a 1992 report titled "Illinois River Cooperative River Basin Resource Base Report," the United States Department of Agriculture stated:

> A significant part of the water quality problems in the basin appear to be a precipitate of the large volume of poultry waste generated and disposed of in the basin each year.

[OK Ex. 3351 at OSU0005179].

370. The chief of the Water Management Division of the Arkansas Natural Resources Commission, Earl Smith, Jr., affirmed the accuracy of the statement in the draft Conservation Reserve Enhancement Program Agreement for the Illinois River Watershed in Arkansas that "nonpoint source impacts affecting the waters in this segment are primarily from pastureland that is also used for application of poultry litter as fertilizer." [TR at 9603:24-9604:13, 9609:24-9610:5; OK Ex. 3366 at A-6].

371. The court finds these government reports to be reliable and accords them considerable weight.

2. Mass of Poultry Waste Generated/Method of Disposal

372. As previously discussed, defendants' birds generate from 354,000 tons per year to 528,000 tons per year of poultry waste in the IRW. [*See* FF #334]. The poultry waste is land-applied throughout the IRW, and is not incorporated into the soil upon which it is spread. [*See* FF ##340-41]. The poultry waste is typically applied in close proximity to where it is generated, and in some fields has been applied at rates in excess of agronomic need. [*See* FF ##343, 362].

373. The fact that poultry waste is not incorporated into the soil is significant in terms of fate and transport because "the surface of the land is where the rain lands, so that's where runoff is generated." [TR at 1852:16-1853:10 (Fisher)]. Both Dr. Johnson and defendants' expert Dr. Connolly testified that long-term land application of manure at rates in excess of agronomic need elevates the level of phosphorus in the soil and increases the concentration of phosphorus in the runoff. [TR at 5028:3-10, 5029:18-22 (Johnson); *see also,* OK Ex. 3312 at ADEQ-226 (stating "[n]itrogen and phosphorus should be applied at a rate not greater than what cover plants can assimilate . . . Excess values built up in the soil will be washed into surface waters whenever erosion occurs")].

374. The concentration of poultry operations also figures into the phosphorus loading analysis. The Oklahoma Conservation Commission's Comprehensive Basin Management Pan for the Illinois River Basin in Oklahoma states, "[t]he disposal of wastes produced by these facilities provides a serious management dilemma for landowners as the amount of animal wastes produced exceeds the amount of land available for waste application." [DJX640 at p. 89]. It further states that "the soils in the watershed are becoming phosphorus-saturated. Additional applications of litter result merely in higher concentrations of nutrients in runoff, rather than increased forage growth." [*Id.*]

375. Even years after the cessation of poultry litter application, runoff water quality can be affected because of phosphorus stored in the soil. [Ct. Ex. 8, B. Haggard Dep. at 9:08-16]. Runoff from a soil that contains phosphorus carries phosphorus that is dissolved in water. Additionally, where erosion is involved (which is likely the case in intensive rainfall events), phosphorus that is adsorbed to particles will also move off with the water. [TR at 5027:15-5028:2 (Johnson)]. Further, as a result of the equilibrium effect described above, water-soluble phosphorus carried off the surface is replaced by de-adsorbed phosphorus from soil surface particles and also by dissolving of solid phase phosphorus. Thus, the soil continues to put out more and more water soluble phosphorus at the surface where it can become part of water moving downslope and be transported. [TR at 5037:12-17 (Johnson)]. The equilibrium effect predominantly occurs in the top two inches of the soil. [TR at 5037:21-5038:3 (Johnson)].

376. The court finds Dr. Johnson's testimony believable and largely uncontroverted, and therefore accords it substantial weight.

3. Phosphorus Loading from Nonpoint Sources

377. Defendant's expert Dr. Connolly testified that wastewater treatment plants account for 15-18 percent of the total amount of phosphorus entering Lake Tenkiller. [TR at 8922:8-20; *see also* TR at 10907:23-25 (Sullivan) (agreeing that the total point-source contribution to the lake is currently less than 20 percent)]. Dr. Connolly estimated nonpoint sources account for 82 percent of the phosphorus in the waters of the IRW. [TR at 9142:5-8 (Connolly)].

378. The phosphorus in nonpoint source runoff is mostly dissolved phosphorus. [TR at 9298:11-9299:4 (Connolly)]. Nonpoint sources directly contribute soluble reactive phosphorus to the waters of the IRW. [TR at 9134:24-9135:7; 9129:12-17; 9133:24-9134:8 (Connolly)]. Under natural rainfall conditions, concentrations of nonpoint source soluble reactive phosphorus can be

equal to or greater than such concentrations from wastewater treatment plants. [TR at 9412:24-9413:7 (Connolly)].

379. Poultry waste leachate contains high concentrations of soluble reactive phosphorus and the State's edge-of-field sampling data show that about 50 percent of the phosphorus in nonpoint runoff from fields that have received land applied poultry waste is soluble reactive phosphorus. [TR at 5233:2-10; 5235:10-15; 5258:4-11; 5356:17-19 (Olsen)].

380. As admitted by defendants' own expert, nonpoint sources are responsible for 82 percent of phosphorus loading of the waters of the IRW. The court accords this evidence great weight in its evaluation of the State's case.

4. Mass Balance Analysis

381. The State retained Dr. Bernard Engel[25] to conduct a mass balance analysis. A mass balance analysis is a study of the inflows to and outflows from a watershed. [TR at 5978:5-14 (Chaubey)]. Defendants' expert, Dr. Connolly, explained:

> Mass balance is a tool. Mass balance is used in the context of fate and transport in order to help evaluating fate and transport. Mass balance is, more specifically, a statement of conservation of mass, that mass can be neither created nor destroyed so that fate and transport calculations and analyses are essentially tracking mass. They're conforming to conservation of mass. They quantify sources, they quantify syncs. And mass balance is looking at the fate and transport within the environment.

[TR at 8842:6-17(Connolly)]. Further:

> Fate and transport is a term of art that's common in our field. And it refers to all of the physical, chemical and biological processes that affect a pollutant as that pollutant moves from its original source to its final destination, and how those

[25] Dr. Engel holds a Ph.D. in agricultural engineering from Purdue University. [TR at 5639:12-20 (Engel)]. He is head of the agricultural and biological engineering program at Purdue. [TR at 5641:11-5642:4 (Engel)]. He served as the court-appointed special master in *City of Tulsa v. Tyson Foods, Inc.*, and was charged with assessing the hydrologic water quality monitoring done in the case. [TR at 5663:3-15 (Engel)].

> processes interact and how they affect the movement and the ultimate disposition of the pollutant.

[TR at 8841:24-8842:5 (Connolly)].

382. Dr. Engel undertook his mass balance analysis in order to: (1) understand the movement of phosphorus into and out of the IRW; (2) identify the most substantial sources of phosphorus moving in and out of the IRW; and (3) identify the sources necessary to include in subsequent analyses, including his watershed modeling analysis. [TR at 5811:14-22 (Engel)]. Regarding this case, Engel testified:

> [T]he mass balance indicates an inflow of nutrients into the watershed and many of those are placed on the landscape within the watershed, and as rainfall interacts with them, they're going to move off-site into the streams, rivers, and ultimately to Lake Tenkiller.
>
> So myself, as well as others who have done mass balances, have found them to be a very important tool in understanding the potential fate and transport of materials like phosphorus.

[TR at 6621:16-25 (Engel)]. The mass balance analysis Dr. Engel conducted in this case was similar to another watershed mass balance analysis he previously conducted. [TR at 5787:5-11 (Engel)].

383. Dr. Engel selected the following phosphorus input sources for inclusion in his mass balance analysis: humans, poultry, swine, dairy cattle, beef cattle, heifers that calved, commercial fertilizers, golf courses, urban runoff, wholesale nurseries, recreational users and industrial users. [TR at 5823:18-5824:6 (Engel); OK Ex. 1091]. With respect to removals of phosphorus, he evaluated the Lake Tenkiller spillway, harvested crops, harvested deer and beef cattle sold. [TR at 5825:1-15 (Engel); OK Ex. 1091]. Dr. Engel selected these input and removal sources based upon his experience in doing mass balance analyses, published literature that has identified sources of

phosphorus in the IRW and his own personal experience with the IRW. [TR at 5824:7-16; 5825:9-15 (Engel)].

384. The data sets Dr. Engel relied upon in conducting his mass balance analysis are of the type typically relied upon by other experts. For example, he used the United States census to determine the number of humans within the IRW. [TR at 5812:23-5813:6 (Engel)]. His livestock population data were derived from the United States agricultural census, which is typically relied upon by scientists in evaluating the nutrient impacts of livestock. [TR at 5813:22-5814:18 (Engel)]. His land use/land cover data were taken from the USGS national land cover data set, which is also traditionally used by scientists to perform mass balance analysis of watersheds. [TR at 5814:19-5815:2 (Engel)].

385. Once the sources were selected and data were assembled, Dr. Engel performed calculations for each of the identified sources. With respect to livestock animals, he utilized data going back to 1949 to determine historical phosphorus inputs in five-year increments. [TR at 5827:5-5828:11 (Engel)]. In calculating the phosphorus inputs for livestock, he first identified the life cycle and weights of each animal group, and obtained phosphorus information from the USDA waste characterization handbook. [TR at 5835:25-5836:15 (Engel)]. Applying a mathematical formula to the data, he calculated the phosphorus inputs for each of the livestock animal groups. [*Id.*]

386. In calculating phosphorus inputs from livestock animals, cattle were treated somewhat differently from the other animal groups. Dr. Engel determined that cattle are mostly recycling phosphorus in the IRW. [TR at 5836:23-5837:7 (Engel)]. That is, because cattle are largely consuming grass and hay, most phosphorus excreted by them already existed within the IRW and is simply being recycled. [TR at 5837:8-20 (Engel)]. The only true phosphorus additions from

beef cattle come from feed supplements; thus, cattle are not "net creators or excretors" of phosphorus in the IRW. [TR at 5794:9-5795:12 (Engel)]. In contrast, the phosphorus in feed consumed by other livestock animal groups such as poultry, swine and dairy cattle is imported into IRW. [TR at 5838:2-9, 5838:16-20 (Engel)].

387. Dr. Engel's calculations for urban runoff and wholesale nurseries differed from the calculations of the other sources. He concluded the best way to determine the net movement of phosphorus from urban runoff and wholesale nurseries was to examine the amount of expected water actually leaving those areas and the concentration of phosphorus in that runoff. [TR at 6622:9-6623:21 (Engel)]. He identified urban runoff areas from the national land cover data, utilized a value of phosphorus in urban runoff and ran the LTHIA (Long-Term Hydrologic Impact Assessment) model to calculate the amount of phosphorus that would actually run off from urban areas in the IRW. [TR at 5845:13-23 (Engel)]. Dr. Engel developed the LTHIA model primarily to look at the impacts of urbanization of land uses on runoff and nonpoint source pollution. [TR at 5657:9-17 (Engel)]. He testified the LTHIA model has been used by himself, as well as other scientists, in work published peer-reviewed journals. [TR at 5657:18-22 (Engel)].

388. With respect to wholesale nurseries, Dr. Engel made an assumption that 20 inches of water ran off from the nurseries per year—an amount he characterized as "a rather large number." [TR at 5847:4-7 (Engel)]. He also relied on a report that identified the concentrations of phosphorus being discharged from nurseries within the IRW. [TR at 5847:9-12 (Engel)]. An equation that relates area, runoff and concentration was used to calculate the mass of phosphorus entering the waters of the IRW from nurseries. [TR at 5847:12-15 (Engel)]. Dr. Engel's nurseries input analysis was a standard method used by scientists to measure the nutrient contribution of nurseries in a watershed mass balance. [TR at 5847:22-5848:2 (Engel)].

389. After making his phosphorus input calculations for each identified source, Dr. Engel conducted his phosphorus removal analysis. For his harvested crops removal calculation, he obtained agricultural census data by area of the crops produced for the amounts produced historically. [TR at 6196:12-19 (Engel)]. For the cattle removal, Dr. Engel again relied on agricultural census data for sales of cattle outside the IRW. [TR at 6196:20-22 (Engel)]. Values that describe phosphorus within cattle flesh were obtained from the American Society of Agricultural Engineers. [TR 6196:23-6197:3 (Engel)]. The same approach was used with respect to deer. [TR at 6197:4-8 (Engel)]. For phosphorus leaving Lake Tenkiller through the power generation portion of the spillway, Dr. Engel obtained data as to the amount of water leaving the spillway and the modeled phosphorus content of the water at the depth at which the phosphorus would be removed and conducted simple multiplication to figure the mass of phosphorus removed by that source. [TR at 6197:9-15 (Engel)].

390. The removals from all sources were summarized historically in a table and placed in the report. [TR at 6197:22-25 (Engel)]. The removals were combined with the additions to obtain net inputs of phosphorus into the IRW watershed. [TR at 6198:1-6 (Engel); OK Ex. 1217].

391. Based on his mass balance analysis, Dr. Engel concluded that the percentage of current net phosphorus additions to the IRW by source is as follows: poultry—76.2 percent; human—3.2 percent; swine—2.9 percent; dairy cattle—5.2 percent; beef cattle—1.7 percent; commercial fertilizer—7.5 percent; urban runoff—0.5 percent; industrial sources—2.7 percent; and all other sources (including wholesale nurseries and golf courses)—0.2 percent. [TR at 6202:21-6203:18; OK Ex. 1154].

392. Using historical data, Dr. Engel also determined that net phosphorus inputs to the IRW had changed over time. Specifically, net phosphorus inputs from poultry increased from 9 percent

of total net phosphorus input in 1949, to 55 percent in 1964, and to 76 percent in 2002. [TR at 6200:15-6201:23 (Engel); OK Ex. 1217].

393. Based upon his mass balance analysis, Dr. Engel opined that—from 1964, when the input exceeded 50 percent, to the present—poultry production has been "the major contributor of phosphorus" to the IRW. [TR at 6207:13-6208:8]. Further, he concluded that from 1949 through 2002, poultry has been responsible for approximately 148,000 tons—or about 68 percent—of the total phosphorus additions of 219,000 tons to the watershed. [TR at 6208:11-24].

394. In a 2002 report commissioned by the Arkansas Water Resources Center and titled "Illinois River Phosphorus Sampling Results and Mass Balance Computation," researchers concluded that during the period of 1997 through 2001, poultry broilers were the most significant contributor of phosphorus loading to the IRW. [TR at 5984:4-5990:16 (Chaubey); OK Ex. 0513].

395. Defendants criticize Engels' mass balance analysis on a number of bases. They contend he did not actually conduct the mass balance analysis himself, but relied on an assistant, Meagan Smith, to do the analysis. However, the evidence established that Smith primarily assisted Dr. Engel with the collection of data and computations. [TR 5787:12-19 (Engel)]. Dr. Engel spent approximately 150-200 hours working on the mass balance analysis. [TR at 5798:12-23 (Engel)]. Engel reviewed Smith's work multiple times and determined that it was reliable and consistent with his directions. [TR at 5798:12-23 (Engel)]. Smith worked under the direction of Dr. Engel, who supervised her work through frequent communication. [TR at 5789:25-5790:9 (Engel)].

396. Defendants also assert the State has not offered any fate and transport analysis demonstrating the movement of phosphorous from poultry litter-amended fields to waters used for recreation or drinking water in the Oklahoma portion of the IRW. However, the State's expert, Dr. Fisher opined:

> Because [poultry] wastes were all similar and the behavior of that waste under the influence of rainfall and gravity is all similar or the same, the waste is fungible, its behavior is fungible, there's no reason to do a site-specific analysis of fate and transport in the Illinois River Watershed. If the waste is put on the ground, it will end up in the streams.

[TR at 1859:14-1860:1 (Fisher)].

397. Defendants' expert Dr. Timothy Sullivan criticized Engel's mass balance because it focused on phosphorus coming into and leaving the IRW as a whole, instead of phosphorus actually going into and exiting the *waters* of the IRW. [TR at 10660:9-10661:12 (Sullivan)].

398. The court recognizes that Dr. Engel's mass balance analysis is not necessarily dispositive concerning the issue of how much phosphorous from poultry waste actually reaches the waters of the IRW. However, the court finds it is helpful in assessing the amount of phosphorus being introduced into the IRW. Therefore, the court accords Dr. Engel's mass balance analysis some weight.

5. Geology of the IRW

399. The topography, hydrology, geology and soils of the IRW clearly influence fate and transport of contaminants in the IRW. [TR at 1593:13-20 (Fisher)].

400. As previously noted, the topography of the IRW is higher in the east and lower in the west and southwest. [OK Ex. 3351 at OSU0005148; TR at 1594:25-1595:1 (Fisher)]. There is very little flat land in the IRW. [TR at 1598:3-7 (Fisher)]. Surface hydrology is determined by the IRWs topography. [TR at 1594:2-3 (Fisher)]. Additionally, groundwater flow follows underlying fractures in the IRW. [TR at 1604:25-1605:21 (Fisher)]. Surface water and groundwater in the IRW are "fairly closely linked." [TR at 1606:14-21 (Fisher)]. The geology of the IRW is one of mantled karst. [TR at 1608:12-15 (Fisher)]. The soils in the IRW generally have intermediate to high run-off potential. [OK Ex. 3351 at OSU0005159-60; TR at 1609:16-

1610:6 (Fisher)]. Activities on the soil surface affect ground water because rainfall will mobilize soluble materials as well as small particulates and move them downward to infiltrate groundwater. [TR at 1625:19-1626:3 (Fisher)]. Further, because the karst geology is characterized by fractures, faults and joints, there is very little soil filtering of groundwater in the IRW. [TR at 1626:4-10 (Fisher)]. Dr. Fisher testified there is no area within the IRW that does not generate runoff. [TR at 1598:8-16 (Fisher)].

401. Dr. Dwayne Edwards[26] testified that "the potential for water quality degradation from eutrophying nutrients (nitrogen and phosphorus) . . . is particularly high, especially in areas such as northwest Arkansas where shallow, cherty soils and karstic geology greatly increase interaction between surface and ground water." [Ct. Ex. 11 at 9 (Edwards Dep.)].

402. The court accords great weight to the uncontroverted evidence that the geology of the IRW permits and/or contributes to phosphorus contamination of the waters of the IRW.

6. Chemical Ratio Analysis

403. The State's sixth line of evidence is a chemical ratio analysis conducted by Dr. Bert Fisher. Fisher analyzed constituents in poultry waste, cow manure, and wastewater treatment plant discharges and concluded that, with respect to several factors, poultry waste differs chemically from cow manure and wastewater treatment plan discharges, and that those differences can be expressed in ratios of phosphorus, copper, zinc and arsenic. [TR at 1824:20-1837:24 (Fisher); OK Ex. 2525]. Dr. Fisher then examined the chemical concentrations and ratios found in the State's soil, edge-of-field, stream sediment, groundwater and lake sediment samples and—he

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[26] Dr. Edwards, an expert for defendants, holds a Ph.D. from Oklahoma State University, and has been a professor in the biosystems agricultural engineering department at the University of Kentucky since 1993. [Court's Ex. 11 at p. 2 (Edwards Dep.)]. Before that, he was an assistant professor from 1988-1993 and an associate professor from 1993-1994 in the department of biological and agricultural engineering at the University of Arkansas. [*Id.*]. Dr. Edwards' research has included study of land use practices and their effect on water quality in northwest Arkansas. [Court's Ex. 11 at pp. 9-10].

claims—was able to identify or track the presence of poultry waste through each of those environmental media. [TR at 1976:14-1977:23; 1996:22-1997:16; 2036:10-18; 2057:25-2058:7; 2083:18-2084:14; 2146:20-2147:2; 2164:19-2166:8 (Fisher)].

404. Dr. Fisher testified that in attempting to track any source of contamination, it is important to determine whether there are any chemical characteristics that make that source unique. [TR at 1821:22-1822:1 (Fisher)]. He stated that in this case, the analysis:

> allows you to identify poultry waste present in the environment both in terms of what's a reasonable source as it relates to the concentrations of materials that are found in the environment. In addition, it allows you to make some statements concerning the origin of that material once you account for any changes due to transportation. It would be part of a transport and fate analysis.

[TR at 1832:17-1833:8 (Fisher)].

405. An animal's waste is a function of its diet; therefore, "[p]oultry waste will reflect the feeds that they're given." [TR at 1800:12-13, 17-18 (Fisher)]. Since each defendant supplies the feed consumed by its birds in the IRW [*See* FF #297], Dr. Fisher sampled defendants' feed and reviewed their feed formulas. [TR at 1793:12-25 (Fisher)]. He testified that defendants' feeds "may differ a bit, but they're all pretty much the same." [TR at 1800:14-15 (Fisher)].

406. Dr. Fisher concluded that "the feeds are compounded with very high levels of copper and zinc compared to the nutritional requirements." [TR at 1794:12-21]. In addition, defendants add phosphorus to the feeds to maintain the bone strength necessary to support rapid growth and to prevent bone breakage during processing. [TR 1796:4-24 (Fisher)]. Defendants—with the exceptions of Cal-Maine and the Tyson Defendants—have also included an organic arsenic compound in the feeds. [TR at 1794:24-1795:3; 2694:13-22 (Fisher)]. Dr. Fisher testified that both the compounded feed and the waste produced by the chickens are high in phosphorus, zinc, copper, and frequently arsenic. [TR at 1822:2-12 (Fisher)]. Dr. Fisher's analysis of the

constituents of poultry waste is comparable with analyses in other published materials. [TR at 1823:4-1824:7; 2812:12-2813:4; 2818:9-16; 2818:17-2819:7; 2825:6-2827:13; 2828:2-2829:9 (Fisher)].

407. Dr. Fisher then compared the chemical composition of poultry waste with that of cattle waste and wastewater treatment plant effluent. [TR at 1824:8-11 (Fisher)]. He found that poultry waste differs from both cattle waste and wastewater treatment plant effluent. [TR at 1829:13-19]. He expressed these differences in ratios of total zinc to total phosphorus (Zn:P), total copper to total phosphorus (Cu:P), total arsenic to total phosphorus (As:P), and total zinc to total copper (Zn:Cu). [OK Ex. 2518].

408. Dr. Fisher testified cattle waste has a much lower concentration of phosphorus than poultry waste, extremely low concentrations of zinc and copper, almost no arsenic, and a different ratio of zinc and copper. [TR at 1824:20-25 (Fisher)].

409. Similarly, he testified that wastewater treatment plant wastes have relatively low levels of phosphorus and a very different zinc-to-copper ratio than poultry waste. [TR at 1825:2-8; TR at 1833:15-16 (Fisher) ("wastewater treatment plant waste is much richer in zinc or much more depleted in copper than poultry waste"); OK Ex. 2518].

410. Fisher testified that finding materials with high concentrations of copper, zinc, and phosphorus indicates that the source is poultry waste. [TR at 1836:20-25 (Fisher)].

411. In analyzing various environmental media, Dr. Fisher first looked at ODAFF records, records produced by defendants, and investigator reports which identified sections in which poultry waste had been land applied. [OK Ex. 2516; TR at 1951:20-1954:4 (Fisher)]. He testified those locations were co-located with the locations of poultry houses and spanned much of the open space within the IRW. [TR at 1954:9-17 (Fisher)]. He sampled only fields of poultry growers

affiliated with defendants. [TR at 1964:9-1965:3 (Fisher)]. He sampled 73 fields affiliated with every defendant except Cal-Maine, which was no longer active in the watershed at the time. [TR at 1965:4-8 and 19-21; 1966:15-20].

412. Dr. Fisher compared the concentrations of phosphorus, copper, zinc, and arsenic in the top two inches of the soil to those in the deeper depths and found the concentrations in the deeper depths were much lower than those in the top two inches. [TR at 1776:24:1777:5 (Fisher)]. He found that the ratio of copper to zinc in the upper two inches of soil to which poultry waste had been applied is consistent with the ratios he found in poultry waste. [TR at 1977:6-9 (Fisher)]. He found that pattern of higher contamination at the surface and lesser or none at depth to be consistent with surface application, which is how poultry waste is applied. [TR at 1977:8-12 (Fisher)]. Additionally, he found the concentration of phosphorus in the soils, especially the surface two inches, and the concentrations of copper, zinc, and arsenic in the poultry-applied fields were inconsistent with contamination from cattle waste, because he "simply can't make the concentrations of phosphorus, copper, zinc, and arsenic that [he] observe[d] in the top two inches of the 73 sample fields by mixing cattle waste into those soils." [TR at 1977:13-23 (Fisher)].

413. Based on his analysis, Dr. Fisher further concluded that the constituents of poultry waste present on land-applied fields (*i.e.*, phosphorus, copper, zinc, and arsenic) are "available for transportation," meaning that they could exit the field in runoff or infiltrate as dissolved constituents in water. [TR at 1997:3-16 (Fisher)].

414. Next, Dr. Fisher analyzed the edge-of-field runoff samples collected by the State. [OK Ex. 2500]. He selected edge-of-field sampling locations based on historical land application records, eyewitness reports of land application, aerial photograph review and topographic infradata. [TR at 2708:7:2709:6 (Fisher)]. Based on the edge-of-field data, he concluded that

runoff from fields where poultry waste had been land applied contains constituents from poultry waste—namely phosphorus, zinc, copper, and arsenic, and that every time there is runoff, poultry constituents move into the watershed and down gradient. [TR at 2033:22-2034:11; 2036:10-18 (Fisher); OK Ex. 2500].

415. After analyzing edge-of-field runoff samples, Dr. Fisher examined the State's stream sediment sampling data. [OK Ex. 2503; TR at 2036:19-24 (Fisher)]. He chose to perform an analysis of stream sediment data because stream sediments are down gradient from edge-of-field runoff sites and because streams contain sediments that have moved from areas at higher elevations, up gradient. [TR at 2036:25-2037:6 (Fisher)]. The stream sediment analysis was important in the evaluation of the fate and transport because the chemical composition of the sediments could be examined in comparison with poultry waste and for the transport history. [TR at 2037:7-14 (Fisher)]. Dr. Fisher and his investigation teams selected approximately 100 stream sampling locations where there were gradient changes that might result in the accumulation of finer-grain material, because that is typically where pollutants such as phosphorus, zinc, copper and arsenic would reside and be concentrated. [TR at 2037:15-2038:12 (Fisher)]. Sediment samples from those locations were analyzed for, *inter alia,* total phosphorus, total zinc, total copper and total arsenic. [TR at 2038:13-18 (Fisher); OK Ex. 2503]. The sediments showed "some fairly substantial" enrichments in phosphorus, as well as in zinc, and some enrichments in copper compared to control soils; and "[t]hey're consistent with putting constituents of poultry waste in the stream sediments and leaching away of the copper." [TR at 2057:14-21 (Fisher)]. Fisher testified the arsenic data "is a little more problematic, but it suggests that arsenic is accumulating in stream sediments." [TR at 2057:22-24 (Fisher)]. Dr. Fisher concluded, based on

his analysis of the samples, that poultry waste is contaminating stream sediments in the IRW. [TR at 2057:25-2058:8 (Fisher)].

416. Dr. Fisher also analyzed groundwater within the IRW. [TR at 2059:20-24 (Fisher)]. He sampled natural resurgences of underground water at springs, some water wells, and water from shallow alluvial aquifers (geoprobe samples). [TR at 2060:1-6 (Fisher)]. As previously discussed, groundwater is susceptible to contamination from surface contaminants because the soils are relatively thin and permeable and the IRW has a karst-type geology with large conduits to move contaminants. [TR at 2060:9-13 (Fisher)].

417. Dr. Fisher compared the concentrations of contaminants in the groundwater samples with those in edge-of-field samples. [OK Ex. 2502]. He testified, with respect to zinc and copper concentrations, that "the edge-of-field samples truly do blend seamlessly . . . with samples collected from the geoprobes and from the springs." [TR at 2079:17-25 (Fisher); OK Ex. 2502]. He concluded that because cattle waste contains low levels of zinc and copper, "the only reasonable source for high levels of zinc and copper" found in the springs and alluvium is poultry waste. [TR at 2080:15-18; 2082:6-12]. Dr. Fisher testified the copper and zinc data coupled with elevated phosphorus levels in groundwater and high levels of arsenic in one stream suggest that poultry waste is entering the ground waters of the IRW. [TR at 2080:9-14; 2083:7-27; 2084:1-14 (Fisher); Ex. 2052].

418. Finally, Dr. Fisher evaluated Lake Tenkiller sediments. [TR at 2084:17-19 (Fisher)]. He did so because Lake Tenkiller is, in his words, the "end of the line for sediments" in the IRW. [TR at 2084:20-2085:8 (Fisher)].

419. In investigating the lake sediments, Dr. Fisher took core samples from four locations, cut the cores into depth segments, analyzed the depth segments chemically and, by looking at the

content of lead-210, was able to obtain the "date of deposition for each sediment integral." [TR at 2086:2-10 (Fisher)]. According to Dr. Fisher, this process permits the reconstruction of a history of chemical inputs to the lake sediments. [TR at 2086:11-13 (Fisher)].

420. Dr. Fisher compared the composition of the lake sediment cores to the composition of control soils. [OK Ex. 2508; TR at 2131:21-2135:24 (Fisher)]. In analyzing the lake core sampling data, Dr. Fisher found that concentrations of zinc increased with the concentrations of total phosphorus; the concentration of total copper increased with the total concentration of phosphorus; and as copper increased, zinc increased. [TR at 2146:15-19 (Fisher); OK Ex. 2511]. He concluded that the source of contamination in the Lake Tenkiller sediments is poultry waste. [TR at 2146:20-2147:2 (Fisher)]. Dr. Fisher based this conclusion on his observations of similar chemical relationships in poultry waste, soils from land-applied fields, edge-of-field runoff and stream sediments. [TR at 2145:7-2146:11 (Fisher)]. He also found that the increase in poultry population in the IRW over time correlates with changes in phosphorus concentrations in Lake Tenkiller sediments. [TR at 2164:19-2166:8 (Fisher); OK Ex. 2513].

421. Dr. Fisher's ratios analysis is novel and unprecedented in the scientific literature. [TR at 2235:4-15; 2238:20-2239:2 (Fisher)]. Copper, zinc, phosphorus and arsenic occur in nature regardless of the presence of poultry litter, and have diverse sources. [TR at 2261:9-22; 2263:6-12 (Fisher); 9008:13-9009:2 (Connolly)].

422. Dr. Fisher's analysis assumes implicitly that phosphorus, zinc, copper and arsenic share common fate and transport characteristics; otherwise, finding them together in the environment would say nothing as to source. Yet Dr. Fisher admitted that this assumption is not well founded. [TR at 1995:24-1996:2; 2330:24-2331:15 (Fisher)]. Copper, zinc, arsenic and phosphorus exhibit different mobility, sorption and bonding characteristics. [TR at 9003:15-9008:17 (Connolly)].

The State's own data confirms that the ratios of these constituents are quite different in poultry litter and litter-amended soil than they are in the surface waters and sediments of the IRW. [TR at 9010:25-9021:2 (Connolly); DJX6096; DJX6105].

423. Additionally, defendants' expert Steve Larson, a hydrologist specializing in groundwater, testified that the Dr. Fisher's data did not demonstrate a relationship between the edge-of-field samples and groundwater samples. [TR at 9734:4-21 (Larson)]. Larson criticized Dr. Fisher's use of arsenic, copper, zinc and phosphorus as tracers because they do not share common fate and transport characteristics. [TR at 9693:6-10; 9695:16-9696:2 (Larson)]. He offered two reasons. First, some of the elements are considered cations in the subsurface and some are anions. [TR at 9693:11-20 (Larson)]. Copper and zinc have positive charges and, as a consequence, they react in a certain way with the environment, either in the water or associated with the solid media. [TR at 9693:20-24 (Larson)]. In contrast, phosphorus has a negative charge and reacts differently. [TR at 9693:25-9694:2 (Larson)]. Second, all four elements tend to be relatively immobile within the subsurface environment, that is, they have a tendency to either react to or absorb onto mineral surfaces, and they do so in different ways under different groundwater conditions. [TR at 9694:3-13 (Larson)]. As a result, some of those chemicals will adsorb more and some less, and as the water containing those elements moves through the groundwater environment they are affected either more or less, depending on their particular characteristics. [TR at 9694:14-19 (Larson)]. For example, zinc tends to be more soluble on a relative scale than copper and consequently, it may be more mobile than copper under certain circumstances. [TR at 9694:10-22 (Larson)]. Those differences in mobility affect how they might be transported through the environment and how their overall movement will occur. [TR at 9694:22-25 (Larson)]. Generally speaking, these elements tend not to be mobile within the groundwater environment; rather, they tend to be

"highly retarded," which means they tend to be adsorbed or react in the subsurface environment. [TR at 9695:1-5 (Larson)]. In contrast, other elements are "conservative," that is, they do not react or interact with the subsurface environment and consequently, they essentially move with the water. [TR at 9695:8-12 (Larson)]. Thus, if the water is moving at one foot per day, then that particular dissolved substance will also move at the rate of one foot per day. [TR at 9695:13-15 (Larson)]. Dr. Fisher's charts displayed the relationships between copper and phosphorus, zinc and phosphorus and arsenic and phosphorus together. Larson prepared charts comparing the data separately. [DJX1624, DJX1625, DJX1626, DJX1627, DJX1628]. He concluded "[t]he relationships you get from looking at the individual groups are different from the relationship that you get from looking at the edge-of-field information that's portrayed on here." [TR at 9698:10-17 (Larson)].

424. Defendants' expert Dr. Connolly rejects both Dr. Fisher's ratio analysis and Dr. Olsen's pathway analysis as attempts to "track [poultry waste] using chemicals that are ubiquitous in the watershed." [TR at 9002:2-8 (Connolly)].

425. Additionally, defendants criticized the State's edge-of-field sampling program as being insufficient in terms of documentation of water flow. Dr. Sullivan stated:

> The edge-of-field samples were collected largely from ditches. There was no permission granted to go onto the landowner's land and set up an apparatus with which to collect flow coming off of pastureland. And by and large, those samples were not collected from flowing water; they were collected from a ditch that was convenient to the road where the samplers could get without having permission to get onto the land.
>
> So there's no way to know where that water came from. Perhaps some of it came off a field. We don't know. It may have come from something upslope associated with that ditch. And if it did come off the field, we don't know what the source of phosphorus on the field was that may have contributed the phosphorus to the edge-of-field water.

[TR at 10751:7-23 (Sullivan)]. Dr. Sullivan testified that the edge-of-field sampling method also failed to document whether the water in the ditch "was flowing somewhere else or it just stayed in the puddle or that ditch and eventually infiltrated into the soil." [TR at 10753:2-5 (Sullivan)].

426. With respect to the source of the sampled ditch water, Fisher testified he was confident the samples were "representative edge-of-field runoff" because they "have run off this field or other fields nearby" and they've "interacted with local soils." [TR at 2712:8-17 (Fisher)]. He explained he had no concern that the runoff was ponded on the edge of a dirt road because the "dirt road is made from local soil" and "if the soil is uncontaminated, then the sample will be uncontaminated," and "[i]f the soil in the road is contaminated with the constituents we're looking at, primarily phosphorus, copper, zinc and arsenic, then it would reflect high concentrations independent of the conditions in the field." [TR at 2712:24-2713:13 (Fisher)]. He also discounted the effect of cars running through a sampled area, stating that "[c]ars aren't big sources of phosphorus, copper, zinc and arsenic." [TR at 2714:1-10 (Fisher)]. In Dr. Fisher's opinion, other than background amounts from background soils, no other sources of copper, zinc, arsenic and phosphorus could possibly contribute to the pond at the levels of poultry waste. [TR at 2714:11-15 (Fisher)].

427. Dr. Fisher testified the protocols for edge-of-field water sampling did not require that the water be "running," and it did not matter whether the samples were from flowing or standing water because all samples were taken within a reasonable time after a rain event, and thus represent runoff. [TR at 2717:8-2718:5 (Fisher)].

428. The court finds Dr. Fisher's chemical ratio analysis is not particularly reliable because the underlying assertion that copper, zinc, arsenic and phosphorus are suitable tracers is not well founded. The court, therefore, gives the analysis little weight.

7. Pathway Concentration Analysis

429. The State's seventh line of evidence is a pathway concentration analysis conducted by Dr. Roger Olsen.[27] His analysis a "traditional gradient fate and transport analys[i]s, where [one] look[s] at concentrations along pathway steps from the source to the ultimate location where it will be deposited, and determine[s] the concentrations to see if the concentrations differences decrease in a logical manner from upgradient to downgradient, from start to finish, consistent with [one's] understanding of the fate and transport of those contaminants." [TR at 5212:4-18 (Olsen)]. Dr. Olsen testified that if one observes a decrease of contaminants along the transport steps, "[i]t's a logical conclusion that what you see at the end of the chain or what you see in the instep in this lake, in Tenkiller or the rivers, came from the source—the source, which is poultry waste." [TR at 5212:19-25 (Olsen)].

a. Leachate Test

430. Dr. Olsen used the EPA's Synthetic participation Leachate Procedure ("SPLP") test, which is a traditional method by which the EPA and other scientists evaluate the mobility of wastes that are subject to rainfall. [TR at 5227:13-17 (Olsen)]. His intent was to compare poultry waste and cattle waste leachate and use the results of that comparison to identify and distinguish the wastes in the environmental samples. [TR at 5210:7-14, 5227:18-5228:4 (Olsen)]. In conducting his test, Dr. Olsen first compared poultry waste leachates with dry and fresh cattle waste leachates and evaluated the differences in the concentrations of certain constituents—namely, copper, zinc, arsenic, potassium, total dissolved phosphorus and soluble reactive

[27] Dr. Olsen received a Ph.D. in geochemistry from the Colorado School of Mines, where he was also an instructor of chemistry and geochemistry. [TR at 5203:10-14, 5204:9-12 (Olsen)]. He is employed at Camp Dresser & McKee, Inc. [TR at 5466:13-20 (Olsen)]. He has more than 30 years consulting experience in the area of environmental geochemistry, during which he has studied environmental contamination at more than 500 sites. [TR at 5204:20-5205:7 (Olsen)].

phosphorus. [TR 5210:7-14, 5233:2-10 (Olsen)]. He prepared a chart that summarizes the data from the leachate test. [TR at 5230:17-5231:3 (Olsen); OK Ex. 3802]. Dr. Olsen then listed the factor by which the concentration of each poultry waste constituent in the leachate exceeded or was less than the concentration of the same constituents in fresh and dry cattle manure leachate. [TR at 5231:25-5232:9 (Olsen); OK Ex. 3802]. The purpose of the factor analysis was to determine which constituents have the biggest differences. [TR at 5232:19-5233:1 (Olsen)]. He concluded that arsenic, copper, zinc, potassium, total dissolved phosphorus and soluble reactive phosphorus were the constituents that would best distinguish poultry waste from cattle manure in environmental samples. [TR at 5233:2-10 (Olsen)].[28] He opined that comparing leachate concentrations in this manner is "one of the most important comparisons to do because this is actually what's being potentially mobilized into the water, so that water ends up as runoff or it ends up as infiltration." [TR at 5237:21-5238:2].

431. He prepared a table using the results of his leachate concentration study and Dr. Engel's mass balance analysis of the amount of waste in the basin to determine potential leachable masses of contaminants from poultry waste versus cattle manure in the IRW. [TR at 5252:8-5253:2 (Olsen); OK Ex. 3743].

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[28] Dr. Olsen's leachate tests showed that total dissolved arsenic in poultry waste was 47.6 times as high as arsenic in fresh or dry cattle manure. [TR at 5233:14-19 (Olsen)]. The concentration of dissolved copper in poultry waste is 188 times higher than dissolved copper in fresh manure and 24 times the concentration in dry cattle manure. [TR at 5234:7-15 (Olsen)]. Potassium concentrate in poultry waste is 13.4 times higher than potassium in fresh cattle manure and 51.4 times higher than potassium in dry cattle manure. [TR at 5234:21-5235:4 (Olsen)]. Zinc concentration in poultry waste is 21.6 times higher than fresh cattle manure and 25.9 times higher than dry cattle manure. [TR at 5235:5-9 (Olsen)]. Soluble reactive phosphorus ("SRP") concentration in poultry waste was 4.3 times higher than SRP in fresh cattle manure and 5 times higher than SRP in dry cattle manure. [TR at 5235:10-14 (Olsen)]. Dissolved P concentrations were 4.3 times higher than dissolved P concentrations in fresh cattle manure and 5.83 times higher than dissolved P concentrations in dry cattle manure. [TR at 5235:16-25 (Olsen)].

432. Overall, based on his leachate test, Dr. Olsen concluded that the composition of poultry waste and cattle manure are distinct and that "we should be able to observe these distinct differences in environmental samples." [TR at 5303:15-23 (Olsen)].

b. Design, Methodology and Results

433. The State's experts used a "component pathway sampling approach" to conduct the pathway analysis. [TR at 5265:1-5 (Olsen)]. Dr. Olsen testified:

> In our sampling efforts, we focused on collecting samples from what I call every environmental component; that is, every media and every transport step from the source—or potential source of contamination through the environment to its ultimate location in Tenkiller.
>
> So, for instance, poultry waste, we would sample the poultry waste, we would sample the soils where it had been disposed, we would sample the edge-of-field runoff, we would sample small tributaries where that would end up and larger tributaries, and then finally we would sample Lake Tenkiller. So it's a whole set of sequential transport steps to determine whether there's a complete pathway or not.

[TR at 5265:8-22 (Olsen)].

434. For his analysis, Dr. Olsen divided the sampling data into "logical groups." [TR at 5318:8-9 (Olsen)]. Specifically, he analyzed concentrations in "solid samples" including poultry waste, soils on the fields, sediments in the rivers and sediments in Lake Tenkiller, and compared them to "reference soils." [TR at 5318:9-15 (Olsen)]. Next he compared concentrations in surface waters, including the runoff surface water from land-applied fields (the edge-of-field samples), the water from small tributaries, the water from larger rivers, the water from Lake Tenkiller, and "reference streams." [TR at 5318:16-5319:1 (Olsen)]. He also compared concentrations in groundwater, including alluvial waters, springs and residential wells. [TR at 5319:1-4 (Olsen)].

435. Dr. Olsen determined that the concentration of phosphorus in all solid media in the IRW exceeded reference soil concentrations. [TR at 5339:2-8 (Olsen)]. He observed that phosphorus concentrations start out higher on the fields at about 1,050 mg/Kg, or 2 percent. [TR at 5335:10-

13 (Olsen); OK Ex. 3808]. In river sediments, the phosphorus concentrations decreased to 522 mg/Kg. [TR at 5335:13-16 (Olsen); OK Ex. 3808]. In Lake Tenkiller sediments, the phosphorus concentrations increased to 967 mg/Kg. [TR at 5335:15-16 (Olsen); OK Ex. 3808]. Dr. Olsen opined that the increased concentrations in the lake sediments are attributable to the large amount of phosphorus transported into the lake, along with a variety of processes in the lake, including uptake with algae and a settling process that incorporates a portion of the phosphorus in the water into the upper sediments. [TR at 5336:19-5337:6 (Olsen)]. He testified the same phenomena occurred in Lake Tenkiller sediments with respect to concentrations of copper, zinc and arsenic. [TR at 5337:7-10 (Olsen)]. Olsen concluded that the concentrations of phosphorus, copper, zinc and arsenic found in the samples collected from solid media were consistent with known fate and transport processes and showed that poultry waste from land applied fields was being transported into the river sediments and lake sediments. [TR at 5343:24-5344:12 (Olsen)].

436. Dr. Olsen performed a similar analysis of surface waters, examining the components of water samples from runoff from poultry-applied fields in a logical pathway to Lake Tenkiller. [TR 5345:10-19 (Olsen); OK Ex. 3590]. With respect to surface water media analysis, Dr. Olsen found phosphorus concentrations exceeded reference levels in each of the environmental media—edge-of-field, water in small tributaries, water in larger rivers, and water in Lake Tenkiller. [TR at 5353:9-22 (Olsen); OK Ex. 3590]. The edge-of-field data showed "extremely high concentrations of phosphorus" (over 8,000 micrograms per liter, or 8.14 milligrams per liter). [TR 5353:13-24 (Olsen); OK Ex. 3590]. Similarly, the small tributaries data showed "very large concentrations" of phosphorus, both in high-flow and base-flow. [TR at 5354:25-5355:7 (Olsen); OK Ex. 3590]. The data also demonstrated "a gradient between the small tributaries into the medium and large size and finally the lowest concentration in Lake Tenkiller." [TR 5355:8-18 (Olsen); OK Ex.

3590]. Overall, Dr. Olsen concluded that for the key contaminants—phosphorus, copper, zinc and arsenic—"there was a logical connection between the edge-of-field and the ultimate deposition in Lake Tenkiller and there was a completed pathway and that the contamination was being completely transported throughout the IRW from the source location; that is, the edge-of-field, into Lake Tenkiller." [TR 5352:6-14 (Olsen)].

437. Dr. Olsen found that about half of the total phosphorus in the State's edge-of-field samples was soluble reactive phosphorus ("SRP"). [TR at 5362:14-5363:2 (Olsen)], and testified that the amount of SRP is typically 80 percent or more of total phosphorus. [TR at 5363:8-21 (Olsen)]. The data showed a dilution in concentration of SRP down gradient until Lake Tenkiller, where it uptakes to algae and becomes a particulate. [TR at 5363:25-5364:8 (Olsen)]. Olsen also testified that as organic-bound phosphorus moves down gradient, it "does break down a little bit in the environment and we end up with a little bit more soluble-reactive" phosphorus. [TR at 5367:20-23 (Olsen)].

c. Olsen's Conclusion

438. In conclusion, Dr. Olsen found that "[b]ased upon my entire [pathway] analysis of the compositions of the various major sources of waste, the level of contamination and my fate and transport analysis, I believe that a portion—a substantial portion of the phosphorus within the IRW waters is a result of runoff from . . . poultry land-applied fields." [TR at 5397:23-5398:11 (Olsen)].

d. Defendants' Critique

439. Defendants' expert, Dr. John Connolly,[29] rejects Dr. Olsen's pathway analysis as an attempt to "track [poultry waste] using chemicals that are ubiquitous in the watershed." [TR at 9002:2-8 (Connolly)].

440. Dr. Connolly disagreed with Dr. Olsen's conclusion that the data he extracted demonstrates changes consistent with known fate and transport mechanisms. [TR at 9033:7-10 (Connolly)]. He explained that "absent following a real pathway, you're looking at unconnected data and it's hard to make that comparison between unconnected data." [TR at 9033:12-16 (Connolly)]. Making such comparisons may lead to "false conclusions." [*Id.*] According to Dr. Connolly, a proper gradient analysis follows a known pathway, "[s]o earlier when we were looking at the Illinois River from upstream to downstream and looking at how concentrations change, that's a gradient analysis." [TR at 9030:20-9031:1 (Connolly)]. A proper gradient analysis, Dr. Connolly testified, "requires you to move along a pathway and look at the concentrations as you move along the pathway." [TR at 9031:2-6 (Connolly)].

441. In Dr. Connolly's opinion, Dr. Olsen's conclusion that concentrations of phosphorus, copper, arsenic and zinc in tributaries are much higher is being driven by his inclusion in the study of two tributaries (designated by plaintiffs as wastewater treatment plant-impacted tributaries) sampled downstream of the wastewater treatment plants. [TR at 9393:22-9394:16 (Connolly)]. He acknowledged, however, that even taking out those two tributaries, the remaining tributaries still show a substantial amount of SRP. [TR at 9395:6-10 (Connolly)]. Further, Dr. Connolly admitted

[29] Dr. Connolly holds a Ph.D. in environmental health engineering from the University of Texas. He taught undergraduate and graduate level courses in environmental engineering for fourteen years a Manhattan College, where he also conducted EPA research. [TR at 8824:7-18 (Connolly)]. He worked for two years at the EPA lab in Gulf Breeze, Florida. [TR at 8823:19-21 (Connolly)]. He is a member of the EPA's standing committee on environmental engineering and the American Academy of Environmental Engineers. [TR at 8826:13-8827:2 (Connolly)].

that 82 percent of the phosphorus leading to Lake Tenkiller is from nonpoint sources and phosphorus from land applied poultry waste makes its way to the Illinois River and Lake Tenkiller. [TR at 9142:5-20; 9183:15-22 (Connolly)].[30]

e. Weight Accorded to Pathway Concentration Analysis

442. The court finds Dr. Olsen's pathway concentration analysis to be of some value in establishing whether and to what extent poultry waste is responsible for phosphorus contamination of the waters of the IRW.

8. Geochronological Sediment Analysis

443. As previously noted, Dr. Fisher evaluated Lake Tenkiller sediments as part of his ratio analysis. Based on the chemistry of Lake Tenkiller sediment samples, Dr. Fisher identified poultry waste as the source of phosphorus contamination in Lake Tenkiller. [TR at 2145:7-2146:11; 2146:20-2147:2 (Fisher)]. Dr. Fisher employed a dating method to reconstruct the history of chemical inputs to Lake Tenkiller sediments since the dam was closed in 1954 and compared that age-dated chemistry to historical animal populations within the IRW. [TR at 1678:25-1679:1; 1679:7-11; 2086:2-14; 2087:22-2088:5 (Fisher)]. He concluded, based on this comparison, that the phosphorus composition of the Tenkiller sediments is driven by the increase in poultry population. [TR at 2088:6-12 (Fisher)].

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[30] Dr. Connolly's most serious criticism of the State's case goes—not to whether phosphorus from land-applied litter is ending up in the waters of the IRW—but instead, to whether the phosphorus has an adverse impact on water quality. Dr. Connolly stated:

> My testimony relates to whether or not nonpoint sources of which that poultry litter application would represent some fraction is substantively impacting the water quality, and my conclusion is that it is not.

[TR at 9183:24-9184:3 (Connolly)]. This criticism is addressed more extensively in Section 13 below.

444. Dr. Fisher took core sediment samples from four locations, ranging from closest to the dam to closest to the river. [TR at 2096:5-12 (Fisher); OK Ex. 2506]. Each core was cut into depth segments "because depth in the core is a way of keeping track of where you are [in time]." [TR at 2100:16-2101:19 (Fisher)]. The top part of the core sediment reflects the very recent past and the deeper portions reflect "earlier and earlier times." [TR at 2101:20-2102:5 (Fisher)].

445. The samples were dried and analyzed for a large list of parameters, including total phosphorus, total zinc, total arsenic, total copper, as well as content of lead-210 and cesium-137—two substances used to help determine the age of sediment deposits. [TR at 2101:9-14, 2102:21-2103:1 (Fisher); OK Ex. 2507]. Scientists assume that if one can assign the time of deposition of the material in a slice of the sediment core based on its location in the core and the lead-210 and cesium analysis, then other chemicals, like phosphorus, copper, zinc and arsenic that are associated in that slice were deposited at the same time. [TR at 2103:10-23 (Fisher)].

446. Lead-210 is a weakly radioactive isotope of lead commonly used by scientists to age-date sediments. [2105:3-7 (Fisher)]. It results from the decay of uranium-238 in the earth's crust to radon, which then decays to lead-210. [TR at 2104:4-17 (Fisher)]. Lead-210 falls from the atmosphere onto the surface of the IRW, and when there is runoff, it moves into the lake. [TR at 2104:19-2105:4 (Fisher)]. Lead-210 is useful for dating because it has a finite rate of decay, with a half life of about 22 years. [TR at 2105:17-19, 2106:10 (Fisher)]. It is a radioisotope that is naturally produced everywhere. [TR at 2107:12-13 (Fisher)].

447. In contrast, cesium-137 is derived from thermonuclear detonations or reactor accidents such as Chernobyl. [TR at 2107:10-21 (Fisher)]. Dr. Fisher testified that cesium-137 is "a pulsed input as opposed to a continuous input like lead-210." [TR at 2108:1-3 (Fisher)]. Further, "when you look at cesium-137 in sediments, you're trying to look for a maximum and that maximum

would be interpreted, in the absence of any other knowledge, as about 1964." [TR at 2108:12-15 (Fisher)].

448. Dr. Fisher elected to use lead-210 to date the core samples. Specifically, he compared the total lead in the sediments to known changes in atmospheric inputs of lead based on the historical use and phase-out of leaded gasoline. [TR at 2087:14-21, 2112:3-21 (Fisher)]. Dr. Fisher testified that, in the early 1970s, about half of all U.S. lead production went into tetraethyl lead that was then burned and dumped into the atmosphere. [TR at 2113:9-11 (Fisher)]. This total lead analysis provided "an independent check on dating, given that we have a chemical input to the lake, whose timing is known, that is independent of other activity in the watershed." [TR at 2112:22-2113:2 (Fisher)].

449. Dr. Fisher testified that because the concentrations of lead in poultry waste are too low for poultry waste to be the source of lead in lake sediments, by comparing concentrations of total lead found in sediment cores with the year of deposition based on lead-210 dating, he was able to confirm that "lead-210 provides a better coincidence in time with the phase-out of lead in gasoline and the behavior of the lead in the core than cesium-137." [TR 2114:9-2115:13; 2115:23-2116:18; 2117:1-20 (Fisher); OK Ex. 2510].

450. Dr. Fisher next established that the sedimentation patterns observed in the core sediment samples are consistent with the general expectation that the sedimentation rate will be higher toward the river end of Lake Tenkiller and lower toward the dam end. [TR at 2128:13-2129:18; OK Ex. 2526]. This variation occurs because sediments fall from suspension as they are transported in water through the lake and the primary contributors of sediments in the lake are the Illinois River and Caney Creek. [TR at 2129:19-2130:6 (Fisher)].

451. Dr. Fisher compared the compositions of control soils to the total concentrations of phosphorus, copper, arsenic, and zinc present in the core sediment samples. [TR at 2130:21-2131:8; 2133:1-2135:24 (Fisher); OK Ex. 2508]. He found that the lake sediment showed contamination relative to the control soils, and that phosphorus contamination has been increasing through time. [TR at 2136:5-12; 2138:11-14 (Fisher)].

452. Although the most recent samples taken closest to the river end of Lake Tenkiller fall off slightly, Dr. Fisher observed that the overall trend in phosphorus is upward. He concludes that "the source" of phosphorus in the sediments has increased over time. [TR at 2137:16-25; 2138:11-14 (Fisher)]. Dr. Fisher testified the samples also show that zinc, arsenic, and copper concentrations are increasing, which indicates the source of those substances is increasing. [TR at 2139:23-2140:16; 2141:20-22; 2143:11-2144:1 (Fisher)].

453. Dr. Fisher determined the IRW's poultry population over time using defendants' production numbers as well as USDA agricultural census data. [TR at 1664:22-1665:3; 1666:22-1667:3; 1668:2-5 (Fisher); OK Ex. 2522]. Defendants reported producing an annual average of over 141 million broilers, pullets and turkeys in the IRW. [OK Ex. 2522]. From country-wide agricultural census data, Dr. Fisher estimated that the number of birds in the IRW increased by a factor of almost eight from the date of dam closure (1954), and from about 12 million in 1950 to approximately 152 million in 2002. [TR at 1678:19-24; 1679:7-11; 1680:4-18 (Fisher); OK Ex. 2529; OK Ex. 2489].

454. Using a measure of animal units of 1,000 pounds, Dr. Fisher compared the biomass of poultry against the biomass of humans, swine and cattle, as reported by Dr. Engel. [TR at 1683:23-1684:6]. In other words, he compared "how many pounds of cows there are versus how

many pounds of poultry there are," to place creatures "on a fair comparison basis." [TR at 1684:7-13]. He concluded that:

> [T]he number of poultry in terms of their total number of animal units have shown a consistent increase within the Illinois River, number one . . . Number two, that they substantially outweigh any other of the animal units considered here. They outweigh humans, they outweigh swine, they outweigh dairy cattle, outweigh beef cattle. And in . . . the distant past, they've outweighed the sum of all of them for some time. . . . [T]he animal units of poultry present in the Illinois River Watershed are the dominant mass of animal present.

[TR at 1684:14-1685:1 (Fisher)].

455. Finally, Dr. Fisher compared the number of animal units to the levels of phosphorus present in Lake Tenkiller sediments as a function of time. [TR at 1686:24-1687:2 (Fisher); OK Ex. 2513; TR at 2164:19-2166:1, 2502:7-2503:5 (Fisher)]. Dr. Fisher found that:

> [T]he change in phosphorus that's observed in the lake sediments appears to have a form in time that looks very much like the change in the number of animal units of poultry within the watershed and is dissimilar from the changes over time of the cattle population in terms of animal units, the human population in terms of animal units, the swine population in terms of animal units or any combination thereof. So if I added up humans and cattle or cattle and swine or humans and cattle and swine, I can't generate the same general shape of increase in time in the phosphorus concentrations.

[TR at 2161:15-2162:1 (Fisher)].

456. Defendants criticize Dr. Fisher's animal unit analysis on a number of bases. Dr. Fisher admitted that in addition to changes in the poultry population since 1950, feeds and supplements have changed, chickens grow faster and the life-span of each chicken is shorter. [TR at 2485:9-2487:6 (Fisher)]. He denied, however, that the shorter life span results in less manure. [TR at 2487:7-16 (Fisher)]. He stated that his analysis "integrates all of the birds that are grown and takes into consideration the lifecycle." [*Id.*] Further, defendants criticized him for not separately calculating poultry waste production since 1950. [TR at 2487:20-2488:7 (Fisher)]. Dr. Fisher asserted his use of animal unit figures did not intrinsically rely on poultry litter production. [*Id.*]

457. Defendants also challenge the validity of Dr. Fisher's animal unit analysis on the basis that the lifespan of a broiler poultry is typically 42 days, while the lifespan of other species in the comparison is at least one year. [2536:17-2537:9 (Fisher)]. The criticism calls into serious question Dr. Fisher's biomass analysis, as it appears to equate the weight of animal units of shorter-lived poultry with the weight of animal units of longer-lived dairy cattle and beef cattle.

458. Defendants' expert Dr. Connolly criticized Dr. Fisher's use of lead-210 rather than cesium-137 in dating the core samples. [TR at 9077:25-9080:6 (Connolly)]. Dr. Connolly contends that, had cesium-137 been used, the dates assigned by Dr. Fisher were off as much as 20 years.

459. The court gives little weight to Dr. Fisher's geochronological analysis.

9. Poultry House Density Analyses

460. Two State experts—Dr. Engel and Dr. Stevenson—performed separate and independent poultry house density analyses.

a. Dr. Engel's Analysis

461. One of the ways to determine the fate and transport of a pollutant is to "look at different land use activities and land management activities, and look at the water quality in those land use and land management activities and try to determine the mathematical relationship between the two, cause and effect relationship." [TR at 5993:20-5994:10 (Chaubey)]. Dr. Engel performed such a study, examining the relationship between measured phosphorus concentrations in IRW streams and poultry house density. [TR at 5738:2-6 (Engel)].

462. Dr. Engel focused on poultry house density because poultry produce waste; the waste contains phosphorus; phosphorus is disposed on the land near the poultry houses; when the waste is disposed, some portion runs off with runoff; and the waste increases soil test phosphorus when

applied at typical rates. [TR at 5769:4-15 (Engel)]. His hypothesis was that the density of poultry houses should be a predictor of the amount of phosphorus in water coming from those watersheds. [TR at 5769:15-5770:3 (Engel)].

463. In Dr. Engel's study, automatic samplers were placed at 14 sub-watershed outlets to collect data as water ran off. [TR at 5738:7-10 (Engel)]. The sub-watersheds were selected based on a range of poultry house densities within them, and data was analyzed to identify phosphorus in the water. [TR at 5738:10-14 (Engel)]. The intent was to avoid point sources within those watersheds, although Dr. Engel testified that subsequently, a couple of watersheds were identified as having point sources of phosphorus within them, so those were excluded from analysis. [TR at 5738:15-19 (Engel)]. Samples were taken both during runoff events and at base flow. [5739:6-7 (Engel)]. Poultry house densities for watersheds were identified based on Dr. Fisher's work, and both active and inactive poultry houses within the IRW plus a two-mile buffer were included. [TR at 5739:14-17; 6630:1-6631:18 (Engel)].

464. From the study, Dr. Engel was able to determine the relationship between the presence of poultry house operations and increased phosphorus in streams flowing out of the sub-watersheds in the IRW. [TR at 5738:20-24 (Engel)]. For example, the 2005-2006 data show a total phosphorus concentration of over 0.180 mg/L in a sub-watershed with seven poultry houses per square mile. [TR at 5770:7-20 (Engel)]. In contrast, the expected total phosphorus concentration in a sub-watershed with no poultry houses is 0.0170 mg/L. [TR at 5773:13-21 (Engel)].

465. Once the data had been gathered, Dr. Engel compared the average total phosphorus concentrations and total poultry house density (plus poultry houses within a two-mile buffer) in each sub-watershed to determine whether there was a linear relationship between the data. [TR at 5767:8-5768:13 (Engel); OK Ex. 1165]. He used an equation to explain the linear relationship and

any variability in the observed relationship between poultry house density and increased phosphorus concentrations. [TR at 5772:17-5773:12 (Engel); OK Ex. 1165)]. The equation he used was: y=0.0184x + 0.0171, with "y" representing total phosphorus runoff, and "x" representing the number of poultry houses per square mile. [TR at 5772:17-5773:1; 5773:23-5774:2; (Engel); OK Ex. 1165]. The "0.0184" value is the increase in phosphorus concentrations expected per the addition of each poultry house per square mile and the "0.0171" value represents the expected phosphorus concentrations in small sub-watershed streams with no poultry houses. [TR at 5774:9-17 (Engel); OK Ex. 1165]. The calculations Dr. Engle used are a "standard approach" for examining relationships between environmental data. [TR at 5773:7-12 (Engel)]. After running his calculations, Dr. Engel arrived at an R^2 value to describe the "goodness of fit"—that is, how much the observed variability in the data is explained by the equation. [TR at 5775:8-12 (Engel); OK Ex. 1165]. The R^2 value for his poultry house density analysis is 0.74, which he testified is "an excellent relationship." [TR at 5775:13-19 (Engel); OK Ex. 1165]. Dr. Engel also found a "p value" of 0.0007, which he testified shows the equation describes a statistically significant relationship. [TR at 5775:20-7776:6 (Engel)].

466. Overall, with respect to his poultry house density analysis, Dr. Engel concluded "there is a statistically significant relationship between poultry house density and phosphorus in both surface runoff and in base flow," and because he had excluded other sources, "this relationship demonstrates a cause-and-effect relationship." [TR at 5786:1-11 (Engel)]. He testified that "the presence of the poultry house operations and the activities that go with those is responsible for the increased phosphorus that one observes in these small watersheds within the Illinois River Watershed," and "[a]s we increase poultry house density, we see corresponding increases in phosphorus from those watersheds." [TR at 5786:12-19 (Engel)]. The relationship exists. He

contends not only with respect to edge-of-field phosphorus but also in-stream phosphorus. [TR at 5786:20-23 (Engel)].

b. Dr. Stevenson's Analysis

467. Dr. Robert Jan Stevenson also performed a poultry house density analysis based on a "conceptual model" that human activities, including poultry house operations, affect nutrient concentrations in the water; that nutrient concentrations affect algal biomass; that algal biomass affects dissolved oxygen and pH; and that changes in dissolved oxygen and pH can affect biodiversity by altering physical habitat. [TR at 7110:18-7111:8 (Stevenson)]. Dr. Stevenson hypothesized that there would be a direct relationship between poultry house density in the IRW and phosphorus concentrations in streams. [TR at 7111:9-19 (Stevenson)]. In addition to sampling data, Dr. Stevenson used data he received from Robert Van Waasbergen on poultry house density in each one of the sub-watersheds delineated for sampling. [TR at 7111:21-7112:2 (Stevenson)]. Van Waasbergen's data, in turn, was based on aerial photographs of locations with poultry houses. [TR at 7112:3-22 (Stevenson)]. Dr. Stevenson used topographic maps and a land cover land use database available through government agencies to delineate the sub-watersheds. [TR at 7112:23-7113:17 (Stevenson)]. As with Dr. Engel's study, poultry house densities for the sub-watersheds were calculated by looking at the number of poultry houses within the sub-watershed and within a two-mile buffer around the edges of the watershed, divided by the number of square miles of the watershed. [TR at 7113:18-7114:2 (Stevenson)].

468. During the summer of 2006 and the spring of 2007, nutrient and algal biomass data were collected from 70 stream sampling sites. [OK Ex. 4468; OK Ex. 4508; TR at 6988:13-14; 6988:21-6989:3; 6991:18-19; 6993:8-15; 6993:22-6994:1; 6995:10-12 (Stevenson)]. Sampling sites were selected based on a random stratified sampling design. [TR at 6991:3-6 (Stevenson)].

Dr. Stevenson testified that a random stratified sampling design is necessary for a regression approach, which requires even numbers of observation sites with low levels of phosphorus and of poultry house density, intermediate levels of phosphorus and poultry house density, and high levels of phosphorus and poultry house density. [TR at 6991:6-11 (Stevenson)]. After stratifying the 70 sampling sites into five groups based on poultry house density, Dr. Stevenson then randomly selected 12 to 15 sites from each stratum for purposes of his analysis. [TR at 6991:12-17 (Stevenson)].

469. Because nutrient concentrations and algal biomass vary a great deal in streams as a result of weather-related events, samples were taken over a two-month period. [TR at 6995:16-6996:11]. For many of the parameters—including nutrients and filamentous green algal cover—each of the sites was sampled eight times. [TR at 6996:12-16 (Stevenson)]. Other parameters such as diatom biodiversity and macrobenthic invertebrate diversity were sampled once, at the end of the sampling period. [TR at 6996:17-19 (Stevenson)].

470. Dr. Stevenson conducted a third sampling campaign in the summer of 2007. [OK Ex. 4477; TR at 6996:20-6997:10 (Stevenson)]. In this campaign, nutrient concentrations and fish assemblages were sampled at 37 locations. [TR at 6997:11-20 (Stevenson)]. Dr. Stevenson explained that fewer locations were sampled in the summer 2007 sampling campaign than the previous two campaigns because it takes longer to sample fish, and because of costs associated with getting additional samples. [TR at 6997:21-6998:3 (Stevenson)]. He testified he considered this number of sites sufficient. [TR at 6998:4-10 (Stevenson)].

471. Once the data had been gathered and stratified, Dr. Stevenson conducted a regression analysis to determine whether a relationship exists between poultry density, phosphorus concentrations, and algal biomass in the streams of the IRW. [TR at 7140:8-12 (Stevenson)]. Dr.

Stevenson's regression analysis showed that phosphorus concentrations increased with the density of poultry houses. [TR at 7146:21-7147:4 (Stevenson)]. In addition, during the spring 2007 sampling campaign, he found a correlation between poultry house density and algal biomass. [TR at 7147:11-16 (Stevenson)]. Overall, Dr. Stevenson concluded:

> [L]ooking at the relationships between poultry house density, . . . there [is] a correlation between poultry houses and phosphorus and poultry houses and algal biomass. There's a relationship between nutrient concentrations, phosphorus and algal biomass, that affect DO and pH, . . . [which in turn have] an effect on fish biodiversity that [is] related to indications of nutrient availability and of poultry house density.

[TR at 7147:22-7148:9 (Stevenson)]. Dr. Stevenson also found a correlation between increased phosphorus concentrations and urban activities. [TR at 7148:10-19 (Stevenson)]. He testified, however, that by using his regression analysis, he was able to isolate poultry house density impacts by looking only at the data that can be assigned to poultry house density versus urban land use. [TR at 7151:18-25 (Stevenson)]. Based on this data and without taking into account other causes such as wastewater treatment plant discharges, Dr. Stevenson concluded that high poultry house density causes injury to IRW streams. [TR at 7151:14-25 (Stevenson)].

472. Dr. Stevenson also performed a multiple regression analysis to differentiate between general agricultural use impacts and poultry house density impacts. [TR at 7153:17-7154:13 (Stevenson)]. He concluded that "something associated with the density of poultry houses in the watershed must be causing the increases in phosphorus concentration and the increases [in] algal biomass and the reductions in fish biodiversity associated with—in the streams of the Illinois River Watershed." [TR at 7154:14-7155:1 (Stevenson)].

c. Defendants' Critique of Poultry House Density Studies

473. Defendants' expert, Dr. Timothy Sullivan, contends Dr. Engel's study shows a statistically significant correlation between septic system density and phosphorus concentration in

streams. [TR at 10713:12-16 (Sullivan)]. He is critical of Dr. Engel for dismissing the correlation as an artifact of another correlation he found with poultry house density. [TR at 10713:17-20 (Sullivan)]. Engel acknowledged "strong cross-correlations" between septic tanks and total poultry house density; "in other words, in areas with high poultry house development, human dwellings are also relatively high." [TR at 6378:17-6379:5 (Engel)]. He concluded, however, that septic tanks are not a significant contributor of phosphorus to surface-based, nonpoint-source pollution for two reasons. First, his analysis, which examined potential impacts of septic tanks in the high-flow sub-watersheds, indicated there was far more phosphorus being exported from those watersheds in a fewer number of events than can be explained by septic tanks. [TR at 6663:22-6664:4 (Engel)]. Second, septic waste is applied underground, so it provides opportunities for absorption of the phosphorus into soil; meaning it would not run off the surface.[31] [TR at 6664:5-15 (Engel)]. Defendants' expert, Dr. Sullivan, conceded that even assuming all phosphorus from septic systems in the IRW were to discharge directly into streams of the IRW, the total phosphorus contributed by septic systems would approximate the phosphorus produced by only 16 of the approximately 1,800 active poultry houses in the IRW. [TR at 10906:12-10907:8 (Sullivan)].

474. Defendants also criticized Dr. Engel and Dr. Stevenson for not including cattle in their studies. [TR at 10729:2-10 (Sullivan)]. Dr. Engel explained the reason for the omission is that beef cattle—which consume grass and hay from fields where poultry waste is land applied—are recycling phosphorus that already exists within the watershed. [TR at 5836:23-5837:20 (Engel)]. Additionally, as previously noted, Dr. Stevenson found a correlation between poultry house density and phosphorus concentrations independent of agricultural influences as a whole. [TR at 7153:17-7155:1 (Stevenson)]. Defendants' expert, Dr. Sullivan, conducted a study of the

[31] This defense ignores the fact that septic systems buried in karst condition are less than ideal for absorption of the septic waste into soil.

correlation between cattle and poultry house density; however, his cattle population data was aggregated by zip code rather than by sub-watersheds. [TR at 10913:20-10914:10 (Sullivan)]. He acknowledged that his study covers a larger land area than simply the sub-watersheds. [TR at 10914:11-19 (Sullivan)].

475. Dr. Sullivan also criticized the State's experts for not considering dirt roads as a source of phosphorus as part of the investigation. [TR at 10708:17-25 (Sullivan)]. Based on his own analysis, he found a correlation between poultry house density and dirt roads within the sub-watersheds studied by Dr. Engel. [TR at 10760:11-22; DJX2258]. He opines that the presence of roads constitutes a "confounder" in the plaintiffs' experts' analysis. [TR at 10760:23-10761:2]. Dr. Engel testified, however, that dirt roads were not considered in his analysis because dirt roads are not an independent source of phosphorus beyond background; the amount of phosphorus lost from dirt roads would be small; and if there is any phosphorus beyond natural background in the dirt roads, one of its sources would be poultry waste. [TR at 6628:22-6629:19 (Engel)].

476. Finally, Dr. Sullivan contends the State's experts' inclusion of a two-mile buffer in their calculation of poultry house density resulted in "double and triple" counting poultry houses within the sub-watersheds. [TR at 10765:14-10767:5 (Sullivan)]. Dr. Engel explained the two-mile buffer was based on IRW-specific scientific reports and materials (as well as his own analysis and that of Dr. Fisher) finding that a majority of poultry waste is land-applied within about two miles of poultry houses. [TR at 6630:1-12 (Engel)]. Based on this analysis, he determined it was logical to consider poultry houses within two miles of watersheds as having the potential to contribute some phosphorus to the waters being sampled. [TR at 6630:13-17 (Engel)]. However, he also performed the analysis without the two-mile buffers and found that the results did not significantly change. [TR at 6630:18-6631:18 (Engel)].

477. The court accords the poultry house density studies by Dr. Engel and Dr. Stevenson substantial weight.

10. Modeling Analysis

478. Dr. Chaubey testified that another way to determine the fate and transport of a pollutant is to do "mathematical modeling to look at elective contribution of different areas in terms of nutrients and how those nutrients then move through the stream system." [TR at 5994:11-21 (Chaubey)]. In this case Dr. Engel employed a computerized watershed model to evaluate phosphorus contamination in the IRW. [TR at 6216:2-4 (Engel)].

479. Dr. Engel conducted his modeling analysis in order to understand the fate and transport of phosphorus within the IRW; to analyze current conditions within the IRW and conditions under certain hypothetical scenarios such as cessation of poultry waste application; and to allocate phosphorus contributions among different sources. [TR at 6216:5-19 (Engel)].

480. In this case, Dr. Engel used a nonpoint source field model known as GLEAMS model to identify runoff and movement of phosphorus within a field to the edge of the field and to route and move the phosphorus from the edge of field to one of three gauging stations within the IRW. [TR at 6219:14-6220:3 (Engel)]. He also used the model to route point source phosphorus from wastewater treatment plan discharges (the quantities of which were already known) to the same gauging stations. [TR at 6219:14-6220:3, 6231:22-6232:6 (Engel)].

481. Dr. Engel testified that a modeler can be confident of the reliability of combining a nonpoint source field model with a routing model because in a region like the IRW, once phosphorus begins moving out of the fields, "it's going to continue to move downhill, downstream." [TR at 6220:4-20].

482. Dr. Engel selected the GLEAMS model because of his experience with it; it represents nonpoint source pollution process and runoff from areas like the IRW; it allows one to readily describe the management systems being used; and because of other modeling work performed in the IRW and the experiences others had with other models. [TR at 6230:4-13 (Engel)]. He testified that GLEAMs is a reliable, established, and well-accepted model and has been featured in many peer-reviewed publications. [TR at 6230:17-23 (Engel)]. Dr. Engel and other modelers have applied GLEAMS on a watershed-wide basis in the past, and Dr. Engel has published papers in peer-reviewed journals regarding studies using GLEAMS on a watershed-wide basis. [TR at 6231:3-14 (Engel)].

483. The GLEAMS model used the "curve number" method of the National Resources Conservation Service ("NRCS") to compute runoff. [TR at 6216:20-6217:7 (Engel)]. The curve number method uses data that describe land use, soil characteristics, and rainfall to calculate the amount of runoff and model the movement of constituents such as phosphorus. [TR at 6217:8-19 (Engel)].

484. With respect to calculation of runoff, the curve model uses data describing the land use, soil characteristics, water movement characteristics, and management conditions. [TR at 6218:14-6219:1 (Engel)]. The data is then used to arrive at a curve number value taken from a well-established set of publications. [TR at 6219:2-3 (Engel)]. That curve number value, along with daily rainfall data, is then used to calculate runoff. [TR at 6219:3-5 (Engel)].

485. The land use data for the GLEAMS model came from the National Land Cover Database ("NLCD"). [TR at 6242:15-19 (Engel)]. The soil data for the GLEAMS model were obtained from the STATSGO soils database. [TR at 6242:20-25 (Engel)]. Rainfall and temperature data came from the National Climate Data Center. [TR a 6243:6-13 (Engel)]. The model used this

data to describe the amount of runoff expected and the movement of constituents in the runoff. [TR at 6243:6-13 (Engel)]. USGS digital elevation model data for the IRW and some area beyond were used to identify sub-watershed boundaries. [TR at 6243:14-19 (Engel)]. USGS flow data was used to determine the amount of flow within the rivers at Barren Fork, Tahlequah and Caney Creek. [6243:20-23 (Engel)]. USGS and Oklahoma Water Resources Board phosphorus concentration data were obtained for those locations as well. [TR at 6243:24-6244:6 (Engel)]. The current poultry waste amount of 354,000 calculated by Drs. Engel and Fisher was used. [TR at 6244:7-13 (Engel)]. Dr. Engel's mass balance analysis was used to supply historical poultry waste figures, as well as nutrient applications from other sources such as fertilizers and other livestock sources. [TR at 6244:15-18; 6244:24-6245:2 (Engel)]. Poultry house locations and poultry waste application locations were determined based on aerial photography. [TR at 6244:19-22 (Engel)]. Soil test phosphorus data came from the Arkansas and Oklahoma State University labs through Dr. Johnson. [TR at 6245:3-8 (Engel)]. Soil test phosphorus background levels were obtained from samples taken by CDM for the state within the Nickel Preserve area. [TR at 6245:9-14 (Engel)]. Wastewater treatment plant phosphorus discharges were derived from NPDES permit compliance system data sets. [TR at 6245:15-19 (Engel)].

486. Dr. Engel used an "empirical" routing model, that is, one based on actual observed data in the IRW. [TR at 6233:12-22]. Other modelers have used empirical routing models in watershed studies, and the form of the routing equation used is utilized by USGS as part of its "LOADEST" software. [TR at 6235:4-14 (Engel)]. The routing model was used to route the GLEAMS runoff output and wastewater treatment plant discharges to the three gauging stations (Baron Fork, Caney Creek and Tahlequah). [TR at 6232:7-13 (Engel)].

487. Dr. Engel used USGS flow data to describe the amount of flow to the three gauging stations; USGS and OWRB phosphorus concentration data for each of the three gauging stations; and wastewater treatment plant phosphorus discharge data from the NPDES permit complaint system. [TR at 6233:23-25; 6243:20-23; 6243:24-6244:6; 6245:15-19 (Engel)]. The data sources used for both the GLEAMS model and the routing model are types typically used by scientists to conduct watershed modeling. [TR at 6245:20-6246:1 (Engel)].

488. The routing model equation used three coefficients (a, b and c) obtained by identifying a relationship between the routing equation and the observed phosphorus load data. [TR at 6239:8-16 (Engel)]. Dr. Engel's routing equation provides that the phosphorus load equals coefficient "a," which describes the amount of phosphorus expected to reach a gauge when there is no flow, plus coefficient "b," times actual flow (represented by Q), times phosphorus accumulation in the stream network, or P Load = a + b(Q)(P) + c(Q^2)(P). [TR at 11311:17-24 (Engel)]. The last term in the equation is coefficient "c" multiplied by flow squared—the concept being that on days in which there are very high flows substantially more phosphorus is being transported—times phosphorus accumulation in the stream network. [TR at 11312:4-9 (Engel)]. Dr. Engel used this routing equation for all of his modeling processes. [TR at 11312:10-12 (Engel)].

489. After inputting data and running the model, Dr. Engel undertook a calibration and validation process. [TR at 6246:2-8 (Engel)]. This process allows the model to identify and test how well the model is performing for the particular location to which it is being applied. [TR at 6246:9-15 (Engel)]. It also allowed Dr. Engel to determine whether the model's predictions matched the observed data and adjust the model coefficients to better match model prediction and observed phosphorus loads. [TR at 6246:22-6247:13 (Engel)]. Through the validation process, a portion of the observed flow and phosphorus load data was reserved (independent of the data used

for calibration) without making any coefficient adjustments. [TR at 6248:2-8 (Engel)]. Then, predictions were made for the conditions represented by the independent observed data and compared with the observed data to determine how well the predicted values and data matched. [TR at 6248:9-14 (Engel)]. According to Dr. Engel, the validation approach he used has been described "hundreds of times in the . . . peer-reviewed journals [regarding] watershed models." [TR at 6247:24-6248:2 (Engel)].

490. As a result of the calibration/validation process, Dr. Engel concluded that the nonpoint source runoff and phosphorus loading portions of the model performed "above levels that would be deemed acceptable by the watershed modeling scientific literature." [TR at 6248:23-6249:12 (Engel)].[32] Further, the process led Dr. Engel to conclude that the model would "certainly . . . provide reliable estimates" of phosphorus loading to Lake Tenkiller." [TR at 6251:9-16 (Engel)].

491. Dr. Engel testified that historically, wastewater treatment plant phosphorus discharge in the IRW peaked at about 200,000 pounds during the late 1990s and early 2000s. From 2003 forward, due to improvements in technology at several of the wastewater treatment facilities, phosphorus discharge declined to about 90,000 pounds per year. [TR at 6224:8-23 (Engel)].

492. Dr. Engel testified that total phosphorus loading in Lake Tenkiller is approximately 500,000 to 505,000 pounds per year. [TR at 6224:24-6225:7; 6225:12-17 (Engel)]. Before 2003, approximately 300,000 pounds per year were attributable to nonpoint sources and 200,000 pounds to wastewater treatment discharge. [TR at 6225:12-14 (Engel)]. From 2003 forward, 410,000

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[32] After the initial calibration of the GLEAMS Model, Dr. Engel discovered that a number of hydrologic response units ("HRUs") had been inadvertently omitted. [TR at 6292:8-6293:25 (Engel)]. Dr. Engel corrected the HRU error and recalibrated and reran the model, which produced new results. [TR at 6294:21; 11287:14-25 (Engel)]. He subsequently corrected his expert report by way of an "errata" to reflect the HRU-related changes. [TR at 6294:21-6295:10; 6295:22-6296:17 (Engel)]. He made additional corrections to his report and submitted a second errata after discovering that some observed phosphorus load data in his expert report was erroneous. [TR at 6294:5-13; 6295:5-10 (Engel)]. He testified that his expert opinions at trial were based on the corrected report. [TR at 6296:13-17 (Engel)].

pounds per year of the phosphorus load came from nonpoint sources and 90,000 pounds came from wastewater discharge. [TR at 6225:16-17 (Engel)].

493. Dr. Engel testified that his calculations are comparable to USGS reports concluding that 80 percent of the phosphorus load in the IRW is from nonpoint sources. [TR at 6225:18-4 (Engel)]. Defendants' expert, Dr. Connolly, similarly testified that 82 percent of the phosphorus reaching Lake Tenkiller is from nonpoint sources. [TR at 9142:5-8 (Connolly)].

494. Dr. Engel also used his model to evaluate hypothetical land use scenarios. [TR at 6253:24-6254:4 (Engel)]. First, he used the model to characterize and evaluate a "status quo" scenario in which defendants would continue to generate the same amount of poultry waste, other phosphorus input sources remained the same and weather data from 1997 through 2006 was used and repeated in 10-year increments for 100 years. [TR at 6254:7-6255:2 (Engel)]. In the status quo scenario, phosphorus loads would be roughly 500,000 pounds per year for the first 10 years, increasing to about 600,000 pounds per year for the next 20 years and then oscillating at a little less than 600,000 pounds. [TR at 6260:1-18 (Engel); OK Ex. 1100].

495. Next, Dr. Engel used the model to predict phosphorus loads if all land application of poultry waste ceased. [TR at 6255:3-5 (Engel)]. In this scenario, all other conditions remained the same. [TR at 6255:6-11 (Engel)]. In the "cessation" scenario, phosphorus loads would decrease by about 18 percent in the first 10 years, and would continue to decline over time until becoming somewhat stable in years 71 through 100. [TR at 6260:19-6261:5 (Engel); OK Ex. 1100]. Dr. Engel testified that in this scenario, soil test phosphorus levels from historic land application of poultry waste would continue to contribute phosphorus runoff for about 70 years after cessation. [TR at 6261:10-25 (Engel)].

496. For his third scenario, Dr. Engel assumed cessation of land application of poultry waste and the addition of vegetative buffer strips along (a) all third-order and larger streams; and alternatively (b) all streams of the IRW. [TR at 6266:8-16, 6268:17-23 (Engel)]. To calculate the impact of vegetative buffer strips, Dr. Engel used a buffer strip reduction coefficient (0.5) from published literature and applied it to the GLEAMS model. [TR at 6267:7-22; 6268:3-6; 6270:14-15 (Engel)]. The model results for the vegetative buffer strip scenario show that phosphorus loads would decrease by an additional 10 to 13 percent above the cessation alone scenario if vegetative buffer strips were installed along all IRW streams. If vegetative buffer strips were installed only along third order and larger streams in the IRW, the reduction in phosphorus loads would only be 5 to 8 percent above the cessation alone scenario. [TR at 6273:5-6274:4 (Engel); OK Ex. 1105; OK Ex. 1106].

497. For his fourth scenario, Dr. Engel assumed phosphorus inputs from land applied poultry waste were increased due to continued growth of the poultry industry in the IRW. [TR at 6262:1-8 (Engel)]. This scenario uses IRW poultry industry growth data from 1982 through 2002 and projects phosphorus growth at the same rate in the future. [TR at 6262:9-23 (Engel)]. The historical data showed a growth in phosphorus from poultry, from 3,800 tons to 4,600 tons. [TR at 6263:8-14 (Engel)]. The model projected that growth rate for 50 years into the future. [*Id.*] All other conditions remained the same as the first scenario. [TR at 6262:19-20 (Engel)]. The model results for the growth scenario project an increase of approximately 70 percent in phosphorus loading to Lake Tenkiller due to poultry waste application in the IRW over a 40 to 50 year period. [TR at 6265:18-6266:7 (Engel); OK Ex. 1100].

498. For his last scenario, Dr. Engel assumed no poultry waste had ever been land applied within the IRW. [TR at 6274:5-8 (Engel)]. Under this scenario, soil test phosphorus levels in the

IRW pastures were set at background levels and the model was run for 100 years with the assumption of no poultry waste application. [TR at 6274:9-14]. Under this scenario, the phosphorus load to the Tahlequah gauging station would be 275,000 pounds less per year than the current phosphorus load. [TR at 6277:14-20; OK Ex. 1108].

499. Dr. Engel also used the model to evaluate historical phosphorus loads to Lake Tenkiller. [TR at 6279:18-23]. Rainfall data and phosphorus input data for 1950 through 1999 were used, as well as historical wastewater treatment plant data. [TR at 6279:24-6280:13 (Engel)]. Based on the historical scenario, the model results show that since 1954, phosphorus loads to Lake Tenkiller from nonpoint sources have increased at a rate of about 8,000 pounds per year. [TR at 6283:7-6284:8 (Engel); OK Ex. 1114].

Defendants' Critique

500. Defendants criticize Dr. Engel's modeling analysis in several respects. First, as Dr. Engel admitted, the GLEAMS model was developed for modeling at the field scale, not the watershed scale. [TR at 6437:17-6443:22; 6454:16-20 (Engel)]. While more robust watershed models were available, Dr. Engle elected not to use them. [TR at 6409:22-6410:10 (Engel)]. Also, GLEAMS was not designed for modeling urban areas. [TR at 6453:25-6454:15 (Engel)]. Although Dr. Engle testified that GLEAMS can be modified to overcome these design limitations, there are a number of reasons to doubt whether, in this case, those modifications were successful.

501. Dr. Engel's model misclassified a number of land uses, treating forests and highways as pastureland. [TR at 6492:25-6496:10 (Engel); 10287:2-10293:1 (Bierman)]. Dr. Engel's model also represented urban areas as alfalfa hay fields, and with hydrological code inappropriate for urban areas. [TR at 6505:21-6507:16; 11359:12-11360:1 (Engel); 10293:11-10295:23 (Bierman); DJX2398; DJX2399; DJX2400].

502. Dr. Engel agreed with the importance of modelers making realistic assumptions. [TR at 6411:20-23; 6486:7-14 (Engel)]. Yet, his model incorporated a number of assumptions that do not represent real-world processes. For example, GLEAMS assumes that all phosphorus on a field has an equal opportunity to run off regardless of its location or any site-specific considerations—an assumption that is inconsistent with fate and transport principles. [TR at 6442:9-6443:17; 6461:23-6463:12 (Engel)]. It assumed, unrealistically, that all litter is applied in the IRW on a single day each year. [TR at 6486:22-6487:11 (Engel)]. It assumed, incorrectly, that litter is applied to every part of every pasture in the IRW. [TR at 6488:19-6490:7 (Engel)]. The model did not consider the statutory and regulatory restrictions on litter application set forth in site-specific nutrient management plans, and in fact assumes conduct in violation of those plans. [TR at 6496:11-6503:12 (Engel)]. Finally, Dr. Engel calibrated his model by comparing his predicted runoff values, which represent runoff all across a million acre watershed, against observed flows into Lake Tenkiller—data sets that bear no relation to one another. [TR at 10269:25-10271:20 (Bierman)].

503. The programming error made by Dr. Engel's post-doctoral assistant and corrected by Dr. Engel most clearly demonstrates the unreliability of the GLEAMS model. The GLEAMS model divides the IRW into three major sub-watersheds (the Illinois River, Baron Fork and Caney Creek), which are in turn divided into 21, 20 and 9 HRUs. [TR at 6398:16-6399:6 (Engel)]. HRUs are not necessarily contiguous land areas, but rather represent portions of each sub-watershed having similar land use, land cover and soil types, among other factors. [TR at 6292:8-13 (Engel)]. The GLEAMS model runs in series to calculate a runoff value for each HRU, and the runoff values are then totaled within each sub-watershed. [TR at 6291:17-6292:13 (Engel)]. Dr. Engel's assistant first developed the code to execute this run for Caney Creek, which has only nine

HRUs. When he copied the code to the other sub-watersheds, he failed to alter it to reflect the larger numbers of HRUs. [TR at 6292:14-6293:25 (Engel)]. Therefore, when the model was calibrated for Dr. Engel's original report, it captured only the first 9 of the 21 HRUs in the Illinois River and the first 9 of the 20 HRUs in the Baron Fork. [TR at 6292:8-6294:4; 6413:25-6420:23 (Engel); 10265:10-13 (Bierman)].

504. Despite omitting half the watershed, Dr. Engel's model nevertheless generated results comparable to a full run which correlated well to the "observed loads" measured by the USGS that Dr. Engel used to calibrate his model. [TR at 6421:18-24; 6477:23-6479:20 (Engel)]. This was possible, Dr. Engel explained, because:

> [T]he model was calibrated, and during that calibration period, some of the parameters available to be modified to adjust the model were changed. In fact, the amount of phosphorus that was applied to these HRUs was the amount of phosphorus applied to the entire watershed.
>
> And based on my knowledge of the model, experience with the model, and similar models, within the working ranges of nutrient applications onto the landscape that we're working within here, that essentially doubling or greatly increasing the application rate provides results that are very similar to more area with the same application, but therefore, at a lower rate-per-unit area.

[TR at 6635:2-24 (Engel)]. Dr. Engel's model made up for the missing land area by randomly adjusting input parameters, including the amount of manure applied and phosphorus present in the soil, and doubling the amount of manure applied to the remaining half. [TR at 6428:24-6433:20 (Engel); 10265:14-10267:9 (Bierman)]. Dr. Engel admitted that in the real world, if the nonpoint source contribution from half the IRW were taken out of the equation, there would be a substantially different phosphorus concentration in Lake Tenkiller. [TR at 6422:2-15 (Engel)]. This admission leads the court to find that Dr. Engel's application of the GLEAMS model does not reliably represent real-world fate and transport processes in the IRW.

505. Defendants also criticized Dr. Engel's "routing model." As previously noted, the routing model embeds on an Excel spreadsheet the equation "P Load = a + b(Q)(P) + c(Q^2)(P)," where a, b and c are coefficients, Q represents USGS-observed flows, and P represents phosphorus accumulated in the river. [*See* FF #488]. To apply his equation, Dr. Engel first "calibrated" it to the IRW by calculating the values for a, b and c that allowed the equation to calculate predicted phosphorus loads to Lake Tenkiller that best matched USGS observed loads. [*See* FF ##489-490]. Dr. Engel testified that once calibrated, the resulting equation represents phosphorus transport from edges of fields throughout the IRW to the gauging stations above Lake Tenkiller at the outlets of each of the Illinois River, Baron Fork, and Caney Creek and accurately relates GLEAMS' prediction of runoff loads to Lake Tenkiller. [TR at 6249:25-6251:16 (Engel)]. As support for the accuracy and reliability of his model, Dr. Engel pointed to the statistical tests he performed, comparing his predicted loads to his observed loads from the routing model. [TR at 6248:15-6249:5 (Engel) ("So R^2s and Nash-Sutcliffe coefficients were both above the range of values that one would hope for calibration, and that was also true for the validation data sets.");[33] 11416:25-11417:22 (Engel)]. Dr. Engel testified the fact that the model could be calibrated and validated demonstrates the validity of his GLEAMS runoff calculations, which are used as inputs into the routing model. [TR at 6466:22-6467:7 (Engel)].

506. The court concludes, however, that Dr. Engel's routing mode is flawed and unreliable for several reasons. Defendants' modeling expert, Dr. Victor Bierman, demonstrated that the model can be calibrated to produce the observed data despite putting in made-up numbers that had nothing to do with phosphorus loads, [TR at 10250:18-10262:2; 10267:10-10269:16 (Bierman);

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[33] R-squared values and Nash-Sutcliffe coefficients are statistical measures of correlation. In both cases, the higher the R-squared value or Nash-Sutcliffe coefficient, the greater the statistical correlation between two sets of data, i.e., the modeled outcomes and observed outcomes. [TR at 6249:25-6251:1; 6476:20-24 (Engel)].

DJX2414; DJX2416]. Notably, when Dr. Bierman replaced Dr. Engel's modeled phosphorus runoff numbers with S&P 500 data for the relevant time period, the S&P data correlated to the observed phosphorus loads with an equally high R-squared value. [*Id.*][34] In rebuttal, Dr. Engel asserted that Dr. Bierman's tests had altered Dr. Engel's coefficients a, b and c, and therefore improperly changed the model, rendering his tests invalid. [TR at 11313:15-11314:19 (Engel)]. Dr. Bierman admitted as much, but explained that he was simply following Dr. Engel's own calibration process, during which the coefficients were not constrained to particular numerical values. [TR at 10375:7-10376:10; 10377:18-10379:19 (Bierman)]; DJX2414; DJX2416; TR at 11428:20-11429:5; 11436:1-11440:23 (Engel)]. The court finds Dr. Bierman's analysis casts substantial doubt on the ability of Dr. Engel's routing model to accurately determine nonpoint source runoff in the IRW.

507. Dr. Engel's routing model achieves a high degree of correlation between predicted and observed loads because both data sets incorporate USGS flow data. Both the predicted and "observed" loads are calculated by multiplying the coefficients and other variables by flow and then again by flow squared. As a matter of simple mathematics, the formula effectively regresses flow data upon itself, essentially ensuring a strong correlation. [TR at 10262:16-10264:2 (Bierman); 11458:8-20; 11461:24-11464:8 (Engel)].

508. Because flow dominates both equations, the routing equation is indifferent to wide variations in phosphorus inputs or coefficient values. Dr. Engel proved this himself by running Dr. Bierman's made-up phosphorus loads through his own routing equation using his own coefficients, and nevertheless generating high R-squared values. [TR at 11448:8-11454:9

[34] Dr. Engel testified during rebuttal that while the S&P numbers correlated well with his GLEAMS numbers on an annual basis, there was substantial variation in the numbers when viewed on a daily basis. [TR at 11507:17-11508:9; 11509:12-11510:14 (Engel)].

(Engel)]. This was further demonstrated during the cross examination of Dr. Engel when significant changes were made to the coefficients in the routing model, which was integrated into an Excel spreadsheet, yet the model produced little or no meaningful change in R-squared or Nash-Sutcliffe values. [TR at 11458:25-11461:23; 11465:17-11467:13 (Engel)].

509. The routing model's inability to accurately represent real world processes was underscored by defendants' demonstration that the routing model will calculate negative phosphorus balances in the rivers and negative phosphorus flows to the lake. [TR at 11471:22-11481:3 (Engel)]. As Dr. Engel admits, such results are clearly impossible in the real world. [TR at 11479:21-11480:4 (Engel)].

510. Because the routing model will in some instances calculate negative phosphorus balances in the rivers and negative phosphorus flows to the lake, Dr. Engel had to modify the equation, adding a constraint or "patch" to prevent phosphorus levels from "going negative." [TR at 11480:5-11 (Engel)]. For two of his sub-watersheds, Dr. Engel did not use the equation disclosed in his expert report and his direct testimony to the court. [TR at 6238:10-6239:12 (Engel)]. Instead, he used an altered version to instruct the model that in the event it calculated more phosphorus loading to the lake than was accumulated in the river, it should reset the P-to-Lake value to the available amount of phosphorus in the river. [TR at 11472:22-11477:4 (Engel)]. Thus, Dr. Engel instructed his model to delete phosphorus it otherwise had calculated for distribution to Lake Tenkiller.

511. Dr. Engel asserted on rebuttal that his "patch" fixed his model. [TR at 11479:21-11480:11 (Engel)]. However, the fact that the routing model will calculate "negative" phosphorus loadings on certain days calls into question whether any of the loadings from this routing model are realistic or representative of actual fate and transport mechanisms. And Dr. Engel's failure to

disclose this "patch" in his direct testimony reflects negatively upon his candor and credibility on this issue.

512. On cross examination, Dr. Bierman agreed that conceptually, GLEAMS may be modified to represent phosphorus transport from urban lands. [TR at 10352:13-17 (Bierman)]. However, this does not overcome the fact that by attempting to do so, Dr. Engel made assumptions and modifications that are unsupportable, such as representing urban lands as alfalfa hay fields. [TR at 10352:18-10354:10 (Bierman)]. The State also suggested Dr. Bierman's critique of Dr. Engel's watershed modeling merited less weight because Dr. Bierman did not develop and run his own watershed or in-stream model. [TR at 10358:2-12 (Bierman)]. Defendants, though, have no obligation to present a competing watershed model; rather, the State bears the burden of establishing its claims.

513. The court finds Dr. Bierman's testimony to be credible and persuasive. It accords no weight to Dr. Engel's watershed modeling analysis.

11. Upstream – Downstream Sampling

514. In the course of its sampling program, the State's experts established a high flow automatic sampling station in an area with no poultry houses. [TR at 5599:2-5 (Olsen)]. However, after noticing high concentrations of phosphorus during high flow events, they investigated and discovered a pasture with land-applied poultry waste just upgradient from the station on the banks of the river. [TR at 5599:5-12 (Olsen)]. Subsequently, during two separate storm events, they sampled the river upgradient of the field and compared them to samples collected downgradient of the field by the automatic sampler. [TR at 5599:13-18 (Olsen)].

515. The upgradient samples were near background for phosphorus (approximately 0.02 mg/L). [TR at 5599:24-5600:3 (Olsen)]. In contrast, the results for the downgradient sampling

were approximately 0.4 mg/L and .07 mg/L respectively. [TR at 5600:3-5 (Olsen)]. Defendants did not challenge the conclusion by the State's expert that the source of the increased phosphorus in the downgradient samples was the pasture with land-applied poultry waste. [TR at 5600:6-10 (Olsen)].

516. While the court recognizes this testimony pertains to a discreet sampling location, the evidence provides some direct proof that phosphorus from land applied litter is running off into the waters of the IRW. Therefore, the court accords this evidence substantial weight.

12. Direct Observation

517. Dr. Caneday testified that in September 2007, while driving on the east side of Chewey Bridge in the Oklahoma portion of the IRW during a rainfall, he observed poultry waste running off a field and that "it looked like the field was actually moving across the road as litter was washed off the field, across the road, down toward the river." [TR at 4366:24-4367:4; 4369:25-4370:1 (Caneday)].

518. Dr. Caneday also testified he had seen poultry waste, straw and feathers, floating on the surface of the Illinois River. [TR at 4365:25-4366:23; 4367:5-8; 4402:23-4405:13 (Caneday)].

519. The court accords Dr. Caneday's testimony substantial weight.

13. Defendants' Expert

520. Defendants' own expert, Dr. Connolly, testified on cross examination:

> Q. (Mr. Page): Okay. Now, doesn't that amount of phosphorus that by definition—that is, nonpoint-source phosphorus—by definition runs off the land indicate to you, sir, that there is a transport pathway of phosphorus from the land to the rivers and streams of the IRW?
>
> A. (Dr. Connolly): Yes.
>
> Q. So you're not suggesting that phosphorus does not run off of fields and forests and urban areas of the IRW and enter the streams of the IRW, are you, sir?

> A. I'd be pretty silly to do that.

[TR at 9142:9-20 (Connolly)].

521. Further, Dr. Connolly admitted that phosphorus from poultry waste runs off the land in the IRW and gets in the waters of the State:

> Q. (Mr. Page): Oh. So you believe there is evidence, then, of a pathway of manures applied to fields within the IRW flowing—their constituents flowing into the streams of the IRW?
>
> A. (Dr. Connolly): If you're asking me whether or not any of the phosphorus in poultry litter applied to fields makes its way to the Illinois River or Lake Tenkiller, the answer is obviously yes . . . .

[TR at 9183:19-22 (Connolly)].

522. The court accords substantial weight to Dr. Connolly's admission that phosphorus from poultry litter makes its way into the waters of the IRW.

14. Defendants' Admissions

523. With the exception of Cal-Maine, defendants have run advertisements in Oklahoma newspapers admitting that phosphorus from land-applied poultry waste is a contributing source to phosphorus loading in the waters of the IRW. In a December 4, 2004, advertisement, the Tyson Defendants, the Cargill Defendants, the George's Defendants, defendant Simmons and defendant Peterson stated:

> Lately, a good deal of concern has been raised about the effect of excess nutrients on the land and waters of Eastern Oklahoma. So where do these nutrients come from? Nutrients can come from many sources, one of which is the use of poultry litter as an organic fertilizer . . . .

[OK Ex. 336]. And in a September 1, 2004, advertisement, the same defendants stated:

> [W]e have been working with the State of Oklahoma on a multi-million-dollar voluntary proposal to improve the management of the poultry-related nutrients that might find their way into Eastern Oklahoma's Scenic River Watersheds. . . .

> . . . We are prepared to do our part to take care of the poultry portion of the nutrient equation.

[OK Ex. 335].

524. George's president Marty Henderson wrote in a company newsletter:

> Litter management has become a major issue in the Poultry industry. There has been a lot of scientific work done the past few years that shows high phosphorus levels in rivers, streams and lakes causes an increase in algae growth which can adversely affect water quality and recreational use. . . . The problem comes when more litter is used than the crops need and phosphorus levels become too high in the soil. During major rain events some of the phosphorus becomes soluble and washes off into the streams and lakes.

[OK Ex. 3043]. In another newsletter, Mr. Henderson wrote:

> Over the years however, studies indicate that continuous use on the same land can increase the phosphorus levels in the soil to levels higher than annual crops can utilize. These studies indicate that in certain watersheds the excess can dissolve into run-off rainwater and get into the streams creating an imbalance in streams and rivers.

[OK Ex. 3045].

525. The Cargill Defendants have admitted:

> Poultry manure is also composed of relatively large amounts of phosphorus . . . . Phosphorus laden soils can be eroded by rainfall and the particles can then be transported into surface water sources. Excessive phosphorus in surface waters can cause excessive plant and algae growth. Excessive algae growth can contribute to fish kills by depleting the dissolved oxygen content of the water . . . Producers should . . . implement an annual soil-sampling program for application fields to determine nutrient concentration and to help calculate application rates. Further applications should not be made to soils containing excessive phosphorus amounts.

[OK Ex. 6131-A at CARTP000010]. They have also stated in a letter to their contract growers that "[p]hosphorus can contaminate water when there is run off after the litter is spread on fields." [OK Ex. 6218].

526. The Tyson Defendants, in a publication titled "Environmental Poultry Farm Management," have stated:

> Poultry production has become one of the major agricultural endeavors in the US. Poultry producing areas are generally located in those parts of the country that are not conducive to traditional row crop agriculture. Examples of these areas include Northwest Arkansas . . . . The main use of poultry litter (poultry manure and bedding material) nutrients has been as a fertilizer for application to field crops and pasture grasses. . . .While the litter has a proven fertilizer value, like any fertilizer, its use also presents the risk of over application.
>
> Over the years, higher phosphorus levels have been noted in some application area soils. Excess phosphorous can be eroded from the soil and washed into nearby waterways. Higher concentrations of phosphorous in surface waters can result in creation of algal blooms. Poultry producers must utilize proper litter nutrient management practices to prevent nutrients from accumulating in soils. The two major nutrients found in poultry litter, nitrogen and phosphorous[,] are essential crop nutrients but can present a risk to the environment if not managed responsibly. . . .
>
> Poultry manure has a high concentration of phosphorous when compared to the concentration of nitrogen. The phosphorous requirements of most plants are less than the nitrogen requirements. If application rates are calculated to meet the nitrogen nutrient requirements of most crops and pasture grasses, it is possible to land apply more phosphorus than is needed. Excess soil phosphorous could then be removed by runoff and transported to water sources . . . .
>
> . . . Excess amounts of soluble phosphorous are also easily incorporated into precipitation and could leave the litter application area.

[OK Ex. 1283, TSN0075CORP-TSN0076CORP]. In a presentation titled "Environmental Poultry Farm Management Workshop," Tyson stated that phosphorus is mobile; it "causes water quality problems [and] accumulates in the soil." [OK Ex. 3207 at TSN117466OK].

527. In a November 24, 1998 memorandum, Peterson's Director of Personnel/Environmental Affairs/Corp., in discussing potential new litter disposal technologies, wrote:

> Time continues to pass with no new solutions of dealing with excess animal waste and environmental problems it is creating. . . . I realize once again I've come with no new solutions, but we continue to look at anything that may solve all or part of our problem. The solution may be one or a combination of these technologies. Or it may mean our industry must make some changes in the way we do business.

[OK Ex. 3034].

528. The court accords these admissions substantial weight in evaluating the State's case.

15. Phosphorus from Land-Applied Poultry Waste Ends Up in the Waters of the IRW

529. As previously stated, poultry waste generated by each defendants' birds has been land applied on fields in the IRW. [*See* FF #372].

530. Dr. Johnson opined that if there is any surface fertilizer or amendment and it rains hard enough and long enough to create some runoff at the edge of the field, it is inevitable that some evidence of it will be detected in the runoff. [TR at 5172:1-6 (Johnson)].

531. Phosphorus runoff calculations made in various coefficient-based studies of land applied poultry waste in the IRW are consistent in finding that approximately five percent of the phosphorus in land-applied litter in the IRW is expected to run off in a typical year. K. Willett, D. Mitchell, H. Goodwin, B. Vieux, and J. Popp, "The opportunity cost of regulating phosphorus from broiler production in the Illinois River Basin," Journal of Environmental Planning and Management 49(2):181-207 (2006); A.N. Sharpley, S. Herron, and T. Daniel., "Overcoming the challenges of phosphorus based management in poultry farming," Journal of Soil and Water Conservation 62(6):375-389 (2007); and M.A. Nelson, K.L. White and T.S. Soerens, "Illinois River Phosphorus Sampling Results and Mass Balance Computation," Arkansas Water Resources Center (2002). [OK Ex. 1025; OK Ex. 1003]. The Willett study concluded that 5.36 percent of phosphorus applied through poultry litter applications in the IRW is lost in runoff each year. The Sharpley study concluded the phosphorus loss from land applied poultry litter in the IRW is 5 percent. [OK Ex. 1025 at p. 378]. The Nelson study found that four to five percent of phosphorus (including that in poultry waste) land applied in the IRW runs off. [OK Ex. 1003 at p. 17].

532. Similarly, Dr. Edwards testified that approximately five percent of the phosphorus in any given land application can be expected to run off. [Ct.'s Ex. 11 (Edwards Dep.) at pp. 7, 23-24]. And the Clean Lakes Report, in discussing run-off coefficients, utilized a coefficient of

0.2-0.65 kg/ha/yr for pasture in the IRW and assumed "that all wastes produced at these locations are susceptible to transport due to rainfall events and erosion." [OK Ex. 3285 at p. 45; p. 46, Table XVII].

533. Defendant Cargill Turkey Products states in its Contract Grower Environmental Best Management Practices Guide: "It should be recognized that some level of nutrient loss to surface and groundwater will occur despite following the recommendations in this manual; however, these losses should be lower than would occur without nutrient management." [OK Ex. 6131-A at CARTP000009].

534. The testimony of Shanon Phillips aptly describes the dynamics of field runoff on both a micro and macro level. She stated that farm ponds act as catchment basements for nutrients in runoff from individual farms, and likened Lake Tenkiller to a catchment basin for the entire IRW. [TR at 1478:18-1479:8; 1511:7-17 (Phillips)].

535. In evaluating the State's case, the court accords substantial weight to the evidence that some fraction of phosphorus from land applied poultry waste runs off to the waters of the IRW.

16. Phosphorus Concentrations in Other Watersheds

536. Defendants introduced evidence of high phosphorus levels in a number of Oklahoma lakes and rivers, as well as eutrophic and hypereutrophic lakes outside of the IRW. [TR at 9122:15-9123:10 (Connolly); TR at 10615:5-8 (Sullivan)].

537. However, as Dr. Sullivan testified, when evaluating the phosphorus in the IRW compared to other watersheds, the best comparison is to look at watersheds that had similar populations of cattle, people, and poultry and similar geology. [TR at 10623:12-23 (Sullivan)]. Defendants conducted no such comparison. Additionally, any comparison between watersheds requires an analysis of background levels of phosphorus. [TR at 10624:16-21 (Sullivan)]. Dr.

Sullivan acknowledged that natural background phosphorus concentrations in the waters of the IRW are probably as low as 0.010 or 0.020 mg/L. [TR at 10624:21-10625:3 (Sullivan)].

538. The court, therefore, accords little weight to defendants' evidence of high phosphorus levels in other Oklahoma lakes and rivers, and to their evidence of eutrophic and hypereutrophic lakes outside the IRW.

N. Phosphorus in Runoff from Land-Applied Poultry Waste is a Significant Source of Phosphorus Causing Injury to IRW Waters

539. The evidence that phosphorus from land-applied poultry waste can and does run off into the waters of the IRW is convincing. As set forth below, the evidence is convincing that poultry waste is a significant source of the phosphorus causing injuries to the rivers and streams of the IRW and to Lake Tenkiller.

540. According to the Tenkiller Clean Lakes study, nonpoint phosphorus loading is responsible for 83.5 percent of the estimated average total phosphorus load to Lake Tenkiller, while point source loading accounts for only 5.5 percent.[35] [OK Ex. 3285, p. 55 (Table XXIV)]. In turn, 76.73% of the nonpoint phosphorus load reaching Lake Tenkiller is the result of manures produced by animal operations in the basin. [OK Ex. 3285 at 46 (Table VII)].[36] Thus, phosphorus loading from animal litter and manures produced in the IRW comprises 63.69% (83% x 76.73%) of the annual phosphorus load reaching the lake.

541. Earl Smith, chief of the Water Management Division of the Arkansas Natural Resources Commission, testified that phosphorus impairs many of the area's streams, including the Illinois River, and that pasture land using land-applied poultry litter as a fertilizer is a significant contributor to nonpoint phosphorus sources. [TR at 9603:9-19; 9609:23-9610:5 (Smith)].

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[35] The remaining 11 percent of estimated average total phosphorus loading to the lake was attributed to "background." [OK Ex. 3285, Table XXIV].

[36] "Animal operations" including poultry, dairy cattle, and beef cattle operations.

542. Shanon Phillips, Director of the Water Quality Division at the Oklahoma Conservation Commission, opined, based on her education and experience, and to a reasonable degree of scientific certainty, that nutrients from land-applied poultry waste contribute to nutrient loading of the waters of the IRW, and that poultry waste adversely affects the water quality of the basin. [TR at 1384:2-7; 1384:22-25; 1532:6-9 (Phillips)].

543. Based on the above and foregoing findings, the court finds that the run off from fields fertilized with poultry waste contain an environmentally significant amount of phosphorus. The court finds that phosphorus that has run off from land-applied poultry waste generated by poultry is a significant source of the phosphorus causing injuries to the waters of the IRW.

O. Defendants' Awareness that Phosphorus from Land-Applied Poultry Waste is Contributing to Water Pollution in the IRW

544. The environmental consequences of phosphorus in land-applied poultry waste in the IRW have long been known to defendants. Even assuming, however, that defendants were unaware of these consequences, the State has presented ample evidence that the environmental consequences of phosphorus in land-applied poultry waste in the IRW have long been *knowable* to defendants.

545. Mark Simmons, Chairman of Simmons Food, testified that the poultry industry started recognizing the potential environmental impact of poultry waste in the 1980s. [TR at 4132:23-4133:10 (Simmons)]. The industry's initial concern was nitrogen enrichment of water bodies, but by the mid-1990's, the industry's concern shifted to phosphorus impact. [TR at 4133:11-24 (Simmons)].

546. In 1988, Martin Maner, then an employee of the Arkansas Department of Pollution Control and Ecology (and later, the chief of the water division of the Arkansas Department of Environmental Quality from 2004 to 2008) authored a paper titled "Agricultural Land Use,

Nutrients, and Water Quality in Benton and Washington Counties." [OK Ex. 3312]. Maner wrote:

> Wastes from animal production . . . disposed of by land application . . . are high in nitrogen and phosphorus and may contribute nutrients to groundwater or surface water via percolation and runoff.
>
> Benton and part of Washington County are largely underlain by fractured limestone of the Boon Formation. The soils overlying the Boone are moderately to excessively well drained. Because of these features, rainfall percolates readily through the soil and into the shallow groundwater aquifer. Therefore soluble materials placed on the surface enter the groundwater with relative ease.
>
> * * *
>
> Nitrogen and phosphorus should be applied at a rate not greater than what cover plants can assimilate. . . . Excess values built up in the soil will be washed into surface waters whenever erosion occurs.
>
> Chicken manure has a higher phosphorus to nitrogen ratio than is utilized by plants. If the application of this material is based on its nitrogen content, an excess of phosphorus will build up.

[OK Ex. 3312 at ADEQ-225-226]. Maner testified the paper was produced within the department's water division and then made available to "interested parties." [Ex. 3 at pp. 12-13 (Maner Dep.)].

547. Also in 1988, the first National Poultry Waste Management Symposium ("NPWMS") was conducted. [Court's Ex. 1 at p. 2 (Blake Dep.); OK Ex. 3391]. As reported in the symposium:

> [T]he Symposium was organized to discuss the issues, problems and potential solutions to problems with poultry waste management and utilization. Growth and concentration of the poultry industry has resulted in large volumes of manure, used litter, hatchery wastes, dead birds, offal and wash water that need to be utilized or disposed of in way[s] that minimize undesirable environmental impacts.

[OK Ex. 3391 at iii]. The symposium included a presentation titled "Runoff Potential from Poultry Manure Applications," which discussed phosphorus runoff from land-applied poultry waste. [*Id.* at pp. vi and 102-106].

548. In 1990, the second NPWMS was held. [OK Ex. 3393]. As reported in the symposium:

> The demand for poultry and poultry products continues to increase rapidly, and is being supplied by very large integrated organizations which are concentrated in relatively small areas of the nation's land mass. The development of these large organizations has resulted in a wealth of sophisticated, uniform, low-cost, highly nutritious poultry products for our nation's consumers; but the concentration of poultry production and processing has also resulted in the production of huge amounts of by-products including manure, farm mortalities, feathers, processing plant offal and hatchery wastes which must be managed on a daily basis.

[*Id.* at p. 1]. One of the presentations, "How Poultry Waste Management Can Prevent Contamination of Ground and Surface Water," stated in pertinent part that "the owner of the flock, generally a feed company and/or processor, can exercise control over individual growers via the contract between the two parties. Contract requirements could be expanded to include environmental concerns." [*Id.* at p. 17].

549. In 1992, the third NPWMS was conducted. [OK Ex. 3395]. As reported in the proceedings:

> Chief among the problems facing the poultry industry are those of waste management and associated environmental issues. Practically all of these problems are addressed in-depth by the wide range of speakers and poster presentations scheduled for this Symposium.

[*Id.* at p. 1].

550. Several of defendants' employees and/or representatives have attended the NPWMS meetings. The 1988 program lists Cargill as a sponsor and two Cargill representatives as attendees. [OK Ex. 3391 at pp. iv, 194], and the Cargill Defendants admit their employees routinely attend NPWMS meetings and seminars. [OK Ex. 860 at pp. 13-14; TR at 4725:17-23

(Maupin); TR at 4926:22-4927:4 (Alsup). Likewise, Claud Rutherford of Simmons testified to attending several of the symposia beginning in 1990, chairing one of its committees and making a presentation at the 1992 NPWMS. [TR at 4226:6-12 (Rutherford); OK Ex. 3395]. Employees of the Tyson Defendants have attended one or more symposia. [OK Ex. 944 at pp. 7-10; OK Ex. 3393; OK Ex. 3395]. At the 1992 NPWMS, an employee of the Tyson Defendants made a presentation titled "Corporate Management Commitment to Waste and Environmental Management." [OK Ex. 3395 at p. 25]. A Cal-Maine employee is identified as having attended the 1996 NPWMS, during which presentations were made on local environmental challenges, new methods of waste management and nutrient management plans. [OK Ex. 3399 at p. iv; OK Ex. 893 at pp. 7-11]. Ed Fite testified that he attended the 1998 NPWMS in Springdale, Arkansas, and saw representatives from the Tyson Defendants, the Cargill Defendants, and Simmons. [TR at 648:11-21; 649:8-650:7 (Fite)].

551. In Arkansas, representatives of the Tyson Defendants, Cargill Defendants and Simmons served on Governor Clinton's Animal Waste Management Task Force, which convened in 1990 and issued its final report in 1993. [OK Ex. 5573 at p. OSRC0001617]. The stated purpose of the task force was "to advance solutions to animal waste disposal problems." [*Id.* at p. OSCR0001607]. Claud Rutherford of Simmons was the vice-chair of the task force and chaired the Problems and Issues Committee, which recognized the environmental degradation and water quality issues presented by animal waste. [*Id.* at OSCR0001626-1627]. The task force's 1993 report included a chart prepared by the Problems and Issues Committee, which listed problems from animal waste, including "environmental degradation," "water quality (fishable and swimmable)," and "drinking water: increase risk of pathogens, violations of MCLs, increased treatment for palatability." [OK Ex. 5573A at OSCR0001627]. Rutherford also chaired the

Voluntary Approach Evaluation Committee of the task force, which reported, "[a] voluntary program has been prepared (A Voluntary Program for the Prevention of Nonpoint Source Pollution as Relates to Animal Waste)." [OK Ex. 5573 at OSR0001610].

552. In 1990, the Southeastern Poultry and Egg Association funded a research project by Dr. Dwayne Edwards at the University of Arkansas. [Court's Ex. 11 at p. 32 (Edwards Dep.)]. The purpose of his study was to obtain data regarding poultry industry impacts on the environment. [*Id.*] One finding of the study was that "masses of litter constituents transported off the plots via runoff significantly increased with both litter application rate and rainfall intensity." [*Id.* at p. 10 (Edwards Dep.)].

553. The U.S. Poultry and Egg Association (formerly the Southeastern Poultry and Egg Association), headquartered in Decatur, Georgia, is a poultry industry trade group. [Court's Ex. 2 at p. 6 (Dalton Dep.)]. In 1992, the association—together with the Soil Conservation Service (later known as the National Resource Conservation Service), the Tennessee Valley Authority and the EPA—formed the Poultry Water Quality Consortium. [*Id.* at pp. 23, 27 (Dalton Dep.)]. The purpose of the consortium was to collect and disseminate information on the current state of knowledge of poultry water quality. [*Id.* at pp. 23-27 (Dalton Dep.)]. The consortium published the Poultry Water Quality Handbook in 1994. [*Id.* at p. 28 (Dalton Dep.); OK Ex. 800]. The handbook stated, in pertinent part:

- How [poultry] waste is disposed of treated, or managed has a direct influence on the cleanliness of surface and groundwater." [*Id.* at PIGEON.0498].
- Poultry wastes . . . contain significant amounts of phosphorus . . . . [I]f it is used improperly, phosphorus can . . . contribute to environmental and water quality problems. It can be a major cause of water quality degradation in surface waters. [*Id.* at PIGEON.0514].
- When nitrogen and phosphorus concentration in waterbodies rise too high, algae and rooted aquatic plants take over, prematurely aging and choking the waterbody

> and creating undesirable conditions—odors, offensive taste, and discoloration—all of which can make the water unfit for consumption or recreational and aesthetic use. Further, these eutrophic conditions can kill fish, clog water treatment plant filters, and lead to the growth of blue-green algae, a species that can be fatal to cattle. [*Id*. at .0514-.0515].

554. The Poultry Water Quality Handbook was widely distributed by the Water Quality Consortium, including the U.S. Poultry and Egg Association's annual trade show. [Court's Ex. 2 at pp. 36-37, 40-42 (Dalton Dep.)]. For instance, Jim Pigeon acquired it at a conference he attended as a field man for Peterson. [TR at 3825:7-24; 3837:25-3838:6 (Pigeon)].

555. A second edition of the Poultry Water Quality Handbook was published in 1998. [OK Ex. 801]. It stated that how poultry manure and litter were disposed of, treated, or managed "will directly influence the cleanliness and safety of surface and groundwater resources"; that when too much poultry waste is applied to the land, it can move with the soil into surface water or through soil into groundwater, impairing water quality; that phosphorus has become a major cause of water quality degradation; that applying poultry waste at rates based on nitrogen needs can lead to phosphorus buildup in the soil; that "[p]hosphorus-laden soils or dissolved phosphorus can move via runoff into rivers, lakes, and streams, where it causes excessive plant and algae growth, which in turn depletes the dissolved oxygen content in the water"; and that "[t]he potential for adverse environmental impacts appears greater as a result of the industry's trend to grow ever larger numbers of birds on smaller areas of land." [*Id*. at CARTP220108, CARTP220134, CARTP220132-0134; CARTP220119]. Peterson distributed the second edition of the handbook to its field men (service techs) and its growers. [TR at 3825:7-3826:15; 3827:25-3828:6 (Pigeon)].

556. After conducting a study of animal waste handling, storage, and disposition practices in Oklahoma, Governor Frank Keating's Animal Waste & Water Quality Protection Task Force

presented its Final Report in December 1997. [DJX2757]. Tulsa attorney Gerald Hilsher, a member of the task force, testified that the task force was concerned that poultry litter was a primary cause of water quality degradation, and therefore, the study focused in part on how the industry is dealing with land application of litter. [TR at 588:17-589:4 (Hilsher)]. Representatives of the Tyson Defendants and Simmons were present at task force meetings. [TR at 651:16-25 (Fite); 600:13-28; 601:10-15 (Hilsher)].

557. Ed Fite testified he has suggested several times to representatives of the Tyson Defendants and Simmons that defendants move poultry waste out of the IRW and increase the cost of birds in the marketplace by one-half to one cent per bird to compensate for the cost of waste removal. [TR at 740:18-741:8; 742:19-743:7; 744:4-745:3; 745:20-746:4; 746:10-747:10 (Fite)].

558. In 1998, the Oklahoma Legislature enacted the Oklahoma Registered Poultry Feeding Operations Act. *See* 2 Okla. Stat. § 10-9.1, *et seq.*

559. In 2001, the City of Tulsa sued a number of the defendants to this lawsuit, alleging that the defendants' poultry waste management practices were polluting the City's water supply in the Eucha/Spavinaw watershed. *See City of Tulsa v. Tyson Foods, Inc.,* Case No. 01-CV-0900-B(C), N.D. Okla. (2001).

560. Representatives of the defendants testified uniformly that they do not know, nor have they attempted to find out, whether land-applied poultry waste generated by their birds in the IRW has contributed to water quality problems in the IRW. [TR at 3409:12-3410:5 (Pilkington for Tyson Defendants); TR at 4734:14-4735:10 (Maupin for Cargill Defendants); TR at 4308:3-14 (McClure for George's Defendants)]; TR at 4146:12-4147:2 (Simmons for Simmons); TR at 4839:5-25 (Houtchens for Peterson); TR at 4453:4-7 (Storm for Cal-Maine)].

561. Based upon the foregoing, the court finds each defendant has known and/or has had reason to know that injuries to the waters of the IRW were and continue to be substantially certain to result from the land application of poultry waste in the IRW.

P. Other Contributors to Phosphorus Loading to the Waters of the IRW

562. A number of sources other than poultry waste also contribute to phosphorus loading of the waters of the IRW.

1. Point Sources (Waste Water Treatment Plants)

563. As previously stated, it is undisputed that point sources account for less than 20 percent of the phosphorus load reaching Lake Tenkiller. *See* FF #259.

2. Urban Runoff

564. Urban areas comprise approximately five to seven percent of the total land area of the IRW. [OK Ex. 3351 at OSU0005156; TR at 10927:23-10928:8 (Sullivan)].

565. The Tenkiller Clean Lakes study concluded that urban runoff accounts for 3.49 percent of total phosphorus loading to Lake Tenkiller. [OK Ex. 3285 at p. 46, Table XVII].

3. Commercial Fertilizers

566. The testimony before this court was that land application of poultry litter is widespread over the IRW and provided a low-cost alternative fertilizer for ranch operations. The record does not appear to contain a credible calculation of phosphorus contributions from commercial fertilizers.

4. Cattle

567. The parties agree that cattle manure is a substantial nonpoint source of phosphorus loading to the streams and rivers of the IRW. However, they disagree about the exact percentage it contributes to the total phosphorus load. And the State asserts that phosphorus from cattle

manure should be attributed to poultry waste because cattle are "recyclers" of phosphorus from poultry waste used as a fertilizer.

568. The State's witness estimated the IRW cattle population at approximately 290,000. [TR at 2437:9-15 (Fisher)]. Defendants' expert put the number at 200,000. [TR at 9835:19-23 (Clay)].

569. Cattle impact water quality in a number of ways, including: depositing manure directly in or next to rivers and streams; removing stream bank vegetation in areas where they loaf, thereby increasing the potential for erosion; compacting soils, thereby reducing the possibility of infiltration; and by channelization. [TR at 2443:20-2444:9 (Fisher); 10719:11-10726:14 (Sullivan)].

570. Defendants' expert, Dr. Billy Clay,[37] testified that cattle in the IRW annually generate hundreds of thousands of dry tons of manure that contain more phosphorus than all the poultry litter available for land application in the IRW. [TR at 9841:1-12; 9847:2-7; 9848:21-9849:6; 9851:22-9854:5 (Clay)]. Specifically, he testified that on a dry weight basis, cattle produce 217,000 tons of manure and poultry produce 157,000 tons of manure annually.[38] [TR at 9851:22-9852:6 (Clay)]. Further, he calculated that phosphorus contributions to the IRW from cattle manure totaled 3,136 tons annually; in contrast, he opined that phosphorus contributions from

[37] Dr. Clay received an M.S. in agricultural sciences with emphasis on agronomy and a DVM, both from Oklahoma State University. [TR at 9802:7-15 (Clay)]. He is board certified in veterinarian toxicology. [*Id.*] He has taught undergraduate classes on forage crops, and veterinary medicine classes related to food animals and herbivorous animals. [TR at 9803:14-24 (Clay)]. He has worked on research and development of pharmaceuticals for private enterprise entities. [TR at 9805:10-21 (Clay)]. Additionally, he has done consulting for companies in matters related to toxicology, veterinary medicine and agronomy. [TR at 9806:11-17 (Clay)].

[38] The poultry manure figure is net of poultry manure exported from the IRW, which he calculated to be 70,000 tons. [TR at 9852:4-10 (Clay)].

poultry manure remaining in the IRW totaled 2,398 tons annually. [TR at 9853:19-23 (Clay); DDX 265, 266].[39]

571. In addition to cattle, other types of livestock and wildlife contribute 950 tons per year of phosphorus in the IRW. [TR at 9850:10-9851:18 (Clay)].

572. Nonetheless, as admitted by Dr. Clay based on his own calculations, poultry manure is a significant contributor of phosphorus (2,398 tons annually) to the IRW. [TR at 9877:17-9878:13 (Clay)]. Moreover, defendants have not refuted the State's evidence that cattle, because they graze in pastures where poultry waste has been land applied, are recyclers of phosphorus from poultry waste. [TR at 916:9-10 (Fite); TR at 6623:22-6624:16 (Engel)].

5. Streambank Erosion

573. Streambank erosion also contributes to the phosphorus load of the streams and rivers of the IRW. Streambanks in the IRW contain nutrients, including phosphorus. [TR at 1527:12-14 (Phillips); TR at 10701:17-20 (Sullivan)]. Defendants' expert, Wayne Grip,[40] using aerial photography, documented channel shifts in the Illinois River over the past 30 to 40 years. [TR at 10007:11-22 (Grip)]. He estimated that 15.5 million cubic yards of streambank soils have eroded into the main channel of the IRW. [TR at 10080:18-21 (Grip)]. However, none of defendants' experts attempted to quantify the amount of phosphorus contributed by streambank erosion. [TR at 10097:23-10098:22 (Grip)]. To further complicate matters, the record reflects that phosphorus from land-applied poultry waste infiltrates streambank soil by percolating through the shallow karst. Thus, phosphorus levels in streambank soils that exceed background levels of phosphorus are caused, at least in part, by land-applied poultry waste.

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[39] Dr. Clay testified that on a dry weight basis, poultry manure has three times as much phosphorus as cattle manure. [TR at 9879:17-23 (Clay)].

[40] Wayne Grip, a photogrammetrist and photointerpretor, is the co-founder and president of Aero-Data Corporation, a consulting firm. [TR at 9986:11-25, 9991:15-17 (Grip)].

6. Roads

574. Defendants' expert, Dr. Timothy Sullivan, estimated there are a total of 2,600 miles of unpaved road in the IRW. [TR at 10708:14-16 (Sullivan)]. However, the State's expert, Dr. Engel, opined that dirt roads are not an independent source of phosphorus beyond background. [TR at 6628:22-6629:19 (Engel)]. He further testified that the amount of any phosphorus running off from dirt roads would be small, and if there is any phosphorus beyond natural background levels on the dirt roads in the IRW, one of the sources of that phosphorus would be poultry waste. [*Id.*]

7. Septic Systems

575. Approximately 73,000 people—or a third of the population of the IRW—use septic tanks. [TR at 6532:4-11 (Engel); TR at 10709:6-12 (Sullivan)]. Dr. Engel testified that on average, the amount of phosphorus contributed to a septic system by an individual is approximately 1.1 pound per year. [TR at 6594:5-14 (Engel)]. Septic systems have the potential to impact both groundwater and surface waters. [TR at 1403:9-17 (Phillips); 6533:2-5 (Engel); 10711:7-9 (Sullivan)].

576. Dr. Sullivan testified that Dr. Engel's study reported a statistically significant correlation between the density of septic systems in the subwatersheds he studied and phosphorus concentration in streams. [TR at 10713:2-16 (Sullivan)]. Although Dr. Engel dismissed the correlation as an artifact of another correlation with poultry house density, Dr. Sullivan believed "there was no adequate basis for that dismissal." [TR at 10713:17-20 (Sullivan)].

577. Nevertheless, Sullivan conceded that—even assuming that all septic systems in the IRW were to discharge directly into streams—the total amount of phosphorus contributed by septic

would be approximately the equivalent of 16 poultry houses (in a watershed with approximately 1,800 active poultry houses). [TR at 10906:12-10907:14 (Sullivan].

578. The parties did not study phosphorus contributions from septic systems in the IRW. [TR at 9154:24-9155:5 (Connolly); TR at 9755:20-23 (Larson)].

8. Nurseries

579. There are three large nursery operations in the IRW. [TR at 834:1-4 (Fite)]. Based on the evidence presented, the court finds that nurseries are not a significant contributor of phosphorus to the IRW.

9. Golf Courses

580. There appear to be one or two golf courses in the IRW. [TR at 518:23-519:1 (Tolbert); TR at 833:12-25 (Fite); TR at 9651:7-12 (Duncan)]. Based on the evidence presented, the court finds that golf courses are not a significant contributor of phosphorus to the IRW. [TR at 6203:12-18 (Engel)].

10. Gravel Mining

581. The State has adopted rules to regulate gravel mining in scenic rivers. [TR at 3538:13-21 (Strong); TR at 940:21-24 (Fite)]. Gravel mining operations are no longer permitted on rivers or streams in the IRW within the jurisdiction of the Oklahoma Scenic River Commission (“OSRC”). [TR at 790:14-19 (Fite)]. One gravel mining operation operates on the Baron Fork at Baron, Oklahoma, outside the jurisdiction of the OSRC. [TR at 790:20-791:20 (Fite)]. There is insufficient evidence before the court to quantify the amount of phosphorus, if any, generated by that operation.

582. Based on his review of prior work, reports and literature regarding the IRW, Dr. Engel excluded gravel mining as a source of phosphorus loading from his modeling analysis. [TR at 6564:11-20 (Engel)].

11. Human Recreational Activity

583. As previously noted, significant recreational activities occur in the IRW. Neither the State nor defendants have provided evidence regarding the extent to which these activities contribute to phosphorus loading in the IRW.

12. State Conduct

584. There is limited evidence on the record that the State has contributed to phosphorus loading to the waters in the Oklahoma portion of the IRW. OSRC director Ed Fite testified he applied a single pickup load of composted poultry waste to four contained flower beds at the OSRC office. [TR at 736:3-737:3 (Fite)]. Additionally, the State's expert, Dr. Caneday, testified he was aware that sewage overflows from Tenkiller State Park's waste management system had occurred during flooding events in the early to mid-1990s, that the overflows would have had a direct pathway to Lake Tenkiller, and that the ODEQ ordered Tenkiller State Park to overhaul its waste management system. [TR at 4394:13-17; 4396:8-15; 4397:21-4398:5; 4398:11-14 (Caneday)]. There has been no evidence that either of these events had any significant impact on phosphorus loading to waters of the IRW.

13. Summary

585. Defendants criticize the State for not adequately considering other potential sources of phosphorus as part of its investigation. However, based on the evidence produced at trial, it is clear that poultry waste is a major contributor to the levels of phosphorus in the waters of the IRW.

586. The court finds, therefore, that while other sources contribute to phosphorus loading of the IRW, poultry waste is the principal contributor of the phosphorus causing injuries to the waters of the IRW.

Q. Efforts by the State of Oklahoma to Address Phosphorus Loading in the IRW

587. The State has taken a number of steps, both on its own and with the State of Arkansas, to address phosphorus loading in the IRW.

588. In 1997, at the request of the State, the Compact Commission adopted a nutrient-reduction goal of reducing the annual loading of phosphorus in the IRW by 40 percent. [TR at 9466:22-9467:10 (Smith)].

589. Recommendations from Governor Keating's Animal Waste Task Force led to passage of ORPFOA in 1998. [TR at 2895:19-2896:9 (Gunter)].

590. In 2003, Arkansas and the State signed a "Statement of Joint Principles and Actions," in which both states agreed, among other things, to coordinate water quality monitoring efforts and to work on a comprehensive watershed management plan. [OK Ex. 5666, Attachment C]. Arkansas also agreed to work with its point source dischargers to lower phosphorus discharges. [*Id.*] The States also agreed to jointly pursue funding, including federal funding for various litter removal and reuse techniques in order to remove excess poultry litter from the affected watershed. [*Id.* at p. 2]

591. Additionally, ODEQ has imposed more stringent limits for phosphorus in new permits for Oklahoma wastewater treatment plants, and assisted with improvements to the plants. [OK Ex. 5664 at p. 5; OK Ex. 5665 at p. 5]. ODEQ also investigated complaints and has undertaken enforcement actions against several gravel mining operations in the IRW. [*Id.*]

592. The State has participated in the USDA's Comprehensive Reserve Enhancement Program and the EPA's Section 319 program to address phosphorus issues in the IRW. [TR at 976:12-977:3; 1299:22-1302:2 (Phillips)]. These programs include various projects to prevent nonpoint source contributions of phosphorus, including projects involving riparian buffers, riparian exclusion of cattle, pasture management and planting to prevent overgrazing, septic system upgrades to replace inadequate septic systems and programs for hauling litter out of the watershed. [TR at 1351:3-12; 1357:10-23; 1361:22-1363:2; 1368:20-25; 1370:13-25 (Phillips)].

R. Remediation

593. The State seeks an injunction that (1) makes defendants responsible for waste generated by their birds and precludes land application of poultry waste in the IRW at rates greater than the agronomic rate; (2) requires remediation of the IRW; and (3) requires defendants, at their own expense, to undertake an investigation of remedial actions to address the effects of land application of poultry waste in the IRW and to pay for the costs of implementing those remedial actions. Additionally, the State requests monitoring of defendants' compliance with the terms of any injunction entered by the court.

594. The State retained Todd King, a principal engineer with Camp, Dresser & McKee, to conduct a preliminary investigation of options for remediation of the IRW. [TR at 7990:12-7991:7 (King)]. King investigated and "retained" the following remedial options: (1) cessation, (2) buffer strips, and (3) increased treatment of drinking water. [TR at 7996:1-7997:22; 7998:10-8001:5; 8007:1-8008:13 (King)]. King suggested the following remedial options be investigated and further assessed: (1) excavation, (2) alum application to fields, (3) crop and nutrient management with nitrogen supplementation, (4) bank stabilization, (5) constructed wetlands, (6)

alum application to Lake Tenkiller, (7) sediment removal from Lake Tenkiller, and (8) layered aeration of Lake Tenkiller. [TR at 8001:6-8006:25; 8008:14-8011:15 (King)].

595. In addition to King's recommendations, witnesses for the State advocated exportation of all poultry litter outside the watershed for application to phosphorus-deficient soil, and lake aeration to improve the fish habitat. [TR at 1514:7-12; 1547:2-18 (Phillips); TR at 7897:14-22 (Welch)].

III. Conclusions of Law

1. Remaining for adjudication in this case are the State's claims for injunctive relief for violation of Oklahoma statutory public nuisance law, federal common law nuisance, and common law trespass, its claims for injunctive relief and penalties under 27A Okla. Stat. § 2-6-205, and its claim for injunctive relief under 2 Okla. Stat. § 2-18.1.

A. Standing

2. The State asserts it has standing on the basis of sovereign and quasi-sovereign interests. *See* Doc. 1822.

3. A state, in its capacity of quasi-sovereign, has "an interest independent of and behind the titles of its citizens, in all the earth and air within its domain." *Georgia v. Tenn. Copper Co.,* 206 U.S. 230, 237 (1907). Further, "the state, as quasi-sovereign and representative of the interests of the public, has a standing in court to protect the atmosphere, the water, and the forests within its territory, irrespective of the assent or dissent of the private owners of the land most immediately concerned." *Hudson Cnty. Water Co. v. McCarter,* 209 U.S. 349, 355 (1908). The State may sue as *parens patriae* to protect its citizens against "the pollution of the air over its territory; or of interstate waters in which the state has rights." *Satsky v. Paramount Commuc'ns, Inc.,* 7 F.3d 1464, 1469 (10th Cir. 1993) (citations omitted).

4. The State has standing to pursue its statutory public nuisance, federal common law nuisance and statutory anti-pollution violation claims (27A Okla. Stat. § 2-6-205 and 2 Okla. Stat. § 2-18.1) based on its quasi-sovereign interests. Additionally, 27A Okla. Stat. § 2-3-504(F)(1) and (2) and 2 Okla. Stat. § 2-16(B) give the Attorney General the authority to sue on behalf of the State for these statutory violations.

5. The State asserts standing to pursue its trespass claim based on its sovereign interests. The State relies in part on 60 Okla. Stat. § 60(A), which provides:

> Water running in a definite stream, formed by nature over or under the surface, may be used by the owner of the land riparian to the stream for domestic uses . . ., but he may not prevent the natural flow of the stream, or of the natural spring from which it commences its definite course, nor pursue nor pollute the same, as *such water then becomes public water and is subject to appropriation for the benefit and welfare of the people of the state*, as provided by law[.]

Id. (emphasis added). The State claims a possessory property interest in waters flowing in definite streams in the Oklahoma portion of the IRW.

6. Defendants argue the State lacks standing to assert its trespass claim because it cannot claim *exclusive* possession of the waters. As the court previously observed, the Cherokee Nation also claims a substantial ownership interest in the waters of the IRW in Oklahoma. *See Oklahoma v. Tyson Foods, Inc.,* 258 F.R.D. 472, 476-78 (N.D. Okla. 2009). Further, the court concluded the State did not have standing as a quasi-sovereign to assert a claim for damages for injury to lands and natural resources in the IRW that fall within the Cherokee Nation's sovereign interests. *Id.* at 483. However, with respect to the claim at issue, the State is seeking injunctive relief, and it asserts a possessory interest in the waters of the IRW. The State's trespass claim does not require that it hold exclusive possessory rights. The State need only establish it has a right to the waters of the IRW superior to defendants' right. *See Lambert v. Rainbolt,* 250 P.2d

459, 461 (Okla. 1952) (finding "occupancy and possession appears to be sufficient to make out a case against anyone, except the rightful owner").

7. The record reflects that the State, at a minimum, regulates, manages and controls the waters of the IRW within Oklahoma.

8. The court concludes as a matter of law that the State's interests in the waters of the IRW within Oklahoma are superior to defendants' interests, and the State, therefore, has the requisite property interest to maintain its trespass claim for injunctive relief against defendants.

B. Causation/Liability Issues

9. The State alleges that phosphorous contained in land-applied poultry litter runs off fields throughout the IRW and finds its way to rivers, streams, and groundwater, where it injures water quality and aquatic populations. Defendants assert the State has not met its burden to prove that phosphorous from land applications of poultry litter for which defendants are legally responsible reaches the waters in the Oklahoma portion of the IRW used for recreation or drinking water in quantities or a form sufficient to cause any of the State's alleged injuries. This argument raises a number of sub-issues, including (1) whether defendants can be held liable for contamination from runoff of poultry litter spread by their growers; (2) whether the State must prove that defendants polluted the IRW by direct evidence; and (3) whether the State must prove what portion of the harm each defendant contributed.

1. Liability for Litter Spread by Growers

10. The State argues defendants are vicariously liable for phosphorus in IRW waters resulting from runoff from land application of their growers' poultry litter. This issue was addressed in *City of Tulsa v. Tyson Foods, Inc.,* 258 F. Supp. 2d 1263 (N.D. Okla. 2003), *vacated in connection with settlement*. There, the City of Tulsa sued Tyson Foods, Inc. and other poultry

industry defendants, alleging that the acts and omissions of the defendants polluted lakes from which Tulsa drew its water supply. As here, the plaintiff alleged that land application of poultry litter by contract growers for the poultry defendants resulted in eutrophication of the lakes from excess phosphorus loading. *Id.* at 1297. And as here, th defendants argued that their growers were independent contractors, and they were not vicariously liable for the growers' actions. *Id.* The court found that while there were factual disputes about the degree of control each defendant exerted over its growers, the integrators could be held liable. *Id.* Citing Restatement (Second) of Torts § 427B,[41] the court held that the Poultry Defendants were vicariously liable for any trespass or nuisance created by their growers because "they were aware that in the ordinary course of doing the contract work, a trespass or nuisance was likely to result." *Id.* at 1296-97.[42]

11. Here, as in *City of Tulsa,* the defendants knew their growers, in the ordinary course of their work for defendants, spread poultry litter on the land in the IRW, and knew or should have known no later than the late 1990s that their growers' land application of litter was a primary source of the excess phosphorus in the waters of the IRW. Once on notice, defendants had a duty to abate the nuisance and put a stop to the trespass, neither of which they have done. *City of*

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[41] Section 427B provides:

> Work Likely to Involve Trespass or Nuisance
>
> One who employs an independent contractor to do work which the employer knows or has reason to know to be likely to involve a trespass upon the land of another or the creation of a public or a private nuisance, is subject to liability for harm resulting to others from such trespass or nuisance.

Restatement (Second) Torts § 427B (1965).

[42] The court views *City of Tulsa* as persuasive authority. The decision was vacated by unopposed motion solely as part of the settlement of the action. *See City of Tulsa,* Case No. 4:01-cv-00900, Doc. 472 and Doc. 473, ¶8.

Tulsa, 258 F. Supp. 2d at 1295-96. Therefore, they are liable for any trespass or nuisance created by their growers. *Id.* at 1296.

2. Concurrent Tortfeasor Liability

12. The State alleges defendants are concurrent tortfeasors. As the Oklahoma Supreme Court has explained:

> Tortfeasors are classified as concurrent tortfeasors when their independent acts concur to produce a single or indivisible injury. In other words, in the case of joint tortfeasors some type of concert of action (or omission) is required, while in the case of concurrent tortfeasors such concert is lacking, but a single or indivisible injury or harm is nonetheless produced. Notwithstanding the lack of concerted action and even though the act of one may not have alone caused the injury or brought about the result, it has long been recognized in Oklahoma that concurrent tortfeasors, like joint ones, are each responsible for the entire result if the patient is free from negligence.

Kirkpatrick v. Chrysler Corp., 920 P.2d 122, 126 (Okla. 1996) (citations omitted). *See also Harper-Turner Oil Co. v. Bridge,* 311 P.2d 947, 952 (Okla. 1957).

13. An injury is indivisible when it is incapable of apportionment. *See Johnson v. Ford Motor Co.,* 45 P.3d 86, 91 (Okla. 2002). Here, as in *City of Tulsa*, the State alleges a single indivisible injury. *See City of Tulsa,* 258 F. Supp. 2d at 1297.

14. "With respect to environmental nuisance, such as pollution of a stream or pollution of the air surrounding a community, courts have commonly found that such pollution constitutes an indivisible injury." *Herd v. Asarco, Inc.,* 2003 U.S. Dist. LEXIS 27381, at *41 (N.D. Okla. July 11, 2003), *vacated in part by Herd v. Blue Tee Corp.,* 2004 U.S. Dist. LEXIS 30673 (N.D. Okla. Jan. 13, 2004)[43] (citing *Union Texas Petroleum Corp. v. Jackson,* 909 P.2d 131, 149-50 (Okla. Civ. App. 1995) (saltwater contamination of city's water supply); *Harper-Turner Oil Co. v. Bridge,* 311 P.2d 947, 950-51 (Okla. 1957) (contamination of water well by oil well); *United*

[43] The court's July 11, 2003 order was vacated as to two defendants only after those defendants settled with plaintiffs, based on unopposed motion. *See* Case No. 01-CV-891-H(C), Doc. 752, N.D. Okla. (2003).

States v. Pesses, 120 F. Supp. 2d 503, 507 (W.D. Pa. 2000) (hazardous substances of cadmium, chromium, copper, lead, magnesium, mercury, nickel, thorium and zinc, some of which was released into the air, soil and water, combined to form indivisible injury).

15. The party claiming an injury is divisible bears the burden of proving it. *See* Restatement (Second) of Torts § 433B(2) ("Where the tortious conduct of two or more actors has combined to bring about harm to the plaintiff, and one or more of the actors seeks to limit his liability on the ground that the harm is capable of apportionment among them, the burden of proof as to the apportionment is upon each such actor."); *Union Texas Petroleum Corp.,* 909 P.2d at 149-50.

16. Even when the principal injury is indivisible and therefore incapable of apportionment, the plaintiff bears the burden of presenting sufficient evidence to prove that "each defendant's act was a contributing factor in producing the plaintiff's injuries." *Johnson,* 45 P.3d at 91; *see also Lee v. Volkswagen of America, Inc.,* 688 P.2d 1283, 1289 (Okla. 1984); *Harper-Turner Oil Co.,* 311 P.2d at 952 ("[O]ne cannot be held to be a joint tort-feasor unless there is some evidence to connect him with the cause of the injury complained of.").

17. This court concurs with the standard for causation articulated in *City of Tulsa*: "[P]laintiffs must show that each defendant contributed to phosphorus loading in the Watershed and that the phosphorus in the Watershed has resulted in the harm and damages sustained by plaintiffs." *City of Tulsa,* 258 F. Supp. 2d at 1300.[44]

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[44] Contributory negligence is not a defense to an intentional tort claim. *City of Tulsa,* F. Supp. 2d at 1301 (citing the Restatement (Second) of Torts § 825, cmt. d (1965)); *Cities Serv. Oil Co. v. Merritt,* 332 P.2d 677, 685 (Okla. 1958). Here, as in *City of Tulsa,* plaintiff has asserted the intentional torts of nuisance and trespass. Thus, evidence showing that the State has contributed to phosphorus loading in the IRW does not, as a matter of law, operate as a defense to the State's claims of nuisance and trespass.

18. The issue then, is whether the State has presented evidence sufficient to prove, with respect to each defendant, that its acts or the acts of its growers contributed to phosphorus loading in the IRW.

3. Direct/Circumstantial Evidence

19. A plaintiff may prove its claims by direct evidence, circumstantial evidence, or any combination of the two. Indeed, "circumstantial evidence is not only sufficient, but may also be more certain, satisfying and persuasive than direct evidence." *Desert Palace, Inc. v. Costa,* 539 U.S. 90, 100 (2003) (citations omitted); *see also Dillon v. Fibreboard Corp.,* 919 F.2d 1488, 1490 (10th Cir. 1990) ("It is acceptable for a party bearing the burden of proof to utilize sufficient circumstantial evidence to support his or her position"); *California Oil Co. v. Davenport,* 435 P.2d 560, 563 (Okla. 1967); *Harper-Turner Oil Co.,* 311 P.2d at 950-51; *Peppers Refining Co. v. Spivey,* 285 P.2d 228, 231-32 (Okla. 1955).

20. Nor is it necessary for the State to "track" the contaminant from its source to the site of the injury. See *Herd,* 2003 U.S. Dist. LEXIS 27381 at *41. In *Herd*—a case involving lead-laden dust alleged to have blown from defendants' chat pile and tailings ponds, commingling in the air, contaminating a community and causing indivisible injury—the court explained:

> Once the lead-laden dust reaches the air stream, it is impossible to trace its precise source. The Court therefore finds that the alleged injury is indivisible and that the . . . legal principles regarding joint and several liability apply. To the extent Defendants argue that they are entitled to summary judgment on grounds that Plaintiffs have failed to allege facts that "trace" or "quantify" the lead-laden dust causing the alleged nuisance in this case as to each individual Defendant's chat pile(s) or tailing pond(s), the Court finds that, under the facts present here, such tracing or quantification is not required.

Id. at *41-42. In *Herd,* the court held that, in order to survive summary judgment, "[p]laintiffs must establish some tangible threshold amount of "contribution"' of contaminants by each defendant, and a *de minimus*, insignificant presence would not suffice. *Id.* at *43. The court relied on defendants' collective contribution of 17 million tons of lead-laden mining waste to conclude plaintiffs had met their burden. *Id.* at *44.

21. The court finds and concludes that the State has proven that each defendant has contributed significantly to phosphorus loading of, and injuries to, the waters of the IRW. Tracing or quantification of the exact contribution is not necessary, and the State need not track phosphorus form any particular field to the waters of the IRW.

C. Nuisance Claims

22. The State asserts a state law nuisance claim for conduct occurring in Oklahoma that caused harm in Oklahoma, as well as a federal common law nuisance claim for conduct occurring in Arkansas that caused harm in Oklahoma.

1. Statutory Public Nuisance

23. Oklahoma defines nuisance as follows:

> **Nuisance defined**
>
> A nuisance consists in unlawfully doing an act, or omitting to perform a duty, which act or omission either:
>
> First. Annoys, injuries or endangers the comfort, repose, health, or safety of others; or
>
> Second. Offends decency; or
>
> Third. Unlawfully interferes with, obstructs or tends to obstruct, or renders dangerous for passage, any lake or navigable river, stream, canal or basin, or any public park, square, street or highway; or
>
> Fourth. In any way renders other persons insecure in life, or in the use of property, provided, this section shall not apply to preexisting agricultural activities.

50 Okla. Stat. § 1. A public nuisance is "one which affects at the same time an entire community or neighborhood, or any considerable number of persons, although the extent of the annoyance or damage inflicted upon the individuals may be unequal." 50 Okla. Stat. § 2. *See also* Restatement

(Second) of Torts § 821B (A public nuisance is "an unreasonable interference with a right common to the general public."); *Holder v. Gold Fields Mining Corp.,* 506 F. Supp. 2d 792, 800 (N.D. Okla. 2007) (a common law nuisance is the "unwarrantable, unreasonable or unlawful use by a person of his own property to the injury of another"). "Pollution of waters of the state constitutes a public nuisance under Oklahoma law." *Fischer v. At'l Richfield Co.,* 774 F. Supp. 616, 619 (W.D. Okla. 1989). The plaintiff need not establish that a defendant's actions were unreasonable, but instead, need only establish that the resulting burden on the plaintiff was unreasonable. *N.C. Corff P'ship, Ltd. V. Oxy USA, Inc.,* 929 P.2d 288, 294 (Okla. Civ. App. 1996) (citing Restatement (Second) of Torts § 822 cmt. b). Further, there is no prescriptive right to maintain a public nuisance. *Fischer,* 774 F. Supp. at 620 (citing 66 C.J.S. Nuisance § 92 (1998)[45]). "No lapse of time can legalize a public nuisance amounting to an actual obstruction of public right." 50 Okla. Stat. § 7. A person is "subject to liability for a nuisance caused by an activity not only when that person caries on the activity[,] but also when that person participates to a substantial extent in carrying it on." Restatement (Second) of Torts § 834 (1979).

24. Defendants contend that they are immunized from liability under 50 Okla. Stat. § 4 because poultry litter was applied pursuant to AWMPs approved by the State. That statute provides:

> Nothing which is done or maintained under the express authority of a statute can be deemed a nuisance.

50 Okla. Stat. § 4.

25. Statutorily authorized acts are immune from suit for public nuisance. *See Miller v. Mayor of New York,* 109 U.S. 385, 395 (1883); *Carson Harbor Vill., Ltd. v. Unocal Corp.,* 270 F.3d 863, 870 (9th Cir. 2001) (*en banc*); *City of Columbus v. Union Pac. R.R. Co.,* 137 F. 869, 872

[45] Now located at 66 C.J.S. § 151 (2009).

(8th Cir. 1905); *Piggott v. Eblen,* 366 S.W.2d 192, 195-96 (Ark. 1963); *McKay v. City of Enid,* 109 P. 520, 521 (Okla. 1910). *See also Holder* 506 F. Supp. 2d at 805 (private plaintiff (not government) may seek damages under a nuisance theory for conduct authorized by law) (citing *E.I. Du Pont De Nemours Powder Co. v. Dodson,* 150 P. 1085, 1087-88 (Okla. 1915).

26. In *Briscoe v. Harper Oil Co.,* 702 P.2d 33 (Okla. 1985), land owners executed an oil and gas lease to an oil company that drilled a dry hole, constructed a reserve pit, and in the course of its operations, damaged the landowners' crops. *Id*. at 35. The landowners sued the oil company for, *inter alia,* nuisance. *Id*. The jury found in favor of the landowners and awarded damages. *Id*. On appeal, the Oklahoma Supreme Court affirmed the award, stating:

> The fact that a person or corporation has authority to do certain acts does not give the right to do such acts in a way constituting an unnecessary interference with the rights of others. A license, permit or franchise to do a certain act cannot protect the licensee who abuses the privilege by erecting or maintaining a nuisance.

Id. at 36. In *Union Oil Co. v. Heinsohn,* 43 F.3d 500 (10th Cir. 1994), defendant oil companies argued they could not be held liable for nuisance because their sour gas processing plants had been properly permitted and licensed by the state environmental agency. *Id*. at 504. The court, citing *Briscoe,* rejected this argument, stating that "[l]icensing is not in itself enough to avoid liability." *Id.* And this court, in *Herd*, rejected the defendant mining companies' argument that their mining activities could not be deemed a nuisance because their actions were pursuant to express statutory authority. *Herd,* 2003 U.S. Dist. LEXIS 27381 at *28. There, defendants relied on a federal statutory scheme regarding the United States' role in overseeing mining activities taking place on Quapaw lands. *Id*. The court found the federal statutes were aimed at protecting Quapaw landowners but in no way sought to regulate environmental problems resulting from mining. *Id.* at *33. Further, and of particular relevance to this case, the court held that the "express authority" cited by defendants "[did] not contain the requisite specificity for the Court to hold that, as a matter of law, all of Defendants' actions in this case that could have created the nuisance were 'expressly authorized by law.'" *Id.* at *35 (citing 66 C.J.S. Nuisances § 24 (1998)[46]). The court concluded that regulations and leases relied upon by defendants were "not sufficient to be considered authorization of an 'exact method of operation,' such that Defendants' creation of the chat piles and tailing ponds is immune from a nuisance claim." *Id.* at *36.

27. Here, the AWMPs issued to growers are not sufficiently specific for the court to conclude, as a matter of law, that all of defendants' actions that created the nuisance were "expressly authorized by law." *Id*. at *35. To the contrary, 2 Okla. Stat. § 10-9.7(B)(4) mandates the "[p]oultry waste handling, treatment, management and removal shall not . . . create an environmental or public health hazard" and "shall not result in the contamination of waters of the state." The AWMPs themselves contain language making it clear that, notwithstanding the 300 lbs/acre STP value, litter must be applied in a manner that will prevent pollution of State waters. *See, e.g.*, DJX3051 at p. 4 (Anderson AWMP providing that "[a]ll waste will be applied in accordance with all state and local laws and ordinances" and that "[d]ischarge or runoff from waste application sites is prohibited"); DJX0001 at p. 4 (Saunders AWMP providing that "[all] waste will be applied in accordance with all state and local laws and ordinances" and that "[a]ny one of the following conditions will prohibit the surface application of litter: . . . .(h) [a]reas where there will be discharge from the application site"); DJX3480 at p. 4 (Reed AWMP providing same)].

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[46] Now located at 66 C.J.S. Nuisances § 27 (2009), which provides that "a statutory sanction may not be pleaded in justification of acts which by the general rules of law constitute nuisance, unless the acts complained of are authorized by the express terms of the status …, or by the plainest and most necessary implication from the powers expressly conferred, so that it can be fairly stated that the legislature contemplated the doing of the very act which occasions the injury."

28. The court therefore concludes that 50 Okla. Stat. § 4 does not immunize defendants from liability for nuisance.

29. The court further concludes that, while Code 590 establishes a maximum land application rate of 300 lbs/acre STP, nothing in either Code 590 or ORPFOA requires that poultry waste be applied at the maximum land application rate.

2. Federal Common Law Nuisance

30. The Supreme Court has stated, "[w]hen we deal with air and water in their ambient or interstate aspects, there is a federal common law, as *Texas v. Pankey* . . . recently held." *Illinois v. City of Milwaukee,* 406 U.S. 91, 103 (1972) ("*Milwaukee I*"); *see also Texas v. Pankey,* 441 F.2d 236, 240 (10th Cir. 1971) (holding "the ecological rights of a State in the improper impairment of them from sources outside the State's own territory, now would and should . . . be held to be a matter having basis and standard in federal common law and so directly constituting a question arising under the laws of the United States").

31. "[F]ederal courts may draw on state common law in shaping the applicable body of federal common law." *Phoenix Mut. Life Ins. Co. v. Adams,* 30 F.3d 554, 564 (4th Cir. 1994). However, in fashioning federal common law, courts do not look to the law of a particular state, but rather should apply common-law doctrines best suited to furthering the goals of the applicable law. "Consequently, federal common law should be consistent across the circuits." *Id.* (citations omitted).

32. "The elements of a claim based on the federal common law of nuisance are simply that the defendant is carrying on an activity that is causing an injury or significant threat of injury to some cognizable interest of the complainant." *Illinois v. City of Milwaukee,* 599 F.2d 151, 165 (7th Cir. 1979) *vacated on other grounds, City of Milwaukee v. Illinois and Michigan,* 451 U.S.

304, 348 (1981) ("*Milwaukee II*"); *see also Connecticut v. American Elec. Power Co., Inc.,* 582 F.3d 309, 352 (2nd Cir. 2009) (adopting the Restatement (Second) of Torts § 821B(1) (1979) definition of public nuisance as the standard for assessing whether the parties have stated a claim under the federal common law of nuisance).

33. The Restatement (Second) of Torts § 821B provides:

> Circumstances that may sustain a holding that an interference with a public right is unreasonable include the following: (a) whether the conduct involves a significant interference with the public health, the public safety, the public peace, the public comfort or the public convenience, (b) whether the conduct is proscribed by a statue, ordinance or administrative regulation, or (c) whether the conduct is of a continuing nature or has produced a permanent and long-lasting effect, and, as the actor knows or has reason to know, has a significant effect upon the public right.

34. Defendants maintain that the federal common law of nuisance has been displaced by the Clean Water Act (a.k.a. Federal Water Pollution Control Act), 33 U.S.C. § 1251, *et seq* (2006). In support of their argument, defendants rely primarily on *Milwaukee II* and *Middlesex Cnty. Sewerage Auth. v. Nat'l Sea Clammers Ass'n,* 453 U.S. 1, 21-22 (1981).

35. In *Milwaukee II,* the Supreme Court explained that "the question whether a previously available common-law action has been displaced by federal statutory law involves an assessment of the scope of the legislation and whether the scheme established by Congress addresses the problem formerly governed by federal law." 451 U.S. at 315 n 8. In *United States v. Texas,* 507 U.S. 529 (1993), the Supreme Court further explained:

> Just as longstanding is the principle that statutes which invade the common law . . . are to be read with a presumption favoring the retention of long-established and familiar principles except when a statutory purpose to the contrary is evident. In such cases, Congress does not write upon a clean slate. In order to abrogate a common-law principle, the statute must speak directly to the question addressed by the common law.
>
> Texas argues that this presumption favoring retention of existing law is appropriate only with respect to state common law or federal maritime law. Although a different standard applies when analyzing the effect of federal legislation on state

> law, there is no support in our cases for the proposition that the presumption has no application to federal common law, or for a distinction between general federal common law and federal maritime law in this regard. We agree with Texas that Congress need not affirmatively proscribe the common-law doctrine at issue. But . . . courts may take it as a given that Congress has legislated with an expectation that the common law principle will apply except when a statutory purpose to the contrary is evident.

Id. at 534 (citations omitted).

36. In *Milwaukee II,* the court concluded that no federal common law remedy was available to the states for water pollution because Congress, by passing the 1972 Amendments to the Clean Water Act, had enacted "an all-encompassing program of water pollution regulation." *Milwaukee II*, 451 U.S. at 318. Shortly after *Milwaukee II,* the court restated this conclusion in broader terms in *Sea Clammers*, holding that "the federal common law of nuisance in the area of water pollution is entirely pre-empted by the more comprehensive scope" of the Clean Water Act. *Sea Clammers*, 453 U.S. at 22.

37. However, as the court pointed out in denying defendants' Rule 52(c) motion on the federal common law nuisance claim, *Milwaukee II* and *Sea Clammers* involved point source discharges and dumping—acts that were either flatly prohibited under a regulatory scheme or "prohibited unless subject to a duly issued permit." *Milwaukee II,* 451 U.S. at 320. [TR at 9304:3-9311:7]. At issue here are *nonpoint* source discharges.[47] In *American Wildlands v. Browner,* 260 F.3d 1192, 1193-94 (10th Cir. 2001), the Tenth Circuit recognized that nonpoint source discharges are not defined by the Clean Water Act and that "[r]ather than vest the EPA with authority to control nonpoint sources through a permitting process, Congress required states to develop water quality standards for intrastate waters." *Id.* at 1194. The EPA's authority is

[47] One court has defined nonpoint source pollution as "nothing more than a pollution problem *not* involving a discharge from a point source." *Nat'l Wildlife Fed'n v. Gorsuch,* 693 F.2d 156, 166 n. 28 (D.C. Cir. 1981).

limited to reviewing the state water quality standards and determining whether they are consistent with the Clean Water Act. *Id.* And in *Defenders of Wildlife v. EPA,* 415 F.3d 1121, 1124 (10th Cir. 2005), the Tenth Circuit held that the state of New Mexico was not required to limit nonpoint source pollutants so long as it continued to set water quality standards and list waters that failed to meet those standards.

38. In denying the defendants' Rule 52(c) motion, this court concluded, based on *American Wildlands* and *Defenders of Wildlife,* that the Clean Water Act does not directly or comprehensively regulate nonpoint source pollution, and that "the defendants have not shown that the 1987 amendments to the Clean Water Act legislate a remedy or actually regulate the nonpoint source alleged nuisance at issue." Doc. 2827, TR at 9311:2-5.

39. The Supreme Court's decision in *American Elec. Power Co., Inc. v. Connecticut*, 131 S. Ct. 2527 (2011), does not change the result. There, the Court held that "[t]he Clean Air Act and the EPA actions it authorizes displace any federal common law right to seek abatement of carbon-dioxide emissions from fossil-fuel fired power plants." *Id*. at 2537. It reiterated that "[t]he test for whether congressional legislation excludes the declaration of federal common law is simply whether the statute speaks directly to the question at issue." *Id.* (citations omitted). Notably, *American Elec. Power* addressed only the Clean Air Act, and not the Clean Water Act.

40. *American Elec. Power* does not alter the court's ruling regarding displacement of the federal common law nuisance claim. The Clean Water Act does not speak directly to regulation of nonpoint pollution, and thus has not displaced the federal common law of nuisance.

41. Oklahoma state law nuisance and federal common law nuisance are substantively similar. *See Cf. Nuveen Premium Income Mun. Fund 4, Inc. v. Morgan Keegan & Co.,* 200 F. Supp. 2d 1313, 1316 n. 2 (W.D. Okla. 2002) (because "the laws of the various jurisdictions which

have an arguable connection to the case were substantially similar . . . a conflict of laws determination was not required").

42. Defendants assert the State's nuisance and trespass claims also fail because they cannot be held liable in Oklahoma for conduct occurring in Arkansas. The legal assertion is incorrect. In *Cameron v. Vandergriff,* 13 S.W. 1092 (Ark. 1890), the Arkansas Supreme Court held that defendants who conducted blasting operations in Indian Territory were liable for negligence to a plaintiff for injuries suffered in Arkansas when he was hit by a flying rock from the defendants' operations. *Id*. at 1092-93. The court explained: "[t]he rock which occasioned the injury was put in motion by the appellants in the Indian Territory; but, by the same force, its motion was continued, and the injury done in this state. The cause of action arose here." *Id.* at 1093. Further, in *Young v. Masci,* 289 U.S. 253 (1933), the Supreme Court rejected the notion that imposition of liability in these circumstances violates an out-of-state defendant's due process rights. *Id*. at 258. The court stated:

> A person who sets in motion in one state the means by which injury is inflicted in another may, consistently with the due process clause, be made liable for that injury whether the means employed be a responsible agent or an irresponsible instrument. The cases are many in which a person acting outside the state may be held responsible according to the law of the state for injurious consequences within it. Thus, liability is commonly imposed under such circumstances for homicide, for maintenance of a nuisance, for blasting operation and for negligent manufacture.

Id. at 258-59 (citations omitted). The court concludes defendants in this case can be held liable for injuries suffered based on defendants' or their growers' conduct in Arkansas.

3. Analysis of Nuisance Claims

43. The court has found that each defendant contributed to phosphorus loading of the waters of the IRW. The Tyson Defendants, Cargill Defendants, and George's Defendants all own or manage poultry farms in the IRW; all defendants have—in the past—placed poultry with

growers located in the IRW; and all defendants except Cal-Maine and Peterson continue to do so. Each defendant has imported phosphorus-laden feed into the watershed. Poultry waste generated at farms is typically land applied on fields in the IRW. And the overwhelming evidence establishes that phosphorus from land-applied poultry waste runs off the fields in environmentally significant quantities, causing injury to the waters of the IRW. Defendants have known or should reasonably have known since at least the mid-to-late 1980s that phosphorus in the runoff of land-applied poultry waste injures the waters of the IRW. Yet they have continued to place their birds in the IRW, to import feed, and to apply—and allow their growers to apply—poultry waste from defendants' birds to fields in the IRW. None of the defendants have made any provision for the appropriate management of the poultry waste.

44. The court concludes all defendants, by their conduct, have unreasonably interfered with the public's right to the use and enjoyment of the waters of the IRW in Oklahoma. The State's injuries from phosphorus concentrations in the rivers and streams of the IRW and Lake Tenkiller are significant. Defendants are liable to the State for statutory public nuisance and for federal common law nuisance with respect to their conduct in the Oklahoma portion of the IRW and their conduct in the Arkansas portion of the IRW.

D. Trespass Claim

45. Under Oklahoma law, a trespass involves an actual physical invasion of the real estate of another without the permission of the person lawfully entitled to possession. *Williamson v. Fowler Toyota, Inc.,* 956 P.2d 858, 862 (Okla. 1998). "One is subject to liability to another for trespass . . . if he intentionally (a) enters land in the possession of another, or causes a thing or a third person to do so, or (b) remains on the land, or (c) fails to remove from the land a thing which

he is under a duty to remove." *Angier v. Mathews Exploration Corp.,* 905 P.2d 826, 829-30 (Okla. Civ. App. 1995) (quoting the Restatement (Second) of Torts § 158 (1965)).

46. The threshold for establishing intentionality is set forth in Restatement (Second) of Torts § 825:

> An invasion of another's interest in the use and enjoyment of land or an interference with the public right, is intentional if the actor:
>
> (a) acts for the purpose of causing it, or
> (b) knows that it is resulting or is substantially certain to result from his conduct.

Comment c to § 825 provides that "[i]t is the knowledge that the actor has at the time he acts or fails to act that determines whether the invasion resulting from his conduct is intentional or unintentional." And Comment d to § 825 states that "when the conduct is continued after the actor knows that the invasion is resulting from it, further invasions are intentional." Thus, the State need not prove that defendants intended to cause the specific harm that resulted from their conduct, but only that defendants knew or were substantially certain that applying poultry litter to fields would result in an invasion of the IRW, and continued to do so in the face of that knowledge. Such conduct is considered "intentional" for purposes of nuisance and trespass under both Arkansas and Oklahoma law. *See Robinson v. City of Ashdown,* 783 S.W.2d 53, 56 (Ark. 1990) ("[w]hen one knows that an invasion of another's interest in the use of enjoyment of land is substantially certain to result from one's conduct, the invasion is intentional."); *Cities Service Oil Co. v. Merritt,* 332 P.2d 677, 685 (Okla. 1958) (defendants' salt water pollution of creek which in turn polluted landowner's well constituted a continuing nuisance for which defendants were jointly and severally liable).

47. Here, the State's claim for trespass is based upon its possessory property interest in waters flowing in definite streams in the Oklahoma portion of the IRW, which, as held above, is a sufficient interest to support the State's claim.

48. The court concludes—as it did with respect to the State's nuisance claims—that compliance by defendants and their growers with the AWMPs, NMPs, or the Arkansas Poultry Growers Act does not immunize defendants against claims of trespass.

49. The court concludes the State has proven by a preponderance of evidence that defendants have trespassed on the waters of the IRW. The Tyson Defendants, Cargill Defendants and George's Defendants all own or manage poultry farms in the IRW. All defendants have—in the past—placed poultry with growers located in the IRW; and all except Cal-Maine and Peterson continue to do so. Poultry waste generated at the poultry farms is typically land applied on fields in the IRW. And the overwhelming evidence establishes that phosphorus from land-applied poultry waste runs off the fields in environmentally significant quantities, causing injury to the waters of the IRW. Defendants have been aware since at least the mid-to-late 1980s that phosphorus in the runoff of land-applied poultry waste injures the waters of the IRW, and yet they have continued to apply—and allow growers to apply—poultry waste from defendants' birds to fields in the IRW. Defendants' actions constitute trespass in violation of Oklahoma law.

50. Poultry waste generated by the operations of each of the defendants and their growers is a significant source of the phosphorus in the rivers and streams of the Oklahoma portion of the IRW and in Lake Tenkiller. The State's injuries from phosphorus concentrations in the rivers and streams of the IRW and Lake Tenkiller are significant.

51. All defendants are vicariously liable for poultry waste causing phosphorus to physically invade the rivers and streams of the Oklahoma portion of the IRW and Lake Tenkiller.

Further, the Tyson Defendants, Cargill Defendants and George's Defendants are directly liable for poultry waste from poultry operations they own or manage.

E. Statutory Violation Claims

52. The State contends defendants are liable for violations of 27A Okla. Stat. § 2-6-105 and 2 Okla. Stat. § 2-18.1.

53. As limited by the court in previous rulings, the State's claim for violations of 27A Okla. Stat. § 2-6-105, pertains to conduct occurring in Oklahoma. Arkansas-based conduct cannot give rise to liability under 27A Okla. Stat. § 2-6-105.

54. The State seeks both injunctive relief and penalties under its 27A Okla. Stat. § 2-6-105 claim. *See* 27A Okla. Stat. § 2-3-504(A)(2) and (4).[48]

55. 27A Okla. Stat. § 2-3-504 became effective on July 1, 1993, and the parties agree that the State's claims for penalties are limited to conduct occurring after that date. The State contends defendants are both directly and vicariously liable for penalties for any field having an STP value of greater than 65 lbs/acre, as reflected by ODAFF records, from the date of each recorded violation to the present, at a rate of $10,000 per day. *See* Doc. 2873 at 344, State's Proposed FF/CL, CL ¶ 137.

56. 27A Okla. Stat. § 2-6-105 provides:

> A. It shall be unlawful for any person to cause pollution of any waters of the state or to place or cause to be placed any wastes in a location where they are likely to cause pollution of any air, land or waters of the state. Any such action is hereby declared to be a public nuisance.
>
> B. If the Executive Director finds that any of the air, land or waters of the state have been, or are being, polluted, the Executive Director shall make an order

[48] Under 27A Okla. Stat. § 2-3-504(A)(2), a violator may be punished by assessment of a civil penalty of not more than $10,000 per day of noncompliance with the Oklahoma Environmental Quality Code. Under 27A Okla. Stat. § 2-3-504(A)(4), a violator may be subject to injunctive relief to prevent a violation of, or to compel a compliance with, any of the provisions of the Oklahoma Environmental Quality Code.

requiring such pollution to cease within a reasonable time, or requiring such manner of treatment or of disposition of the sewage or other polluting material as may in his judgment be necessary to prevent further pollution. It shall be the duty of the person to whom such an order is directed to fully comply with the order of the Executive Director.

57. 27A Okla. Stat. § 2-1-102(12) defines "pollution" as

> the presence in the environment of any substance, contaminant or pollutant, or any other alteration of the physical, chemical or biological properties of the environment or the release of any liquid, gaseous or solid substance into the environment in quantities which are or will likely create a nuisance or which render or will likely render the environment harmful or detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish or other aquatic life, or to property . . . .

58. 27A Okla. Stat. § 2-6-102 sets forth the policy and purpose of § 2-6-105 as follows:

> Whereas the pollution of the waters of this state constitutes a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life, and impairs domestic, agricultural, industrial, recreational and other legitimate beneficial uses of water, and whereas the problem of water pollution of this state is closely related to the problem of water pollution in adjoining states, it is hereby declared to be the public policy of this state to conserve the waters of the state and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses; *to provide that no waste or pollutant be discharged into any waters of the state or otherwise placed in a location likely to affect such waters without first being given the degree of treatment or taking such other measures as necessary to protect the legitimate beneficial uses of such waters;* to provide for the prevention, abatement and control of new or existing water pollution; and to cooperate with other agencies of this state, agencies of other states and the federal government in carrying out these objectives.

(emphasis added).

59. ODEQ enforcement action pursuant to 27A Okla. Stat. § 2-6-105(B) is not a prerequisite to enforcement of the statute. *See Burlington Northern and Santa Fe Ry. Co. v. Grant,* 505 F.3d 1013, 1024-25 (10th Cir. 2007).

60. Defendants are both directly and vicariously liable under 27A Okla. Stat. § 2-6-105(A) for the same reasons they are liable for common law trespass. They have structured and conducted their business in the Oklahoma portion of the IRW in a manner that causes pollution of the waters of the IRW. Thus, they are directly liable for "caus[ing] pollution of . . . waters of the state" and for "caus[ing] to be placed . . . waste[s] in a location where they are likely to cause pollution." 27A Okla. Stat. § 2-6-105(A).[49] Each defendant has consciously concentrated a segment of its poultry operations in the Oklahoma portion of the environmentally-sensitive IRW; placed large numbers of its birds in this concentrated area; and imported enormous amounts of phosphorus-laden feed into the area. Their birds annually generate hundreds of tons of poultry waste containing phosphorus the defendants have brought into the IRW. Further, despite knowledge that the majority of the poultry waste will be land applied in close proximity to where it is generated, the defendants have not made provisions for the appropriate management of the waste.

61. As a result, poultry waste continues to be applied to the phosphorus-saturated fields in the Oklahoma portion of the IRW, where an environmentally significant portion of the phosphorus contained in the waste runs off the fields and enters the waters of the IRW. Further, phosphorus from land-applied poultry waste that enters the waters of the IRW constitutes "pollution" for the purposes of Okla. Stat. § 2-6-105. *See* 27A Okla. Stat. § 2-1-102(12). In sum, through their own independent conduct, defendants have "cause[d] pollution of . . . waters of the state." 27A Okla. Stat. § 2-6-105(A). Similarly, defendants are also directly liable under 27A

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[49] The State seeks to hold all defendants except Peterson and Cal-Maine liable based on their past and present conduct. It seeks to hold Peterson and Cal-Maine, who have exited the IRW, liable for past conduct only.

Okla. Stat. § 2-6-105(A) because they have "cause[d] to be placed . . . wastes in a location where they are likely to cause pollution of . . . waters of the state."

62. Under the Restatement (Second) of Torts § 427B, defendants are vicariously liable for violation of 27A Okla. Stat. § 2-6-105(A), for the conduct of their growers.

63. For the reasons set forth in these Findings and Conclusions, the court concludes that the State is entitled to injunctive relief for each defendant's violations of 27A Okla. Stat. § 2-6-105(A).

64. The State also seeks imposition of civil penalties for each defendant's violation of 27A Okla. Stat. § 2-6-105(A). Civil penalties are authorized by 27A Okla. Stat. § 2-3-504, which provides in pertinent part:

> (A) Except as otherwise specifically provided by law, any person who violates any provisions of, or who fails to perform any duty imposed by, the Oklahoma Environmental Quality Code . . . .
>
> * * *
>
> (2) May be punished in civil proceedings in district court by assessment of a civil penalty of not more than Ten Thousand Dollars ($10,000.00) for each violation . . . .
>
> * * *
>
> (C) Any person assessed an administrative or civil penalty shall be required to pay, in addition to such penalty amount and interest thereon, attorneys fees and costs associated with the collection of such penalties.
>
> (D) For purposes of this section, each day or party of a day upon which such violation occurs shall constitute a separate violation.
>
> * * *
>
> (H) In determining the amount of a civil penalty the court shall consider such factors as the nature, circumstances and gravity of the violation or violations, the economic benefit, if any, resulting to the defendant from the violation, the history of such violations, any good faith efforts to comply with the applicable requirements, the economic impact of the penalty on the defendant, the defendant's degree of culpability, and such other matters as justice may require.

65. The State asserts penalties should be imposed for all instances in which a defendant's grower applied poultry waste on a field with STP levels in excess of 65 lbs/acre.

66. The State also seeks injunctive relief pursuant to 2 Okla. Stat. § 2-18.1, which provides:

> A. It shall be unlawful and a violation of the Oklahoma Agricultural Code for any person to cause pollution of any air, land or waters of the state by persons which are subject to the jurisdiction of the Oklahoma Department of Agriculture, Food, and Forestry pursuant to the Oklahoma Environmental Quality Act.
>
> B. If the State Board of Agriculture finds that any of the air, land, or waters of the state which are subject to the jurisdiction of the Oklahoma Department of Agriculture, Food, and Forestry pursuant to the Oklahoma Environmental Quality Act have been or are being polluted, the Board shall make an order requiring that the pollution cease within a time period determined by the Department, or require a manner of treatment or of disposition of the waste or other polluting material as may in the judgment of the Board be necessary to prevent further pollution. In addition, the Board may assess an administrative penalty pursuant to Section 2-18 of this title. The person to whom the order is directed shall fully comply with the order of the Board and pay any fine and costs assessed.

67. ODEQ enforcement action pursuant to 2 Okla. Stat. § 2-18.1(B) is not a prerequisite to enforcement of Section A of the statute. *See Burlington Northern,* 505 F.3d at 1024-25.

68. Under 2 Okla. Stat. § 1-3, a "person" is "the state, any municipality, political subdivision, institution, individual, public or private corporation, partnership, association, firm, company, public trust, joint-stock company, . . . or any other legal entity or an agent, employee, representative, assignee or successor thereof." Each defendant, as a company or private corporation, fits within this definition.

69. With respect to a claim brought pursuant to 2 Okla. Stat. § 2-18.1, 2 Okla. Stat. § 2-16(c) provides, in pertinent part, that "[t]he court shall have jurisdiction to determine the action [to redress or restrain a violation of the Oklahoma Agricultural Code] and to grant the necessary or appropriate relief, including but not limited to mandatory or prohibitive injunctive relief . . . ."

70. Under 27A Okla. Stat. § 1-3-101(D)(1)(a), ODAFF has environmental responsibility over "nonpoint source runoff from agricultural crop production, agricultural services, livestock production, silviculture, feed yards, livestock markets and animal waste."

71. By its terms, 2 Okla. Stat. § 2-18.1 is a statute of general application addressing pollution from all entities that fall under ODAFF's jurisdiction and is not limited only to the actions of poultry growers. Defendants fall under the broad sweep of this statute as persons under the jurisdiction of ODAFF. *See, e.g.*, 2 Okla. Stat. § 10-9.5(G) ("No integrator shall enter into any contract with an operator of a poultry feeding operation who is not in compliance with the requirements of subsection F of this section."). Accordingly, the court concludes that each defendant is a person subject to ODAFF's jurisdiction pursuant to the Oklahoma Environmental Quality Act.

72. The State's claim for violations of 2 Okla. Stat. § 2-18.1 pertains only to conduct occurring in Oklahoma.

73. The liability provision of 2 Okla. Stat. § 2-18.1 prohibiting a "person" from "caus[ing] pollution of any . . . waters of the state" is substantively identical to 27A Okla. Stat. § 2-6-105(A)'s prohibition against any "caus[ing] pollution of any waters of the state." Based on the reasoning contained in Conclusion of Law ##60-61 above, the court concludes each defendant is liable, both directly and vicariously, under 2 Okla. Stat. § 2-18.1.

F. Affirmative Defenses

74. Defendants have asserted a number of affirmative defenses. The court has addressed defendants' arguments concerning pre-emption of federal common law above. Other affirmative defenses are addressed below.

75. Defendants contend the Commerce Clause constrains this court from applying Oklahoma common law to enjoin poultry waste application in the Arkansas portion of the IRW. The Commerce Clause provides that "Congress shall have power . . . [t]o regulate Commerce . . . among the several States." U.S. Const., art. I, § 8, cl. 3. "The Commerce Clause . . . even without implementing legislation by Congress is a limitation upon the power of the States." *Edgar v. Mite Corp.,* 457 U.S. 624, 640 (1982) (citations omitted). Not every exercise of state power with some impact on interstate commerce is invalid. *Id.* In this case, the State relies on Oklahoma statutory nuisance, Federal common law nuisance, and Oklahoma common law trespass in an attempt to enjoin activity by defendants that is polluting the waters of the Oklahoma portion of the IRW. The State does not seek to directly regulate interstate commerce. Moreover, the burden imposed an interstate commerce by applying Oklahoma common law of trespass and Federal common law nuisance to enjoin poultry waste in the Arkansas portion of the IRW is not excessive in light of the interests of the law of trespass purports to further.

76. Defendants also argue the State's requested relief violates principles of federalism. They contend that allowing Oklahoma to apply its own law through this court to enjoin conduct in Arkansas that is authorized under Arkansas statute and regulations would impermissibly invade Arkansas' prerogative to legislate within its own borders. "A basic principle of federalism is that each State may make its own reasoned judgment about what conduct is permitted or proscribed within its borders, and each State alone can determine what measure of punishment, if any, to impose on a defendant who acts within its jurisdiction." *State Farm Mut. Auto. Ins. Co. v. Campbell,* 538 U.S. 408, 422 (2003). But, the cases defendants rely upon involve challenges to punitive damage awards based on out-of-state conduct, and the courts expressed concern about the due process implications of punishing defendants for conduct that was not illegal in their home

state. *Id.*; *BMW of N. Am., Inc. v. Gore,* 517 U.S. 559, 575-76 (1996). In contrast, the relief sought in this case is not penal in nature, but instead aimed at redressing tortious conduct by defendants which has caused and is continuing to cause injury in Oklahoma. Courts routinely handle claims involving allegations of nuisance and trespass. *See, e.g., Herd,* 2003 U.S. Dist. LEXIS 27381 at *28.

77. Indeed, it is not uncommon for courts to apply the law of the state where injury to the plaintiff occurred as a result of defendant's tortious conduct in another state. *See* Conclusion of Law #42; *see also Gentry v. Jett,* 173 F. Supp. 722, 734 (W.D. Ark. 1959) (Oklahoma law applied to injured truck driver's claim that defendant truck owner in Arkansas negligently installed defective breaks in truck because truck driver's injuries occurred in collision in Oklahoma); *Otey v. Midland Valley R. Co.,* 197 P. 203, 204 (Kansas 1921) (defendant railroad company was liable to plaintiff for property damage in Kansas caused when sparks from fire locomotive engine in Oklahoma blew across state line onto plaintiff's property in Kansas); *Dallas v. Whitney,* 188 S.E. 766, 767 (W.Va. 1936) (injury to plaintiff's storeroom in Ohio caused by defendant's blasting activity in West Virginia was construed to state a claim for trespass under Ohio law); *Brinkley & West, Inc. v. Foremost Ins. Co.,* 331 F. Supp. 475, 478 (E.D. La. 1971) (Louisiana law applied to Louisiana plaintiff's claim for alleged piracy of plaintiff's subagents by defendant in other states, because injury to plaintiff occurred in Louisiana).

78. In *Young v. Masci,* 289 U.S. 253 (1933), the Supreme Court rejected the notion that imposition of liability in these circumstances violates an out-of-state defendant's due process rights. The court stated:

> A person who sets in motion in one state the means by which injury is inflicted in another may, consistently with the due process clause, be made liable for that injury whether the means employed be a responsible agent or an irresponsible instrument. The cases are many in which the person acting outside the state may be held

> responsible according to the law of the state for injurious consequences within it. Thus, liability is commonly imposed under such circumstances for homicide, for maintenance of a nuisance, for blasting operation and for negligent manufacture.

Id. at 258-59 (citations omitted).

79. Defendants also contend the Arkansas River Basin Compact preempts or displaces the State's tort claim. The court disagrees. The compact states in pertinent part:

> That States of Arkansas and Oklahoma mutually agree to:
>
> * * *
>
> Utilize the provisions of all federal and state water pollution laws and to recognize such water quality standards as may be now or hereafter established under the Federal Water Pollution Control Act in the resolution of any pollution problems affecting the waters of the Arkansas River Basin.

82 Okla. Stat. § 1421, Art. VII(E). Moreover, the stated purpose of the compact is "[t]o encourage the maintenance of an active pollution abatement program in each of the two states and to seek the further reduction of both natural and man-made pollution in the waters of the Arkansas River Basin." 82 Okla. Stat. § 1421, Art. I (D). Finally, the compact expressly disclaims any requirement that the State proceed before the Commission prior to asserting its rights in court:

> [T]he making of findings, recommendations, or reports by the Commission shall not be a condition precedent to instituting or maintaining any action or proceeding of any kind by a signatory state in any court, or before any tribunal, agency or officer, for the protection of any right under this Compact or for the enforcement of any of its provision[s].

82 Okla. Stat. § 1421 Art. IX(A)(8).

80. The court concludes defendants in this case may be enjoined pursuant to both Federal common law and Oklahoma statutory nuisance from continuing nuisance suffered by plaintiff in Oklahoma based on conduct by defendants or their growers. Further, the defendants may be enjoined pursuant to Oklahoma common law trespass based on conduct by defendants or their growers and the actual physical invasion of the plaintiff's property in Oklahoma.

81. Compliance by Arkansas growers with Arkansas laws and regulations does not immunize defendants, as it is axiomatic that Arkansas cannot enact legislation permitting a continuing nuisance and/or trespass in Oklahoma.

G. Injunctive Relief

82. A court should issue an injunction "only where the intervention of a court of equity is essential in order effectually to protect property rights against injuries otherwise irremediable." *Weinberger v. Romero-Barcelo,* 456 U.S. 305, 312 (1982).

83. "For a party to obtain a permanent injunction, it must prove (1) actual success on the merits; (2) irreparable harm unless the injunction is issued; (3) the threatened injury outweighs the harm that the injunction may cause the opposing party; and (4) the injunction, if issued, will not adversely affect the public interest." *Prairie Band Potawatomi Nation v. Wagnon,* 476 F.3d 818, 822 (10th Cir. 2007) (citations omitted).

84. With respect to the State's claims under 27A Okla. Stat. § 2-6-105(A) and 2 Okla. Stat. § 2-18.1, the court is statutorily authorized to grant injunctive relief. *See* 27A Okla. Stat. § 2-3-504(A)(4); 27A Okla. Stat. § 2-3-504(F)(2); 2 Okla. Stat. § 2-16(B) and (C).

85. The State seeks an injunction:

- prohibiting defendants from allowing poultry waste generated by birds they own, lease or control to be land-applied in the IRW on fields having an STP in excess of 65 lbs/acre based on a Mehlich III six inch sample;
- requiring that land application in the IRW be conducted in accordance with the 65 lbs/acre limit, as well as an Animal Waste Management plan or Nutrient Management Plan;
- requiring defendants to remove from the IRW and appropriately manage, at defendants' expense, all poultry waste generated by birds they own, lease or control that cannot be land-applied in the IRW under this standard;
- prohibiting defendants from land-applying poultry waste removed from the IRW on any field having an STP in excess of 65 lbs/acre in watersheds located in whole or

in part in Oklahoma that are designated nutrient surplus areas, nutrient limited watersheds or nutrient vulnerable groundwater areas;

- requiring remediation of the IRW, at defendants' expense, the exact nature of which would be determined following an investigation of remedial alternatives, also to be funded by defendants; and
- reporting, monitoring and auditing of defendants' performance of their obligations under the injunction sought from the court, as well as water quality monitoring to assess the impact of relief ordered in this case.

86. Defendants assert that the appropriate remedy is development of a Total Maximum Daily Load ("TMDL") pursuant to Section 303(d) of the CWA, 33 U.S.C. § 1313(d)(1)(C) (2000). Section 303(d) of the CWA requires states to (1) identify those waters within its boundaries for which the effluent limitations required by 33 U.S.C. § 1311(b)(1) parts (A) and (B)[50] are not stringent enough, and (2) implement any water quality standard applicable to such waters. Effluent limitations under the CWA apply only to point sources of pollution; they do not address nonpoint sources of pollution such as runoff from land applied animal wastes at issue here. *See, e.g., Pronsolino v. Nastri,* 291 F.3d 1123, 1125-26 (9th Cir. 2002) ("Effluent limitations pertain only to point sources of pollution; point sources of pollution are those from a discrete conveyance, such as a pipe or tunnel. Nonpoint sources of pollution are non-discrete sources; sediment run-off from timber harvesting, for example derives from a nonpoint source.").

87. For waters identified as impaired on the CWA section 303(d) list, a state must determine the TMDL for pollutants at a level necessary to achieve the applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality. *See* 33 U.S.C. § 1313(D)(1)(C). "A TMDL defines the specified maximum amount of a pollutant which

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[50] 33 U.S.C. § 1311(B)(1)(A) and (B) address effluent limitations for point sources other than publicly owned treatment works and publicly owned treatment works, respectively.

can be discharged or 'loaded' into the waters at issue from all combined sources." *Dioxin/Organochlorine Ctr. v. Clarke,* 57 F.3d 1517, 1520 (9th Cir. 1995). The implementing regulation divides the loading capacity of receiving water between nonpoint and point sources. "Load allocations" are calculated for nonpoint sources and "wasteload allocations" are calculated for point sources. *See* 40 C.F.R. § 130.2(g) and (h). "Thus a TMDL represents the cumulative total of all 'load allocations' which are in turn best estimates of the discrete loading attributed to nonpoint sources, natural background sources, and individual wasteload allocations ('WLAs'), that is, specific portions of the total load allocated to individual point sources." *Dioxin,* 57 F.3d at 1520. The CWA directly mandates technological controls to limit the pollution point sources may discharge into a body of water. However, it "provides no direct mechanism to control nonpoint source pollution"; rather, it "uses the 'threat and promise' of federal grants to the states to accomplish this task, thereby recogniz[ing], preserv[ing], and protect[ing] the primary responsibilities and rights of the States to prevent, reduce, and eliminate pollution, [and] to plan the development and use . . . of land and water resources" in accordance with Section 101(b) of the CWA. *Pronsolino,* 291 F.3d 1123, 1126-27 (citations omitted).

88. Section 303(d) is part of the CWA's "carrot-and-stick approach to attaining acceptable water quality without direct federal regulation of nonpoint sources of pollution." *Id.* at 1127. States are required to subject a 303(d) list of impaired waters and any associated TMDLs to the EPA for approval or disapproval. *See* 33 U.S.C. § 1313(d)(2). Approved TMDLs must be incorporated into the state's continuing planning process that the EPA must also approve. *Id.* "The upshot of this intricate scheme is that the CWA leaves to the states the responsibility of developing plans to achieve water quality standards if the statutorily-mandated point source controls will not alone suffice, while providing federal funding to aid in the implementation of the

state plans." *Pronsolino,* 291 F.3d at 1128. Thus, the CWA, with its TMDL provisions, does not in and of itself, require states to reduce nonpoint source pollution loads as a result of a TMDL.

89. Oklahoma law requires state environmental agencies (including the ODAFF) to utilize and enforce Oklahoma Water Quality Standards established by the OWRB. 27A Okla. Stat. § 1-1-202(A)(2). The agencies, with the help of the OWRB, are required to develop Water Quality Standards Implementation Plans ("WQSIPs") aimed at restoring protecting and maintaining water quality. 27A Okla. Stat. § 1-1-202(B)(1). Each WQSIP is required, *inter alia,* to "detail the manner in which the agency will comply with mandated statewide requirements affecting water quality developed by other state environmental agencies including, but not limited to, [TMDL] development, water discharge permit activities and nonpoint source pollution prevention programs." 27A Okla. Stat. § 1-1-202(B)(3)(f). Notably, however, the statute requires only "development" of WQSIPs—and not "implementation" or "enforcement" of WQSIPs. 27A Okla. Stat. § 1-1-202(A). ODAFF's WQSIP for its animal waste jurisdictional area is embodied in a regulation whose sole reference to TMDLs states: "ODAFF will participate in the TMDL process as resources permit . . . ." Okla. Admin. Code § 35:45-1-7(f). This falls far short of any legal authority or duty to enforce any load allocation identified in a TMDL against defendants.[51]

90. The court concludes that, while ODAFF has environmental enforcement tools at its disposal—including injunctions and fines for violations of the act (*see, e.g.,* 2 Okla. Stat. § 10-9.11), state law does not require that ODAFF use them to enforce load allocations identified in a TMDL under the CWA, nor does it require ODAFF to enforce nonpoint source reductions as might be called for in a TMDL.

[51] Ironically, as discussed in Section F.1. above, the ORPFOA prohibits *any* discharge or runoff of poultry waste from the application site. 2 Okla. Stat. § 10-9.7(C)(6)(c).

91. The inherent limitations of TMDLs with respect to nonpoint source loadings, the uncertainty about whether and when a TMDL for the IRW will be implemented, the limited enforcement authority of both the EPA and the State to use TMDLs to reduce load allocations originating in Arkansas all weigh against reliance on TMDLs to reduce phosphorus loading of the waters of the IRW.

Irreparable Harm

92. A plaintiff seeking injunctive relief must demonstrate irreparable harm in the absence of express legislative intent to the contrary. *Weinberger,* 456 U.S. at 312; *Mical Commc'ns, Inc. v. Sprint Telemedia, Inc.,* 1 F.3d 1031, 1035 (10th Cir. 1993).

93. The court concludes that the actual and ongoing injury to the waters of the IRW constitutes irreparable harm and warrants injunctive relief.

94. Possession of an AWMP is a prerequisite to any land application of poultry waste in the Oklahoma portion of the IRW. 2 Okla. Stat. § 10-9-19a. Further, any application of poultry waste in the Oklahoma portion of the IRW must not "create an environmental or a public health hazard" or "result in the contamination of waters of the state." 2 Okla. Stat. § 10-9.7(B)(4)(a) and (B)(4)(b). The AWMPs themselves make it clear that any land application poultry waste is subject to this overarching principle. *See, i.e.,* DJX0001 at p. 4 (Saunders AWMP prohibiting surface application of litter in "[a]reas where there will be discharge from the application site").

95. Thus, although Code 590 of ORPFOA sets a maximum rate of 300 lbs/acre STP for the land application of poultry waste, an applicator must ensure that no environmental hazards or

contamination are created by the poultry waste application. 2 Okla. Stat. § 10-9.7(B)(4)(a) and (B)(4)(b).[52]

96. This court has concluded that defendants' conduct in both Oklahoma and Arkansas constitutes a public nuisance and a trespass on the waters in the Oklahoma portion of the IRW. Although Arkansas has a regulatory scheme pertaining to the management of poultry waste, that scheme must yield to the law set forth in *Cameron* and its progeny. Moreover, it is axiomatic that Arkansas cannot "permit" nonpoint source pollution of Oklahoma's waters.

IV. Conclusion

For the foregoing reasons, the court finds in favor of the State and against defendants on the State's claims of statutory public nuisance, federal common law nuisance, trespass, for violation of 27A Okla. Stat. § 2-6-105, and for violation of 2 Okla. Stat. § 2-18.1.

The Court Clerk shall substitute the current relators pursuant to Fed. R. Civ. P. 25(d), as set forth in footnote 1 above.

The Environmental Protection Agency has recognized that nutrient pollution caused by phosphorus is one of America's most widespread, costly, and challenging environmental problems. The parties are hereby directed to meet and attempt to reach an agreement with regard to remedies to be imposed in this action. On or before March 17, 2023, they shall advise the court whether they have been able to do so. The agreed remedies, if any, must be approved by the court. In the event the parties are unable to reach an accord, the court shall enter judgment.

[52] Under Oklahoma law, courts must construe legislative acts "in such a manner as to reconcile the different provisions and render them consistent and harmonious, and give intelligent effect to each. Thus, where parts of a statute reasonably are susceptible of a construction which will give effect to both, without doing violence to either, such construction should be adopted." *Oklahoma Indep. Petroleum Ass'n v Youngker,* 769 P.2d 109, 114 (Okla. 1988) (citation and quotations omitted).

ENTERED this 18th day of January, 2023.

GREGORY K. FRIZZELL
UNITED STATES DISTRICT JUDGE