Arkansas Department of Health

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Governor Asa Hutchinson
Nathaniel Smith, MD, MPH, Director and State Health Officer

October 25, 2016

Mr. Jim Wise
Ecologist Coordinator, Office of Water
Arkansas Department of Environmental Quality
5301 Northshore Drive
North Little Rock, AR 72118-5317

Dear Mr. Wise:

Upon receiving your request on September 14, 2016, the Arkansas Department of Health (ADH) Environmental Epidemiology Section reviewed the historic dioxins in fish flesh data for Evergreen Packaging (formerly International Paper Company) in Pine Bluff, AR. Data were sent to ADH via multiple emails by the Arkansas Department of Environmental Quality (ADEQ) from September 15 – 20, 2016. ADH has completed this health consultation supported by funds from a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), U.S. Department of Health and Human Services, although ATSDR has not evaluated this document. ADH prepared this health consultation letter in response to your request to evaluate potential public health issues related to Evergreen Packaging's permit renewal for continued dioxin fish flesh sampling in the Arkansas River.

Chlorinated dibenzo-*p*-dioxins (*a.k.a.* dioxins) are a family of 75 different compounds with similar properties. Dioxins may be formed by pulp and paper mill processes. Dioxins are highly toxic and can cause cancer, reproductive and developmental problems, damage to the immune system, and can interfere with hormones. Dioxins degrade slowly and can persist and accumulate in soils, sediments, and organisms for a long time [1].

When evaluating dioxins, the effects of all dioxin-like compounds are assumed to be additive due to a similar mode of action. A mathematical method called Toxicity Equivalence (TEQ) is used to assess the risk of exposure to this mixture of dioxin-like compounds. A Toxicity Equivalence Factor (TEF) for each dioxin has been developed to compare its individual relative toxicity to that of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) [2, 3] (see Appendix A).

The fish samples reviewed in this health consultation were collected in October of 2012 from the Arkansas River both upstream and downstream of the Evergreen-Pine Bluff mill discharge. Each composite sample consisted of a 200-gram homogenate sample of fish tissue taken from five fish of the same species that were of similar size, and collected at the same time. Right-side and left-side fillets were composited separately. Composite samples submitted for analysis were made up of right-side fillets from five fish in the target species. Five composite samples were analyzed. One upstream composite sample included five smallmouth buffalo fish. Four downstream samples were taken including one blue catfish, two smallmouth buffalo, and one largemouth bass [4]. Results are presented in Table 1.

The buffalo fish samples had the highest levels of dioxin among the species tested. Therefore, the upstream buffalo fish sample with a maximum TEQ value of .55 ppt was used to calculate exposure dose values in order to determine potential health risks to children and adults.

Table 1. Summary of Maximum Dioxin Concentrations for 2012 Evergreen Packaging Fish Flesh Report

Waterbody Location*	Sample Number	Species	2,3,7,8-TCDF	TEQ**
			(ppt)	(ppt)
Downstream	1	Blue Catfish	1.60	.163
Downstream	2	Smallmouth Buffalo	3.60	.362
Downstream	3	Smallmouth Buffalo	2.20	.222
Downstream	4	Largemouth Bass	0.81	.081
Upstream	5	Smallmouth Buffalo	5.50	.550

2,3,7,8-TCDF = 2,3,7,8-Tetrachlorodibenzofuran; TEQ = Toxicity Equivalence; ppt = parts per trillion

*All samples were collected in the Arkansas River near the Evergreen Packaging site in Pine Bluff, AR

**For comparison to Toxicity Equivalency Factors, see table in Appendix A

The exposure dose calculations were examined for people eating fish in either the children and adults general population category (nationwide average) or the children and adults subsistence fisher category (95th percentile nationwide). To find the daily exposure dose for each of these groups, an estimate (standardized variable) of the amount of fish consumed and individual body weight was used. For a child fish meal consumption value, the general population category is approximately two 2.25-ounce fish meals per month, and the subsistence fisher category is approximately 22 2.25-ounce fish meals per month. For an adult fish meal consumption value, the general population category is approximately two 8-ounce fish meals per month, and the subsistence fisher category is approximately 22 8-ounce fish meals per month. A body weight of 13.8 kilograms (kg) or 80 kg was attributed to the child and adult exposure dose calculations, respectively [5, 6].

The daily exposure doses for all child and adult fish consumption scenarios are listed in Table 2. Total dioxin TEQs do not have assigned health comparison values; the values for 2,3,7,8-TCDD were used as the surrogate values for comparison purposes. As listed in the toxicological profile, the ATSDR chronic Minimal Risk Level (MRL) for 2,3,7,8-TCDD is 1.0E-09 mg/kg/day [1]. In addition, as listed in the Environmental Protection Agency (EPA) Integrated Risk Information System (IRIS) database, the Reference Dose (RfD) for 2,3,7,8-TCDD is 7.0E-10 (mg/kg-day) [7]. The estimated exposure dose for the general population and subsistence fisher child and adult consumption rate is below the MRL and RfD for the fish species sampled.

The Hazard Quotient (HQ) was calculated for each potentially exposed child or adult (equations shown in Appendix B). An HQ is the average daily intake divided by a chemical specific guidance value, such as the ATSDR MRL or EPA RfD to further evaluate the potential for non-cancer health effects. If the HQ for a chemical is equal to or less than one, it is believed that there is no appreciable risk that non-cancer health effects will occur. If the HQ exceeds one, there is some possibility that non-cancer effects may occur, although an HQ above one does not indicate an effect will definitely occur. This is because of the margin of safety inherent in the derivation of all guidance values. The larger the HQ value, the more likely it is that an adverse effect may possibly occur. For this evaluation, the HQs were calculated using the EPA RfD, as it has been recently updated and represents the best available science for dioxin [5]. Refer to Table 2 for HQ values.

Because 2,3,7,8-TCDD is reasonably anticipated to be carcinogen, a cancer risk value was calculated using the exposure dose (based on the TEQ maximum concentration from the 2012 fish flesh data.) These values are based on a daily exposure dose of 26 years over a 70-year lifespan. The 26-year exposure dose was based on 6 years as a child plus 20 years as an adult reasonably anticipated to be spent in the community [6]. See Appendix B for all individual variables and equations. Table 2 represents a summary of the estimated risk-based calculated values derived using the maximum TEQ concentration from the Evergreen Packaging 2012 fish flesh data for this health consultation.

Table 2: Summary of Estimated Risk-based Values Calculated Using the 2012 Evergreen Packaging Fish Flesh Report

Fish Species	Community Members	Daily Exposure Dose	Hazard Quotient*	Lifetime Cancer Risk**
		mg/kg/day	unitless	unitless
Buffalo	General Population: Child	1.7E-11	0.0	8.3E-07
Buffalo	General Population: Adult	1.1E-11	0.0	5.1E-07
Buffalo	Subsistence Fisher: Child	1.9E-10	0.3	9.1E-06
Buffalo	Subsistence Fisher: Adult	1.2E-10	0.2	5.6E-06

mg/kg/day = milligrams per kilogram per day

*Reference dose for 2,3,7,8-tetrachlorodibenzo-p-dioxin is 7E-10 mg/kg/day. Based on Environmental Protection Agency Regional Screening Level Table; January 2015.

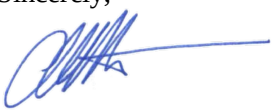
** Oral Cancer Slope Factor for 2,3,7,8-tetrachlorodibenzo-p-dioxin is 1.3E5 $(mg/kg/day)^{-1}$. Based on Environmental Protection Agency Regional Screening Level Table; January 2015.

Based on these limited data, the results from the risk calculations show that for children and adults in the general population and subsistence fishers, the daily exposure dose and HQ (non-cancer estimate) do not exceed public health risk levels for the fish species tested.

However, due to the continued presence of the dioxin-like compounds, such as 2,3,7,8-Tetrachlorodibenzofuran, in the 2012 fish samples from the Arkansas River near the Evergreen Packaging Plant and the persistent nature of these compounds in both fish and the environment, for prudent public health safety, ADH recommends that ADEQ continue to include the periodic fish flesh sampling permit requirement for dioxins in Evergreen Packaging's National Pollutant Discharge Elimination System (NPDES) permit. Additionally, periodic fish flesh sampling data evaluations will ensure public exposures do not exceed health risk levels.

Thank you for giving ADH the opportunity to work with your office on this site. Please feel free to contact me at 501-614-5227 or chris.hemann@arkansas.gov, if you have any questions.

Sincerely,



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References

1. Agency for Toxic Substances and Disease Registry, "Toxicological Profile for Chlorinated Dibenzo-*p*-dioxins (CDDs)". Atlanta: US Department of Health and Human Services; December 1998. Accessed at: http://www.atsdr.cdc.gov/toxprofiles/tp104.pdf.
2. Van den Berg M., Birnbaum L.S., Denison M., De Vito M., Farland W., et al. "The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds," Toxicological Sciences; 93(2):223–241; 2006.
3. U.S. Environmental Protection Agency, 2010. Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin and Dioxin-like Compounds. (EPA/100/R-10/005) Risk Assessment Forum, USEPA; December 2010.
4. FTN Associates. Fish Tissue Concentrations of Dioxin in the Arkansas River Upstream and Downstream of Evergreen Packaging Pine Bluff, Arkansas. January 8, 2013.
5. U.S. Environmental Protection Agency. Exposure Factors Handbook: 2011 Edition. Accessed at: https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=236252.
6. U.S. Environmental Protection Agency. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. Accessed at: https://rais.ornl.gov/documents/OSWER-Directive-9200-1-120-Exposure-Factors_corrected.pdf.
7. U.S. Environmental Protection Agency. Integrated Risk Information System: 2,3,7,8-Tetrachlorodipenzo-p-dioxin (TCDD); CASRN 1746-01-6; 2012. Accessed at: http://www.epa.gov/iris/subst/1024.htm#revhis.

Appendix A

Toxicity Equivalence Factors of Dioxins and Dioxin-like Compounds

Recommended toxicity equivalence factors (TEFs) for human health risk assessment of polychlorinated dibenzo-*p*-dioxins, dibenzofurans, and dioxin-like polychlorinated biphenyls.

Compound	**TEF**
Polychlorinated dibenzo-*p*-dioxins (*PCDDs)*	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
Polychlorinated dibenzofurans (*PCDFs)*	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003
Polychlorinated biphenyls* (*PCBs)*	
3,3',4,4'-TCB (77)	0.0001
3,4,4',5-TCB (81)	0.0003
3,3',4,4',5-PeCB (126)	0.1
3,3',4,4',5,5'-HxCB (169)	0.03
2,3,3',4,4'-PeCB (105)	0.00003
2,3,4,4',5-PeCB (114)	0.00003
2,3',4,4',5-PeCB (118)	0.00003
2',3,4,4',5-PeCB (123)	0.00003

Sources:

U.S. Environmental Protection Agency, "Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin and Dioxin-Like Compounds," Office of the Science Advisor, Risk Assessment Forum; December 2010.

Van den Berg M., Birnbaum L.S., Denison M., De Vito M., Farland W., et al. "The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-like Compounds," Toxicological Sciences; 93(2):223–241; 2006

Appendix B

Exposure Dose Equation for Ingestion of Fish from the Arkansas River near Evergreen Packaging in Pine Bluff, AR

ED = (C x IR x AF x EF x CF) / BW

ED = Exposure Dose (milligrams per kilogram per day, mg/kg/day)
C = Contaminant Concentration
IR = Intake Rate of Contaminated Fish
AF = Bioavailability Factor (unitless)
EF = Exposure Factor (unitless)
CF = Conversion Factor
BW = Body Weight (kilograms, kg)

Receptor Scenario Variables*:
C = .55 parts per trillion TEQ
IR = general population-adult (8 oz/meal) 2 meals per month for 1 year
IR = general population-child (2.25 oz/meal) 2 meals per month for 1 year
IR = subsistence fisher-adult (8 oz/meal) 22 meals per month for 1 year
IR = subsistence fisher-child (2.25 oz/meal) 22 meals per month for 1 year
EF = 6.74 E-2 (general population) or 7.42 E-1 (subsistence fishers);
AF = 1E-1; CF = 1E-12
BW = 13.8 kg (child) or 80 kg** (adult)

*Reference: Agency for Toxic Substances and Disease Registry (ATSDR). Public Health Assessment Guidance Manual (Update), Appendix G: Calculating Exposure Doses; January 2005.
**Reference: U.S. Environmental Protection Agency. Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors.

Hazard Quotient Equation for Estimating Short-Term Health Effects

HQ = ED / RfD

HQ = Hazard Quotient (unitless)
ED = Exposure Dose (milligrams per kilogram per day, mg/kg/day)
RfD = Reference Dose (milligrams per kilogram per day, mg/kg/day)

RfD for 2,3,7,8-TCDD = 7.0E-10 $(mg/kg/day)^{-1}$

Lifetime Cancer Risk Equation for Estimating Possible Carcinogen Effects

LCR = ED x CSF x (estimated exposure years / 70 years lifetime)

LCR = Lifetime Cancer Risk (unitless)
ED = Exposure Dose (milligrams per kilogram per day, mg/kg/day)
CSF = Cancer Slope Factor (1 / milligrams per kilogram per day, $mg/kg/day^{-1}$)
Estimated exposure years = 70 years (lifetime)
CSF^{ϕ} for 2,3,7,8-TCDD = 1.3E05

$^{\phi}$California Environmental Protection Agency (Cal/EPA). Technical Support Document for Cancer Potency Factors. Office of Environmental Health Hazard Assessment, Air Toxicology and Epidemiology Branch. Berkeley, CA. 2009.