



PETITION TO ORDER TESTING OF THE CHLORINATED PHOSPHATE ESTER CLUSTER FLAME RETARDANTS (TCEP, TCPP and TDCPP) UNDER SECTION 4(a) OF THE TOXIC SUBSTANCES CONTROL ACT (JANUARY 6, 2017)

Via Federal Express & Electronic Mail

Gina McCarthy, Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Mail Code: 1101A
Washington D.C. 20460
McCarthy.Gina@epa.gov

Dear Administrator McCarthy:

Earthjustice,¹ Natural Resources Defense Council (NRDC),² Toxic-Free Future (TFF),³ Safer Chemicals, Healthy Families (SCHF),⁴ BlueGreen Alliance (BGA),⁵ and Environmental Health Strategy Center (EHSC)⁶ submit this Petition to the U.S. Environmental Protection Agency (“EPA”), pursuant to section 21 of the Toxic Substances Control Act (“TSCA”),⁷ to

¹ Earthjustice is the nation’s largest environmental law organization. Protecting people and the environment from exposure to toxic substances is a key part of its mission. Earthjustice submits this petition on behalf of NRDC, SCHF, TFF, BGA, and EHSC.

² NRDC is an international nonprofit environmental organization with more than 2 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world’s natural resources, public health, and the environment. Protecting families and communities from toxic chemicals is a key NRDC goal.

³ TFF advocates for the use of safer products, chemicals, and practices through advanced research, advocacy, grassroots organizing, and consumer engagement to ensure a healthier tomorrow.

⁴ SCHF is a coalition representing over 450 organizations and businesses united by a common concern about toxic chemicals in our homes, places of work, and products we use every day.

⁵ BGA unites the largest labor unions in the United States with major environmental organizations to solve environmental challenges in ways that create and maintain quality jobs and build a stronger, fairer economy. A key component of BGA’s work is the creation of quality jobs across the country that ensure the health of workers and the environment. Improving job safety by improving the safety of workplace chemicals is a key BGA goal.

⁶ EHSC is a public health organization that works nationally for food, water, and products that safer for people and the planet, and for a sustainable economy with justice for all.

⁷ 15 U.S.C. § 2620.

issue an order under TSCA section 4,⁸ requiring that testing be conducted by manufacturers and processors on the three chemical substances that EPA has identified as the chlorinated phosphate ester cluster of flame retardant chemicals: tris(2-chloroethyl) phosphate (“TCEP”) (CAS 115-96-8), 2-Propanol, 1-chloro-, phosphate (“TCPP”) (CAS 13674-84-5); and 2-Propanol, 1,3-dichloro-, phosphate (“TDCPP”) (CAS 13674-87-8) (together, the “CPE Cluster”).⁹ The CPE Cluster of flame retardants are high production volume chemicals that are widely used in additive applications for paints and coatings, textiles, building insulation and polyurethane foam. CPE flame retardants have been the primary replacements in foam for the polybrominated diphenyl ether flame retardants (“PBDEs”) that are widely understood to be toxic,¹⁰ and that were phased out of U.S.-production pursuant to voluntary agreements with EPA a decade ago.

The basis for the testing order is laid out below. The specific protocols and methodologies for the development of information that we ask EPA to seek in a CPE Cluster testing order are set forth in Appendix A hereto.

Pursuant to TSCA section 21(b)(3), we ask EPA to respond to this Petition by issuing the requested test order by April 6, 2017, which is 90 days after the Petition was filed in the principal office of the Administrator of the EPA on January 6, 2017.

⁸ 15 U.S.C. § 2603.

⁹ The CPE Cluster was the subject of an EPA TSCA Work Plan Chemical Problem Formulation and Initial Assessment, dated August 2015. Office of Chem. Safety & Pollution Prevention, EPA, Doc. No. 740-R1-5001, *TSCA Work Plan Chemical Problem Formulation and Initial Assessment: Chlorinated Phosphate Ester Cluster Flame Retardants* (2015), https://www.epa.gov/sites/production/files/2015-09/documents/cpe_fr_cluster_problem_formulation.pdf (“CPE Cluster Problem Formulation”).

¹⁰ PBDEs have been shown to present a range of very serious human health risks, including immune and endocrine disruption, and adverse reproductive and neurodevelopmental effects. See Victoria Linares, Montserrat Bellés, & José Domingo, *Human exposure to PBDE and critical evaluation of health hazards*, 89 Archives of Toxicology 335 (2015).

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I. INTRODUCTION

When Congress adopted TSCA in 1976, it stated that “it is the policy of the United States that adequate data should be developed with respect to the effect of chemical substances and mixtures on health and the environment and that the development of such data should be the responsibility of those who manufacture and those who process such chemical substances and mixtures.”¹¹ This congressional statement of national policy has been virtually ignored for several decades.¹² But this state of affairs cannot continue. Due to an overall lack of available data or existing data gaps, EPA will be unable to conduct the robust chemical risk evaluations mandated by the reformed TSCA unless it requires manufacturers and processors to develop health and safety information about their chemicals. For the reasons below, there is little doubt that the existing information about the risks posed by the CPE Cluster more than satisfies the TSCA section 4 criteria for scenarios where “the Administrator *shall* … require that testing be conducted.”¹³ We therefore urge EPA to issue a section 4 testing order for the substances in the CPE Cluster as soon as possible.

II. LEGAL CRITERIA FOR ISSUING A TEST ORDER

To facilitate the policy that “adequate information should be developed with respect to the effect of chemical substances and mixtures on health and the environment and that the development of such information should be the responsibility of those who manufacture and those who process such chemical substances and mixtures,”¹⁴ TSCA requires EPA to direct testing on a chemical substance or mixture if it finds the following criteria are met:

- (1) the “manufacture, distribution in commerce, processing, use, or disposal of a chemical substance or mixture, or that any combination of such activities, *may present an unreasonable risk of injury to health or the environment,*”
- (2) there is “*insufficient information and experience* upon which the effects of such manufacture, distribution in commerce, processing, use, or disposal of such substance or mixture, or of any combination of such activities on health or the environment can reasonably be determined or predicted,” and

¹¹ 15 U.S.C. § 2601(b)(1). The reformed TSCA left this statement of policy intact; the only revision changed the term “data” in two places to “information.”

¹² U.S. Gen. Accounting Office, GAO-05-458, *Chemical Regulation –Options Exist to Improve EPA’s Ability to Assess Health Risks and Manage Its Chemical Review Program* (2005); U.S. Gen. Accounting Office, GAO/RCED-94-103, *Toxic Substances Control Act-Legislative Changes Could Make the Act More Effective* (1994).

¹³ 15 U.S.C. § 2603(a) (emphasis added).

¹⁴ 15 U.S.C. § 2601(b)(1).

(3) “*testing . . . is necessary* to develop such information.”¹⁵

While TSCA reform revised the process for requiring testing, the above-stated criteria for testing under section 4(a)(1) remain essentially unchanged.¹⁶ Thus, case law developed under the prior version of section 4 remains applicable here. Case law shows that a mere rational concern about the risks posed by a chemical justifies a testing order.

A. **EPA Has Consistently Found the “May Present” Standard Is Satisfied Where There Is a More-Than-Theoretical Risk**

EPA has previously taken the position that the “may present” finding is satisfied where “the existence of an ‘unreasonable risk of injury...’ is . . . more than merely theoretical, speculative, or conjectural.”¹⁷ Both the D.C. Circuit and Third Circuit Courts of Appeals have deferred to the agency’s broad interpretation of its testing authority.¹⁸

In *Chemical Manufacturers Association v. EPA*, the D.C. Circuit deferred to EPA’s expansive interpretation of the “may present” language and upheld a testing rule directed to manufacturers of the chemical 2-ethylhexanoic acid.¹⁹ The court noted that the legislative history of the original TSCA section 4 indicates congressional intent that EPA issue testing rules when unreasonable risk could not yet be “reasonably predicted.”²⁰ The court emphasized that both the statutory wording and legislative history reveal congressional intent for EPA to act on the basis of rational concern even in the absence of “adequate information” relating to the risks of a chemical substance or mixture.²¹

In *Ausimont U.S.A., Inc. v. EPA*, the Third Circuit also deferred to EPA’s reading of section 4 and upheld a testing rule directed to manufacturers of fluoroalkenes.²² Rejecting the chemical industry’s arguments, the court noted that Section 4 “focuses on investigating areas of

¹⁵ *Id.* § 2603(a)(1). With the reformed TSCA, EPA can *order* that such testing be conducted rather than proceeding by rulemaking as was required under the prior version of TSCA. *Id.* A section 4 testing order must require that

testing be conducted . . . to develop information with respect to the health and environmental effects for which there is an insufficiency of information and experience and which is relevant to a determination that the manufacture, distribution in commerce, processing, use, or disposal of such substance or mixture, or that any combination of such activities, does or does not present an unreasonable risk of injury to health or the environment.

Id.

¹⁶ The reformed TSCA changes the word “data” to “information.”

¹⁷ *Chem. Mfrs. Ass’n v. EPA*, 859 F.2d 977, 983-985 (D.C. Cir. 1988).

¹⁸ *Id.*; see also *Ausimont U.S.A., Inc. v. EPA*, 838 F.2d 93 (3d. Cir. 1988).

¹⁹ 859 F.2d at 983-985.

²⁰ *Id.* at 985.

²¹ *Id.*

²² 838 F.2d at 93.

uncertainty as a prelude to regulating harmful substances,”²³ and that “questions broaching the frontiers of scientific knowledge highlight the need for testing,” rather than undercutting the conclusion that sufficient probability of risk is present to require testing.²⁴ The court upheld EPA’s reliance on the structure activity relationship between VDF, one of the chemicals subject to the test rule, and vinylidene chloride, a suspected carcinogen, as supporting the need for testing.²⁵

B. Courts Have Deferred to EPA’s View That the “May Present” Finding Is Satisfied So Long as Evidence of Exposure Is More Than Theoretical

In both *Chemical Manufacturers Association* and *Ausimont U.S.A.*, chemical manufacturers argued that EPA’s testing rules were improper because evidence of exposure was limited. The courts in these cases deferred to EPA, giving it broad latitude to *infer* exposure. In *Chemical Manufacturers Association*, the chemical industry argued that when industry evidence casts doubt on the existence of exposure, the burden shifts to EPA to produce direct evidence documenting actual instances in which exposure has taken place. While EPA agreed that some exposure is a necessary component of “unreasonable risk,” it argued that it is permitted to *infer exposure* from the circumstances under which a chemical substance is manufactured and used.²⁶ It contended that Section 4 allowed it to issue a test rule so long as it could show a “more-than-theoretical basis for inferring the existence of exposure.”²⁷ The D.C. Circuit deferred to this interpretation, holding: “[w]e conclude that it is reasonable for EPA to rely on inferences in issuing a section 4 test rule, so long as all the evidence - including the industry evidence - indicates a more-than-theoretical probability of exposure.”²⁸ Likewise in *Ausimont U.S.A.*, the industry challengers asserted that exposure to fluoroalkenes was minimal. The court deferred to EPA’s concern, finding that it was “not prepared to say that the element of risk is insignificant.”²⁹

* * *

The clear take-away from court rulings interpreting the scope of EPA’s authority to require testing under section 4 is that EPA has broad discretion to require testing based on rational concern that the chemical may present an unreasonable risk.

²³ *Id.* at 96.

²⁴ *Id.*

²⁵ *Id.*

²⁶ 859 F.2d at 984.

²⁷ *Id.* at 988.

²⁸ *Id.* at 989.

²⁹ 838 F.2d at 97.

III. EPA SHOULD ISSUE A SECTION 4 TEST ORDER FOR THE CHEMICAL SUBSTANCES IN THE CPE CLUSTER

The standard for issuing a test order is easily met for the CPE Cluster. As a result, EPA “shall ... require that testing be conducted.”³⁰

A. The CPE Cluster “May Present” an Unreasonable Risk

The potential that TCEP, TDCPP and TCPP pose an “unreasonable risk of injury” is “more than merely theoretical, speculative, or conjectural.”³¹ Because “[r]isk implicates two concepts – toxicity and exposure,”³² we address each of these concepts for the three CPE Cluster substances separately below.

1. The CPE Cluster Is Likely Toxic

There is substantial evidence that each of the three CPE Cluster substances may be toxic to both human health and the environment.

With respect to the **mammalian toxicity** of the chemicals in the CPE Cluster, EPA’s CPE Cluster Problem Formulation reports that:

- In chronic studies with TCEP and TDCPP, precancerous and cancerous lesions were observed in the kidneys. In addition, in subchronic toxicity tests, kidney effects were noted with all three chemicals.³³
- Mild liver toxicity (increased liver weights) was also observed in two studies, one on TCDPP and another with TCEP.³⁴
- Thyroidal effects were seen with TCPP and TDCPP.³⁵
- TCEP and TDCPP are considered animal carcinogens. For example, TCEP exposure was associated with renal tubule adenomas and carcinomas (rats, mice) and follicular cell adenoma or carcinoma of the thyroid (female, high dose rats). A two-year study of TDCPP in rats identified kidney tumors (males, females, testicular tumors (males) and adrenocortical tumors (females).³⁶

³⁰ 15 U.S.C. § 2603(a)(1)(B).

³¹ 859 F.2d at 983-985.

³² 838 F.2d at 96.

³³ CPE Cluster Problem Formulation at 26.

³⁴ *Id.*

³⁵ *Id.*

³⁶ *Id.*

- All three CPE Cluster chemicals are considered weak inhibitors of acetylcholinesterase, meaning they may impact neurological function. A number of studies testing TCEP identified neurological effects, such as seizures or convulsions.³⁷
- With respect to impacts on fertility, high doses of TCEP (≥ 350 mg/kg/day) reduced the number of litters in a continuous breeding study and sperm parameters were reduced.³⁸
- In a two-year study with rodents exposed to TDCPP, testicular lesions were noted.³⁹
- A study of rats administered TDCPP on GD 6-15 resulted in increased resorptions, reduced fetal viability, decreased skeletal development and decreased mean fetal weight.⁴⁰

In addition, the following findings of authoritative bodies have raises significant concerns about the toxicity of CPE Cluster substances:

- TDCPP was found by the state of California to be a “known carcinogen,” and in 2011 added to the list of chemicals requiring warning labels under California Proposition 65 law.⁴¹
- TCEP was added to California’s Proposition 65 list of chemicals “known to the State to cause cancer” in 1992.⁴²

³⁷ CPE Cluster Problem Formulation at 26.

³⁸ *Id.* at 27.

³⁹ *Id.*

⁴⁰ *Id.*

⁴¹ Cal. EPA, Office of Environmental Health Hazard Assessment (“OEHHA”), Chemicals Known to the State to Cause Cancer or Reproductive Toxicity 21 (Oct. 21, 2016), <http://oehha.ca.gov/media/downloads/proposition-65//p65single10212016.pdf>; OEHHA, Reproductive and Cancer Hazard Assessment Branch, *Evidence on the Carcinogenicity of Tris(1,3-Dichloro-2-Propyl Phosphate* (July 2011), <http://oehha.ca.gov/media/downloads/proposition-65/chemicals/tdcpp070811.pdf>.

As EPA noted in its Problem Formulation, carcinogenicity is not the only concern with TDCPP. TDCPP levels in house dust were associated with altered hormone levels in men recruited through an infertility clinic. See John D. Meeker & Heather M. Stapleton, *House dust concentrations of organophosphate flame retardants in relation to hormone levels and semen quality parameters*, 118 Envtl. Health Persp. 318 (2009). In addition, an *in vitro* study suggests that TDCPP is toxic to the nervous system and affects cell development and DNA synthesis. See Laura V. Dishaw et al., *Is the PentaBDE replacement, tris (1,3-dichloro-2-propyl) phosphate (TDCPP), a developmental neurotoxicant? Studies in PC 12 cells*, 256 Toxicology & Applied Pharmacology 281 (2011).

⁴² OEHHA, Chemicals Known to the State to Cause Cancer or Reproductive Toxicity 21 (Oct. 21, 2016), <http://oehha.ca.gov/media/downloads/proposition-65//p65single10212016.pdf>.

- The European Union (“EU”) classifies TCEP as a “Substance of Very High Concern” based on reproductive toxicity.⁴³
- The California Safer Consumer Products program lists TCPP as a candidate chemical based on carcinogenicity.⁴⁴

With respect to **ecological toxicity**, the CPE Cluster Problem Formulation reports that

- Sublethal effects from exposure to all three CPE Cluster substances were observed in acute tests with fish that included loss of coordination that culminated in overturned fish, edema, darkened pigmentation and hyperventilation. EPA concluded that “[t]hese effects suggest potential for long-term population level concerns in fish.”⁴⁵

In addition, EPA’s Design for the Environment recently conducted a hazard assessment of the chemicals in the CPE Cluster.⁴⁶ An excerpt of the table summarizing the hazard assessment for the CPE Cluster substances is reproduced immediately below:

Carcinogenicity is not the only concern with TCEP. TCEP has also been linked to reproductive toxicity and neurotoxicity based on animal studies. See European Comm’n, *European Union Risk Assessment Report: Tris(2-chloroethyl)phosphate, TCEP* (July 2009), <http://www.baua.de/en/Chemicals-Act-biocide-procedure/Documents/RAR-068.pdf?blob=publicationFile&v=1>; Wash. State Dep’t of Health, *Children’s Safe Products Act Rationale for Chemicals listed under Reporting Requirements* (Apr. 18, 2011), <http://www.cj-elec.com/UploadPicFile/20121123141853694.pdf>; Minn. Dep’t of Health, *Toxicological Summary for Tris(2-chloroethyl)phosphate* (last visited Jan. 4, 2017), <http://www.health.state.mn.us/divs/eh/risk/guidance/gw/tcep.pdf>.

⁴³ European Chemicals Agency, *Support Document for Identification of Tris(2-Chloroethyl)Phosphate as a Substance of Very High Concern Because of its CMR Properties* 3 (Nov. 27, 2009), <https://echa.europa.eu/documents/10162/6d09755f-7fc8-4a00-b7ce-91ab45a2e5af>.

⁴⁴ See CalSAFER, *Candidate Chemical Details* (last visited Jan. 4, 2017), <https://calsafer.dtsc.ca.gov/chemical/ChemicalDetail.aspx?chemid=20838>.

It is relevant that TCPP is structurally similar to TCEP and TDCPP. See CPE Cluster Problem Formulation at 11-12 (the three substances in the CPE Cluster are structurally similar and similar “in terms of physical chemical properties and fate, in particular vapor pressure, water solubility and octanol water partition coefficient”); see also European Comm’n Scientific Comm. on Health & Env’tl. Risks, *Opinion on tris(2-chloroethyl)phosphate (TCEP) in Toys* (Mar. 22, 2012), http://ec.europa.eu/health/sites/health/files/scientific_committees/environmental_risks/docs/scher_o_158.pdf. On this basis, it is more than merely theoretical or conjectural to be concerned that TCPP may be similarly toxic in terms of carcinogenicity and reproductive toxicity unless demonstrated otherwise. We note that the EU banned TCPP in toys based on toxicity concerns. Commission Directive 2014/79, 2014 O.J. (L 182) 49.

⁴⁵ CPE Cluster Problem Formulation at 25.

⁴⁶ EPA, Doc. No. 744-R-15-002, *Flame Retardants Used in Flexible Polyurethane Foam: An Alternatives Assessment Update* (Aug. 2015), https://www.epa.gov/sites/production/files/2015-08/documents/frr_final.pdf.

Table 2-1. Screening Level Toxicity Hazard Summary

This table contains hazard information for each chemical; evaluation of risk considers both hazard and exposure. Variations in end-of-life processes or degradation and combustion by-products are discussed in the report but not addressed directly in the hazard profiles. The caveats listed below must be taken into account when interpreting the information in the table.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from predictive models and/or professional judgment.

* Each hazard designation for a mixture is based upon the component with the highest hazard, whether it is an experimental or estimated value. For Firemaster® mixtures there is no corresponding profile in Section 7.

[^] This component of Firemaster® 550 may be used alone or in other mixtures as an alternative.

^Y Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures, which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Chemical (for full chemical name and relevant trade names see the individual profiles in Section 7)	CASRN	Human Health Effects												Aquatic Toxicity	Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Tris (2-chloroethyl) phosphate (TCEP)	115-96-8	H	H	M	M	H	M	M	L		L	L	H	H	M	L
Tris (2-chloro-1-methylethyl) phosphate (TCPP)	13674-84-5; 6145-73-9	L	M	L	H	H	M	M	L		L	L	M	M	H	L
Tris (1,3-dichloro-2-propyl) phosphate (TDCPP)	13674-87-8	L	H	M	H	M	L	H	L		L	L	H	H	H	L

Id. at 2-2.

Each of the three chemicals in the CPE Cluster is considered a high hazard for more than one human health effect, as well as for aquatic toxicity, based on empirical data (rather than predictive models or professional judgment). In addition, TCPP and TDCPP are considered to be highly persistent.

In sum, multiple studies and assessments have raised significant concern that the CPE Cluster substances present a hazard to humans and the environment.

2. Human and Environmental Exposure to the CPE Cluster Substances Is Established

There is substantial evidence that humans and the environment are exposed to the CPE Cluster substances. The following evidence of extensive human exposure to the CPE Cluster is taken from EPA's Problem Formulation:

- “CPEs have been detected in several studies of [U.S.] drinking water.” According to EPA, in one study of 19 water utilities across the United States examining source water, finished water and tap water CPEs were detected in up to 50% of the samples.⁴⁷
- “Numerous studies have measured concentrations of CPE FRs in infant products such as high chairs, bath mats, car seats, nursing pillows, carriers . . . , sofas . . . , and camping tents . . . Because many of these products are used in indoor

⁴⁷ CPE Cluster Problem Formulation at 67-68.

environments, such as homes, consumer and children are likely to be exposed on a continuing basis using these products.”⁴⁸

- “Small children may have additional exposures through contact with baby products containing CPEs and via mouthing behaviors.”⁴⁹
- “A number of published studies have reported levels of CPEs in indoor air and dust. For children and adults, exposures in the home and in other common microenvironments (e.g., schools, daycares, public and commercial buildings, vehicles).” As a result, “exposures to CPE FRs [in] indoor environments [is] possible through inhalation of vapor, incidental ingestion of inhaled dust and hand-to-mouth transfer of settled dust.”⁵⁰

Ecological exposure to the CPE Cluster substances is also established. According to the CPE Cluster Problem Formulation, “several studies throughout the US and abroad have reported levels of the CPEs in surface water. ... *Collectively, these data indicate high potential for exposures to ecological receptors, and in particular, aquatic organisms.*”⁵¹ In addition, TCEP, TCPP, and TDCPP have all been measured in herring gull eggs from the Lake Huron area.⁵²

B. There Is Insufficient Information To Determine or Predict the Effects of the CPE Cluster Substances During Their Full Life Cycle

The CPE Cluster Problem Formulation provides abundant evidence that there is “insufficient information and experience upon which the effects of [the] manufacture, distribution in commerce, processing, use, or disposal of [CPE cluster substances] or of any combination of such activities on health or the environment can reasonably be determined or predicted.”⁵³ In other words, it shows that the second requirement for a testing order is satisfied here. The CPE Problem Formulation identifies seven critical data gaps around exposures and hazards of these flame retardants:

1. Exposure pathways: dermal and inhalation
2. Hazard: Reproductive and endocrine toxicity
3. Exposure: Environmental releases from non-industrial uses
4. Exposure: Community and worker exposures from manufacturing, processing, industrial and non-industrial uses
5. Exposure: Community and worker exposures from recycling
6. Exposure: Community, worker and environmental exposures from disposal

⁴⁸ *Id.* at 24.

⁴⁹ *Id.*

⁵⁰ *Id.*

⁵¹ CPE Cluster Problem Formulation at 23 (emphasis added).

⁵² *Id.* at 68.

⁵³ 15 U.S.C. § 2603(a)(1)(A)(II).

7. Hazard: Toxicity to birds, wildlife, sediment organisms

The bullets below, which spell out the data gaps for the CPE cluster flame retardants, are taken directly from the CPE Cluster Problem Formulation. All italics are added.

1. Dermal and inhalation exposure

- “EPA/OPPT expects industrial worker exposures to be primarily via inhalation of vapor and dermal contact; given *the lack of toxicity data* for inhalation and dermal routes of exposure, these exposure pathways *cannot be quantified* in a risk assessment.”⁵⁴
- “Because the predominant consumer uses of CPE-containing polymers, such as insulation and furniture, are in indoor environments, the potential for consumer exposure via inhalation of indoor air and dust, dermal contact with products and incidental ingestion of dust is high. ...[N]either inhalation nor dermal contact will be considered in this assessment *due to absence of route-relevant toxicological data.*”⁵⁵
- “There is no PBPK model readily available for route-to-route extrapolation. EPA/OPPT has *identified this as a critical data gap* since the exclusion of dermal and inhalation exposure routes will result in the underestimation of risks.”⁵⁶

2. Hazard endpoints: Reproductive and endocrine toxicity

- Male Reproductive Toxicity: “Given the uncertainty surrounding the impact of long-term exposures and male reproductive toxicity, *it is not possible to quantify risks* at this time.”⁵⁷
- Endocrine Activity: “The conflicting data and lack of consistent adverse endpoints *makes it difficult to evaluate quantitatively.*”⁵⁸

3. Environmental releases from non-industrial and consumer uses

- “Down the drain releases to water from consumer uses are plausible...yet *there are insufficient data* to quantify these inputs.”⁵⁹

4. Exposures from manufacturing, processing, industrial and non-industrial uses

⁵⁴ CPE Cluster Problem Formulation at 29.

⁵⁵ *Id.*

⁵⁶ *Id.* at 37.

⁵⁷ *Id.* at 70.

⁵⁸ *Id.* at 71.

⁵⁹ *Id.* at 27.

- “EPA/OPPT also searched the scientific literature for data related to releases to the environment from industrial sites, but *did not find any chemical-specific data*. US Toxic Release Inventory (TRI) *data are not available* for these chemicals.”⁶⁰
- “Occupational inhalation exposure monitoring data for industrial workers in the US *are not available*, but monitoring data for inhalation exposure of European workers to TCPP or TDCPP vapors at industrial facilities are reported....”⁶¹
- “Workers cutting PU foam at industrial sites may inhale dust containing CPEs, but EPA/OPPT *does not have the necessary data* to evaluate this potential exposure.”⁶²

5. Exposures from recycling

- According to the conceptual models presented in the CPE Problem Formulation, EPA will not consider community or worker exposures related to the recycling of products containing CPE flame retardants.⁶³ This exclusion likely reflects a data gap.

6. Exposures from disposal

- According to the conceptual models presented in the CPE Problem Formulation, EPA will not consider community, worker or environmental exposures related to the disposal of products containing CPE flame retardants.⁶⁴ This exclusion likely reflects a data gap.

7. Exposures of birds, wildlife and sediment organisms

- “Fish and other wildlife are exposed to these chemicals via ambient air, surface water, sediment, or soil. EPA/OPPTs has limited ability to quantify risks for sediment, soil, sludge and ambient air because *very little monitoring data and no hazard endpoints* exist for these media.”⁶⁵
- Sediment Toxicity: “*No data were available* to characterize the toxicity of sediment dwelling organisms.”⁶⁶
- Terrestrial Toxicity: “*Limited data were available* to characterize the toxicity of terrestrial organisms.”⁶⁷

⁶⁰ CPE Cluster Problem Formulation at 23.

⁶¹ *Id.*

⁶² *Id.* at 29.

⁶³ *Id.* at 28, 30.

⁶⁴ *Id.*

⁶⁵ *Id.* at 28.

⁶⁶ *Id.* at 69.

In sum, EPA’s own CPE Cluster Problem Formulation demonstrates that EPA has insufficient information with which to conduct the type of full life cycle risk evaluation that TSCA section 6 requires.

C. Testing Is Necessary to Develop This Information

The third criterion for a testing order is also satisfied for the CPE Cluster because “*testing . . . is necessary* to develop [the] information”⁶⁸ on the basis of which “the effects of [the] manufacture, distribution in commerce, processing, use, or disposal of [the CPE Cluster] or of any combination of such activities on health or the environment can reasonably be determined or predicted.”⁶⁹ Appendix A to this petition lays out the testing that is necessary to determine the effects of the manufacture, distribution in commerce, processing, use, and disposal of the CPE Cluster substances. Also set out in Appendix A is an explanation of why the EPA is “justifie[d]” in ordering “more advanced testing of potential health or environmental effects or potential exposure without first conducting screening-level testing,” pursuant to TSCA section 4(a)(4).⁷⁰

IV. THE TEST ORDER SHOULD BE DIRECTED TO MANUFACTURERS AND PROCESSORS

For the reasons above, the CPE Cluster satisfies the criteria for issuing a TSCA section 4 testing rule. Accordingly, EPA “shall . . . require that testing be conducted on [the CPE Cluster substances] to develop information with respect to the health and environmental effects for which there is an insufficiency of information and experience and which is relevant to a determination [regarding whether the CPE Cluster] does or does not present an unreasonable risk of injury to health or the environment.”⁷¹

We urge EPA to direct the section 4 testing order for the CPE Cluster to all persons who “manufacture[] or intend[] to manufacture” or “process[] or intend[] to process” the CPE Cluster substances.^{72,73}

⁶⁷ *Id.*

⁶⁸ 15 U.S.C. § 2603(a)(1)(A)(i)(III).

⁶⁹ *Id.* § 2603(a)(1)(A)(i)(II).

⁷⁰ *Id.* § 2603(a)(4).

⁷¹ *Id.* § 2603(a)(1)(B).

⁷² TSCA defines the act of “manufacturing” as importing into the U.S., producing or manufacturing. 15 U.S.C. § 2602(9).

⁷³ Processor is defined in TSCA section 3 to include anyone who processes a chemical substance, and the action of processing it defined as the “preparation of a chemical substance or mixture, after its manufacture, for distribution in commerce.” 15 U.S.C. § 2602(13)-(14).

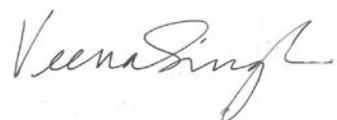
V. CONCLUSION

For the reasons set forth above and in Appendix A, we urge EPA to issue a TSCA section 4 testing order to fill the data gaps for the CPE Cluster chemicals that EPA has already identified.

Sincerely,



Eve Gartner
Staff Attorney
Earthjustice



Veena Singla
Staff Scientist
Natural Resources Defense Council

cc: Mr. Jim Jones, Assistant Administrator, OCSPP (Jones.Jim@epa.gov)

APPENDIX A

1) DERMAL AND INHALATION EXPOSURE TOXICITY

EPA identified in the chlorinated phosphate esters (CPE) Problem Formulation that inhalation and dermal exposure are significant routes of exposure to CPE, but there are limited route-specific toxicokinetic and toxicological data available for assessment of these pathways. This is a critical data gap since the exclusion of dermal and inhalation exposure routes will result in the underestimation of risks.¹ According to the CPE Cluster Problem Formulation, EPA expects industrial worker exposures to be primarily via inhalation of vapor and dermal contact; but, given the lack of toxicity data for inhalation and dermal routes of exposure, these exposure pathways cannot be quantified in a risk assessment.² Further, the predominant consumer uses of CPE-containing polymers such as insulation and furniture are in indoor environments, so the potential for consumer exposure via inhalation of indoor air and dust, dermal contact with products and incidental ingestion of dust is high. For other consumer product uses of CPE, such as textiles or printed circuit boards, EPA acknowledges much less is known about consumer exposures.³ The dermal exposure pathway is likely relevant to exposures following direct contact with treated textiles. However, due to absence of route-relevant toxicological data, neither inhalation nor dermal contact will be considered for consumers.⁴

Route-to-route extrapolation is reasonable for risk assessment but requires the development and validation of a physiologically-based pharmacokinetic (PBPK) model. Although there are limited data on absorption of CPE, there are insufficient data for toxicokinetics following dermal or inhalation exposures to inform such a PBPK model. As such, at a minimum, robust toxicokinetics data should be generated.

1A) DERMAL EXPOSURE TOXICITY

Assessment of available information

There is limited information available for toxicity following dermal exposure to CPE. This is a critical data gap as the dermal exposure pathway is likely to be particularly relevant for workers and consumers.

At present, no validated alternative methods completely cover absorption, distribution, metabolism, and excretion, necessitating further *in vivo* testing in order to generate the toxicokinetics data needed. However, dermal absorption parameters are of particular interest and novel *in vitro* models for absorption may also provide additional data for assessment. These models have been widely used in pharmacological studies, and are now being used for environmental exposures as well. A recent dermal absorption study demonstrated 28%, 25% and 13% absorption of the applied dose (500 ng/cm²) of TCEP, TCPP, and TDCPP respectively in ex

¹ CPE Cluster Problem Formulation at 37.

² *Id.* at 29.

³ *Id.* at 31.

⁴ *Id.*

vivo skin, and comparable absorption profiles in a commercially available 3D human skin-equivalent⁵.

Acute toxicity testing following dermal exposure is also needed in order to fill the data gap identified in the Problem Statement on toxicity following this route of exposure. Validated methods exist for model organisms exposed via this route.

Testing requested

In vivo study will generate the most informative and appropriate toxicokinetics data for risk assessment, due to the intact physiological and metabolic systems present in test animals. The **Organization for Economic Cooperation and Development (OECD) guidelines for toxicokinetics (OECD 417)**,⁶ with references as directed to the earlier **OECD guidelines for skin absorption: in vivo absorption (OECD 427)**,⁷ provide an appropriate approach to generate further *in vivo* toxicokinetics data via the dermal route for CPE. Under these guidelines, the respective CPE is administered to the selected test species, typically a rodent, with at least 4 animals of each sex for each dose, although a larger sample size should be used to evaluate low dose effects. The exposure occurs either in a single dose or repeated doses with 6 or 24 hours between application and removal of test substance by skin washing, based on expected human exposure scenarios. The 24 hour exposure period should be used for residential exposure scenarios as U.S. dust testing data indicates widespread presence of CPE in indoor environments.⁸ At least two concentrations should be tested, determined based on the results of the existing studies cited in the Problem Assessment and more recent work, including the *ex vivo* absorption study cited previously. Following the exposure period, CPE and respective metabolites are then determined in body fluids, tissues and waste products. The guideline further recommends identification of metabolites present at concentrations of at least 5% of the administered dose, which provides additional information needed for assessment of toxicity of CPE via the dermal pathway.

As to dermal toxicity testing, it is appropriate to start with an acute dermal exposure toxicity study, such as the protocol described in **EPA's OPPTS 870.1200 guidelines**.⁹ This protocol is

⁵ Abdallah, M. A. E., Pawar, G., & Harrad, S. (2016). Human dermal absorption of chlorinated organophosphate flame retardants; implications for human exposure. *Toxicology and Applied Pharmacology*, 291, 28-37.

⁶ OECD (2010). Test No 417: Toxicokinetics. Guideline for the testing of chemicals. In *OECD Guidelines for the Testing of Chemicals, Section 4: Health Effects*. OECD Publishing, Paris.

⁷ OECD (2004). Test No. 427: Skin Absorption: In Vivo Method. In *OECD Guidelines for the Testing of Chemicals, Section 4: Health Effects*. OECD Publishing, Paris.

⁸ Mitro, S. D., Dodson, R. E., Singla, V., Adamkiewicz, G., Elmi, A. F., Tilly, M. K., & Zota, A. R. (2016). Consumer product chemicals in indoor dust: a quantitative meta-analysis of US studies. *Environmental Science & Technology*, 50(19), 10661-10672. <https://doi.org/10.1021/acs.est.6b05530>

⁹ EPA Office of Prevention, Pesticides and Toxic Substances (1998). OPPTS 870.1200

Acute Dermal Toxicity. Retrieved from <https://www.regulations.gov/document?D=EPA-HQ-OPPT-2009-0156-0004>

intended for rat, rabbit, or guinea pig model organisms, but it is adaptable for non-rodent mammalian species. Such an acute dermal toxicity study is the initial step in evaluation, providing information on health hazards likely to arise from short-term exposure via the dermal pathway.

1B) INHALATION EXPOSURE TOXICITY

Assessment of available information

At present, no validated alternative methods completely cover absorption, distribution, metabolism, and excretion, necessitating further *in vivo* testing in order to generate the toxicokinetics data needed. While *in vitro* models may provide some toxicokinetic information, particularly as regards absorption, which are increasingly used in analogous pharmacological studies,^{10,11} no national or international authority has yet validated such an alternative testing strategy for risk assessment purposes. *In vivo* study remains the most informative for risk assessment, representing an intact physiological and metabolic system and further *in vivo* testing is needed in order to generate the toxicokinetic data needed for quantitative assessment.

Acute toxicity testing following inhalation exposure is also needed in order to fill the data gap identified in the Problem Statement on toxicity following this route of exposure. Validated methods exist for model organisms exposed via this route.

Testing requested

The **OECD guidelines for toxicokinetics (OECD 417)** via the inhalation route are the most widely accepted guidance and should be implemented with a standard mammalian species. Species selection in this methodology is for a rodent model by default, but species determination should take into consideration models used in existing toxicity studies. Under the OECD 417 guidelines, CPE is administered using a “nose-cone” or “head-only” apparatus to prevent absorption by alternate routes of exposure. As a number of published studies have reported levels of CPEs in indoor air and dust,¹² and additional studies have been published since the Problem Statement was finalized, including those by LaGuardia and Hale (2015)¹³ and Schreder et al. (2016),¹⁴ doses used in testing should take into consideration the range of relevant environmental

¹⁰ Nahar, K., Gupta, N., Gauvin, R., Absar, S., Patel, B., Gupta, V., ... & Ahsan, F. (2013). In vitro, *in vivo* and *ex vivo* models for studying particle deposition and drug absorption of inhaled pharmaceuticals. *European Journal of Pharmaceutical Sciences*, 49(5), 805-818.

<https://doi.org/10.1016/j.ejps.2013.06.004>

¹¹ Sarmento, B. (2015). *Concepts and Models for Drug Permeability Studies: Cell and Tissue Based in Vitro Culture Models*. Woodhead Publishing.

¹² CPE Cluster Problem Formulation at 24.

¹³ La Guardia, M. J., & Hale, R. C. (2015). Halogenated flame-retardant concentrations in settled dust, respirable and inhalable particulates and polyurethane foam at gymnastic training facilities and residences. *Environment International*, 79, 106-114. <https://doi.org/10.1016/j.envint.2015.02.014>

¹⁴ Schreder, E. D., Uding, N., & La Guardia, M. J. (2016). Inhalation a significant exposure route for chlorinated organophosphate flame retardants. *Chemosphere*, 150, 499-504.

<http://dx.doi.org/10.1016/j.chemosphere.2015.11.084>

concentrations. A single exposure over a defined period, typically 4 to 6 hours in duration, should be used for each group of subjects. Subsequent to exposure, CPE and its metabolites are determined in body fluids, tissues and waste products. The guideline recommends that metabolites present at concentrations of at least 5% of the administered dose should be identified, which provides information needed for assessment of toxicity of CPE via the inhalation pathway.

As to inhalation toxicity, it is appropriate to start with an acute inhalation toxicity study, such as the protocol described in EPA's OPPTS 870.1300 guidelines.¹⁵ This protocol is intended for rats, but is adaptable for non-rodent mammalian species. Such an acute inhalation toxicity study is the initial step in evaluation, providing information on health hazards likely to arise from short-term exposure via inhalation.

2) HAZARD ENDPOINTS: REPRODUCTIVE AND ENDOCRINE TOXICITY

2A) Reproductive Toxicity

Assessment of available information

According to the Problem Statement, it is not possible to quantify risks at this time for male reproductive toxicity following CPE exposure.¹⁶ There is uncertainty with regards to the reviewed studies, with results differing not only between model organisms tested, but also in exposure duration. Of particular concern is uncertainty surrounding the impact of long-term exposures. Though the Problem Formulation focuses on male reproductive toxicity, female reproductive toxicity is also a data gap according to the EU risk assessments.¹⁷ The EU assessment also claims that protecting against male reproductive toxicity is likely to be protective for female effects, but there is no evidence to support this assumption. Without data on female reproductive toxicity, there is no way to evaluate which is the more sensitive endpoint, male or female. Thus data on female reproductive toxicity is also needed.

There is also related uncertainty on developmental endpoints, such as limited data on developmental neurotoxicity.¹⁸ Additional data supporting the concern for developmental neurotoxicity are now available from recent studies, including a study of progeny of zebrafish exposed to TDCPP (Wang et al. 2015),¹⁹ and of Japanese medaka in early life stages exposed to

¹⁵ EPA Office of Prevention, Pesticides and Toxic Substances (1998). OPPTS 870.1300: Acute Inhalation Toxicity. Retrieved from <https://www.regulations.gov/document?D=EPA-HQ-OPPT-2009-0156-0005>

¹⁶ CPE Cluster Problem Formulation at 70.

¹⁷ *Id.* at 62 ("TDCPP: The EU concluded that there is a need for further information and/or testing regarding the effects on female fertility... TCPP: The EU noted that there is need for further information and/or testing for female reproductive effects.").

¹⁸ *Id.* at 39.

¹⁹ Wang, Q., Lai, N. L. S., Wang, X., Guo, Y., Lam, P. K. S., Lam, J. C. W., & Zhou, B. (2015). Bioconcentration and transfer of the organophorous flame retardant 1, 3-dichloro-2-propyl phosphate causes thyroid endocrine disruption and developmental neurotoxicity in zebrafish larvae. *Environmental Science & Technology*, 49(8), 5123-5132.

TCEP (Sun et al. 2016),²⁰ among others. As such, a more definitive reproductive toxicity study should be ordered, with longer duration of exposure, to allow for evaluation of reproductive toxicity in a quantitative risk assessment. Ideally, the reproductive toxicity study selected will also inform developmental toxicity, especially developmental neurotoxicity.

Testing requested

The endocrine activity concerns discussed in the following section, 2B: Endocrine Activity, in conjunction with the reproductive toxicity data needs could justify an expanded toxicity study to provide a more comprehensive and informative assessment of CPE effects. The ideal study would be the NTP **Modified One Generation Study**,²¹ which is discussed in further detail in Section 2B below.

Alternatively, an *in vivo* reproductive toxicity screening test, such as the EPA test guidelines for **Reproduction and Fertility Effects (OPPTS 870.3800)**,²² recommended to meet requirements for human health impacts of chemical substances under FIFRA and TSCA, and based on the **OECD 416**,²³ could be ordered. This guidance is intended for oral administration, but includes adaptation directions for other routes. It would be appropriate to potentially also consider inhalation exposure, since inhalation is a primary route of exposure for CPE. The testing protocol involves administration of the test substance using at least three graded dose levels, with a concurrent control, to male and female animals, typically rats. Daily dosing of parental animals of both genders begins when they are five weeks old, allowing for at least ten weeks of dosing prior to the mating period. Daily dosing of offspring begins at weaning. For all animals, daily dosing continues until termination. As such, this study design includes in utero as well as postnatal exposure. Outcomes related to integrity and performance of both the male and female reproductive systems (including gonadal function, estrous cycle, mating behavior, conception, gestation, parturition, lactation, and weaning, and growth and development of offspring) are assessed by clinical observations and measurements in addition to necropsy and histopathology. This test may also provide information about the effects of CPE on neonatal morbidity / mortality and serve as a guide for subsequent tests.

2B) Endocrine Activity

Assessment of available information

²⁰ Sun, L., Tan, H., Peng, T., Wang, S., Xu, W., Qian, H., ... & Fu, Z. (2016). Developmental neurotoxicity of organophosphate flame retardants in early life stages of Japanese medaka (*Oryzias latipes*). *Environmental Toxicology and Chemistry*, 35(12), 2931-2940..

²¹ National Toxicology Program (n.d.). *Modified One-Generation Studies*. Retrieved from <https://ntp.niehs.nih.gov/testing/types/mog/index.html>

²² EPA Office of Prevention, Pesticides and Toxic Substances (1998). OPPTS 870.3800 Reproduction and Fertility Effects. Retrieved from <https://www.regulations.gov/document?D=EPA-HQ-OPPT-2009-0156-0018>

²³ OECD (2001). OECD Test No. 416: Two-Generation Reproduction Toxicity. In *OECD Guidelines for the Testing of Chemicals, Section 4: Health Effects*. OECD Publishing, Paris.

The Problem Formulation describes the conflicting data and lack of consistent adverse endpoints for endocrine activity of CPE, which makes it difficult to evaluate quantitatively.²⁴ The experimental and observational studies described do not constitute a complete screening battery for such effects. Furthermore, it is not surprising to see varied results from studies using differing model organisms, routes of administration, dosing, endpoint selection and other design considerations. Findings from human, amphibian, and avian studies reviewed in the Problem Formulation, in addition to subsequently published studies including Wang et al. (2015)²⁵ and Fernie et al. (2015),²⁶ suggest a potential for CPE to interact with thyroid hormone systems, with the former demonstrating neurodevelopmental toxicity as well. As such, additional data is warranted to generate data to allow for a quantitative assessment of risk for such endpoints.

Testing requested

Existing data support potential for CPE to interact with thyroid hormone systems, and additional testing should prioritize thyroid endpoints for evaluation of adverse effects. A single testing protocol may be sufficient to address these mixed results, the **Larval Amphibian Growth and Development Assay (LAGDA) (OCSPP 890.2300)**.²⁷ The LAGDA, which is included as a Tier 2 assay in the Endocrine Disruptor Screening Program, is based on amphibian metamorphosis, a well-studied thyroid-dependent process, and incorporates molecular and histological endpoints that are diagnostic of mode-of-action, which are the basis of comparison for species extrapolation. When implemented following OCSPP guidelines, the LAGDA can detect perturbations of normal function of the hypothalamic-pituitary-thyroid (HPT) system and also of reproductive development through hypothalamic-pituitary-gonadal (HPG) axis interference. Testing under this protocol in a model amphibian such as *Xenopus laevis*, as a validated approach designed to inform the risk assessment process, would identify adverse endocrine-related effects of CPE and establish a quantitative relationship between dose and effects.

Alternatively, the endocrine disruption concerns in conjunction with the reproductive toxicity data needs discussed in Section 2A, could justify an expanded toxicity study to provide a more informative assessment of CPE effects. The **NTP Modified One Generation Study**,²⁸ or MOG, assesses reproductive toxicity with extended exposure duration, including pre/post-natal

²⁴ CPE Cluster Problem Formulation at 71.

²⁵ Wang, Q., Lai, N. L. S., Wang, X., Guo, Y., Lam, P. K. S., Lam, J. C. W., & Zhou, B. (2015). Bioconcentration and transfer of the organophorous flame retardant 1, 3-dichloro-2-propyl phosphate causes thyroid endocrine disruption and developmental neurotoxicity in zebrafish larvae. *Environmental Science & Technology*, 49(8), 5123-5132. <https://doi.org/10.1021/acs.est.5b00558>

²⁶ Fernie, K. J., Palace, V., Peters, L. E., Basu, N., Letcher, R. J., Karouna-Renier, N. K., ... & Rattner, B. A. (2015). Investigating endocrine and physiological parameters of captive American kestrels exposed by diet to selected organophosphate flame retardants. *Environmental Science & Technology*, 49(12), 7448-7455. <https://doi.org/10.1021/acs.est.5b00857>

²⁷ EPA Office of Chemical Safety and Pollution Prevention (2015). *OCSPP 890.2300, Larval Amphibian Growth and Development Assay (LAGDA)*. Retrieved from <https://www.regulations.gov/document?D=EPA-HQ-OPPT-2009-0576-0018>

²⁸ National Toxicology Program (n.d.). *Modified One-Generation Studies*. Retrieved from <https://ntp.niehs.nih.gov/testing/types/mog/index.html>

exposures, while also providing more robust data for other endpoints. The MOG approach involves exposure of pregnant females throughout gestation, lifetime exposure of the F1 and generation of two cohorts of F2 animals. The study design uses fewer animals than a classical two-generation study, but allows for full evaluation of first generation offspring animals following pre- and postnatal chemical exposure. At weaning, offspring are assigned to a number of different cohorts,²⁹ with endpoint inclusion informed by existing data. For CPE, cohorts should include a breeding and littering cohort and a developmental neurotoxicity cohort to address the existing data gaps in endocrine activity, reproductive toxicity, and developmental neurotoxicity and allow for consideration of these endpoints of concern in risk assessment.³⁰

3) ENVIRONMENTAL RELEASES FROM NON-INDUSTRIAL AND CONSUMER USES

Assessment of available information

CPE flame retardants are used extensively, and in a wide variety of consumer products. Down-the-drain releases to water from consumer uses and contribution to CPE in environmental media are described in Schreder and La Guardia (2014),³¹ however EPA has stated there are insufficient data to quantify these inputs.³² The Problem Formulation also states that several studies that include U.S. waters have reported levels of the CPEs in the effluent and influent of wastewater.³³ Such data has been utilized by Environment and Climate Change Canada³⁴ to create predicted environmental concentrations of CPE from consumer uses. Effluent waters from municipal treatment plants should be used to assess the potential contribution from down-the-drain uses to CPE in waters of the United States.

Testing requested

If EPA continues to conclude there is insufficient data to assess the potential contribution from down-the-drain uses to CPE in waters of the United States, additional testing is warranted. This could include sampling of effluent waters from municipal treatment plants. EPA has extensive guidelines for sampling strategies and study designs which guide development of new studies.

²⁹ The standard cohorts include: a prechronic toxicity cohort (analogous to a standard 90-day study) for evaluating clinical pathology and target organ toxicity and pathology; a teratology cohort for evaluating prenatal development; and another cohort to evaluate breeding and littering for potential examination of the subsequent generation.

³⁰ National Toxicology Program (n.d.). *Guidance Document for the Developmental neurotoxicity arm of the MOG Study*. Retrieved from https://ntp.niehs.nih.gov/ntp/test_info/mog_guidance_508.pdf

³¹ Schreder, E., & La Guardia, M. (2014, May). *A Laundry Load of Chlorinated Flame Retardants: A pathway from households to wastewater treatment plants*. Session presented at the Salish Sea Ecosystem Conference, Seattle, WA. Abstract retrieved from <http://cedar.wwu.edu/ssec/2014ssec/Day2/47/>

³² CPE Cluster Problem Formulation at 27.

³³ *Id.*

³⁴ Environment Canada (2016). *Draft Screening Assessment, Certain Organic Flame Retardants Substance Grouping*. Retrieved from <http://www.ec.gc.ca/ese-ees/default.asp?lang=En&n=B4374491-1>

EPA's **Guidance for Data Useability in Risk Assessment (Part A)**,³⁵ for example, presents an extensive discussion of sampling strategies, sampling methods, and analytical methods. Generally, for a sampling approach, grab samples would be expected to provide a reasonable snap-shot view of the environment, and should be appropriate for this purpose, so long as sufficient repeat surveys are conducted under different conditions, to ensure the sampling locations are as representative as is reasonably possible. Quality assurance and control protocols including blank and duplicate samples will depend on final study design, but must be taken into consideration as well, in compliance with EPA's **Guidance on Choosing a Sampling Design for Environmental Data Collection**.³⁶ In development of testing protocols, existing sample handling and storage procedures currently utilized for similar organic compounds under regulatory monitoring can be applied to CPE.

Though existing sampling approaches can be applied for testing of CPE, a sensitive and specific analytical method for determination and quantification of CPE in sampled waters is still required. EPA has not recommended an analytical method for analysis of CPE, however, the interagency National Environment Methods Index (NEMI) lists two U.S. Geological Survey (USGS) analytical methods for analysis of relevant CPE.^{37,38} In addition, there are a number of peer reviewed, published methods for determination and quantification of CPE in a variety of environmental media. This includes several optimized for environmental water samples, such as the two mass-spectrometry based methods described in Wang et al. (2011)³⁹ and Gao et al. (2015),⁴⁰ which could be adopted and validated for testing purposes, in lieu of novel method development.

³⁵ EPA Office of Research and Development (1991). *Guidance for Data Useability in Risk Assessment (Part A)*. Retrieved from <https://rais.ornl.gov/documents/USERISKA.pdf>

³⁶ EPA Office of Environmental Information (2002). *Guidance on Choosing a Sampling Design for Environmental Data Collection*. Retrieved from <https://www.epa.gov/sites/production/files/2015-06/documents/g5s-final.pdf>

³⁷ Zaugg, S.D., Smith, S.G., Schroeder, M.P., Barber, L.B., & Burkhardt, M.R. (2002). *Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of Wastewater Compounds by Polystyrene-Divinylbenzene Solid-Phase Extraction and Capillary-Column Gas Chromatography/Mass Spectrometry* (U.S. Geological Survey Water-Resources Investigations Report 01-4186). Denver, CO: U.S. Geological Survey.

³⁸ Zaugg, S.D., Smith, S.G., & Schroeder, M.P. (2006). *Determination of Wastewater Compounds in Whole Water by Continuous Liquid-Liquid Extraction and Capillary-Column Gas Chromatography/Mass Spectrometry*. (U.S. Geological Survey Techniques and Methods 5-B4). Reston, VA: U.S. Geological Survey.

³⁹ Wang, X. W., Liu, J. F., & Yin, Y. G. (2011). Development of an ultra-high-performance liquid chromatography–tandem mass spectrometry method for high throughput determination of organophosphorus flame retardants in environmental water. *Journal of Chromatography A*, 1218(38), 6705-6711.

⁴⁰ Gao, L., Shi, Y., Li, W., Ren, W., Liu, J., & Cai, Y. (2015). Determination of organophosphate esters in water samples by mixed-mode liquid chromatography and tandem mass spectrometry. *Journal of Separation Science*, 38(13), 2193-2200.

4) EXPOSURES FROM MANUFACTURING, PROCESSING, INDUSTRIAL AND NON-INDUSTRIAL USES

Assessment of available information

According to the CPE Problem Formulation, “Occupational inhalation exposure monitoring data for industrial workers in the US are not available, but monitoring data for inhalation exposure of European workers to TCPP or TDCPP vapors at industrial facilities are reported.⁴¹ Further, workers cutting PU foam at industrial sites may inhale dust containing CPE, but EPA does not have the necessary data to evaluate this potential exposure.”⁴² NIOSH previously conducted an exposure assessment for workers installing spray foam; according to the study results, “High concentrations [of TCPP] were found in samples collected away from the sprayer and in adjacent rooms as well as near the sprayer.”⁴³ These results indicate the potential for high TCPP exposures to spray foam installers, and also suggest concern for workers in other non-industrial occupations who install, apply or handle CPE containing products.

EPA did not find any chemical-specific data on CPE releases to the environment from industrial sites in its scientific literature review. Therefore, monitoring of facilities known to manufacture, process, or use CPE should be conducted. As there are no TRI data for releases of CPE,⁴⁴ alternative sources of information, such as the TSCA Chemical Data Reporting database for manufacturers and importers of CPE, should be used to identify relevant facilities. For example, EPA notes the potential for releases to water from ICL-IP America’s Gallipolis Ferry, WV site, which produces 79% of the national TCPP production volume in addition to being the only US site at which TDCPP is manufactured.⁴⁵

4A) COMMUNITIES

Given the paucity of data regarding concentrations of CPE in ecological and human communities, sampling studies to determine environmental contaminations are necessary to estimate exposures. No single method applies to all monitoring and assessment needs. For a multimedia environmental assessment of CPE in communities in the vicinity of manufacturing, processing, and other industrial use facilities, media-specific approaches must be employed. At a minimum, media including air, soil, and water should be included in the overarching assessment strategy; however, media evaluated will necessarily be specific to each site assessed. Representative sampling sites should be based on available data for sources of CPE and include communities near these sources (such as the WV production site), and also take into consideration properties of CPE and relevant exposure pathways for communities of interest.

⁴¹ CPE Cluster Problem Formulation at 23.

⁴² *Id.* at 29.

⁴³ Marlow, D., DeCapite, J., & Garcia, A. (2014). *Spray Polyurethane Foam Chemical Exposures during Spray Application: All About Kids, Crestwood, KY.* (EPHB Report No. 005-163). Louisville, KY: National Institute for Occupational Safety and Health. Retrieved from <https://www.cdc.gov/niosh/surveymethods/pdfs/005-163.pdf>

⁴⁴ CPE Cluster Problem Formulation at 23.

⁴⁵ CPE Cluster Problem Formulation at 28.

Testing requested

As possible, existing EPA guidance for similar compounds in respective media should be utilized for sampling strategy design and protocols, and comply with EPA's Guidance on Choosing a Sampling Design for Environmental Data Collection.⁴⁶ However, for analytical determination and quantification, existing agency methods may require modification or, alternatively, substitution with existing peer-reviewed, published methods, as EPA has not recommended an analytical method for analysis of CPE. The interagency National Environment Methods Index (NEMI) lists two U.S. Geological Survey (USGS) analytical methods for analysis of relevant CPE which may also be appropriate.^{47,48}

Air

For assessment of CPE in ambient air, a high-volume air sampling approach, such as that of **EPA Air Method Toxic Organics-9A** (TO-9A, Determination Of Polychlorinated, Polybrominated And Brominated/Chlorinated Dibenz-p-Dioxins And Dibenzofurans In Ambient Air),⁴⁹ should be employed. High-volume air sampling approaches for semi-volatile chemicals are expected to provide sufficient analyte for detection limits with shorter sampling periods.⁵⁰ Although originally designed for dioxins and furans in ambient air, the approach described can be implemented for other semivolatile organic compounds with similar properties. This method uses a high-volume air sampler equipped with a quartz-fiber filter and polyurethane foam (PUF) adsorbent cartridge for sampling 325 to 400 m³ ambient air over a 24-hour sampling period, with sample analysis based on high resolution gas chromatography-high resolution mass spectrometry. This detection method should be further modified for CPE; modifications could readily be made to the analytical method based on those used in recent peer-reviewed sampling

⁴⁶ EPA Office of Environmental Information (2002). *Guidance on Choosing a Sampling Design for Environmental Data Collection*. Retrieved from <https://www.epa.gov/sites/production/files/2015-06/documents/g5s-final.pdf>

⁴⁷ Zaugg, S.D., Smith, S.G., Schroeder, M.P., Barber, L.B., & Burkhardt, M.R. (2002). *Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory--Determination of Wastewater Compounds by Polystyrene-Divinylbenzene Solid-Phase Extraction and Capillary-Column Gas Chromatography/Mass Spectrometry* (U.S. Geological Survey Water-Resources Investigations Report 01-4186). Denver, CO: U.S. Geological Survey.

⁴⁸ Zaugg, S.D., Smith, S.G., & Schroeder, M.P. (2006). *Determination of Wastewater Compounds in Whole Water by Continuous Liquid-Liquid Extraction and Capillary-Column Gas Chromatography/Mass Spectrometry*. (U.S. Geological Survey Techniques and Methods 5-B4). Reston, VA: U.S. Geological Survey.

⁴⁹ EPA Office of Research and Development (1999). *Compendium Method TO-9A: Determination Of Polychlorinated, Polybrominated And Brominated/Chlorinated Dibenz-p-Dioxins And Dibenzofurans In Ambient Air*. Retrieved from <https://www3.epa.gov/ttnamti1/files/ambient/airtox/to-9arr.pdf>

⁵⁰ Longer sampling periods could reasonably use either a passive air sampling approach or a low-volume air sampling approach, such as that of EPA Air Method Toxic Organics-10A (TO-10A, Determination of Pesticides and Polychlorinated Biphenyls in Ambient Air Using Low Volume Polyurethane Foam (PUF) Sampling Followed by Gas Chromatographic/Multi-Detector Detection (GC/MD)).

studies of CPE in indoor air, such as Schreder et al. (2016),⁵¹ and in atmospheric air samples, such as Salamova et al. (2016).⁵²

Soil

Sampling of soils or sediment will vary based on the type of material present, but should follow considerations for screening sampling such as are discussed in guidances like **Preparation of Soil Sampling Protocols** (EPA/600/R-92/128),⁵³ which provides methods, techniques, and procedures for designing a variety of soil measurement programs, or field assessment guides like **Description and Sampling of Contaminated Soils** (EPA/625/12-91/002).⁵⁴ Existing EPA analytical methods, such as **Method 8270**, for semivolatile organics do not include CPE, but outline sample preparation and gas chromatography/mass spectrometry-based analysis of semivolatile organic pollutants in multiple matrices, including solid waste and soil.⁵⁵ Such methods could be adapted to include CPE, or more specific extraction and mass spectrometry-based analytical methods as described in recent peer-reviewed methods of CPE analysis in environmental matrices including sediments, such as Giulivo et al. (2016) could be adopted.⁵⁶

Water

Approaches for sampling studies of CPE in water will vary based on the type of water; drinking water, surface water, and ground water require different considerations, but each have sampling strategies for similar compounds recommended by EPA which could be utilized for sampling for CPE. In terms of analysis of collected water samples, there are a number of peer reviewed, published methods optimized for environmental water samples. As described above, these include two mass-spectrometry based methods described in Wang et al. (2011)⁵⁷ and Gao et al. (2015),⁵⁸ which could be adopted and validated for testing purposes, in lieu of novel method development.

⁵¹ Schreder, E. D., Uding, N., & La Guardia, M. J. (2016). Inhalation a significant exposure route for chlorinated organophosphate flame retardants. *Chemosphere*, 150, 499-504.

⁵² Salamova, A., Peverly, A. A., Venier, M., & Hites, R. A. (2016). Spatial and Temporal Trends of Particle Phase Organophosphate Ester Concentrations in the Atmosphere of the Great Lakes. *Environmental Science & Technology*, 50(24), 13249-13255.

⁵³ Mason, B. J. (1992). *Preparation of Soil Sampling Protocols: Sampling Techniques and Strategies*. EPA Office of Research and Development Environmental Monitoring Systems Laboratory, Las Vegas.

⁵⁴ EPA Center for Environmental Research Information (1991). *Description and Sampling of Contaminated Soils: A Field Pocket Guide*. Retrieved from <https://www.epa.gov/hscip>.

⁵⁵ EPA (2014). *Publication SW-846, Method 8270D: Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)*. Retrieved from <https://www.epa.gov/hw-sw846/sw-846-compendium>.

⁵⁶ Giulivo, M., Capri, E., Eljarrat, E., & Barceló, D. (2016). Analysis of organophosphorus flame retardants in environmental and biotic matrices using on-line turbulent flow chromatography-liquid chromatography-tandem mass spectrometry. *Journal of Chromatography A*, 1474, 71-78.

⁵⁷ Wang, X. W., Liu, J. F., & Yin, Y. G. (2011). Development of an ultra-high-performance liquid chromatography-tandem mass spectrometry method for high throughput determination of

4B) WORKERS: MANUFACTURING, PROCESSING, AND INDUSTRIAL

Occupational assessments including biological and environmental monitoring, should be conducted in representative manufacturing, processing and industrial use facilities.

Testing requested

Representative sites should be determined using existing data sources. Testing of CPE in air and dust inside plants requires a sampling strategy that minimizes the differences between measured proxies and actual exposure levels. The approaches used should keep with those recommended by OSHA as published in the Technical Manual,⁵⁹ with sampling and analytical methods that have been validated by either OSHA or the National Institute for Occupational Safety and Health (NIOSH) used whenever possible.

Air sampling: There is not a publically available OSHA sampling/analytical method for CPE. A sampling method could be adapted from existing occupational air sampling methods for chemicals with similar properties; a standard approach involves drawing air from the surroundings by a mechanical pump to a glass filter and solid phase disc in a cartridge. For the subsequent extraction to elute retained compounds of interest prior to instrumental analysis and the instrumental analysis itself, there are recently published, peer reviewed studies of CPE in air in a variety of indoor environments in the United States from which an analytical approach could be adapted. One such approach, involving UPLC-APPI/MS analysis, is presented in La Guardia and Hale (2015),⁶⁰ with additional details available in La Guardia et al. (2013).⁶¹ Unless OSHA or NIOSH have a validated analytical method that is as sensitive and specific, this approach, or one similar, should be adopted for occupational air sampling. For this type of indoor air sampling, either area or personal sampling devices may be used.

CPE-containing particle size and composition may vary in these occupational environments. Therefore, to best evaluate occupational exposures to CPE, sampling that allows for separation and collection of respirable and inhalable dust fractions should be

organophosphorus flame retardants in environmental water. *Journal of Chromatography A*, 1218(38), 6705-6711.

⁵⁸ Gao, L., Shi, Y., Li, W., Ren, W., Liu, J., & Cai, Y. (2015). Determination of organophosphate esters in water samples by mixed-mode liquid chromatography and tandem mass spectrometry. *Journal of Separation Science*, 38(13), 2193-2200.

⁵⁹ OSHA (n.d.). *OSHA Technical Manual, OSHA Instruction TED 01-00-015*. Retrieved from <https://www.osha.gov/dts/osta/otm/index.html>.

⁶⁰ La Guardia, M. J., & Hale, R. C. (2015). Halogenated flame-retardant concentrations in settled dust, respirable and inhalable particulates and polyurethane foam at gymnastic training facilities and residences. *Environment International*, 79, 106-114. <https://doi.org/10.1016/j.envint.2015.02.014>

⁶¹ La Guardia, M. J., Hale, R. C., & Newman, B. (2013). Brominated flame-retardants in Sub-Saharan Africa: burdens in inland and coastal sediments in the eThekweni metropolitan municipality, South Africa. *Environmental Science & Technology*, 47(17), 9643-9650.

conducted in addition to total air sampling. After collection, separation, and application of an appropriate method for extraction, the CPE from the respirable and inhalable dust fractions can also be analyzed by the instrumental methods for total air sampling. The recommended OSHA approach involves use of a cyclone apparatus to separate and capture those particles in defined size ranges, for which many devices are commercially available. There are, however, alternative designs that meet OSHA air particulate sampling criteria and allow for collection of these fractions, such as the commercially available personal sampling device used in two recent peer reviewed studies of CPE in respirable and inhalable fractions.^{62,63}

Dust sampling: In addition to air sampling approaches, settled dust sampling should be conducted to assess the presence of CPE on surfaces that may lead to worker exposure, either through direct dermal exposure, transfer to foodstuffs and accidental ingestion, or surface agitation causing particles to resuspend in air, resulting in additional inhalation exposure. Bulk dust sampling and surface wipe sampling approaches should both be utilized. Quantitative surface wipe sampling, in which an area of specified size is wiped, should be used as it is necessary to determine the concentration of a contaminant on a surface and subsequently estimate the amount of contamination to which workers are potentially exposed. According to the OSHA Technical Manual (OSHA Instruction TED 01-00-015 [TED 1-0.15A]) the standard surface area to be wiped is a 10 cm x 10 cm square, as it approximates the surface area of a worker's palm.⁶⁴ Bulk dust sampling is conducted on a larger scale, typically with a vacuum, for which there are methods for a wide range of compounds and surfaces, although not all are applicable to occupational settings.⁶⁵ However, in addition to gathering bulk dust for analysis, these methods are also useful when sampling very large surface areas or surface areas that are porous or irregular, where it is impractical to use wipes. Extraction methods exist for similar compounds from standard wipes and from dust as a matrix, which would be followed by an instrumental analysis as previously described.

Biomonitoring: Biological monitoring should follow protocols of current NIOSH and/ or peer-reviewed studies. In **Assessment of Occupational Exposure to Flame**

⁶² La Guardia, M. J., & Hale, R. C. (2015). Halogenated flame-retardant concentrations in settled dust, respirable and inhalable particulates and polyurethane foam at gymnastic training facilities and residences. *Environment International*, 79, 106-114. <https://doi.org/10.1016/j.envint.2015.02.014>

⁶³ Schreder, E. D., Uding, N., & La Guardia, M. J. (2016). Inhalation a significant exposure route for chlorinated organophosphate flame retardants. *Chemosphere*, 150, 499-504.

⁶⁴ OSHA (n.d.). *OSHA Technical Manual, OSHA Instruction TED 01-00-015*. Retrieved from <https://www.osha.gov/dts/osta/otm/index.html>

⁶⁵ Creek, K. L., Whitney, G., & Ashley, K. (2006). Vacuum sampling techniques for industrial hygienists, with emphasis on beryllium dust sampling. *Journal of Environmental Monitoring*, 8(6), 612-618. <https://doi.org/10.1039/b601572g>

Retardants,⁶⁶ conducted by NIOSH for NTP, exposure to PBDEs and nine alternative flame retardants including TCPP and TDCPP are assessed through air, urine, and sera samples from workers for a variety of occupations (workers in construction, plastic goods manufacturing, gymnasium workers, and firefighters).⁶⁷ Butt et al. (2016)⁶⁸ describes protocols and analytical methodology for quantification of urinary metabolites of CPE. Dermal exposure should also be considered for manufacturing, processing and recycling workers.

4C) WORKERS: NON-INDUSTRIAL

Occupational assessments based on personal monitoring should be used for non-industrial workers such as spray foam installers who are more likely to have individual or task-specific exposures to CPE rather than facility-based exposures to CPE.

Testing requested

Representative occupations should be determined using existing data sources, and testing should be based on personal exposure monitoring rather than facility assessment. This should include biological monitoring, with the addition of personal air sampling for those occupations involving application of spray foam or similar products. Biological monitoring should, as possible, follow the protocols of the current study, **Assessment of Occupational Exposure to Flame**

Retardants, conducted by NIOSH for NTP.⁶⁹ In this study, exposure to PBDEs and nine alternative flame retardants including TCPP and TDCPP are assessed through air, urine, and sera samples from workers for a variety of occupations (workers in construction, plastic goods manufacturing, gymnasium workers, and firefighters).⁷⁰ Dermal exposure should also be considered for relevant occupations.

Additionally, the NIOSH study **Spray Polyurethane Foam Chemical Exposures during Spray Application** could guide air sampling for non-industrial workers.⁷¹ The approaches used should

⁶⁶ National Toxicology Program (2015). NTP at NIOSH: Comprehensive Assessment of Occupationally Relevant Exposures. In *2015 Annual Report*. Retrieved from https://ntp.niehs.nih.gov/annualreport/2015/partners/niosh_comprehensive/index.html

⁶⁷ National Institute of Occupational Safety & Health (2014). *Update on NIOSH Projects*. Retrieved from https://ntp.niehs.nih.gov/ntp/about_ntp/bsc/2014/dec/nioshupdate_508.pdf

⁶⁸ Butt, C. M., Hoffman, K., Chen, A., Lorenzo, A., Congleton, J., & Stapleton, H. M. (2016). Regional comparison of organophosphate flame retardant (PFR) urinary metabolites and tetrabromobenzoic acid (TBBA) in mother-toddler pairs from California and New Jersey. *Environment International*, 94, 627-634.

⁶⁹ National Toxicology Program (2015). NTP at NIOSH: Comprehensive Assessment of Occupationally Relevant Exposures. In *2015 Annual Report*. Retrieved from https://ntp.niehs.nih.gov/annualreport/2015/partners/niosh_comprehensive/index.html

⁷⁰ National Institute of Occupational Safety & Health (2014). *Update on NIOSH Projects*. Retrieved from https://ntp.niehs.nih.gov/ntp/about_ntp/bsc/2014/dec/nioshupdate_508.pdf

⁷¹ Marlow, D., DeCapite, J., & Garcia, A. (2014). *Spray Polyurethane Foam Chemical Exposures during Spray Application: All About Kids, Crestwood, KY*. (EPHB Report No. 005-163). Louisville, KY: National Institute for Occupational Safety and Health. Retrieved from <https://www.cdc.gov/niosh/surveymreports/pdfs/005-163.pdf>

keep with those recommended by OSHA as published in the Technical Manual,⁷² with sampling and analytical methods that have been validated by either OSHA or the National Institute for Occupational Safety and Health (NIOSH) used whenever possible.

5) EXPOSURES FROM RECYCLING

Assessment of available information

The Problem Formulation does not address community, worker or ecosystem exposures related to recycling of products containing CPE flame retardants, nor does it propose to consider such exposures. There is currently no information on the levels of CPE in U.S. recycling facilities; however, studies in electronics dismantling facilities in other countries indicate potential for inhalation and dermal exposures to CPE for workers.⁷³ There is information available on CPE concentrations in U.S. consumer products from product testing. The state of Washington's Hazardous Waste and Toxics Reduction Program quantified chlorinated phosphate flame retardants in twenty-seven components (twenty-one foam, five fabric, and one plastic) from 24 products in 2012-13.⁷⁴ The Ecology Center in Michigan recently tested children's car seat components for flame retardants including CPE.⁷⁵ Such information on CPE-containing products could be utilized to identify relevant disposal processes, including recycling, and estimate CPE exposures in, and from, such facilities.

As communities and workers may be exposed by recycling processes, testing is warranted to estimate CPE exposures from recycling facilities in the U.S.

Testing requested

5A) COMMUNITIES

As ecological and human communities in the vicinity of recycling facilities may experience exposure to CPE, environmental media should be assessed or monitored for CPE. Assessments of representative recycling facilities which include air, soil and water testing should be carried out as described in Section 4A: Communities above.

5B) WORKERS

⁷² OSHA (n.d.). *OSHA Technical Manual, OSHA Instruction TED 01-00-015*. Retrieved from <https://www.osha.gov/dts/osta/otm/index.html>.

⁷³ Mäkinen, M. S., Mäkinen, M. R., Koistinen, J. T., Pasanen, A. L., Pasanen, P. O., Kallikoski, P. J., & Korpi, A. M. (2009). Respiratory and dermal exposure to organophosphorus flame retardants and tetrabromobisphenol A at five work environments. *Environmental Science & Technology*, 43(3), 941-947. <https://doi.org/10.1021/es802593t>

⁷⁴ Washington State Department of Ecology (2014). Flame Retardants in General Consumer and Children's Products. (Publication No. 14-04-021). Washington State Department of Ecology: Olympia, WA. Retrieved from <https://fortress.wa.gov/ecy/publications/documents/1404021.pdf>

⁷⁵ Miller, G. Z. & Gearhart, J. (2016). *Traveling with Toxics: Flame Retardants & Other Chemicals in Children's Car Seats*. Ecology Center: Ann Arbor, MI. Retrieved from <http://www.ecocenter.org/healthy-stuff/pages/childrens-car-seat-study-2016-report>

Air testing, dust testing, surface wipe testing and worker biomonitoring as described above in Section 4B: Workers –Manufacturing, Processing, and Industrial should be carried out for representative recycling facilities.

6) EXPOSURES FROM DISPOSAL

Assessment of available information

The Problem Formulation does not address community, worker or ecosystem exposures related to disposal of products containing CPE flame retardants, nor does it propose to consider such exposures. As described above, available information on CPE-containing consumer products could be utilized to determine relevant disposal processes and estimate CPE exposures in, and from, such facilities.

As communities and workers may be exposed by disposal of products containing CPE, testing is warranted to estimate CPE exposures from disposal facilities in the U.S.

Testing requested

6A) COMMUNITIES

As ecological and human communities in the vicinity of recycling facilities may experience exposure to CPE, environmental media should be assessed or monitored for CPE. Assessments of representative municipal landfills which include air, soil and water testing should be carried out as described in Section 4A: Communities above.

6B) WORKERS

Air testing, dust testing, surface wipe testing and worker biomonitoring as described above in Section 4B: Workers –Manufacturing, Processing, and Industrial should be carried out for representative municipal landfill facilities.

7) EXPOSURES OF BIRDS, WILDLIFE AND SEDIMENT ORGANISMS

Assessment of available information

Fish and other wildlife are exposed to CPE through environmental media, including ambient air, surface water, sediment, and soil, for which concentrations of CPE have been reported in the United States. However, EPA has limited ability to quantify risks for sediment, soil, sludge and ambient air because very little monitoring data and no hazard endpoints exist for these media.⁷⁶ Of particular concern is that no data were available to characterize the toxicity of CPE to sediment dwelling organisms,⁷⁷ and only a single *in ovo* study of TCPP and TDCPP exposure to chicken eggs, which suggests potential for sub-lethal effects, was available to characterize toxicity to terrestrial organisms. CPE are present in sewage sludge, wastewater and reclaimed

⁷⁶ CPE Cluster Problem Formulation at 28.

⁷⁷ CPE Cluster Problem Formulation at 69.

water used on fields,^{78,79} but there are no available data on effects to vegetation following exposure to CPE.⁸⁰ Further toxicity testing is warranted for these ecological endpoints to provide initial data required for evaluation.

Testing requested

Monitoring studies as described in Section 4A: Communities above, including air, soil and water testing should be carried out for representative ecological communities to obtain sufficient monitoring data for risk assessment. As to hazard endpoints, the data suggestive of sublethal effects in an avian model supports the use of an avian testing protocol to generate toxicity data for terrestrial organisms. EPA's **OPPTS 850.2100**, the Avian Acute Oral Toxicity Test,⁸¹ is a guidance recommended to meet requirements for ecological effects of chemical substances under FIFRA, FFDCA, and TSCA. This protocol for acute oral toxicity to a representative avian model (from select water fowl, game birds, or a passerine species) is based on a single oral dose of the test substance with an observation period of at least two weeks, and is designed to develop data for a median lethal dose (LD_{50}) and inform the slope of the dose-response relationship. Dosing of CPE should take into consideration the Farhat et al. study addressed in the Problem Statement.⁸² The guideline also specifies that this protocol may be used to obtain information for sublethal effects used in EPA evaluations. Sublethal effects monitored include appearance and behavior of the birds, with histopathological and physiological changes also monitored. Additional testing, for avian species or other terrestrial species, should be ordered as needed from the existing EPA **Series 850 Ecological Effects Test Guidelines**.

As for sediment dwelling organisms, **OCSPP 850.3100: Earthworm Subchronic Toxicity Test**⁸³ is a standard test recommended to meet requirements for ecological effects of chemical substances under FIFRA, FFDCA, and TSCA. This toxicity test is conducted using test species *Eisenia fetida andrei* (Bouche), with acclimated earthworms placed in test chambers containing formulated soil spiked with the test substance. The CPE concentration tested should take into consideration reported levels of CPE in soil. Earthworms ingest this test mixture *ad libitum*, with mortality and other effects examined on a weekly basis for 28 days. The primary result of this study is a 28-day LC_{50} (median lethal concentration), however sublethal effects may also be

⁷⁸ Hyland, K. C., Blaine, A. C., & Higgins, C. P. (2015). Accumulation of contaminants of emerging concern in food crops—part 2: Plant distribution. *Environmental Toxicology and Chemistry*, 34(10), 2222-2230.

⁷⁹ Hyland, K. C., Blaine, A. C., Dickenson, E. R., & Higgins, C. P. (2015). Accumulation of contaminants of emerging concern in food crops—part 1: Edible strawberries and lettuce grown in reclaimed water. *Environmental Toxicology and Chemistry*, 34(10), 2213-2221.

⁸⁰ CPE Cluster Problem Formulation at 58.

⁸¹ EPA Office of Prevention, Pesticides and Toxic Substances (1998). *OPPTS 850.2100: Avian Acute Oral Toxicity Test*. Retrieved from: <https://www.regulations.gov/#/documentDetail;D=EPA-HQ-OPPT-2009-0154-0010>

⁸² CPE Cluster Problem Formulation at 69.

⁸³ EPA Office of Chemical Safety and Pollution Prevention (2012). *OCSPP 850.3100: Earthworm Subchronic Toxicity Test*. Retrieved from: <https://www.regulations.gov/#/documentDetail;D=EPA-HQ-OPPT-2009-0154-0019>

determined using this protocol. Alternatively, for microbial communities, an EC₅₀ could be estimated by conducting a study following EPA's **OCSPP 850.3200: Soil Microbial Community Toxicity Test**⁸⁴ guidelines.

For terrestrial vegetation, EPA's **Early Seedling Growth Toxicity Test (OCSPP 850.4230 guideline)**⁸⁵ is designed to screen a test substance to determine its potential to cause phytotoxicity in an early growth stage in terrestrial plants, mainly using commercially important crop species. Surface deposition is the anticipated mode of terrestrial plant exposure to CPE from air, for which the foliar exposure protocol in the testing method should be used. Additional testing using the root exposure protocol will allow consideration of the scenarios of wastewater, reclaimed water and sewage sludge application to agricultural fields.

⁸⁴ EPA Office of Chemical Safety and Pollution Prevention (2012). *OCSPP 850.3200: Soil Microbial Community Toxicity Test*. Retrieved from <https://www.regulations.gov/document?D=EPA-HQ-OPPT-2009-0154-0020>

⁸⁵ EPA Office of Chemical Safety and Pollution Prevention (2012). *OCSPP 850.4230: Early Seedling Growth Toxicity Test*. Retrieved from <https://www.regulations.gov/document?D=EPA-HQ-OPPT-2009-0154-0025>.