

Polybrominated Diphenyl Ethers (PBDEs) in the Great Lakes Basin:

Reducing Risks to Human Health and the Environment



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This report may be cited as: International Joint Commission (2016). Polybrominated Diphenyl Ethers (PBDEs) in the Great Lakes Basin: Reducing Risks to Human Health and the Environment.

November 2016

ISBN: E95-2/28-2016E-PDF

Cat. No.: 978-0-660-06807-7

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Foreword

General Objective iv of the 2012 Great Lakes Water Quality Agreement states that the waters of the Great Lakes should “be free from pollutants in quantities or concentrations that could be harmful to human health, wildlife, or aquatic organisms, through direct exposure or indirect exposure through the food chain.” A class of flame retardants known as polybrominated diphenyl ethers, or PBDEs, has been found at levels that could be harmful to human health in the Great Lakes basin. Of particular concern is the presence of PBDEs in fish consumed by anglers and their families. Subsistence anglers, in particular indigenous peoples, are at greatest risk.

Based on the best science available, the US and Canadian governments designated PBDEs as chemicals of mutual concern (CMCs) in May 2016 pursuant to Annex 3 of the 2012 Agreement. This sets in motion the development of a binational strategy, which may include research, monitoring, surveillance and pollution prevention and control provisions. This International Joint Commission (IJC) report and recommendations are intended to contribute to that effort, emphasising the need for action.

Governments should no longer consider only control of pollutants as they are generated. Instead, the full product life cycle-- from initial design to final disposal – must be considered and controlled. PBDEs illustrate the problems that are created when the environmental fate of a chemical product is either not anticipated or externalized to society at large. In the future, manufacturers should be encouraged or mandated to consider the full life cycle in the design of new products, using environmentally benign materials instead of hazardous chemicals, or to reduce the need for chemical additives. This imperative reaches far beyond PBDEs to numerous other chemicals and products.

The IJC advises that this innovative approach be embedded in the binational strategies for control or elimination of CMCs developed by the US and Canadian governments. The IJC urges the Parties to consider the substitution of nonhazardous substances in the implementation of strategies for other flame retardants.

The IJC expresses its appreciation for the work of the Great Lakes Water Quality Board in developing a report on PBDEs, which serves as the basis of this report, and hopes both reports lead to achievement of the objectives of the Agreement.

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Executive Summary

This report provides recommendations from the International Joint Commission to the governments of Canada and the United States with regard to the development of a strategy to address polybrominated diphenyl ethers (PBDEs) in the Great Lakes. The recommendations are offered in accordance with the IJC's responsibility under the Great Lakes Water Quality Agreement to tender advice and recommendations to the Parties (the US and Canadian governments) on matters covered under the Annexes of the Agreement and approaches and options that the Parties may consider to improve effectiveness in achieving the purpose and objectives of this Agreement. This work particularly relates to General Objective (iv), which declares that waters of the Great Lakes should "be free from pollutants in quantities or concentrations that could be harmful to human health, wildlife, or aquatic organisms, through direct exposure or indirect exposure through the food chain."

PBDEs have been widely used as flame retardants since the 1970s and have been deliberately added to a wide range of commercial and consumer products, such as electronic devices, plastics, mattresses and carpets. Numerous studies have demonstrated adverse impacts on the environment and wildlife from exposure to PBDEs, which have been identified as persistent, toxic, and bioaccumulative. Adverse impacts on wildlife include increased mortality rates, malformations, and thyroid system and metabolic impairment. PBDEs are present in the sediment, water, air, wildlife and humans of all five Great Lakes.

The IJC provides the recommendations in this report noting that in May 2016, the governments designated PBDEs as one of the first Chemicals of Mutual Concern (CMC) under the 2012 Agreement. For each designated CMC, the governments are directed by the Agreement to prepare binational strategies and coordinate the development and application of domestic water quality standards, objectives, criteria and guidelines. The recommendations in this report have been identified as priorities by the IJC, based on the recommendations of the Great Lakes Water Quality Board, principal advisor to the IJC under the Great Lakes Water Quality Agreement. The recommendations are aimed at contributing to the governments' strategy development process.

Recommendation 1

Now that PBDEs have been designated as a Chemical of Mutual Concern under the Great Lakes Water Quality Agreement, a binational strategy to reduce these chemicals in the Great Lakes basin should be developed and implemented before the end of 2017.

Recommendation 2

The entire basin should be protected by equally effective restrictions on the manufacture, use and sale of PBDEs and PBDE-containing products. As part of the federal governments' strategy for addressing PBDEs, they should assess the various regulatory and non-regulatory methods that they can use to protect the basin from PBDE contamination and ensure that equally protective actions are taken throughout the basin.



Recommendation 3

The federal governments should develop a plan for reducing and eliminating potential releases of PBDEs in products during the recycling and disposal stages. This plan should be developed in cooperation with a wide range of stakeholders.

Recommendation 3A

The federal governments should develop and promote guidance for industry, municipalities and the public -- incorporating best practices -- for product end-of-life management, such as recycling and disposal, that provides equal protections in all parts of the Great Lakes basin.

Recommendation 3B

The responsible governments (federal, provincial and state) should develop and implement Extended Producer Responsibility programs throughout the basin to require industries to be responsible for their products containing PBDEs after use and to ensure that they are properly recycled and disposed, to be undertaken in two phases:

Phase 1: electronics, appliances, carpets, mattresses, and furniture

Phase 2: construction, renovation and demolition wastes

Recommendation 4A

The federal, provincial and state governments should develop and distribute guidance for industry on methods to assess PBDE substitutes and encourage use of methods for addressing flammability concerns that are less reliant on chemicals or avoid chemical use altogether.

Recommendation 4B

The federal governments should require industry, in advance of making a chemical substitution, to demonstrate to governments the basis for their decision and to obtain government approval for the substitution.

Recommendation 5A

The federal governments should establish a product registry identifying which products, generated within and imported to the basin, contain PBDEs and how much they contain. This will help determine which products need the most disposal control, and will help governments, industry and the public make wise, informed choices in their purchasing.

Recommendation 5B

The responsible government jurisdictions (federal, provincial and state) should ensure that research and monitoring is carried out to improve the understanding of the extent to which and how PBDEs are released to the environment in the recycling and disposal stages.

Recommendation 5C

The responsible government jurisdictions (federal, provincial and state) should continue and increase monitoring of PBDEs in environmental media (water, sediment, air, biota [fish, gull eggs, etc.]) in order to assess effectiveness of policies aimed at reducing PBDEs in the environment.



In making these recommendations, the IJC notes that PBDEs are just one example of a wide array of toxic substances in products broadly available around the basin. The governments should use the information, findings and recommendations in this report and what is learned through the application of these recommendations to deal with other substances in products, particularly other flame retardant chemicals. Most importantly, the application of life-cycle thinking to either reduce or eliminate the need for chemical additives or identify more environmentally friendly substitutes is broadly applicable. The recommended strategy components presented in this report, while specific to PBDEs, can be adapted for many other substances.

As noted throughout the report, it is highly important for governments to engage a variety of stakeholders in the development and implementation of a strategy for PBDEs.

In the coming months, the Water Quality Board, through its Legacy Issues Work Group, will engage a variety of stakeholders to further explore some of the issues from the report, particularly alternative methods to address flame retardant needs and best management practices for product end-of-life management for Phase 1 product categories (i.e., electronics, appliances, carpets, mattresses and furniture) and the role Extended Producer Responsibility could play in the implementation of these best practices. Further recommendations on these subjects from the IJC to the governments may follow in due course.



Credit: International Joint Commission, PBDE Chemicals in the Great Lakes video



Acknowledgements

The IJC commends the work of the Water Quality Board (WQB) and the Board's Legacy Issues Work Group in bringing this issue and proposed recommendations forward to the IJC. The work group was supported by Antonette Arvai, John Wilson and Clayton Sereres of the IJC's Great Lakes Regional Office. The IJC also recognizes the excellent and thorough work of the consultants who produced the report upon which the Water Quality Board based its recommendations to the IJC, and the work of Kennan Zhou, IJC intern, who produced a background document on PBDEs. A special thank you is extended to the external work group experts who provided review and valuable input on both the consultants' report and the PBDEs background document for the WQB. Finally, the IJC would like to thank those who reviewed the documents during the comment period, participated in the associated webinar and submitted comments on the report.

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Section 1: Introduction to the PBDE Report

The purpose of this report

This report provides a brief overview of the issue of PBDEs in the Great Lakes and specifically their use as additives in consumer products, which provides pathways for their release during product manufacture, use and end-of-life actions. The report further provides recommendations for the development of strategies by the governments of Canada and the United States to manage PBDE-containing products in order to reduce the release of PBDEs to the environment.

The findings and recommendations presented have been identified as priorities, based on recommendations from the IJC's Great Lakes Water Quality Board, a consultants' report contracted by the board that includes numerous, additional valuable recommendations and public comment. The Water Quality Board report, the consultants' report, and an IJC intern-developed PBDE background document are provided as appendices to this report.

The IJC and the Great Lakes

The IJC is an independent binational organization created by Canada and the United States under the Boundary Waters Treaty of 1909. Under the Treaty, the two countries cooperate to prevent and resolve disputes relating to the use and quality of the many lakes and rivers along their shared border. At the request of both governments, under the Great Lakes Water Quality Agreement (the Agreement), the IJC also has a role in advising the two countries on restoration and maintenance of the chemical, physical, and biological integrity of the waters of the Great Lakes. This is a special report of the IJC under Article 7 (1) (l) of the Agreement.

The recommendations in this report are offered in accordance with the IJC's responsibility under the Agreement to tender advice and recommendations to the Parties on matters covered under the annexes of the Agreement and approaches and options that the Parties may consider to improve effectiveness in achieving the purpose and objectives of this Agreement. This work particularly relates to General Objective (iv), which declares that the waters of the Great Lakes should be free from pollutants in quantities that or concentrations that could be harmful to human health, wildlife, or aquatic organisms, through direct exposure or indirect exposure through the food chain. PBDEs were designated by governments as a Chemical of Mutual Concern (CMC) in May 2016 under Annex 3 of the Agreement. The recommendations are intended to aid in the development of effective binational management strategies.

The Great Lakes Water Quality Board

The Great Lakes Water Quality Board is the principal advisor to the IJC on issues related to Great Lakes Water Quality Agreement. The Water Quality Board assists the



IJC in reviewing and assessing progress in Agreement implementation. It identifies emerging issues and recommends strategies and approaches for preventing and resolving the complex challenges facing the Great Lakes. It is further charged with providing advice on the role of relevant jurisdictions to implement these strategies and approaches. The board is composed of an equal number of members from Canada and the United States and includes representatives from the Parties, state and provincial governments and tribal governments, First Nations, Métis, municipal governments, watershed management agencies, business, agriculture and environmental nongovernment organizations and the public at large.

Project genesis/process

In 2015 the Water Quality Board formed the Legacy Issues Work Group, which identified the impact of polybrominated diphenyl ethers on the Great Lakes as a priority issue and noting in particular the need for a product life-cycle management approach to reduce chemical loading to the Great Lakes.

In order to properly assess the status of response to the presence of PBDEs in the Great Lakes region, the work group undertook a binational assessment of:

- (1) the handling of products containing PBDEs during and after use and
- (2) the adequacy of actions by governments and other institutions to minimize the release and consequent presence of PBDEs in the Great Lakes basin.

The assessment was conducted by a team led by Duncan Bury Consulting with input and direction from the Legacy Issues Work Group. Following completion of the consultants' report, work group recommendations were developed, discussed with the full Water Quality Board and revised for endorsement by the board and forwarding to the IJC.

Public consultation

Before formulating the recommendations included in this report, the IJC held a public comment period on the recommendations provided by the board and supporting materials. The public comment period lasted from July 5 to August 5, 2016. During the comment period, the report was posted on the IJC website along with the consultants' report and a video backgrounder on PBDEs in the Great Lakes. An informational webinar was held and also added to the consultation web page.

To promote the consultation, the IJC sponsored advertisements and posts on Facebook, and circulated the information via Twitter, the IJC Facebook account and the IJC's Great Lakes Connection newsletter. A Facebook video ad notifying people of the approaching end of the comment period was seen by more than 2,700 people, resulting in 53 visits to the consultation webpage and more than 500 views of the video. A news article on the report and comment period also was circulated on Facebook, including a link to the



comment page. Close to 3,300 people saw the shared article on the IJC Facebook page, and it was shared 38 times and received 61 likes (increasing the article's exposure). In all, there were 792 visits to PBDE consultation-related pages and links.

Comments and questions were received during the webinar. Six written comments were received. All of these comments have been fully considered in the development of this advice and recommendations for government.

Section 2: PBDEs in the Great Lakes Basin

Polybrominated Diphenyl Ethers (PBDEs)

Polybrominated diphenyl ethers (PBDEs) are a class of substances used as flame retardants in a wide variety of products since the 1970s. According to Environment Canada (2011) and the U.S. Environmental Protection Agency (2010), PBDEs are a group of 209 chemical compounds, referred to as congeners. All congeners have anywhere from one to ten bromine atoms attached to a diphenyl ether molecule. The three principal PBDE mixtures produced commercially have been identified as penta-, octa-, and deca-BDE (Environment Canada 2011).

Fire-retardant chemicals such as PBDEs are added to products to inhibit the ignition of flammable materials and thus impede the spread of fire. PBDE use increased significantly in the 1980s as consumer products were increasingly treated with PBDE-based flame retardants (Diamond et al., 2014). Such products include (Abbasi, et al., 2014; U.S. Environmental Protection Agency 2010):

- Electronics, including circuit boards, computer cases, and televisions
- Polyurethane foam, used in a wide variety of products such as furniture and car seats
- Textiles, carpets and plastics
- Motor vehicles

Reports show that brominated flame retardants are the second largest group of flame retardants used worldwide, accounting for about 20 to 25 percent of overall flame retardant use.^{1,2} Their popularity in the North American market may be associated with the specific requirements of various product flammability standards.³

¹ Abbasi, G., Buser, A. M., Soehl, A., Murray, M. W., & Diamond, M. L. (2015). Stocks and flows of PBDEs in products from use to waste in the U.S. and Canada from 1970 to 2020. *Environmental Science & Technology*, 49(3), 1521-1528.

² Swerea IVF. (2009). Guidance on alternative flame retardants to the use of commercial pentabromodiphenylether (c-PentaBDE). Retrieved from http://chm.pops.int/Portals/0/docs/POPRC4/intersession/Substitution/pentaBDE_revised_Stefan_Posner_final%20version.pdf

³ Zota, A. R., Rudel, R. A., Morello-Frosch, R. A., & Brody, J. G. (2008). Elevated house dust and serum concentrations of PBDEs in California: Unintended consequences of furniture flammability standards? *Environmental Science & Technology*, 42(21), 8158-8164.



All five Great Lakes contain some level of PBDEs, but Erie and Ontario have the highest concentrations in water.⁴ Huron, Michigan and Superior are all relatively less contaminated and have statistically insignificant differences in concentrations.⁵



Source: Venier, M., Dove, A., Romanak, K., Backus, S., & Hites, R., 2014. Flame retardants and legacy chemicals in Great Lakes' water. *Environmental Science & Technology*. 48(16), 9563-9572.

Why are PBDEs of concern?

Research has concluded that PBDEs are persistent, bioaccumulative, and toxic to both humans and the environment.

The widespread use of flame retardants containing PBDE compounds in consumer products and their persistent, bioaccumulative nature have led to high exposure amongst humans, from fetal stages through to adulthood. Exposure pathways are present in daily life for much of the population. However, much of the data is presently inconclusive. Health effects possibly associated with PBDE exposure relate primarily to thyroid disorders, reproductive health, cancers and neurobehavioral and developmental disorders.

Studies on mice and rats have shown that exposure to PBDEs and polybrominated biphenyls (PBBs) cause neurodevelopmental toxicity, weight loss, toxicity to the kidney, thyroid and liver and dermal disorders. This may have implications for human health. Studies on animals and humans have shown that some PBBs and PBDEs can act as endocrine system disruptors and also tend to deposit in human adipose tissue. PBDEs are bioaccumulative, meaning they build up as they move through the food chain.

⁴ Venier, M., Dove, A., Romanak, K., Backus, S., & Hites, R. (2014). Flame retardants and legacy chemicals in Great Lakes' water. *Environmental Science & Technology*, 48(16), 9563-9572.

⁵ Ibid



Numerous studies have shown that exposure to PBDEs harms wildlife by increasing mortality rates, causing malformations, and impairing thyroid and metabolic systems.

A recent study found that prenatal exposure to PBDEs in children is associated with lower IQ and higher hyperactivity scores in children.⁶

PBDEs in the Great Lakes basin

PBDEs have been widely used in the Great Lakes basin since the 1970s in manufacturing, and in commercial and consumer products that contain them.

The Great Lakes Commission has undertaken research to quantify sources of PDBEs in the Great Lakes region in particular. The Great Lakes PBDE Reduction Project was undertaken between 2011 and 2013 to quantify sources of PBDEs in the Great Lakes region and identify metrics for tracking reductions in this region. This study also estimated the quantities of PBDEs in the Great Lakes region, as outlined in the following table.

Table 1: Estimated Quantities of PBDEs⁷

PBDE	Tonnage Range	Where found - percent of total PBDE use	Quantities expected to enter waste phase or still be in use by 2020
Penta	2000t – 10,000t (2004)	Furniture foams 60-65% Vehicle foams 30-35% Electronic and electrical equipment 2-3%	All to leave the use phase
Octa	500t - 2,000t (2004)	Electronic and electrical equipment 90% Auto sector 10%	90% to leave the use phase
Deca	10,000t – 70,000t (2013)	Automotive 25% Textiles 25% Construction materials 25% Electronic and electrical equipment 15%	50% remain in use (of 2008 peak inventory)
Total PBDEs	15,000t – 80,000t (2004)		40% of the peak value (mainly deca) remain in use

⁶ Chen, A., Yolton, K., Rauch, S.A., Webster, G.M., Hornung, R., Sjödin, A., Dietrich, K.N., & Lanphear, B.P. (2014). Prenatal Polybrominated Diphenyl Ether Exposures and Neurodevelopment in U.S. Children through 5 Years of Age: The HOME Study. *Environmental Health Perspectives*, 122(8), 856-862.

⁷ Great Lakes PBDE Reduction Project, Summary Paper No. 1, PBDE Product Inventory.



PBDEs can enter the environment through the following pathways:⁸

- To surface water: 1) when products and materials containing these substances are sent for final disposal to landfill and the landfill produces leachate, which is then discharged to surface water (either onsite following treatment or via municipal wastewater treatment plant); 2) through industrial wastewater discharges to surface water or to municipal wastewater treatment plants;
- To sediments: through land application of municipal sewage sludge left over from treated wastewater;
- To air: when the product undergoes processing such as shredding for recycling; and
- To air: day-to-day use of products containing PBDE flame retardants has potential to release PBDEs to the environment via emission to air due to the vaporization of PBDEs from products as they age (e.g. foam particles from furniture, plastic housings of electronic equipment, plastics in vehicle interiors).

What has been done to manage PBDEs

Management of Individual PBDE congeners

With federal requirements in Canada and the US, and restrictions in four of the Great Lakes' states regarding penta-BDE and octa-BDE, the production, processing, and distribution of these substances are well covered. In addition, the regulatory requirements address a range of products and sectors. However, four of the nine Great Lakes provinces and states (ON, PA, OH, and WI) do not regulate PBDEs directly or at all (some do have electronics Extended Produce Responsibility laws, which aim to keep electronics out of landfills, but there are no end-of life regulations for all other product categories listed in the above table). In Canada, provinces do not have authority to regulate chemicals or chemicals in products, but they do have ultimate authority for waste management. Indiana only requires that manufacturers report whether video display devices sold exceed the limits for PBDEs under the RoHS Directive 2002/95/EC of the EU.

Deca-BDE is currently unregulated in the US Great Lakes jurisdictions. However, implementation of a law passed in Minnesota in May 2015 is set to begin in 2018. This law prohibits manufacture and sale of deca-BDE specifically for use in children's products and residential upholstered furniture, and also prohibits manufacturer substitution of chemicals for deca-BDE that are known to, or suspected of, causing certain health effects.

⁸ Environment Canada (2010). Risk Management Strategy for Polybrominated Diphenyl Ethers (PBDEs) 2010.



Federal Initiatives

The Canadian and US governments have undertaken extensive PBDE management actions over the past ten years. At the federal level in the US, non-regulatory initiatives in combination with the prospect of regulatory action were successful in achieving voluntary commitments from the primary manufacturers and an importer of penta-BDE, octa-BDE, and deca-BDE to phase out production and import of these substances. In addition in both countries, detailed strategies and action plans were developed in consultation with many stakeholders to address concerns related to these substances in 2006-2009.

During the same period, the Canadian government adopted regulations to restrict manufacture and import of a variety of PBDEs, and the US government promulgated regulations to restrict manufacture and import of penta- and octa-BDE. Canada has also ratified and implemented thresholds under the Stockholm Convention on Persistent Organic Pollutants, which requires prohibition and/or elimination of the production and use, as well as import and export, of tetra, penta-, hexa- and hepta-BDEs. Canada ratified the Basel Convention, which requires that transboundary movement of hazardous and other wastes, such as PBDE substances, are minimized and that any such movement is conducted in a manner protective of human health and the environment.

There has been somewhat less activity at the federal level for initiatives targeting products containing PBDEs. The Canadian federal government has not acted on products containing PBDEs. From the US federal government, products containing PBDEs were part of proposed regulatory changes that are currently not in force.

While not specifically targeting PBDEs, the Canadian Council of Ministers of the Environment (CCME), a body representing all provincial and territorial Ministers of Environment, developed a 2009 Canada-Wide Action Plan for Extended Producer Responsibility (EPR), which targeted some product categories for increased diversion from disposal at end of life including several products and materials that contain PBDEs such as construction and demolition materials, furniture, textiles, carpet, and appliances. This action plan, however, is voluntary and under the jurisdiction of each provincial and territorial Environment Minister and each is progressing at very different rates in regulating EPR programs for these materials.

More recently, both countries have pursued additional regulatory action on PBDEs through proposed rules which, while not yet final, may have placed additional pressure to find suitable alternatives and/or reduce use of PBDEs. In the US, non-regulatory activity in the past few years has focused on evaluating alternatives to decaBDE, including in specific product areas (flexible polyurethane foam and printed circuit boards). This effort has engaged industry, state and local governments, other federal agencies, academics, and nongovernment organizations. The Government of Canada also has had an active PBDE monitoring program in place for landfills and wastewater



treatment plants since 2008 to assess the progress and effectiveness of the risk management actions taken to date by the government.

Despite these efforts PBDEs are still imported into Canada and the US when they are contained within finished products such as electrical and electronic equipment, household appliances, upholstered furniture, carpets, curtains and blinds, textiles, mattresses and pillows, automotive/aircraft seating and moulded interiors, and some construction materials such as coated wires and some insulation. In fact, due to strict flammability standards in both countries (which differ for various products), flame retardancy is required in many of these consumer products in order to be sold on the market and used in home building.

With respect to manufacture or import, federal requirements do not exist in either country that address finished products containing PBDEs (other than mixtures, polymers, and resins in Canada). US jurisdictional authority is unclear for EPA with respect to parties other than chemical manufacturers, processors, and formulators. Thus, there is no US federal enforcement for end users of the chemicals in other manufacturing avenues. At the state level, a weakness of US requirements is in addressing imports of penta-BDE and octa-BDE, or imports of products containing these substances.

According to Environment Canada's 2006 ecological assessment report, PBDEs were entering the environment in a quantity or concentration or under conditions that have or may have an immediate or long-term harmful effect on the environment or its biological diversity.

Provincial and State Initiatives

Half of the US Great Lakes states have enacted prohibitions on manufacturing, processing and distribution of products and flame-retardant parts of a product containing penta- and octa-BDE above a given threshold. In eight of the nine states and provinces surrounding the Great Lakes, EPR laws for electronics require recycling at end of life, and most of these laws also include landfill and/or incineration bans for electronics. Four of these jurisdictions include requirements that manufacturers disclose whether electronic products exceed the limits for PBDEs under the Restriction on Hazardous Substances Directive 2002/95/EC of the European Union. Of the Great Lakes provincial and state jurisdictions, Minnesota has the most extensive regulatory program related to PBDEs. This includes: 1) a prohibition on manufacture, processing or distribution of a product or flame-retardant part of a product containing more than 0.1 percent of penta-BDE or octa-BDE; 2) state agency procurement requirements; 3) an EPR law for electronics; 4) landfill bans for certain electronics; and 5) the only requirements of any US jurisdiction in the Great Lakes region regulating deca-BDE, substitutes for deca-BDE, and specific product categories (children's products and residential upholstered furniture).



Canada and US Regulatory and Policy Gaps

In the US, PBDE requirements are fairly comprehensive in addressing production and sales of PBDE substances, but there is a significant gap in addressing imports of products. The lack of requirements to regulate end-of-life product management containing PBDEs also significantly reduces the degree of comprehensiveness overall in the Great Lakes region. Additional US research regarding the degree of enforcement carried out would also provide a clearer picture of the effectiveness of existing laws across the states in minimizing releases of PBDEs. In addition, governments have under-utilized potential economic controls such as purchasing policies or product registries across all PBDE-containing product categories. Product categories with no significant or comprehensive action include vehicle seats, polymer mouldings and resins, children's car seats and foam products, mattresses and pillows, carpets, small appliances, construction waste such as foam insulation and wire coatings, and upholstered furniture. The technology exists to recycle mattresses, carpets, and small appliances so these might be considered a priority for action. Other categories are more difficult to recycle and no technologies are readily available today (vehicle seats, polymer mouldings, children's car seats and foam products, upholstered furniture and construction waste such as foam insulation and wire coatings are in this category since they are typically mixed).

Consistency in approaches to PBDE regulation in the Great Lakes region is evident, as is collaboration among jurisdictions. There are indications, however, that all jurisdictions could benefit from increased collaborative initiatives across the border, between states, between states/provinces and their federal governments, within federal governments and within states and provinces, specifically to address product imports, potential product registries, and end-of-life management of products.

Regulatory focus on PBDEs exists, in particular for manufacture, distribution and import of substances and products. However, there is a critical need for specific focus on end-of-life management of PBDE-containing products, including recycling, disposal and monitoring.

Initiatives to curb PBDE use appear to have been effective. The Great Lakes Fish Monitoring and Surveillance Program tracks the health of the Great Lakes through testing top predator fish. PBDE concentrations in these fish increased from 1980 to 2003, however a decrease was observed in trout from 2000 to 2004⁹. Results from air and precipitation samples collected every 12 days at five sites near the Great Lakes from 2005 to 2011 show that the decline in the environment of PBDEs correlated with the phase-out of penta- and octa-PBDE.

⁹ Bernard S. Crimmins, James J. Pagano, Xiaoyan Xia, Philip K. Hopke, Michael S. Milligan and Thomas M. Holse. (2012). Journal of Environmental Science and Technology. Polybrominated Diphenyl Ethers (PBDEs): Turning the Corner in Great Lakes Trout 1980-2009



Section 3: Key Findings and Recommendations

Development of Binational Strategies

Now that PBDEs have been designated as Chemicals of Mutual Concern (CMC) under the Great Lakes Water Quality Agreement, the governments of Canada and the United States are developing the required binational strategy to address this issue. The IJC urges governments to accept the recommendations below as they begin to develop the strategy and to do so in a timely manner. The priority strategy components are based on a mix of relatively easy and quick “low hanging fruit” and long-term, more challenging solutions. Both are needed to solve the problem of PBDEs in the Great Lakes basin. The governments are urged to involve a range of stakeholders, including industry, municipalities and environmental groups in the development of the strategy.

RECOMMENDATION 1

Now that PBDEs have been designated as a Chemical of Mutual Concern (CMC) under the Great Lakes Water Quality Agreement, a binational strategy to reduce CMCs to the Great Lakes should be developed and implemented before the end of 2017.

Restrictions and bans on PBDE manufacture, use and import

Various governments in the Great Lakes basin have placed bans or restrictions on the manufacture, use, sale, import and distribution of certain PBDEs.¹⁰ These actions have already had substantial impact, with levels of PBDEs declining in the Great Lakes basin.¹¹ However, as the IJC has observed with other banned substances, after an initial significant drop in levels these declines may slow or even begin to increase. The Canadian and US governments have taken actions on the same list of PBDEs (c-penta-BDE, c-octa- BDE, tetra-BDE, hexa-PDE, hepta-BDE, nona-BDE, and deca-BDE). However, the nature of the actions varies substantially between the two jurisdictions. In Canada, the approach for all of the PBDEs listed above has been on regulations to restrict or ban the manufacture and use of these substances. In the United States, in only two cases (c-penta-BDE and c-octa-BDE) has the federal government used regulations to restrict or ban the use of these substances. For the others, the US emphasis has been on non-regulatory measures combined with the prospect of regulations. This has resulted in voluntary commitments by major manufacturers to restrict the manufacture and import of these types of PBDEs. It has also resulted in some Great Lakes states passing their own legislation to restrict the manufacture and use of some PBDEs.

Government actions targeting the import or sale of products containing PBDEs are scarce in the Great Lakes jurisdictions. Likewise, only rarely are their programs aimed at controlling the disposal of PBDE-containing products.

¹⁰ For details see Duncan Bury Consulting, October 30, 2015. Polybrominated Diphenyl Ethers in the Great Lakes Basin: Final Report. Submitted to the International Joint Commission – Great Lakes Water Quality Board. Sections 4.2 – 4.4, Tables 4 and 6.

¹¹ For details see Zhou,K., August 10, 2015 Background Document on Polybrominated Diphenyl Ethers. Submitted



A diversity of restrictions in Great Lakes jurisdictions on manufacture and sale of PBDEs and the almost total absence of restrictions on the import or sale of PBDE-containing products within the basin fails to provide adequate protection from PBDEs. Because the pollution from the manufacture, import and use of PBDEs and of the use of PBDE-containing products around the basin spreads throughout the basin, there must be strong controls throughout the entire basin that address products and pathways.

RECOMMENDATION 2

The entire basin should be protected by equally effective restrictions on the manufacture, use and sale of PBDEs and PBDE-containing products. As part of the federal governments' strategy for addressing PBDEs, they should assess the various regulatory and non-regulatory methods that they can use to protect the basin from PBDE-contamination and ensure that equally protective actions are taken throughout the basin.

Addressing PBDE release during recycling and disposal

Although their production has been banned or discontinued, residual PBDE flame retardants are still present throughout the Great Lakes basin in a vast array of products, as was shown by the Great Lakes Commission study.

PBDEs do not disappear when taken out of use. They may be released when the products they are in are recycled or disposed. This after-use stage presents a threat to the Great Lakes that needs to be addressed. Also, it is important to note that in addition to the 15,000 tonnes of PBDEs estimated to be in products in use in 2004, there are also thousands of tonnes of PBDEs that have already gone into landfills in the Great Lakes basin from products that were taken out of use prior to 2004. These PBDEs will not necessarily remain contained in these landfills in the long term and could migrate to the surrounding environment.

RECOMMENDATION 3

The federal governments should develop a plan for reducing and eliminating potential releases of PBDEs in products during the recycling and disposal stages. This plan should be developed in cooperation with a wide range of stakeholders.

Numerous actions have been identified that the governments could include in a strategy.⁷ The IJC places its highest priority on two of these actions.

RECOMMENDATION 3A

The federal governments should develop and promote guidance for industry, municipalities and the public -- incorporating best practices -- for product end-of-life management, such as recycling and disposal, that provides equal protections in all parts of the Great Lakes basin.

This is an action that the governments should be able to carry out in the next work cycle (2017-2019) of Agreement implementation. In some cases, governments within the Great



Lakes basin have already developed such guidance. In other cases, governments elsewhere – especially in Europe – have developed guidance from which governments here can learn. The Canadian and US governments should work together and with stakeholder groups to assess and determine the most appropriate guidance. Since it is often municipalities that directly deal with recycling and disposal issues, including wastewater treatment and biosolids, the governments should ensure that they fully engage municipalities in this guidance development.

To be sure that the guidance has substantial impact on what happens to PBDEs, those who are recycling or disposing the PBDE-containing products should be required to abide by it. In cases where municipalities have a role in recycling and disposal, the federal and provincial and state governments should provide municipalities with sufficient resources to carry out these actions. If necessary, the governments should develop the guidance into regulations to ensure adherence.

RECOMMENDATION 3B

The responsible governments (federal, provincial and state) should develop and implement Extended Producer Responsibility programs throughout the basin to require industry to be responsible for their products after use and to ensure that they are properly recycled and disposed, to be undertaken in two phases:

Phase 1: electronics, appliances, carpets, mattresses, and furniture

Phase 2: construction, renovation and demolition wastes

The producers of PBDE-containing products need to have a more substantial role in ensuring that recycling and disposal problems are avoided. The Organization of Economic Cooperation and Development (OECD) defines Extended Producer Responsibility (EPR) as... *an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle. There are two related features of EPR policy: (1) shifting of responsibility (physically and/or economically; fully or partially) upstream toward the producer and away from municipalities, and 2) to provide incentives to producers to incorporate environmental considerations in the design of their products.*⁸

Some jurisdictions in the Great Lakes basin and in places elsewhere in the world, especially Europe, already have EPR programs for some PBDE-containing products.¹² Implementing EPR for Phase 1 product categories (electronics, appliances, carpets, mattresses, and furniture) is more easily and quickly achievable since there are programs currently in place in various jurisdictions for some of these products within the basin and/or in other countries, and because of the ease of product source separation. Addressing these Phase 1 product categories can have a substantial impact due to the significant presence of PBDEs in the products in these categories.¹⁰ The product categories in Phase 2 (construction, renovation and demolition wastes) are more of a challenge to address but should be pursued in the long term. Again, the IJC

¹² For details on EPR, see Duncan Bury Consulting. *op. cit.* Section 5.1.2.



urges full involvement of a range of stakeholders in the development of the EPR programs around the basin.

Substitution of PBDEs¹³

In phasing out PBDEs, it is important to ensure that one hazardous flame retardant is not substituted for another hazardous one, potentially creating a whole new set of environmental and health problems for future generations to deal with. For example, two derivative substances of Tetrabromobisphenol A (an alternative to PBDEs) are now being found to bioaccumulate in the herring gull food chain (Letcher, R.J. & Chu, S., 2010).¹⁴

Chemicals policy should therefore require a demonstration of safety for new or replacement chemicals. In the United States, signing of the Frank R. Lautenberg Chemical Safety for the 21st Century Act into law on June 22, 2016 was a step in this direction. The law requires EPA review of and a risk determination for all new chemicals. In Canada, the risks posed by new substances are determined through risk assessments conducted under the Canadian Environmental Protection Act of 1999.

There is also a need to look at non-chemical alternatives as methods to address fire concerns. This means designing and building products so that they are inherently less flammable, thus reducing or eliminating the need for chemical flame retardants. For example, studies have shown that increasing foam density in furniture can be sufficient to satisfy fire safety requirements without adding flame retardants to the foam. The EPA is currently pursuing this type of approach through its “Design for the Environment Alternatives Assessment” program.

RECOMMENDATION 4A

Federal, provincial and state governments should develop and distribute guidance for industry on methods to assess PBDE substitutes and encourage use of methods for addressing flammability concerns that are less reliant on chemicals or avoid chemical use altogether.

RECOMMENDATION 4B

The federal governments should require industries, in advance of making a substitution, to demonstrate the basis for their decision and to obtain government approval for the substitution.

¹³ For discussion of this issue, see Duncan Bury Consulting. *op. cit.* Section 2.3.

¹⁴ Letcher, R.J. & Chu, S., 2010. High-Sensitivity Method for Determination of tetrabromobisphenol-S and Tetrabromobisphenol-A Derivative Flame retardants in Great Lakes Herring Gull Eggs by Liquid Chromatography- Atmospheric Pressure Photoionization-Tandem Mass Spectrometry. *Environmental Science & Technology*. 44(22), 8615-8621.



Knowledge gaps

There are many gaps in our knowledge of PBDEs.¹⁵ The governments should ensure that research is carried out and that systems are created to fill some of the most important knowledge gaps. This is essential to assess progress in addressing the PBDE problem and to determine which actions to take. Major gaps include limited knowledge on the extent of PBDE presence in products and the release of PBDEs during recycling and disposal. The IJC notes two gaps in knowledge that it considers particularly pressing.

RECOMMENDATION 5A

The federal governments should establish a product registry identifying which product, generated within and imported to the basin, contain PBDEs and how much they contain. This will help determine which products need the most disposal control, and will help governments, industry and the public make wise, informed choices in their purchasing.

RECOMMENDATION 5B

The responsible government jurisdictions (federal, provincial and state) should ensure that research and monitoring is carried out to improve the understanding of the extent to which and how PBDEs are released to the environment in the recycling and disposal stages.

RECOMMENDATION 5C

The responsible government jurisdictions (federal, provincial and state) should continue and increase monitoring of PBDEs in environmental media (water, sediment, air, biota [fish, gull eggs, etc.]) in order to assess effectiveness of policies aimed at reducing PBDEs in the environment.

The full range of stakeholders should be involved in helping gather this information, especially industry. The Binational Toxics Strategy under the former Great Lakes Water Quality Agreement and the work carried out by the Great Lakes Commission's PBDE project are excellent examples of the value of this kind of cooperative multi-stakeholder research.

¹⁵ For detailed discussion of this, see Duncan Bury Consulting, op.cit., Sections 2.6 and 6.5



Summary and Conclusions

PBDEs are just one example of a wide array of toxic substances in products broadly available around the basin. The governments should use what is learned through the PBDE experience to deal with other substances in products and how to prevent these problems in the first place. The recommended strategy components presented in this report, while specific to PBDEs, can be adapted for other substances. As noted throughout the report, it is highly important to engage a variety of stakeholders for the successful development and implementation of a strategy.

IJC Next steps

In the coming months, the Water Quality Board, through its Legacy Issues Work Group, will work to engage a variety of stakeholders to further explore some of the issues from this report, particularly alternative methods to address flame retardant needs and best management practices for product end-of-life management for Phase 1 product categories (i.e., electronics, appliances, carpets, mattresses and furniture) and the role Extended Producer Responsibility could play in the implementation of these best practices. Further recommendations on these subjects from the IJC to the governments may follow in due course.

Appendices

The appendices for this report are available online at http://www.ijc.org/en/_pbdes.

Appendix A - WQB report

Appendix B - Polybrominated Diphenyl Ethers in the Great Lakes Basin Final Report (submitted by Duncan Bury Consulting)

Appendix C - Background Document on Polybrominated Diphenyl Ethers (submitted by Kennan Zhou, IJC intern)



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