Strategies for Eliminating and Reducing Persistent Bioaccumulative Toxic Substances: Common Approaches, Emerging Trends, and Level of Success

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Abstract
This paper reviews nine of the best-known strategies for eliminating and reducing substances in the category known as “persistent bioaccumulative toxic substances” (PBTSs). The nine strategies are as follows: 1) Ontario’s Candidate Substances List for Bans and Phase-outs (1992), 2) Canada’s ARET Program (1994), 3) Canada’s Toxic Substances Management Policy (1995), 4) the Commission for Environmental Cooperation’s Sound Management of Chemicals Initiative (1995), 5) the Great Lakes Binational Toxics Strategy (1997), 6) the U.S. Environmental Protection Agency’s (U.S. EPAs) draft National PBT Strategy (1998), 7) U.S. EPAs Waste Minimization Program (1998), 8) the U.N. Stockholm Convention on Persistent Organic Pollutants (2001), and 9) Washington State’s Rule on Persistent Bioaccumulative Toxins (2006). The review describes the commonalities among the strategies, including their goals and principles, design approaches, and other common elements. It also discusses several emerging trends, such as the increasing importance of economic considerations, human health information, and nonregulatory management approaches. The paper concludes with a discussion of how effective the strategies have been at achieving their goals of elimination and reduction of persistent bioaccumulative toxic substances.

Introduction
Over the past 13 years, government organizations in North America and internationally have developed strategies to eliminate and reduce the production, use, and release of persistent bioaccumulative toxic substances (PBTSs) in response to the mounting scientific evidence that toxic substances of this type pose greater risks to human health and the environment than do others. These unique risks result from the propensity of PBTSs to remain in the environment for a long time without breaking down; their potential to bioaccumulate in human, animal, or fish tissues; and their toxicity. As a result of their characteristics, PBTSs often migrate from one environmental medium to another and travel thousands of miles via long-range atmospheric transport to regions far from where they originally entered the environment. Moreover, many species, especially top predators, can experience long-term cumulative exposures to PBTSs over their entire lifetimes.

The unique risks posed by PBTSs were first acknowledged by the governments of the United States and Canada in the Great Lakes Water Quality Agreement (1978), which stated: “The discharge of any or all persistent toxic substances (should) be virtually eliminated” (International Joint Commission United States and Canada, 1989). Nearly all persistent substances have the potential to bioaccumulate.

PBTSs include some pesticides, such as aldrin; some chemicals used in commerce, such as PCBs; some products of incomplete combustion, such as dioxins and furans; and some heavy metals, such as mercury, lead, and cadmium.

This article reviews nine strategies for eliminating and reducing PBTSs, starting with the earliest and concluding with possibly the most recent. Although there are many other strategies for managing toxic chemicals in general, as well as for managing individual PBTSs, the ones reviewed here are the nine best-known strategies for managing PBTSs as a category.

Summary of Strategies
Ontario’s Candidate Substances List for Bans and Phase-outs (1992)
To develop the list, the ministry assessed the persistence, bioaccumulative potential, and toxicity of approximately 800 substances known to be present in the Great Lakes basin. The Candidate Substances List for Bans and Phase-outs did not lead directly to the ban or phase-out of any substances, although it served as an important precedent for subsequent strategies for eliminating and reducing PBTSs.

Canada’s ARET Program (1994)
The multi-stakeholder Accelerated Reduction/Elimination of Toxics (ARET) Program developed a list of 117 PBTSs based on an evaluation of over 2,000 substances (Environment Canada, 2003). In 1994, ARET issued a voluntary challenge to Canadian industry to virtually eliminate releases of 30 PBTSs on the list and to reduce releases of the other 87 substances to levels insufficient to cause harm. ARET also issued two short-term goals: To reduce emissions of PBTSs by 90 percent and all other emissions of toxic substances by 50 percent by 2000. ARET was judged to be successful by the Canadian government, which stated: “The ARET challenge proved to be very successful. By the year 2000 ARET succeeded in attracting participation from 8 major industry sectors, 171 companies and government organizations, and 318 individual facilities. Collectively, these participants achieved a total reduction in releases to the environment of almost 28,000 tonnes” (Environment Canada, 2003). One review of ARET found, however, that reported emission reductions had largely resulted from an economic downturn that had led to decreased industrial activity, rather than from the program itself (Environment Canada, 2000).

Canada’s Toxic Substances Management Policy (TSMP) contains two management objectives (Government of Canada, Environment Canada, 1995a): 1) virtual elimination from the environment of toxic substances that result predominantly from human activity and that are persistent and bioaccumulative (referred to as Track 1 substances) and 2) management of other toxic substances and substances of concern throughout their entire lifecycles (referred to as Track 2 substances). The policy contains specific criteria for persistence and bioaccumulation (Government of Canada, Environment Canada, 1995b). Toxicity is assessed using procedures outlined in the Canadian Environmental Protection Act, which also contains provisions to implement the policy.

The Toxic Substances Management Policy was reviewed in 1999 by the federal Commissioner of the Environment and Sustainable Development as part of a larger audit of how the Canadian government was managing the risks from toxic substances. In her review, the commissioner commented: “The Toxic Substances Management Policy … is not being fully implemented, nor is there a government-wide plan to do so. Strategies for the management of specific substances, although required by the policy, have not been developed or implemented. Established government objectives are not being achieved” (Commissioner of the Environment and Sustainable Development, 1999, § 4.140). She added: “The current programs are insufficient to ensure that risks will be adequately addressed in the future. Substance-specific objectives for the protection of human health and the environment have not been adequately defined, and agreed reductions in the release of toxic substances are not assured” (Commissioner of the Environment and Sustainable Development, 1999, § 4.141).

In 1995, the Commission for Environmental Cooperation of North America passed a resolution to improve the management of chemicals, giving priority to persistent, toxic substances of mutual concern to the United States, Canada, and Mexico (Commission for Environmental Cooperation of North America, 2003). To accomplish this, the resolution called for the development of North American regional action plans (NARAPs). To date, plans for six specific substances have been developed (DDT, chlordane, PCBs, mercury, dioxins/furans, and hexachlorobenzene).

In the future, the Sound Management of Chemicals Initiative plans to emphasize implementation of the existing plans; reporting on emerging issues of concern; building partnerships and capacity; improving biomonitoring and environmental monitoring; and public involvement, communications, and outreach (North American Working Group on the Sound Management of Chemicals, 2004). Thus, it is unlikely that many more substance-specific North American regional action plans will be developed.

Great Lakes Bidential Toxics Strategy (1997)
The Great Lakes Bidential Toxics Strategy (U.S. Environmental Protection Agency [U.S. EPA], 1997) is based on the commitment to virtual elimination of certain toxics made by the Great Lakes Water Quality Agreement of 1978 (International Joint Commission United States and Canada, 1989). The strategy identifies 12 “Level 1” substances as the primary focus for U.S. and Canadian government actions. These substances have been targeted for virtual elimination because of their actual or potential environmental effects and their presence in the Great Lakes basin. The strategy contains specific U.S. and Canadian “challenges” for individual Level 1 substances. The strategy also identifies 14 “Level 2” substances that are subject to pollution prevention activities. These substances were selected because they have the potential to significantly affect the Great Lakes ecosystem. In 2001, the International Joint Commission reviewed the Great Lakes Bidental Toxics Strategy (International Joint Commission, 2001). The review focused on the Level 1 substances and concluded that the strategy had achieved its purpose of setting forth a “collaborative process by which Environment Canada (EC) and the United States Environmental Protection Agency …, in consultation with other federal departments and agencies, Great Lakes states, the Province of Ontario, Tribes, and First Nations, will work in cooperation with their public and private partners toward the goal of virtual elimination of persistent toxic substances resulting from human activity, particularly those which bioaccumulate, from the Great Lakes Basin, so as to protect and ensure the health and integrity of the Great Lakes ecosystem” (U.S. EPA, 1997).

The review went on to state, however, that “many of the reductions made in releases of Level 1 substances cannot be attributed to the Strategy unequivocally” (International Joint Commission, 2001).

The U.S. EPA draft National PBT Strategy (U.S. EPA, 1998) focuses on the same 12 Level 1 substances addressed by the Great Lakes Bidential Toxics Strategy, and it proposes to develop a national action plan for each one. Only one plan has been finalized (for alkyl lead), and the strategy has never been finalized.
The Waste Minimization Program seeks to reduce or eliminate waste in manufacturing by focusing on 31 priority chemicals that are tracked through the Toxics Release Inventory. Specifically, the program's goals include the "complete elimination of, or substitution for, priority chemicals, wherever possible" (U.S. EPA, 2003a). The principal vehicle for achieving the program's goals is the National Partnership for Environmental Priorities, which encourages public and private organizations to form voluntary partnerships with U.S. EPA to reduce the use or release of any of 31 priority chemicals. The goal is to reduce the amount of priority chemicals reported to the Toxics Release Inventory by 10 percent by 2008, with the year 2001 taken as a baseline.

U.S. EPA developed the Waste Minimization Prioritization Tool, partly to support the Waste Minimization Program (Notice of Availability of Waste Minimization Software and Documents, 1997). The tool is a software package that ranks substances according to their persistence, bioaccumulative potential, and toxicity.

The U.N. Stockholm Convention on Persistent Organic Pollutants requires the elimination or reduction of 12 persistent organic pollutants (United Nations Environment Programme, 2001). It also contains a process for adding new chemicals and a financing mechanism to help developing countries and countries with economies in transition to meet the obligations of the agreement. The convention entered into force in 2004, after it had been signed and ratified by 50 countries. At present, 114 countries have ratified the convention. They do not include the United States, which has signed but not ratified the convention.

In 2006, Washington State adopted a rule on PBTs, making Washington the first state to have a regulatory strategy to manage PBTs as a category of substance. Several other states have strategies for individual PBTs, but no other state has a strategy for PBTs as a group.

Washington's rule consists of a two-step process, comprising a procedure for selecting a list of PBTs, and then one to select which PBTs on the list will have "chemical action plans" prepared for them. The rule (Washington Department of Ecology, 2006) comprises criteria for persistence, bioaccumulation, and toxicity, an initial list of PBTs based on the criteria, a procedure for updating the list, criteria for selecting PBTs for which chemical action plans will be prepared, and guidance on the scope of chemical action plans.

Commonalities Among the Strategies

Goals
All of the strategies considered in this review have the ultimate goal of eliminating or banning the use, production, release, or disposal of the most hazardous PBTs, as well as of reducing releases of others. The precise meaning of the word elimination can, however, be problematic because advances in analytical chemistry are permitting the measurement of ever-decreasing concentrations of substances. The Canadian Environmental Protection Act of 1999, which provides the legal authority for the Toxic Substances Management Policy, deals with this issue by defining "virtual elimination" as "the ultimate reduction of the quantity or concentration of the substance in the release below the level of quantification" (Department of Justice Canada, 1999). Other strategies, such as Washington State's PBT Rule, do not define elimination, and they deal with this issue on a substance-by-substance basis.

Principles
Several of the strategies refer to the need for precautionary action, including the Toxic Substances Management Policy, the Sound Management of Chemicals Initiative, and the Stockholm Convention. The essence of the precautionary approach is that it is often necessary to take action on environmental health issues without complete scientific information on the risks. There are various ways of articulating the precautionary approach, but perhaps the best-known is Principle 15 of the Rio Declaration, which states that "where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation" (U.N. Environment Programme, 1992). None of the U.S. strategies mention the need for a precautionary approach.

A second common principle is the lifecycle or cradle-to-grave approach. This refers to the management of PBTs from manufacture and production through use and ultimate disposal. For example, the Toxic Substances Management Policy contains a section on lifecycle management (Government of Canada, Environment Canada, 1995a) that links this principle with pollution prevention (discussed below). Similarly, in its resolution 95-05, the Commission for Environmental Cooperation of North America states that its Sound Management of Chemicals Initiative recognizes "the need to assess and develop strategies for addressing new and existing chemicals in North America, throughout their life cycles" (2003, p. 19). The Waste Minimization Program takes this principle a step further and promotes cradle-to-cradle management that emphasizes closed-loop management systems and recycling whenever elimination or minimization are not possible (U.S. EPA, 2004).

Pollution prevention is a third principle common to several of the strategies. Pollution prevention has been defined as follows: "The reduction or elimination of pollution at the source (source reduction) instead of at the end-of-the-pipe or stack" (National Pollution Prevention Roundtable, n.d.). For example, the Toxic Substances Management Policy states that "pollution prevention is often the most cost-effective management strategy and in such cases will be promoted" (Government of Canada, Environment, 1995a, pp. 6-7). In contrast, in its resolution 95-05, the Commission for Environmental Cooperation of North America simply states that "the prevention of pollution ... is both desirable and imperative in order to protect and improve the environment of North America" (2003, p. 20).

Design Approach
The environmental mobility of PBTs poses a unique management challenge because it means that they can cross programmatic, institutional, and jurisdictional boundaries with ease. Thus, strategies intended to manage PBTs in a single environmental medium are likely to have limited success. Similarly, policies or legislation implemented by a single institution or jurisdiction are unlikely to manage PBTs comprehensively.

Thus, a key design consideration in all of the strategies is the need for cross-program, multimedia approaches to PBTs. This need is most clearly articulated in U.S. EPA's draft national PBT strategy which states that "EPA is committing, through this strategy, to create an enduring cross-office system that will address the cross-media issues associated with
priority PBT pollutants” (U.S. EPA, 1998, p. iv). Similarly, the Stockholm Convention is based on the recognition that an international approach is necessary for controlling the transboundary movement of PBTs.

**Common Elements**

To achieve their goals of elimination and reduction, all of the strategies comprise two or more of the following four elements: criteria for persistence, bioaccumulation, and toxicity used to develop an initial list of PBTs; an initial list of PBTs; management objectives for individual PBTs on the initial list; and a process for adding new substances to the initial list of PBTs. Table 1 gives a comparison of these common elements in the nine strategies.

<table>
<thead>
<tr>
<th>Name of Strategy</th>
<th>Criteria for Persistence, Bioaccumulation, and Toxicity</th>
<th>Initial List of PBTs</th>
<th>Management Objectives for Individual Substances on Initial List</th>
<th>A Process for Adding New Substances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario’s Candidate Substances List for Bans and Phaseouts (1992)</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
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<td>Canada’s ARET Program (1994)</td>
<td>Yes</td>
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<td>Canada’s Toxic Substances Management Policy (1995)</td>
<td>Yes</td>
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<td>Commission for Environmental Cooperation’s Sound Management of Chemicals Initiative (1995)</td>
<td>Yes</td>
<td>Yes</td>
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<td>Great Lakes Binational Toxics Strategy (1997)</td>
<td>No</td>
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<td>U.S. EPA’s draft National PBT Strategy (1998)</td>
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<td>U.S. EPA’s Waste Minimization Program (1998)</td>
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<td>U.N. Stockholm Convention on Persistent Organic Pollutants (2001)</td>
<td>No</td>
<td>Yes</td>
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<td>Washington State PBT Rule (2006)</td>
<td>Yes</td>
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**Criteria for Persistence, Bioaccumulation, and Toxicity**

Six of the strategies contain physicochemical criteria for persistence, bioaccumulation, and toxicity, including Ontario’s Candidate Substances List, ARET, the Toxic Substances Management Policy, the Sound Management of Chemicals Initiative, the Waste Minimization Program, and Washington State’s PBT Rule. The most common way of determining persistence is to consider the half-life of the substance in the environment. A half-life can be defined as the time taken for half of a substance to degrade or be transformed in the environment. Half-lives can be measured in various environmental media, including soil, water, and sediments. They vary depending on the medium, the specific degradation process studied, and site-specific conditions such as climate. The Toxic Substances Management Policy (Department of Justice Canada, 1999) and the Sound Management of Chemicals Initiative (Commission for Environmental Cooperation of North America, 2003) allow substances to be categorized as persistent if there is evidence of atmospheric transport to remote regions such as the Arctic.

The strategies determine bioaccumulation potential using one or more of three measures: the bioaccumulation factor (BAF), the bioconcentration factor (BCF), and the log of the octanol-water partition (log Kow). BAFs and BCFs are more biologically relevant because they take account the metabolism of an organism, whereas the log Kow is a chemical measure only. BCFs are laboratory measures of the change in concentration of a substance from the environment into tissues, and BAFs are field measures that take account of actual availability in the environment. In brief, the log Kow is the most reproducible but the least similar to real-life field conditions, and the BAF is the least reproducible but the most similar to field conditions.

All five strategies measure toxicity in terms of acute and chronic toxicity, as well as carcinogenicity or teratogenicity. Some use scoring systems for toxicity that contain assumptions and values about the relevant importance of different types of health effects. The most complex scoring system is probably the Waste Minimization Prioritization Tool (Notice of Availability of Waste Minimization Software and Documents, 1997).

**Initial Lists of PBTs**

Eight of the strategies have an initial list or lists of PBTs for action. These lists vary in length from four substances (the Sound Management of Chemicals Initiative) to 87 substances (ARET). There is a high degree of overlap in the substances listed in different strategies.

**Management Objectives for Individual Substances on the Initial List(s)**

Of the eight strategies with an initial list or lists of PBTs for action, three provide management objectives for the individual listed substances (the Great Lakes Binational Toxics Strategy, U.S. EPA’s draft National PBT Strategy, and the Stockholm Convention). For example, the Great Lakes Binational Toxics Strategy contains specific management objectives for the U.S. and Canadian governments for each of its Level 1 substances.

**A Process for Adding New Substances**

Five of the strategies contain a specific process for adding new substances to the initial list (the Toxic Substances Management Policy, the Sound Management of Chemicals Initiative, the Waste Minimization Program,
the Stockholm Convention, and Washington State's PBT Rule). These processes vary in terms of their length and complexity, but all require that candidate substances meet the criteria for persistence, bioaccumulation, and toxicity.

**Emerging Trends**

**Economics**

The role of economics has become more prominent in the strategies over time. Economic factors were not mentioned in the first two strategies (Ontario's Candidate Substances List and ARET). The Toxic Substances Management Policy states that “while socio-economic factors have no bearing on setting the ultimate objective for a Track 1 substance—its virtual elimination from the environment—such factors will be taken into account when determining and implementing risk management measures under this policy. For example, they will help to determine interim targets, appropriate management strategies and time lines” (Government of Canada, Environment Canada, 1995a, p. 9). All subsequent strategies have included economics as a factor to be considered in decisions about the elimination and reduction of PBTs.

To date, the economic factors considered in decisions have focused on the costs of eliminating and reducing PBTs. The societal costs of the continued use of PBTs, or the economic benefits of eliminating or reducing them, are not generally considered. The Waste Minimization Program recognizes this consideration, asking: “What are the true costs to society of toxicants that eventually find their way into the tissues of plants, animals, and people?” (U.S. EPA, 2005a). Some researchers are now beginning to answer this question by estimating the economic costs associated with the health and related effects of PBTs (Landrigan, Schechter, Lipton, Fahs, & Schwartz, 2002; Trasande, Landrigan, & Schechter, 2005). The inclusion of information on both the costs of eliminating and reducing PBTs and the costs of their continued use could facilitate decisions about the elimination and reduction of PBTs.

**Health Information**

In recent years, the role of health information in the identification of substances as PBTs has increased in two ways. First, a broader range of health effects are being included in the toxicity criteria. For example, the toxicity criteria given in Ontario's Candidate Substances List refer only to acute and chronic/subchronic toxicity, carcinogenicity, and teratogenicity; whereas the more recent Washington State PBT Rule refers to carcinogens, developmental and reproductive toxicants, neurotoxicants, and acute and chronic toxicity (Washington Department of Ecology, 2006). This change probably has occurred because it is becoming clear that PBTs are associated with a wide diversity of health effects. Second, it is likely that the increasing availability of epidemiological studies and the current policy climate in the United States are leading to a greater emphasis on studies that demonstrate actual effects in human populations.

**Feasibility**

The early strategies called for the elimination and reduction of PBTs, without considering whether these goals were feasible or practical. Ontario's Candidate Substances List, ARET, and the Toxic Substances Management Policy do not mention the technological feasibility of elimination and reduction, or the availability of alternatives or substitutes. The idea that feasibility should influence the goals of elimination and reduction came later, in the Sound Management of Chemicals Initiative, which states that the “availability of alternatives” is one of the considerations in nominating a substance for action (North American Commission for Environmental Cooperation, 1997). The feasibility of elimination and reduction has been included in all subsequent strategies.

**Nonregulatory Approaches**

Over the years, there has been a trend toward nonregulatory environmental management approaches, including the use of voluntary, economic, and incentive-based instruments (Press & Mazmanian, 2006). This trend has also held for PBTs strategies. Two of the early strategies, Ontario's Candidate Substances List and the Toxic Substances Management Policy, emphasized regulatory or command-and-control approaches. In contrast, the more recent strategies emphasize either voluntary approaches, as in the Waste Minimization Program, or blended approaches, as in Washington State's PBT Rule. None of the international strategies contain binding regulatory measures because of the need to safeguard national sovereignty.

**The Success of Strategies for Reducing PBTs**

Have the strategies achieved their goals of eliminating and reducing PBTs in the environment? Unfortunately, the answer is not at all clear. There are several reasons. First, the monitoring information on levels in the environment of most of the listed PBTs is insufficient to establish convincing temporal trends for the geographic regions covered by the strategies. For example, only a few of the PBTs listed in the strategies are subject to reporting under the Toxics Release Inventory, and these data do not show any clear trends over time. In some years, reported releases of PBTs have increased, and in others they have decreased. Data from 2000–2001 show a decrease of about 2 percent (U.S. EPA, 2003), while data from 2001–2002 and 2002–2003 show increases of 3 percent (U.S. EPA, 2004) and 11 percent (U.S. EPA, 2005b), respectively.

Moreover, it is virtually impossible to track the effectiveness of the individual strategies because only one (ARET) has a mechanism for reporting reductions in emissions. None of the other strategies contain a mechanism for monitoring environmental outcomes. The need to measure success in terms of environmental results is recognized in the draft national PBT strategy, which states: “EPA will measure progress on actions under this strategy through: (1) environmental or human health indicators, (2) chemical release, waste generation, or use indicators” (U.S. EPA, 1998, p. 11). This measurement does not appear to have occurred, however.

A second reason that it is difficult to make definitive statements about the success of the strategies is that many of the substances on the initial lists of PBTs were already banned or controlled before the strategies were developed. For example, all 12 PBTs identified by 1999 as persistent, bioaccumulative, and toxic under the Toxic Substances Management Policy were subject to bans or management controls before the introduction of the policy in 1995. Eight were pesticides that had been banned in Canada for many years, and another was PCBs, whose use has been restricted since 1980. The other three substances—dioxins, furans, and hexachlorobenzene—were subject to stringent control actions before the implementation of the policy in 1995 (Commissioner of the Environment and Sustainable Development, 1999). This circumstance is true for other strategies as well. Thus, the strategies themselves probably had little effect on many
of the listed PBTSs because those substances had already been banned or controlled.

Third, implementation of several strategies has been extremely slow or has not taken place. For example, Ontario’s Candidate Substances List did not lead directly to any bans or phase-outs. In its 10-year life, the Sound Management of Chemicals Initiative has developed North American regional action plans for six substances. In other cases, most notably the Stockholm Convention and Washington State’s PBT Rule, it is too early to evaluate their success.

Fourth, any reductions in environmental levels of PBTSs may be due to a variety of factors. As noted above, many of the PBTSs on the initial lists had already been banned or controlled, and these measures may have resulted in reduced levels. Other factors that are likely to be relevant include economic considerations. For example, a review of ARET found that reported emission reductions were largely a result of an economic downturn that led to decreased industrial activity, rather than to ARET itself (Environment Canada, 2000). This finding suggests that economic trends are likely to significantly influence emissions of PBTSs.

Concluding Thoughts
It is clear that there are many similarities among the PBTS strategies that have been developed over the past 14 years, and that there are also several emerging trends. It is unclear, however, whether collectively they have been successful in achieving their goals of elimination and reduction of PBTSs in the environment.

Despite this uncertainty, they have drawn attention to the issue of PBTSs in many different sectors of society. Policy makers are now much more aware of the need to manage these substances through government policies and programs, and one strategy has led to another. Similarly, the public is becoming more aware of the health hazards associated with PBTSs, and some people are now limiting their exposures through personal lifestyle choices. Industry is increasingly cognizant of the need to eliminate and reduce PBTSs. For example, participation in Responsible Care®, an international program whose purpose is to advance the safe and secure management of chemical products and processes, is now mandatory for all members of the American Chemistry Council (American Chemistry Council, 2005). Also, researchers are now studying the health and environmental effects of PBTSs with a depth and breadth that were unimaginable 15 years ago. The increase in research has led to knowledge of the endocrine-disrupting potential of many PBTSs, among other information. Although it is unclear that the strategies have been successful at eliminating and reducing PBTSs, they have been very effective in raising awareness.

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