Contaminants

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BACKGROUND

More than 23,000 chemicals are in use in Canada. Some are intended for controlled use in the environment (such as pesticides and water purification chemicals) and some may be released into the environment as byproducts (such as from burning wood and petroleum products) or accidentally through spills and leaks. Apart from pesticides and pharmaceuticals, which are regulated under other acts, more than 120 substances currently are either on the List of Toxic Substances (Schedule 1) of the *Canadian Environmental Protection Act*, 1999 (CEPA), or are considered by Environment Canada and Health Canada to have met the criteria for a toxic substance under CEPA. CEPA defines a substance as toxic if it enters, or may enter, the environment in amounts or under conditions that may pose a risk to human health or the environment. Substances are also considered to be toxic if any products formed as they break down in the environment meet this definition. These substances are listed either individually or as part of a group of substances that are considered to have met the criteria for a toxic substance. (A list is available from the National Pollutant Release Inventory at: *www.ec.gc.ca/NPRI-INRP-COMM//default.asp?lang=en&n=53E2467F*.)

The indicators in this paper were chosen to represent a spectrum of issues and consequences with respect to known contaminants in the environment. Indicators range from an estimate of how much chemical contamination is being released into the Canadian environment to trends in specific pollutants in food webs.

CONTAMINANT DEFINITIONS

In this paper, the term “contaminant” refers to substances, including those found naturally, that are present at concentrations above natural background levels, or whose distribution in the environment has been altered by human activity.

The term “pollutant” refers to a contaminant whose concentration in the environment is high enough to result in deleterious effects (GESAMP 1983).

Persistent Organic Pollutants (POPs)

Most of the indicators in this paper concern the group of substances known as persistent organic pollutants (POPs). They persist for a very long time in the environment because they resist being broken down by chemical and microbial processes. These chemicals have a variety of toxic effects, including disruption of hormone and immune systems of mammals. POPs include a wide variety of chlorinated and other halogenated chemicals, such as dioxins and furans, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and other less well understood chemicals. They are fat soluble and accumulate in the fat reserves of organisms because they are resistant to being broken down metabolically. Through the process of bioaccumulation, such compounds become more concentrated as living organisms take them up and store them in body tissues faster than they can be broken down or excreted. When contaminated organisms are eaten by other animals, the compounds become more and more concentrated in the bodies of the predators. In a process called biomagnification, concentrations tend to increase at each step up the food web, often reaching high levels in the top predators. This means that POPs may accumulate in wildlife to concentrations that affect their health or risk the health of humans who consume them.

POPs were mostly used in industrial applications or are byproducts of incineration or other industrial processes; some were used as insecticides. As a group, POPs vary greatly in their toxicity, persistence in the environment, and how they are transported once they enter the environment. Many are now banned or are subject to stringent regulations controlling their use and release. After restrictions on their production and use came into effect from the 1970s onward, concentrations of several POPs in the Canadian environment decreased substantially. Because they resist chemical decomposition, however, the contaminants already in the environment continue to circulate and, for this reason, they are often referred to as legacy POPs.

The main groups of POPs discussed in this paper are PCBs, dioxins and furans, PBDEs, and DDT. The following notes are brief descriptions of each group of chemicals. Much more detail on chemistry, use, and regulation of these and other contaminants is available on Environment Canada websites.

- For PCBs, see the Waste Management Polychlorinated Biphenyls website: *www.ec.gc.ca/wmd-dgd/default.asp?lang=En&n=75C647A7-1*.
- For other substances, see the Management of Toxic Substances website: *www.ec.gc.ca/toxics/en/index.cfm*.

PCBs

Polychlorinated biphenyls (PCBs) are a class of stable, waxy to oily compounds that were used as heat-resistant coolants or insulators in electrical equipment, as plasticizers, solvents, and in several industrial processes. There are 209 different forms or congeners of PCBs. Congeners are variants on a common chemical structure; although related, they differ in toxicity and their fate in the environment. The PCBs sold and used commercially were mixtures of congeners.

Manufacture, import, and most non-electrical uses of PCBs were banned in North America in 1977 and it was made illegal to release PCBs to the environment in 1985. Canadian legislation allows PCB-filled equipment to be used until the end of its service life, but handling, storage, and disposal are subject to stringent government requirements. As a result of these measures, the quantity of PCBs in use declined by 54% between 1992 and 2003 (Environment Canada 2005). Most PCBs now enter the environment through leaks or improper disposal of waste oils and electrical equipment.

PCBs have a wide range of toxic effects. They affect the immune, reproductive, neurological, and endocrine systems of mammals, including causing cancer (Safe 1993). One group of about a dozen congeners are structurally similar to the highly toxic dioxin 2,3,7,8-TCDD and have similar effects on immune systems and fetal development. The toxic effects of other PCB congeners stem from their metabolic breakdown into highly toxic intermediate compounds that affect thyroid and vitamin A physiology.

Dioxins and Furans

The dioxins (polychlorinated dibenzo-p-dioxins) consist of a group of 75 congeners; furans (polychlorinated dibenzo-p-furans) are a group of 135 congeners. The most toxic dioxin congener, 2,3,7,8-TCDD, is the standard for comparing the relative toxicity of similar compounds (see text box, “Toxic Equivalents”).

These compounds form as byproducts of industrial activities such as chlorine bleaching in pulp mills and incineration of waste. Dioxins and furans are structurally similar to PCBs and were also unintended contaminants of commercial PCB formulations and some herbicides. The 2,3,7,8-TCDD congener first appeared in sediments in the early 1960s when pulp mills converted to chlorine liquid bleaching.

Long-term exposure in mammals to 2,3,7,8-TCDD can affect reproduction, cause cancer and birth defects, damage the liver, and suppress the immune system (Environment Canada 1990). The US Environmental Protection Agency has classified 2,3,7,8-TCDD as a probable human carcinogen (ATSDR 1998). Because there is the potential for fish and shellfish to bioaccumulate dioxins and furans, people who eat large amounts of seafood may be at risk (reviewed in Ross and Birnbaum 2003).

TEFS & TEQS: TOXIC EQUIVALENTS

A system has been devised to estimate the combined toxic effect of the most common congeners of dioxins, furans, and PCBs. The system is based on the similarity between species in the physiological effects of toxicity. Each congener is assigned a toxic equivalency factor (TEF) relative to the most toxic dioxin (2,3,7,8-TCDD). The toxicity of a congener is calculated by multiplying its TEF by the concentration found in the environment to arrive at the toxic equivalent concentration or TEQ. The total toxicity of a PCB, dioxin, or furan mixture is estimated by summing the TEQs of the congeners.

PBDEs

Polybrominated diphenyl ethers (PBDEs) are widely used today as flame retardant chemicals in consumer products. One form used in polyurethane foam has been phased out, but others are added to plastics used in furniture upholstery, carpet backings, electrical insulation, computer and TV cases, and other consumer goods. PBDEs are less toxic than PCBs but are structurally similar and have similar environmental properties. They are generally soluble in fat and biomagnify within the food chain, but they are more susceptible to environmental degradation than PCBs. Mammalian toxicity of the 209 congeners of PBDEs is thought to increase as the number of bromine atoms in the molecule decreases (Gill et al. 2004).

The main source of PBDEs in the environment comes from consumer products during use and after disposal. PBDEs break down in water and sediment through microbial degradation and other processes (e.g., Gouin and Harner 2003). As PBDEs break down in the environment or in the tissue of animals they lose bromine atoms, which may transform them into more toxic, mobile, and bioaccumulative forms (research reviewed in Environment Canada 2006a). PBDEs enter the human body by ingestion or inhalation. They are suspected of causing cancer, decreasing thyroid hormone levels, and disrupting endocrine systems (McDonald 2002), causing liver toxicity, immune system effects (Gill et al. 2004), hyperactivity, and reproductive effects (Kuriyama et al. 2005).

Production of PBDEs ramped up during the 1970s. Three commercial mixtures of PBDEs have been manufactured: octaBDE, and pentaBDE, both of which were banned by the European Union (EU) and were discontinued in 2004 by the only North American manufacturer. The other mixture, decaBDEs, continues to be used around the world. Most (ca. 80%) is used in the plastics and electronics industry in the manufacture of circuit boards, wire coatings, and mobile telephone equipment. The remaining 20% of world use is for textiles, upholstery, cables, and insulation materials.

In December 2006, Environment Canada proposed the Polybrominated Diphenyl Ethers Regulations under CEPA, which would prohibit the manufacture of all PBDEs (none are currently manufactured in Canada) as well as the use, sale, and import of pentaBDE and two other less used forms, tetraBDE and hexaBDE (Canada, Department of Environment 2006). The proposed regulations do not ban the import or use of the most common mixture, decaBDEs, therefore a formal Notice of Objection has been filed by environmental groups.

Concentrations of PBDEs in animal tissue and human milk have been increasing steeply (Rahman et al. 2001; Hites 2004). In Canada, PBDEs have been found in human breast milk and blood, food, indoor and outdoor air, and water (Health Canada 2004a,b,c,d). A 2004 Health Canada study showed that Canadian women had the second highest concentrations of PBDEs in their breast milk in the world after women in the USA (Ryan 2004). Food represents the principal source of exposure for people, with breast milk accounting for 92% of the exposure for breast-fed infants (Ryan 2004; review of literature in Environment Canada 2006b). The effect of these residues in people, if any, is largely unknown.

DDT

The once commonly used pesticide DDT (dichlorodiphenyl trichloroethane) breaks down in the environment into DDE (dichlorodiphenyl dichloroethylene)—a highly persistent and endocrine disrupting chemical. DDE is produced in most animals when the body attempts to break down and excrete DDT; it was also a contaminant in DDT formulations. DDT was used in Canada to control biting insects and agricultural and forest pests from 1947 to 1969. It was banned after it was discovered that metabolites of the pesticide (mainly DDE) were bioaccumulating in tissue of predatory birds and causing egg-shell thinning and breakage. The use of DDT was banned in Canada in 1972 and its use is also currently prohibited in the United States and Europe. It continues to be used elsewhere in the world to control mosquitoes that carry malaria and on agricultural crops.

DDE residues from past pesticide use are still measurable in soil, sediment, and wildlife. These residues continue to be augmented by atmospheric transport of DDE from other continents where DDT is still in use.

ENDOCRINE DISRUPTING SUBSTANCES

Most of the POPs discussed in this report have endocrine disrupting properties in addition to other toxic effects. Endocrine disrupting substances (EDS) mimic or block vertebrate steroid hormones by interacting with hormone receptors in the body's hormone regulatory system. Typical effects include feminization of male animals or masculinization of females, eggshell thinning in birds, and disruption of vitamin A and thyroid hormone physiology in mammals. Although such effects were not suspected until research in the late 1980s began to raise questions, it is now a key area of research because of the health implications.

The EDS also appear to affect behaviour in many fish, mice, birds, and primates. Recent studies found changes in social and mating behaviour, increases in hyperactivity and aggression, impaired motor skills, and reduced ability to learn (Clotfelter et al. 2004; Zala and Penn 2004).

How Contaminants Move in the Environment

Contaminants enter the environment directly and indirectly through several routes. They may originate from a specific outlet ("point source"), such as a discharge pipe or smokestack from an industrial factory; they also may come from "non-point sources," which are the many and diffuse sources of pollutants, such as those carried off the land in urban or agriculture runoff or emitted to air from vehicle exhaust. They may also enter the atmosphere as vapours re-emitted from chemical residues already in the environment.

Once in the atmosphere, POPs can travel great distances before being deposited. They may be directly deposited on land or water by precipitation or on dust particles. The vapour form of contaminants may also enter water or snow through gas exchange processes. Once in the atmosphere, POPs travel on prevailing winds until the air masses reach cool regions, such as mountaintops and high latitudes, where the vapours condense into precipitation. The chemicals may accumulate in ice or snow until they are released into ecosystems through snowmelt and spring runoff (e.g., Li and Macdonald 2005). Many small lakes and reservoirs in the Rocky Mountains fed by glacial runoff contain concentrations high enough to affect wildlife at the top of the food chain (e.g., Hempel 2000).

ATMOSPHERIC TRANSPORT OF CONTAMINANTS IN SOUTHERN B.C.

A study to determine the relative contribution of global and local sources of airborne PCBs and PBDEs found that deposition of air pollutants onto coastal waters is likely to be an important first step in the contamination of marine mammal food webs (Noel et al. 2007). The study analyzed air and rain data collected in high-volume air samplers at two sites over the course of a year (2004). One site was at Ucluelet, a remote location on the west coast of Vancouver Island exposed to global contaminants from the Pacific; the other was on Saturna Island in the Georgia Basin, close to local sources of contaminants from industry and urban centres.

The study found that deposition of the heavier congeners of PCBs and PBDEs (decaBDE) was higher at Saturna, indicating local sources of contaminants. There were significant concentrations of decaBDE in rain and in particulates in the air, showing that it is readily transported atmospherically. Although models that trace air masses flowing across the Pacific showed that Asia is an important source of air pollutants, there are also regional sources of contaminants. Further research is underway to better document the importance of local air pollution in B.C.

INDICATORS

1. Key Indicator: Total on-site discharge of toxic substances in B.C., 2002–2005

The weight of toxic substances released into the environment is a pressure indicator. It is a measure of the pressure or stress on the environment from human activities that release contaminants into the environment. This indicator shows the reported discharges of toxic substances listed in Canada’s National Pollutant Release Inventory (NPRI).

Established in 1992, the NPRI now tracks release, disposal, and recycling of more than 300 pollutants by industrial, commercial, and institutional facilities. Legislated under the *Canadian Environmental Protection Act, 1999* (CEPA 1999), the NPRI requires companies to report annually to the government on releases and transfers of key pollutants. This information is available to the public in an annual report and through an online database. Polluters that meet specific reporting requirements (reporting thresholds) must report on the NPRI-listed contaminants they release. Reporting must identify any releases or transfers as waste whether to air, water, or land, injected underground, or transferred off-site for treatment, disposal, or recycling. Throughout this indicator, the term “total on-site discharge” will include both on-site releases and on-site disposal of contaminants.

THE NATIONAL POLLUTANT RELEASE INVENTORY

The NPRI list has been periodically restructured to incorporate more substances and different reporting thresholds. Since this indicator was last reported in 2002, the NPRI has adopted the following groupings of substances:

Part 1a: Core substances
Part 1b: Alternate threshold substances: This group includes heavy metals such as mercury, lead, and hexavalent chromium. These substances have lower reporting thresholds than the Part 1a substances (5 kg or 50 kg).
Part 2: Polycyclic aromatic hydrocarbons
Part 3: Dioxins and furans and hexachlorobenzene
Part 4: Criteria air contaminants
Part 5: Volatile organic compounds

For more information, the 2003 NPRI reporting guide is available at *www.ec.gc.ca/pdb/npri/2003guidance/guide2003/toc_e.cfm*.

Currently, anyone in Canada owning or operating a facility must report to NPRI if they fulfil both of the following criteria:

- They have employees working a total of 20,000 hours or more in the reporting year (or the facility was used for an activity to which the 20,000-hour employee threshold does not apply, such as biomedical waste incineration), and
- The facility manufactures, processes or otherwise uses any of the NPRI (Part 1a) substances in concentrations of 1% or higher and in quantities of 10 tonnes or more. The exceptions are NPRI substances considered to be byproducts, but the total weight of byproducts must also be included in the calculation of the 10-tonne threshold for each NPRI Part 1a substance. Certain substances have reporting thresholds lower than 10 tonnes.

Facilities that would report to NPRI include companies that make chemicals and chemical products, metal, mineral or rubber products, food products, textiles, electrical equipment, pulp and paper, cement. Companies involved in oil and gas extraction or mining and smelting activities report to NPRI, as do public utilities and companies with processes involving waste handling, incineration, wood preservation, printing, and other activities. Some types of facilities are exempt, such as educational and research institutions, vehicle repair shops, and those involved in growing and harvesting in the agriculture, forestry, and fisheries sectors.

Starting in 2000, facilities used for certain types of incineration and for wood preservation also reported to the NPRI whether or not they met the 20,000-hour threshold for working hours. In 2002 alternative thresholds were incorporated for cadmium, arsenic, lead, and hexavalent chromium. Requirements to report sulphur dioxide and 6 other criteria air contaminants (CACs) were added in 2002. More substances were added to the reporting list in 2003, including more volatile organic compounds, nonylphenol and related compounds. Starting in 2003, oil and gas wells and pumping stations were also required to report to NPRI, resulting in large increases in total number of facilities reporting. There were no significant reporting changes in 2004 and 2005.

This indicator deals with total on-site discharges of contaminants to the environment that are reported to NPRI as on-site releases and on-site disposal. These discharges can be unintentional (spills and leaks) or intentional releases (emissions to air from stacks, discharges to surface waters), or on-site disposal (to landfills, to underground injection) within the boundaries of the facility site.

Methodology and Data

Data for this indicator and the following supplementary information were obtained in early 2007 from Environment Canada's National Pollutant Release Inventory (NPRI): Communities Portal website at *www.ec.gc.ca/npri-inrp-comm/Home-WSBB01134D-0_En.htm* and from the NPRI database available through *www.ec.gc.ca/pdb/npri/npri_dat_rep_e.cfm*.

This indicator shows total on-site discharges (on-site releases and on-site disposal) reported to NPRI from 2002 to 2005 for British Columbia. Trends for earlier years are shown in Environmental Trends in British Columbia: 2002 (BCMWLAP 2002). They were not included here because there have been so many changes in reporting that totals for later years are not comparable with earlier years.

Most substances reported in this indicator are NPRI Part 1 substances; these are all reported in tonnes and account for most of reported substances. Sulphur dioxide, a Part 4 substance (criteria air contaminant), is included in the calculations with the Part 1 substances because of the large quantity that is discharged and its importance as an environmental contaminant. Other substances listed in Parts 2, 3, and 4 were not included because they are reported at different thresholds, such as kilograms, grams, or toxic equivalents, rather than tonnes.

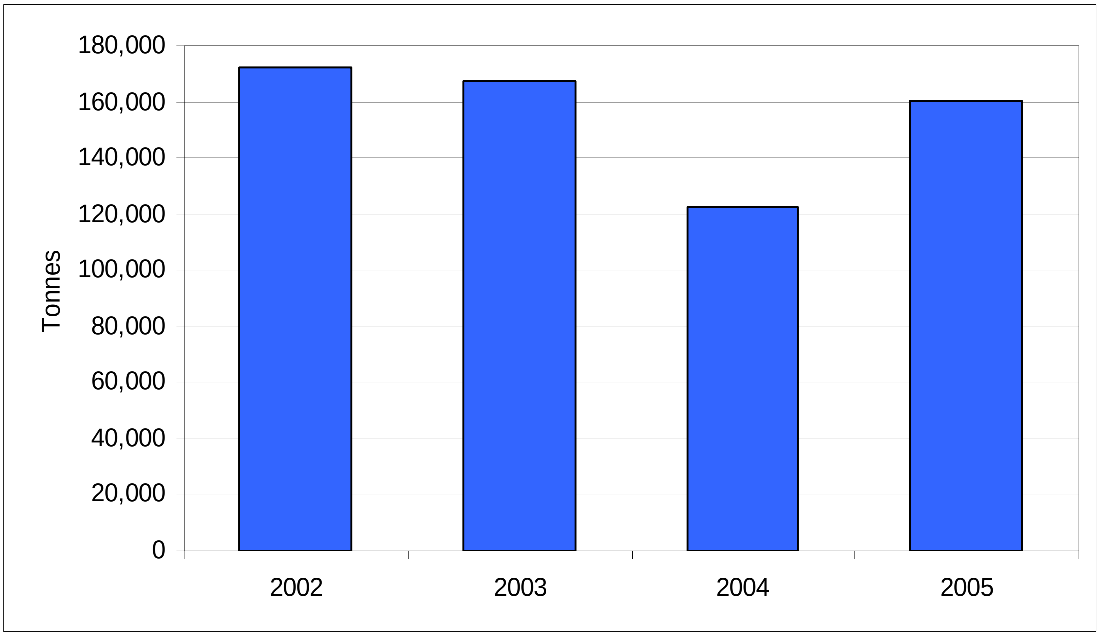
"Off-site discharges" includes pollutants transferred from a facility to another location, such as for disposal in landfill or for storage, application to land off-site, or injection underground off-site. Data on off-site discharges are shown in Table 1, but they are not added to the total on-site discharges shown in Figure 1 to avoid double counting. Because both originating and receiving facilities may be required to report to NPRI, some quantities would be double reported. For the same reason, substances sent off-site for recycling or to generate energy are not included in the Figure (see Figure 2 for hydrogen sulphide recycling data).

For NPRI reporting:

- Burial of wastes in an on-site landfill is reported as an on-site disposal. If an NPRI pollutant is transferred to an off-site landfill, it is reported as an off-site transfer for disposal.
- On-site land treatment is reported as an on-site release. It is also called land application farming, where the waste is incorporated into soil for biological degradation. This type of treatment method is usually approved under provincial jurisdiction.
- Underground injection is included as a method of on-site disposal for H_2S from acid gas extracted from natural gas. Subject to provincial regulation, these gases are injected into known geological formations at great depths, usually at the site of origin.
- Discharges to municipal wastewater treatment plants are reported as off-site transfers for treatment and are not included in the on-site figures.

Total on-site releases (including disposal) of NPRI substances are B.C. is shown in Figure 1 and Table 1.

Figure 1. Total on-site discharge (on-site release + on-site disposal) in B.C. of NPRI Part 1 substances plus sulphur dioxide, 2002–2005.



Source: The National Pollutant Release Inventory (NPRI), Environment Canada, 2007, *www.ec.gc.ca/pdb/npri/npri_dat_rep_e.cfm*.

Note: Lower figures in 2004 resulted from more hydrogen sulphide transferred off-site to be injected underground than in other years.

View graph data in excel.

Table 1. Total on-site discharge (on-site release + disposal) of contaminants in B.C., 2001–2005 (in tonnes, rounded to nearest tonne).

Year	Air release	Water release	Land release	Total on-site release	On-site disposal	Total on-site discharges (releases + disposal)	Off-site disposal	Recycle	# of facilities
2002	62,797	14,657	0	76,154	96,116	172,270	2,258	879,021	389
2003	68,568	13,835	7	83,346	84,238	167,584	2,524	774,413	444
2004	74,693	13,734	36	88,470	34,239 *	122,709	51,347*	806,671	450
2005	71,909	13,539	50	85,506	74,656	160,162	11,849	851,338	466

Source: The National Pollutant Release Inventory (NPRI), Environment Canada, 2007, *www.ec.gc.ca/pdb/npri/npri_dat_rep_e.cfm*.

Note: Total releases may be greater than the sum of the releases by environmental medium, since releases of less than 1 tonne could be reported as undifferentiated total releases.

* In 2004 more hydrogen sulphide was transferred to off-site injected locations than in other years; total injected hydrogen sulphide, on- and off-site, remains similar each year.

No releases of Part 1 substances to land were reported for 2002. Because manganese is the major reported substance released to land, records for all facilities that reported manganese releases to land in 2005 were checked to verify that no releases were reported to land for 2002.

The 12 toxic pollutants released on-site in the largest quantities in B.C. between 2002 and 2005 were: ammonia, chlorine dioxide, hydrochloric acid, hydrogen fluoride, hydrogen sulphide, manganese, methanol, nitrate, styrene, sulphur dioxide, sulphuric acid and zinc (Table 2).

In 2005, the pollutants released in the largest quantities on-site in B.C. (Table 2) were:

- Hydrogen sulphide (74,225 tonnes, accounting for 46% of B.C.'s total), a flammable poisonous gas that is removed as an impurity by natural gas extraction facilities and injected underground into reservoirs.
- Sulphur dioxide (61,099 tonnes or 38% of the total), a toxic, colourless gas, used in pulp and paper mills, ore refining, and as a solvent. It irritates the respiratory system and plays a part in acid rain. The increasing quantities reported since 2002 likely come from the increasing number of new wells drilled and increased economic activity in other sectors, such as aluminum smelting.
- Ammonia (14,058 tonnes, just under 9% of the total), which is released as a colourless gas to air or in an aqueous solution to water by wastewater treatment facilities and, in lesser amounts, by pulp and paper facilities. Ammonia gas is extremely corrosive and irritating to the skin, eyes, nose, and respiratory tract. Exposure to high concentrations (above approximately 2500 ppm) is life threatening, causing severe damage to the respiratory tract, resulting in bronchitis, chemical pneumonitis, and pulmonary edema.
- Methanol (4,941 tonnes, about 3% of the total), a flammable poisonous liquid that is used during processing and manufacturing by the paper and allied products industry. It is also a

byproduct of this industry, formed during biological decomposition of biological wastes and sludge. The oil and gas industry also uses methanol to prevent the water in the gas from freezing in the pipeline. Methanol is not known to be carcinogenic but has short and long-term health effects.

Table 2: Total on-site discharge of selected toxic substances in B.C. (in tonnes, rounded to nearest tonne).

	Amount discharged (tonnes)			
Substance	2002	2003	2004	2005
Hydrogen sulphide	95,960	84,307	33,042	74,225
Sulphur dioxide	50,880	58,305	64,534	61,099
Ammonia	12,486	12,880	12,961	14,058
Methanol	5,692	6,241	5,701	4,941
Hydrochloric acid	2,095	1,814	1,609	1,745
Manganese	1,221	1,032	1,305	1,240
Nitrate	1,328	1,477	1,403	1,097
Styrene	410	524	534	746
Hydrogen fluoride	328	449	493	398
Zinc	229	264	277	256
Chlorine dioxide	116	150	146	181
Sulphuric acid	1,525	139	118	175
Total	172,260	167,582	122,123	160,161
# of facilities reporting	389	444	450	466

Source: National Pollutant Release Inventory, Environment Canada, 2007, *www.ec.gc.ca/pdb/npri/npri_dat_rep_e.cfm*.

In 2005, 466 facilities in British Columbia reported on-site release and disposal of 160,161 tonnes of toxic contaminants to the National Pollutant Release Inventory (NPRI). The number of facilities reporting increased from 389 in 2002 to 466 in 2005.

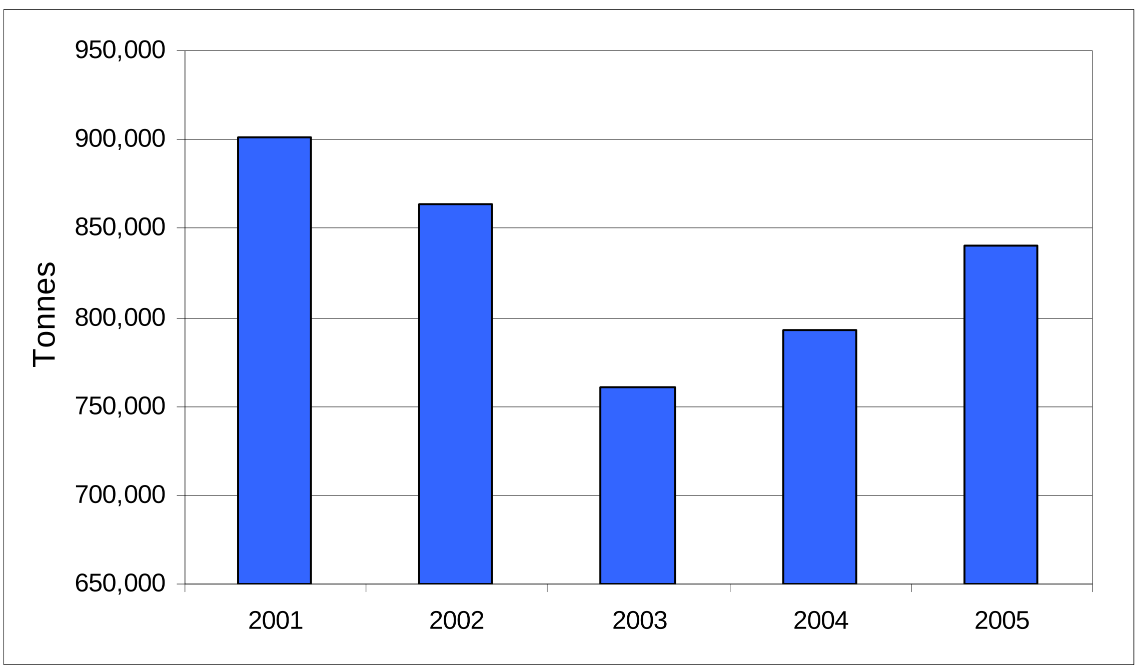
Since its inception in 1993 the NPRI reporting requirements have been continually adjusted and the list of substances expanded. In some cases, these changes result in reported increases in on-site releases even though facilities were not actually releasing higher amounts of contaminants than in previous years. For example, there was a sudden large increase in reported on-site releases in 1999 when 73 new substances were added to the NPRI. The 2002 to 2005 period was stable in terms of what substances were reported under Part 1.

The quantity of NPRI pollutants released to the environment does not show all pollutants entering the environment. Other substances, such as greenhouse gases, pesticides, and substances already scheduled for phase-out or that have been banned (e.g., chlorofluorocarbons and PCBs) are not included on the list. There are many smaller or non-point sources that release less than the reporting threshold of 10 tonnes. Such sources include cars and other vehicles, construction equipment, gas stations, dry cleaners, and other small facilities. The emissions from small facilities that do not meet reporting requirements may collectively account for the majority of releases of some pollutants. This shortcoming was partially addressed in 2000 when different thresholds were established for reporting some highly toxic substances that are usually released in small quantities. There are also natural sources, such as forest fires, that release pollutants into the environment, which are not captured.

Supplementary Information: Recycling NPRI substances

Part of the substances recorded as off-site transfers are sent for recycling, reuse or to be used as an energy source. Pollutants are sent off-site to recover solvents, acids and bases, metals and inorganic materials, for refining or reuse of used oil, and other recycling. In 2005 in British Columbia, more than 840,000 tonnes of hydrogen sulphide, which is a byproduct of the natural gas industry, were transferred off-site for recovery (Figure 2). Hydrogen sulphide is corrosive and is removed from the gas to meet safety and environmental protection requirements. For recycling, it is pelletized and made into sulphuric acid for use in fertilizer manufacturing, ore processing and oil refining, waste water processing, and other industries. Other substances that are recycled include copper, zinc, and lead.

Figure 2. Amount of hydrogen sulphide recycled in B.C., 2001–2005.



Source: The National Pollutant Release Inventory (NPRI), Environment Canada, 2007, *www.ec.gc.ca/pdb/npri/npri_dat_rep_e.cfm*.

View graph data in excel.

Supplementary Information: On-site toxic substance releases in Canada in 2005, by province and territory

In 2005, British Columbia ranked fourth in Canadian jurisdictions in total reported on-site pollutant releases and disposal, accounting for about 12% of the Canadian total (Table 3).

Table 3. Total on-site releases and disposal of toxic pollutants in Canada 2005, by province and territory.

Jurisdiction	Total releases +on-site disposal (tonnes)	% of national total
Alberta	1,427,811.2	29.4%
Ontario	1,030,774.4	21.3%
Quebec	677,172.8	13.9%
British Columbia	576,172.7	11.9%
Manitoba	435,041.3	9.0%
Saskatchewan	269,053.9	5.5%
Nova Scotia	179,782.6	3.7%
New Brunswick	152,370.0	3.1%
Newfoundland	90,061.5	1.8%
NWT	8,903.6	0.2%
Nunavut	5,168.8	0.1%
PEI	2,659.4	<0.1%
Yukon	146.3	<0.1%
Canada	4,855,118.6	

Source: The National Pollutant Release Inventory (NPRI), Environment Canada, 2007. *www.ec.gc.ca/pdb/npri/npri_dat_rep_e.cfm*.

Notes: Figures include on-site releases to air, water, land, and underground. Waste transfers off–site for disposal, recycling, or reuse are not included.

2. Secondary Indicator: Trends in dioxin and furan levels in pulp and paper mill effluent, sediments, and Dungeness crab tissues

This is both a pressure and a response indicator. It shows the past pressure on the environment from dioxins and furans in pulp mill effluents and the results of the societal response by governments and industry to eliminate this pressure on the environment. The indicator addresses the questions: What is the impact of industrial pollutants released to the environment? Are efforts to protect the environment from industrial pollutants effective? This indicator has been reported in previous Environmental Trends and recently in greater detail in the B.C. Coastal Environment: 2006 report (BCMOE 2006), and is therefore summarized here.

When elevated dioxin and furan concentrations were found in fish and shellfish collected near coastal pulp and paper mills in the late 1980s, investigation showed that the chemicals were being generated as a byproduct of the pulp bleaching process. Both the federal and provincial government then introduced regulations to control dioxin and furan discharges. This indicator shows the effect of regulatory measures and changes in mill technology as industry complied.

Methodology and Data

Data for this indicator were collected under two federal programs:

- The Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations (1992), of the *Canadian Environmental Protection Act*.
- The Coastal Mills Dioxin and Furan Trend Monitoring Program.

In 1991, nine pulp and paper mills discharged secondary-treated effluent to B.C.'s coastal waters and were included in the monitoring program. Since then, some mills have closed and others have switched to bleaching technology that does not use elemental chlorine. By 2002, six mills and by 2004 only three mills required annual monitoring.

Results from sampling programs for effluent loadings of dioxin, dioxin and furan concentration in sediments near mill outfalls, and dioxin and furan concentrations in crab hepatopancreas tissue are shown in Figure 3. Due to the low levels, mill effluent monitoring for dioxin/furans is now conducted at 3-year intervals, so no new data were available for updating the graph.

Data tables for the graph and more details on methodology are reported in the Industrial Contaminants paper published as part of the British Columbia Coastal Environment: 2006 report (*www.env.gov.bc.ca/soe/bcce/02_industrial_contaminants/technical_paper/industrial_contaminants.pdf*).

Figure 3 illustrates the correlation between the steep decline in dioxin concentrations in mill effluents and the improvement in concentrations in local sediment and crab tissue.

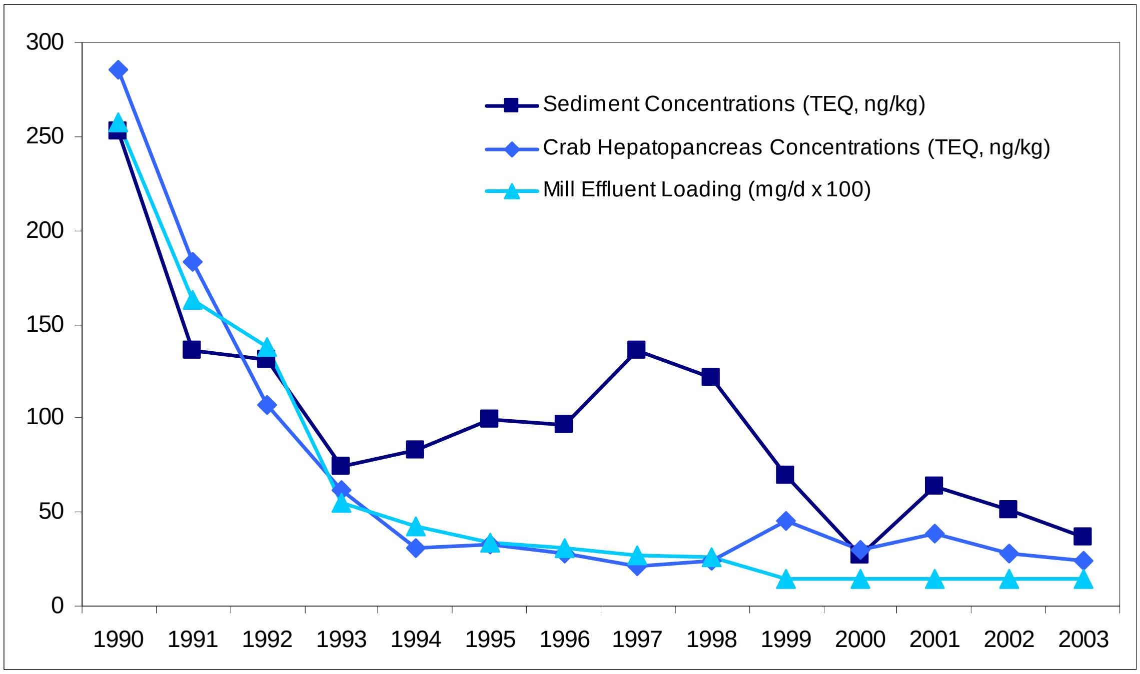
Changes in technology and processes brought about a 95% drop in total daily loading from all coastal B.C. pulp and paper mills for 2,3,7,8-TCDD in effluents. After 1999, 2,3,7,8-TCDD was not detectable in the effluent of any mills. At the same time, total daily loadings for the furan 2,3,7,8-TCDF also declined by more than 99% by 2004. Both substances are now present only in minute quantities that fall within federal discharge limits.

The improvement in effluent quality was reflected in a rapid decline in levels of dioxins and furans in the environment (sediments) and local organisms (crabs). Contamination in crabs near outfalls closely tracked the drop in concentrations in effluent. Contamination in sediment dropped, but not as rapidly as in crab tissue, in part because dioxins and furans have a strong affinity for sediments and break down very slowly.

This indicator shows that measures taken to eliminate this source of persistent contaminants in the marine environment have been effective. The continuing low, relatively stable, levels of dioxins and furans in sediments and crab tissue also show how persistent these chemicals are. It may also indicate that there is a continuing low level of input of dioxins and furans from other sources (e.g., regional incinerators and other local combustion, global atmospheric transport).

Unfortunately, given their persistence, low levels of dioxins and furans will remain in the environment for many years.

Figure 3. Total 2,3,7,8-TCDD loadings in pulp mill effluents from all mills reporting at each date, and dioxin and furan concentrations in sediments near the outfall and in crab hepatopancreas, 1990–2003.



Source: Pollution Prevention and Assessment, Environmental Protection, Environment Canada, 2005.
Note: Number of mills reporting: 9 mills for 1990–1997; 8 mills in 1998; 4 mills for 1999–2003.

View graph data in excel.

3. Secondary Indicator: Cleanup of contaminated sites in B.C.

This is a response indicator showing a societal response to the problem of industrial contamination. It addresses the question: What is being done about environmental contamination?

An area is considered contaminated if the site is unsuitable for specified land or water uses. Such sites may have become contaminated through spills or through deposits of chemicals during the course of commercial and industrial activity. At some locations, toxic substances in soil, surface water, and groundwater are a threat to the environment and human health. Contaminated sites can release toxic substances into the surrounding environment, infiltrating the food chain, entering the groundwater, and contaminating neighbouring areas. Many sites were contaminated by past activities, up to a century or more ago, before the impact of such activities was known.

The contamination affects both land and water, and the size of contaminated sites ranges from less than a hectare to several square kilometres. The largest single source of site contamination in B.C. has been activities related to fossil fuels and vehicles, such as petroleum and natural gas storage and distribution, and vehicle salvage and wrecking. Heavy metals such as lead, arsenic, cadmium, and mercury are also common at contaminated sites in B.C. Organic chemicals, including benzene and toluene from gasoline, occur at about two-thirds of the sites. Chlorophenols are found where wood treatment operations took place, as are benzo[a]pyrene and naphthalene from creosote. PCBs often occur at sites where heavy electrical equipment was used.

With the exception of federally managed sites, the B.C. Ministry of Environment is responsible for managing contaminated sites in the province. The Ministry ensures that site managers meet cleanup requirements to restore damaged lands to standards set out in the B.C. *Environmental Management Act*. The standards include requirements for protecting human health and improving ecosystem health by reducing or eliminating toxic materials and by performing other activities to return land to a condition suitable for more general use.

Methodology and Data

The B.C. Ministry of Environment has been collecting information on contaminated sites since 1988. The Contaminated Sites Registry was created in 1997 to provide public access to information on sites that are, or were, contaminated and the current status of the cleanup or remediation of the site. Not all of the sites entered in the Registry are necessarily contaminated: some were found to be clean after they were registered, and others were contaminated at one time but were remediated before being entered in the Registry. The Registry also contains sites awaiting complete assessment, for which the degree of contamination has not been determined.

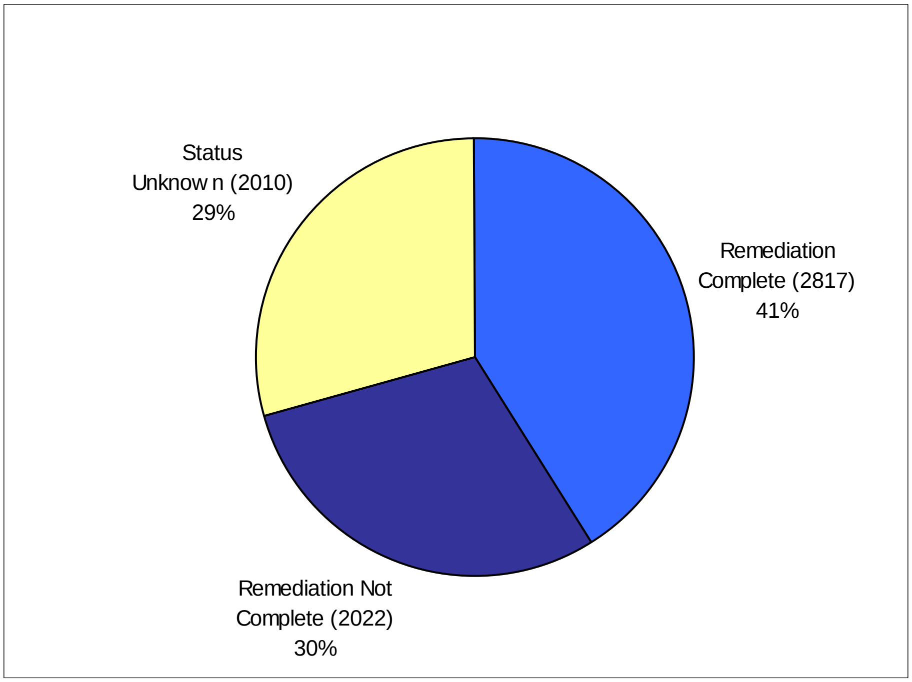
The Contaminated Sites Registry does not contain all contaminated sites in the province. Local governments, for example, can opt out of the registry program but must register a site if remediation is underway or if it is being decommissioned. Contaminated sites under federal jurisdiction (e.g., on federal Crown land) are also managed separately (see Supplementary Information, below); 268 of the federally managed sites in B.C. are included in the provincial Sites Registry.

For this indicator, the number of all contaminated sites was obtained from the Registry records. The proportion of the total sites was determined for which remediation is complete, in process, or for which a complete assessment is pending (Figure 4).

As of June 2007, 6,849 sites were registered in the whole province; 2,817 sites had been remediated and 2,022 were listed as actively under remediation. The remainder were contaminated sites for which assessment had not been completed.

More information on provincial contaminated sites remediation and regulation is available at *www.env.gov.bc.ca/epd/epdpa/contam_sites/*.

Figure 4. Remediation status of contaminated sites in B.C. recorded in the Contaminated Sites Registry.



Source: Data from Contaminated Sites Registry, B.C. Ministry of Environment, 2007.

View graph data in excel.

Interpretation

There is no way to know how many, as yet unregistered, contaminated sites exist in the province. However, since the Ministry of Environment's Site Registry started, 41% of the known contaminated sites entered in the registry have been remediated and 30% are actively under remediation. In total, about 70% of the known contaminated sites in B.C. that were registered in the Sites Registry have met, or are in the process of meeting cleanup requirements under the B.C. *Environmental Management Act*.

Supplementary Information: Federal Contaminated Sites

The figures used in the indicator above do not include contaminated sites under federal jurisdiction, which are maintained in a separate federal contaminated sites inventory. Table 4 shows the status of federal contaminated sites in B.C. as of July 2007. The federal process of assessment, planning, remediation, and long-term monitoring is broken down into a 10-step process (for more information, see *www.ccme.ca/assets/pdf/ntnl_clssfctn_system_e.pdf*). The federal system does not use the same categories as the provincial SITE database, so the steps in the federal process that correspond to provincial categories are listed in the table.

Table 4: Status and number of B.C. contaminated sites in the Federal Contaminated Sites Inventory.

Status	Number of sites	Steps in federal process
Unknown/To be determined [a]	1368	Steps 1 to 6
Remediation not yet begun (includes sites for which a remediation plan is being developed)	112	Step 7
Remediation in progress (only sites for which a remediation plan is being implemented)	525	Steps 8 & 9
Remediation complete	131	Step 10
Total	2136	

Source: Federal Contaminated Sites Inventory: *www.tbs-sct.gc.ca/fcsi-rscf/*. Figures shown were current July 6, 2007; numbers change daily as reporting organizations update site data.

[a] Includes 204 records in “Highest step not reported” category.

As with provincial contaminated sites, the most common contaminants for sites providing this information are petroleum hydrocarbons and PAHs, heavy metals, metalloids (intermediate elements such as arsenic and selenium), and other metallic compounds. Soil is the most commonly contaminated media, followed by groundwater and sediment (CSMWG 1999).

4. Key Indicator: Long-term trends in persistent organic pollutants in bird eggs in B.C. (Great Blue Heron, Cormorant, Osprey)

This is a pressure indicator and also a response indicator. It shows the pressure on bird species from both the older persistent chlorinated pollutants (dioxins and furans, PCBs, pesticides) and from the more recently released polybrominated diphenyl ethers (PBDEs) in the environment. The trends in contaminant levels of the older compounds also show the effects of societal efforts to respond to the problem. It addresses the questions: What is the impact of persistent pollutants in the environment? Are efforts to protect the environment from industrial pollutants effective?

Trends in time and in regional environmental contamination, including contamination in other species, can be evaluated by measuring contaminant concentrations in eggs of birds. This indicator reports a summary of data compiled from monitoring programs for contaminants in bird eggs carried out by the Canadian Wildlife Service of Environment Canada, in some cases since the early 1970s.

The indicator compares toxic levels in eggs of three species of birds that use different habitats in several areas of British Columbia. Herons, cormorants, and osprey feed mainly on fish, therefore changes in the amount of contaminants entering the food chain rapidly show up in their prey and then in their eggs.

Methodology and Data

The Canadian Wildlife Service of Environment Canada (CWS) has been monitoring contaminant compounds in bird eggs since the 1970s. Compounds reported in this indicator are industrial organochlorines (PCBs, dioxins and furans, and PBDEs) and organochlorine pesticides (DDE, chlordane, dieldrin). For descriptions of the properties and sources of these compounds, see the introductory section of this paper.

The levels of contaminants in bird eggs were usually determined by the Environment Canada national laboratory using methods of the period. One exception is the PBDEs that were recently analyzed in archived samples by a private laboratory (Elliott et al. 2005). Not all contaminants were measured in each year or for each species. Unused portions of samples are maintained in a tissue bank, which facilitates analysis and retrospective trends to be assessed as new contaminants are identified. Specific methods for analyzing eggs are described in detail in Elliott et al. (1998, 2000, 2001, 2005); and Harris et al. (2003a,b, 2005).

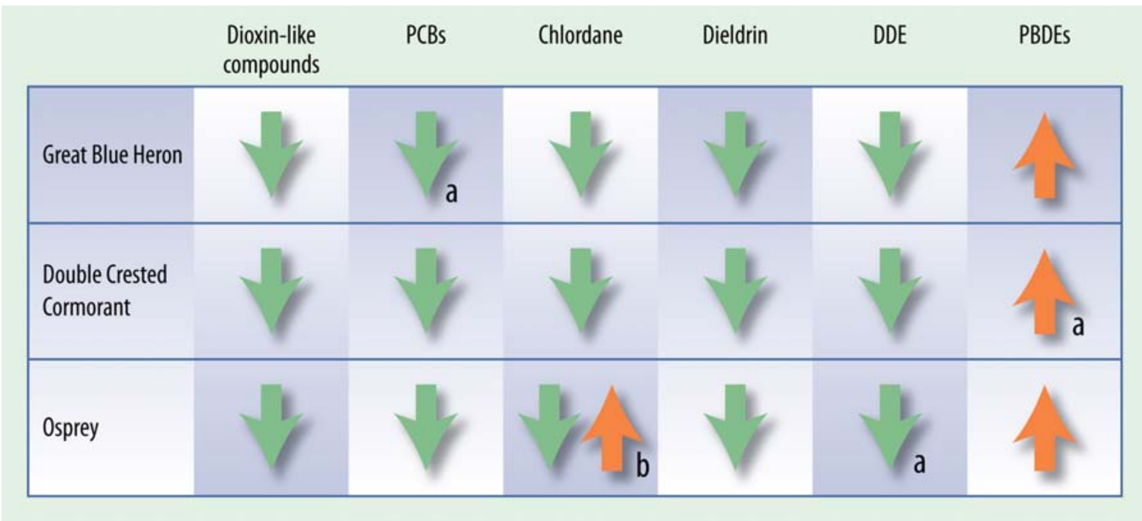
The sum of PCBs is the sum of 31 to 51 PCB congeners, except for samples collected in early years where estimated PCBs were derived from relationships with measured Aroclor (Aroclor was a technical mixture of PCBs used until 1977). Concentrations of dioxin-like compounds (includes polychlorinated dibenzodioxins, PCDDs; polychlorinated dibenzofurans, PCDF; non-ortho PCBs) are presented as toxic equivalent concentrations (TEQs) on a wet weight basis using standard conversion factors for birds (Van den Berg et al. 1998). (Note: these TEQs are not comparable to data reported in Indicator 5 for marine mammals, which uses TEQs based on lipid weight.) PBDEs are the sum of 18 congeners, as listed in Elliott et al. (2005).

Great Blue Heron (*Ardea herodias*): Herons feed mainly on small fish, and changes in the amount of contaminants entering the food chain are rapidly reflected in contaminant levels in their prey, and later in their eggs. The coastal populations of herons are year-round residents although they move small distances between different seasonal preferred forage grounds. Contaminants in their eggs therefore reflect local conditions of the intertidal and estuarine forage sites near each colony. The CWS has monitored toxins in more than 20 Great Blue Heron colonies since the 1970s. Three colonies in the Georgia Basin were chosen for in-depth monitoring: a University of British Columbia colony, which reflects non-point source urban pollution; a Nicomekl colony, representing a rural habitat that should be less exposed to industrial contaminants; and a Crofton colony, chosen to reflect point-source pollution from a nearby pulp and paper mill (Table 5).

Double-crested Cormorants (*Phalacrocorax auritus*): Cormorants specialize on foraging prey (fish, crustaceans) from the waters and sea floor in the intertidal (littoral-benthic) zone. Contaminant levels in their eggs tend to reflect contaminant burdens in the sedimentary deposits in this zone. Cormorants are also resident birds, although their movements during non-breeding season may be over a somewhat greater distance than herons. CWS began monitoring toxins in Double-crested Cormorant eggs from the colony on Mandarte Island in the Georgia Basin in 1970 (Table 6).

Osprey (*Pandion haliaetus*): Osprey are a migratory species that winters in Mexico and Central America. Osprey return to nesting sites in the Pacific Northwest approximately a month before laying eggs. In that time they consume large amounts of fish from the local river systems, therefore, contaminants in their eggs largely reflect local environmental conditions. CWS monitored toxins in Osprey eggs from upstream and downstream of pulp mills located at Kamloops on the Fraser River and Castlegar on the Columbia River in the early and late 1990s (Table 7).

Figure 5: Contaminant trends in bird eggs in British Columbia from earliest sample year to most recent sample year (range 6-32 years).



Note: (a) Contaminants increased mid-cycle of trend period; (b) chlordane levels increased in Osprey on Fraser River but decreased in Osprey on Columbia River to a much greater extent.

Tables 5, 6, and 7 report total PCBs, dieldrin, and DDE as presented in published papers, and dioxin-like compounds and sum chlordane values recalculated by summing averages reported in the published papers (details and references are in the table footnotes).

Table 5. Summary of contaminants in Great Blue Heron eggs in B.C., comparing concentrations in first year and most recent year of monitoring.

	UBC		Nicomekl		Crofton	
Contaminant	Year		Year		Year	
Dioxin-like compounds (TEQs ng/kg wet weight)	1983	208	1983	100	1983	495
	1998	58	1990	120	1994	44
Sum PCBs * (mg/kg wet weight)	1977	9.57	1977	1.67	1983	0.456
	1998	43.4	1999	0.312	1986	0.912
	2000	1.09			1994	0.435
DDE (mg/kg wet weight)	1977	2.82	1977	0.914	1983	0.333
	2000	0.359	1999	0.212	1995	0.102
Dieldrin (mg/kg wet weight)	1977	0.098	1977	0.029	1983	0.005
	2000	0.016	1999	0.013	1995	<0.0001
Sum chlordanes (mg/kg wet weight)	1977	0.102	1977	0.093	1983	0.018
	2000	0.038	1999	0.044	1995	0.018
PBDEs (µg/kg wet weight)	1987	12.5				
	2002	455				

Source: All data from Canadian Wildlife Service studies: Great Blue Herons: Elliott et al. 2001, 2005; Harris et al. 2003a.

Notes: Dioxin-like compounds: used column titled “estimated TEQs”; Sum chlordanes: summed averages for up to 5 of 6 chlordanes, when measured (includes: trans-nonachlor, cis-nonachlor, oxy-chlordane, cis-chlordane, heptachlor epoxide; does not include trans-chlordane).

* Three years of data are provided where there was a marked peak in contaminant levels between first and last year of monitoring. Data presented as geometric means.

Table 6. Summary of contaminants in Double-crested Cormorant eggs in B.C., comparing concentrations in first year and most recent year of monitoring.

	Mandarte Island	
Contaminant	Year	
Dioxin-like compounds (TEQs ng/kg wet weight)	1973	524
	1998	106
Sum PCBs (mg/kg wet weight)	1970	12.5
	2002	0.48
DDE (mg/kg wet weight)	1970	4.07
	2002	1.38
Dieldrin (mg/kg wet weight)	1970	0.040
	2002	0.007
Sum chlordanes (mg/kg wet weight)	1970	0.035
	2002	0.017
PBDEs * (µg/kg wet weight)	1979	0.24
	1994	385
	2002	62.5

Source: All data from Canadian Wildlife Service studies: Double-crested Cormorant: Harris et al. 2003b, 2005; Elliott et al. 2005.

Notes: Dioxin-like compounds: added 2 columns (Σ PCDD+PCDF TEFs and Σ PCB TEFs); Sum chlordanes: average of all 6 chlordanes.

* Three years of data are provided where there was a marked peak in contaminant levels between first and last year of monitoring. Data presented as geometric means.

Table 7. Summary of contaminants in Osprey eggs in B.C., comparing concentrations in first year and most recent year of monitoring.

	Upstream Kamloops		Downstream Kamloops		Upstream Castlegar		Downstream Castlegar	
Contaminant	Year		Year		Year		Year	
Dioxin-like compounds (TEQ ng/kg wet weight)	1991	25	1991	65	1991	28	1991	88
	1997	18	1997	13	1995	29	1997	35
Sum PCBs (mg/kg wet weight)	1991	0.366	1991	0.297	1991	0.612	1991	2.360
	1997	0.251	1997	0.199	1995	0.996	1997	1.240
DDE * (mg/kg wet weight)	1991	1.170	1991	1.650	1991	1.910	1991	1.820
	1997	1.190	1995	3.170	1995	1.010	1993	3.770
			1997	0.706			1997	1.100
Dieldrin (mg/kg wet weight)	1991	0.0001	1991	0.0007	1991	0.0026	1991	0.0044
	1997	0.0001	1997	0.0002	1995	0.00005	1997	0.0003
Sum chlordane (mg/kg wet weight)	1991	0.0016	1991	0.0028	1991	0.0365	1991	0.0358
	1997	0.0038	1997	0.0044	1995	0.019	1997	0.0096
PBDEs (µg/kg wet weight)					1991	18.4	1991	7.84
							1997	195

Source: All data from Canadian Wildlife Service studies: Osprey: Elliott et al. 1998, 2000, 2005.

Notes: Dioxin-like compounds: TEQs calculated using averages of 2378-TCDD, 12378-PnCDD, 123678-HxCDD, 1234678-HpCDD, OCDD, 2378-TCDF, 23478-PnCDF and CBs 77, 126, 169, 118, 105. Sum chlordanes: summed average of r-chlordane (includes trans-nonchlor, cis-nonachlor, oxychlordane, trans-chlordane, cis-chlordane) and average of heptachlor epoxide.

* Three years of data are provided where there was a marked peak in contaminant levels between first and last year of monitoring. Data presented as geometric means.

PCBs, dioxin-like compounds: Monitoring shows that concentrations of PCBs and dioxin-like compounds have decreased in heron eggs since their use was banned or restricted in the late 1970s through the early 1990s (Table 5). The Crofton heron colony was the most contaminated by dioxins and furans, which were coming from the nearby pulp and paper mill. The drop in egg contamination coincides with changes in pulp mill technology in the 1990s that eliminated these contaminants from effluent (see Indicator 2: Trends in dioxin and furan levels in pulp and paper mill effluent). The UBC colony, which forages in the Fraser River estuary, showed high exposure to PCBs, which likely originated from a variety of non-point and point sources in the urbanized region. Over the years, the decline in PCBs in bird eggs has occurred reflecting changes in ambient environmental levels. The lower levels of all contaminants in eggs from the

Nicomekl colony are consistent with what would be expected for a rural colony away from direct urban or industrial influence.

The Double-crested Cormorant colony at Mandarte Island show a similar history of declining concentrations of PCB and dioxin-like compounds measured in eggs (Table 6).

Over the 1990s the PCB levels in Osprey eggs have declined along both riverways (Table 7). PCBs are likely higher in the Columbia than in the Fraser River Basin due to extensive hydroelectric generation and related industries (PCBs were used in electrical insulating fluids until the early 1970s). PCBs burdens in Osprey in the late 1990s are much lower than levels measured in herons at UBC during the same time period (50–100fold). Dioxin-like compounds in Osprey eggs collected from the Fraser and Columbia River Basins decreased substantially between 1991 and 1997. This decline was most evident downstream of pulp mills, such as the areas downstream of Kamloops and Castlegar. Again, levels are much lower than concentrations observed in the herons/cormorants in the Georgia Basin.

PBDEs: The bird egg monitoring shows the recent and increasing threat from PBDEs in the environment with concentrations increasing rapidly. Mean concentration of PBDEs was 455 ng/g wet weight in the heron eggs from the UBC colony in 2002. At some locations, concentrations of the most toxic PBDE congener (penta-dibromodiphenyl ether) in fish are approaching levels potentially toxic to fish-eating birds (Elliott et al. 2005). Although production of the octa- and penta- mixtures of PBDEs was banned by the European Union and voluntarily discontinued by the only North American manufacturer in 2004, the decaBDEs are still in use. Recent regulations proposed in Canada would ban manufacture of all PBDEs, including decaBDEs, but would not ban the import of decaBDEs.

Organochlorine pesticides: Monitoring shows that overall concentrations of DDE, dieldrin, and chlordane in herons, cormorants and osprey have been declining over time since regulations banning their use were implemented. As with the industrial contaminants described above, there are local differences in concentration, with the greatest concentrations of those pesticides found in cormorant eggs from Mandarte Island and heron eggs from UBC. All of these pesticides were used in urban environs for insect control, but the predominant source was most likely commercial upstream agricultural activities. The variable levels of DDE in Osprey suggest exposure may have occurred outside of the breeding grounds because there are no evident local sources.

In birds, the impact of organochlorine pesticides is apparent in thinner eggshells, which are easily damaged, lowering reproductive success. Shell thickness has increased at all three heron colonies (UBC, Crofton, and Nicomekl) since 1987 (Harris et al. 2003a), which coincides with the reduction in use of these pesticides. Permits for most uses of chlordane were suspended in 1985; use as a termite control was discontinued in 1995. The sale of dieldrin was heavily restricted in the mid-1970s, with its last registered use in Canada in 1984.

Interpretation

Long-term monitoring of contaminants in bird eggs shows that, in general, overall levels of the older, so-called legacy POPs have decreased in the environment since the 1980s. This is consistent with efforts to phase-out and eliminate these compounds, which began in the late 1970s and became more stringent in the 1980s and 1990s. The continued presence of these compounds in eggs, however, and the fact that in some cases concentrations are quite variable among individuals many years after they are no longer used in Canada, shows the very long persistence of the chemicals in the environment and the ongoing atmospheric deposition of compounds (Wilson et al. 1996). Although DDT was banned in Canada in 1969, the breakdown product DDE is still present in wildlife at toxicologically significant concentrations. These residues likely come from atmospheric transport from regions where DDT is still used for insect control, as well as from persistent residues in B.C. soils and sediments from past agricultural use.

The rapidly increasing contaminant level of a newer class of compounds, the PBDEs, reflects the widespread use and release of these compounds since the 1970s when production began to expand. Limited phasing out of PBDEs began in 2004, with the voluntary restriction of some groups of congeners. One group, the decaBDEs, is still in use around the world. It is not known what effect the toxicity from these chemicals may be having on birds, especially in combination with other stressors such as loss or degradation of habitat.

5. Secondary Indicator: Persistent organic pollutants in tissues of marine mammals on the B.C. coast

This is a pressure indicator. It shows the accumulation of persistent contaminants in killer whales and harbour seals. It addresses the question: What is the extent of contamination from persistent organic pollutants (POPs) in the coastal environment? A summary of recent data for this indicator is presented here; for greater detail and data on other species, see the British Columbia Coastal Environment: 2006 report (*www.env.gov.bc.ca/soe/bcce/)*

Persistent organic pollutants (POPs) enter the marine food chain when organisms at the bottom of the food web, such as plankton, accumulate the contaminants from water, sediment, and food. POPs are fat soluble and persistent; therefore, through biomagnification, the tissue contaminants become more concentrated as they move up the food chain to seals and killer whales.

This indicator reports on levels of POPs in harbour seals (*Phoca vitulina*) and three groups of killer whales (*Orcinus orca*) inhabiting the B.C. coast—transients and the southern and northern populations of resident killer whales. The transient whales are predators on other marine mammals, whereas both resident whale populations eat mainly fish. Because killer whales travel over a large area and feed on salmon that are thought to accumulate contaminants from their time at sea, contaminants found in their tissues may reflect the general state of contamination in the Pacific Ocean ecosystem.

In contrast, harbour seals are year-round residents on the coast and occupy relatively small ranges of about 20 km^2 (Cottrell et al. 2002). This makes them better indicators of contamination at a local to regional scale. Stocks of two of their preferred food fish, herring and hake, however, do undertake local migrations, so there may be some sources of contaminant from sources outside the harbour seals' immediate range (Ross et al. 2004).

Methodology and Data

Killer whale samples: Blubber samples were collected with biopsy darts from killer whales of both sexes and various ages in the three coastal populations. PCBs, dioxins, and furans were analyzed using high-resolution gas chromatography/high-resolution mass spectrometry (Ross et al. 2000). A slightly different grouping drawn from the same original sample set was analyzed later for PBDEs (Rayne et al. 2004). The identity of each individual sampled was confirmed using a photo identification database containing all resident and many transient whales. This provided demographic information and ensured that the same whale was not sampled twice.

Harbour seal samples: Tissue samples from harbour seal pups were collected in 1996 from four locations in the Strait of Georgia (Victoria, Vancouver, Crofton, and Hornby Island) and from Queen Charlotte Sound. The concentration of POPs in harbour seals increases with age, especially in males. Therefore, by sampling only pups, researchers could ensure that subjects were all the same age (3 to 6 weeks) and that virtually all of the contaminants carried by pups come from their mothers through the placenta and in milk (Ross et al. 2004).

Total PCBs and total PBDEs in blubber of killer whales of various ages and harbour seal pups are summarized in Table 8 and shown in Figure 6.

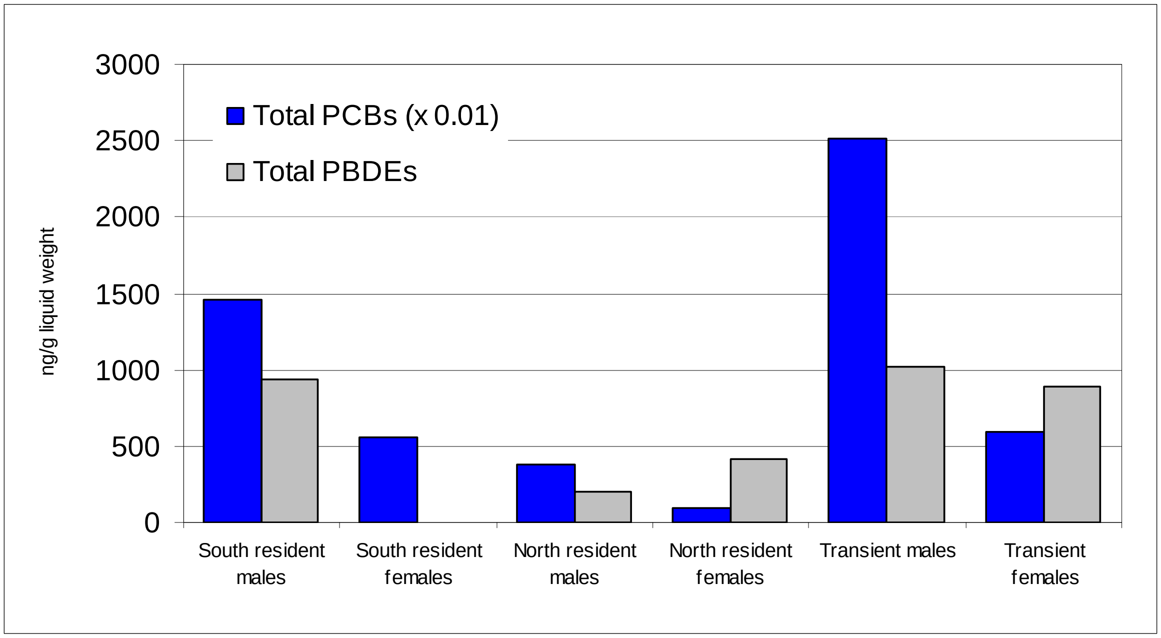
Table 8. Total PCBs and PBDEs in the blubber of killer whales of various ages and harbour seal pups (3–6 weeks old) on the coast of B.C.

		Total PCBs (ng/g)		Total PBDEs (ng/g)		
Species	Population sampled	Mean (n)	SD	Mean (n)	SD	Data source
Killer whale	S. resident males	146,300 (4)	32,700	942 (5)	291	PCBs: Ross et al. 2000
	S. resident females	55,400 (2)	19,300	–	–	
	N. resident males	37,400 (8)	6,100	203 (13)	58	PBDEs: Rayne et al. 2004
	N. resident females	9,300 (9)	2,800	415 (8)	338	
	Transient males	251,200 (5)	54,700	1,015 (6)	302	
	Transient females	58,800 (5)	20,600	885 (7)	353	
Harbour seal (pups)	Strait of Georgia	2,475 (31)	174	–	–	Ross et al. 2004
	Queen Charlotte Sound	1,143 (5)	262	–	–	

Notes: Concentrations are in ng/g (ppb) lipid weight. PCB data on whales are for adults only; PBDE data for whales include some juveniles.

Large variances about the means (SD = standard deviation) are due to the wide age range in whales sampled as well as the small sample sizes.

Figure 6. Total PCBs and PBDEs (ng/kg lipid weight) in the blubber of killer whales of various ages on the coast of B.C.



Sources: Compiled from Ross et al. 2000 and Rayne et al. 2004.

View graph data in excel.

Interpretation

Of the three B.C. groups of killer whales tested, PCB concentrations were the lowest in the northern resident whales and highest in the transient population. Although the two groups of resident whales have a similar diet, the more contaminated southern population likely eats more contaminated fish from the industrialized areas of B.C. and Washington state (Ross et al. 2000). The health risk to killer whales of this concentration of contaminants is not known, but they are among the most contaminated marine mammals in the world (Ross et al. 2004). A high tissue concentration of PCBs was one reason for the recent classification of southern resident killer whales as Endangered under Canada's *Species at Risk Act.*

Of the three groups of harbour seal pups tested for PCBs, those born in Puget Sound were the most contaminated and those from Queen Charlotte Sound the least contaminated (Ross et al. 2004). This is consistent with the finding that herring from the Southern Strait of Georgia have lower contaminant concentrations than herring from the central and southern portions of Puget Sound (O'Neill and West 2005). The contamination in the diet of adult harbour seals is likely reflected in regional differences in contamination of their pups.

The studies cited show that PCB concentrations in killer whales are roughly 100 times higher than PBDE concentrations (Rayne et al. 2004), which likely reflects the earlier period of use of PCBs relative to PBDEs. PCBs may also accumulate to a greater extent because PCB molecules are smaller than PBDE molecules, and small size favours more rapid uptake. The most common PBDE congener, BDE-47 (one of the more toxic forms), accounted for about 60–75% of the PBDEs found in killer whales (Rayne et al. 2004) and is widely distributed in environmental samples (Gill et al. 2004). In all three killer whale populations, males were more contaminated with PCBs (but not PBDEs) than females. This is consistent with the fact that females shed some of their body burden of PCBs and related compounds through the birth and lactation of each calf, whereas males would continue to accumulate contaminants throughout their lives. The lack of difference between males and females for PBDEs may reflect a barrier in females that prevents ready transfer to their calves (Ross 2006).

Although the health risk to whales from these contaminants is unknown, concentrations in most whales were higher than those likely to cause immunotoxicity in harbour seals (Ross et al. 2000). The burden of mixed contaminants has been shown to impair the immune system in seals (de Swart et al. 1996). Research has shown that Vitamin A and thyroid hormone physiology in harbour seals in the Strait of Georgia and Puget Sound have been affected by exposure to contaminants (Simms et al. 2000; Mos et al. 2006, 2007; Tabuchi et al. 2006). Contaminant concentrations in Strait of Georgia seals are still below those likely to cause immunotoxicity (Ross et al. 2004).

Overall, this indicator shows that POPs released into the environment continue to accumulate through the food webs and recycle in ecosystems long after measures intended to curtail emission from industrial sources have taken effect. It shows that PCBs, which have been the target of regulation and pollution control efforts for decades, are still accumulating in whale and seal tissues. Adding to the tissue contamination of the earlier "legacy" POPs are the PBDEs, which appear to have been accumulating within the marine food chain since the 1970s. They have emerged only recently as an environmental concern, in much the same way that PCBs were considered 30 years ago. Recent research suggest that it may take up to 60 years before southern resident killer whales are likely to experience a real reduction in health risks associated with PCB exposure (Hickie et al. 2007).

6. Key Indicator: Trends in pesticide use by professional landscape services in the Lower Mainland of B.C.

The quantity of pesticides applied to landscapes is a pressure indicator. It shows the total weight of pesticide active ingredients used in the Lower Mainland by professional landscape services.

Pesticides are materials or microorganisms that are used to prevent, destroy, repel, or otherwise reduce pest populations. The term "pesticides" includes insecticides and insect repellents, herbicides, fungicides, rodenticides, wood preservatives and anti-sapstain chemicals, slimicides (biocides used in cooling towers and papermaking) and other compounds. Pesticides registered for use in Canada include a wide variety of active ingredients and modes of action. These range from high toxicity, persistent compounds to low-toxicity and non-toxic substances and microorganisms (microbial products).

It is an accepted international goal to reduce risks to human health and the environment from pesticide use (c.f., OECD/FAO 1998); the British Columbia government has been actively promoting this objective since 1991. Risks to human health from use of pesticides can occur for pesticides applicators, farm workers, bystanders, consumers (e.g., of agricultural commodities), and site users (e.g., in lawns and landscapes). Environmental effects include harm to nontarget organisms, such as beneficial insects, birds, and other wildlife, as well as contamination of air, water, or soil.

Because of the wide differences in the various properties of substances used as pesticides, there is not complete agreement on the best way to measure progress in reducing impacts. In 1991, B.C. chose to compile records on each pesticide active ingredient separately because it would permit tracking of individual active ingredients and provide data that could be aggregated later if needed for further analysis.

Methodology and Data

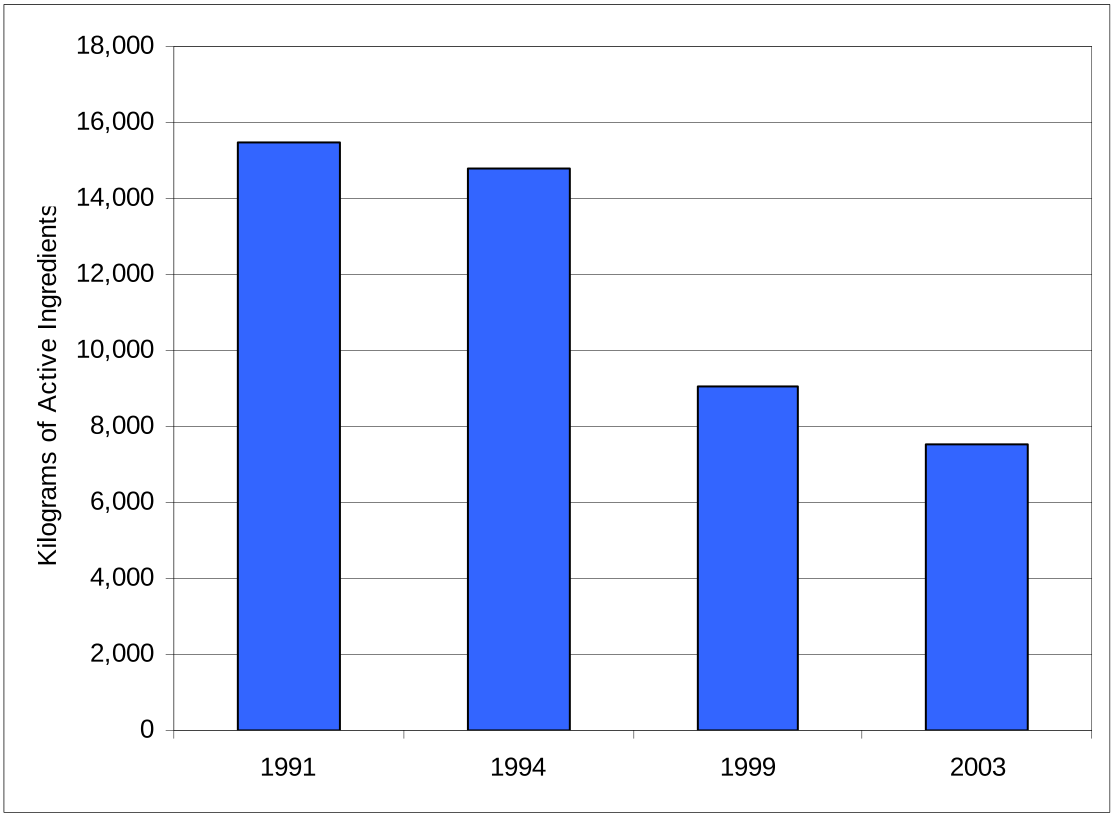
The data for this indicator came from a series of four studies of all pesticide sales and use in British Columbia. The studies were conducted in 1991, 1995, 1999, and 2003 in partnership between the B.C. Ministry of Environment and Environment Canada. The complete reports, including original data tables for the 1995, 1999, and 2003 studies are available online at *www.env.gov.bc.ca/epd/epdpa/ipmp/tech_reports.html*.

This indicator reports an analysis of a subset of the data: annual summaries of pesticide use from all Lower Mainland British Columbia businesses with licences to use pesticides in the landscape category (e.g., lawn services, landscapers). This subset of data was chosen because it was the most complete, and the accuracy of the records was evaluated for each of the four years. It is also an area of pesticide use that is of particular concern to the public.

Complete records (called Service Licence Use Summaries) are available from licensed pesticide services because each service must submit an annual summary of pesticide use to the B.C. Ministry of Environment as a condition of renewing their licence to conduct a business involving pesticides. The only exceptions are those businesses that do not require a licence because they use only pesticides classified as Excluded under the *Integrated Pest Management Act* Regulation (previously classified as Exempted under the B.C. *Pesticide Control Act* Regulation). Excluded pesticides are generally of low-toxicity, such as insect repellents, insecticidal soap, corn gluten meal herbicides, boron compounds, and swimming pool chemicals. For all Non-Excluded pesticides, service licence holders must keep a daily record of the pesticides used and the quantity.

Service Licence Use Summaries show the name of each pesticide and the quantity used. This information was used to calculate the weight of each active ingredient used that year. Sources of error and irregularities on the summaries were identified, followed up with the licensees, and corrected where possible (for detailed analyses of sources of error, see the original reports). In the 2003 study, only 6 (3%) of the 188 Service Licence Use Summaries submitted contained errors.

Figure 7. Total pesticide active ingredients (in kg) used by Lower Mainland B.C. pest control services licensed in the landscape category, 1991–2003.



Source: B.C. Ministry of Environment and Environment Canada pesticide surveys (1991, 1994, 1999, 2004).

View graph data in excel.

The following trends were identified:

- The use of pesticides by landscape services showed a statistically significant decrease of 50% between 1991 and 2004. Over the 4 years, total weight of active ingredients used dropped from 15,468 kg in 1991 to 7,541 in 2003 (Table 9).
- The largest decreases in 2003 among the top 20 pesticides were mineral oil and the herbicide glyphosate. Use of insecticidal mineral oil varies widely from year to year and therefore the decrease was not statistically significant.
- Over the span of 12 years, several pesticides disappeared from records as they were discontinued (see text box “Phasing Out Toxic Home and Garden Pesticides”). These included the insecticide methoxychlor and the herbicide paraquat, which was among the top 20 pesticides used in 1991.
- Use of other registered pesticides used in 1999 ceased entirely by 2003. Among these were sodium metaborate tetrahydrate and sodium chlorate, which are formulated in certain herbicide products, and the fungicide bromacil.

- The use of chlorothalonil (a turf fungicide) increased between 1991 and 2003 and use of quintozene (another turf fungicide) increased between 1991 and 1999, but dropped off in 2003. Since these fungicides are used for turf diseases that spread in humid conditions, such variability reflects differences in weather from one season to the next, as well as changes in registrations and use patterns.
- The top 20 list included two new, least-toxic active ingredients that were not sold in early years: two herbicides, acetic acid and fatty acid.

Table 9. Top 20 active ingredients used by Lower Mainland B.C. pest control services licensed in the landscape category, 1991–2003

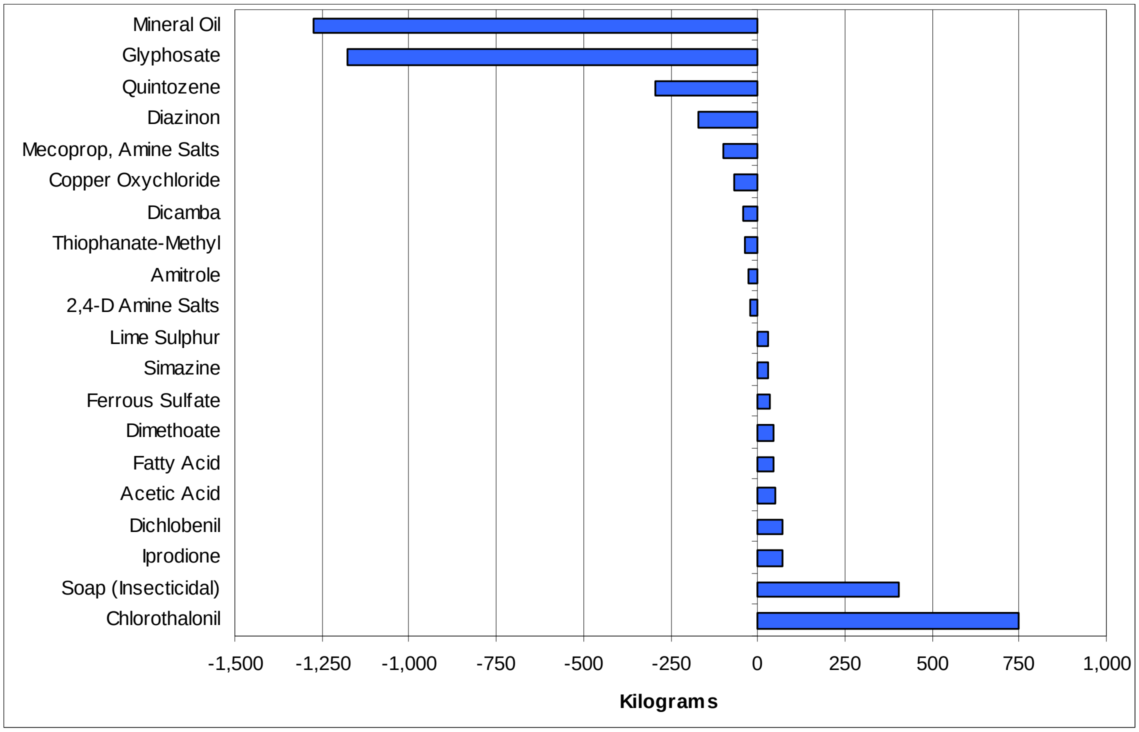
	Total used (kg)				
Active ingredient	1991	1995	1999	2003	Change from 1991 (kg)
Mineral oil (insecticidal or adjuvant)	2,443	4,183	1,342	1,171	–1,272
Glyphosate	2,145	1,068	1,084	968	–1,177
2,4-D amine salts	921	1,088	863	899	–22
Diazinon	676	539	639	507	–169
Mecoprop, amine salts	669	903	567	569	–100
Quintozene	468	371	794	175	–293
Dichlobenil	394	636	452	464	+70
Lime sulphur	328	379	428	300	+28
Soap (insecticidal)	314*	359	1,031	654	+403*
Dicamba	140	204	129	100	–40
Copper oxychloride	132	146	74	62	–70
Thiophanate-methyl	93	40	30	58	–35
Amitrole	91	47	44	64	–27
Iprodione	50	62	128	124	+73
Simazine	41	94	77	74	+32
Chlorothalonil	28	72	371	774	+748
Fatty Acid	0	38	67	46	+46
Ferrous sulphate	0	82	65	36	+36
Acetic acid	0	0	0	51	+51
Dimethoate	0	0	0	45	+45
Total	15,468	14,802	9,071	7,541	–7,954
Number of licensed services	200	235	189	162	–38

Source: B.C. Ministry of Environment and Environment Canada pesticide surveys (1991, 1994, 1999, 2004).

Note: Values from source table are rounded to nearest whole number.

* Error in 1999 report on quantity of insecticidal soap in 1991 has been corrected in this table.

Figure 8. Change in the top 20 active ingredients used by Lower Mainland B.C. pest control services licensed in the landscape category, 1991–2003



Source: B.C. Ministry of Environment and Environment Canada pesticide surveys (1991, 1994, 1999, 2004).

View graph data in excel.

Interpretation

As an indicator of trends in pesticide impacts, the total weight of active ingredients used has the benefit of being a relatively accurate measurement. The main drawback is that the large number of substances registered as pesticides includes those that are very toxic in small quantities as well as those that are low toxicity, thus their impacts are not all comparable on a weight basis. For example, if someone switches to using a higher toxicity product, the total weight of active ingredient used decreases, but the environmental impact could increase. If a heavier, but lower toxicity active ingredient, such as horticultural oil, replaced a more toxic chemical, the weight used would increase, but the environmental impact could be less.

When interpreting pesticide use data, it is also important to realize that pesticide use patterns can depend on weather conditions, pest populations, cost and availability of products, changes in registration status, and other factors. For example, fungicide use on turf in coastal areas depends on rainfall and humidity patterns, which can vary widely from year to year. Also, the status of products for landscape use continues to change as registrations are withdrawn or cancelled. Since 1991, several of the most toxic active ingredients have disappeared from the market (see text box).

The results in this indicator may underestimate the total weight of Excluded pesticide use. This is because Excluded pesticides are listed in the B.C. regulations as pesticides that can be used by landscape businesses without the need to obtain a licence or to submit annual records to the Ministry of Environment. Thus, the use of insecticidal soap (an Excluded pesticide), may in fact be greater than shown because only businesses that were reporting other non-Excluded pesticides would have submitted records showing use of soap. In the past it was unlikely that a landscape service could manage without using at least some reportable pesticides, but this has changed for several reasons:

- Since 1991, the provincial government has had a policy to reduce and eliminate pesticide uses by promoting adoption of integrated pest management (IPM) programs. This is a systematic approach based on prevention. The policy was implemented by sponsoring IPM training, revising the provincial pesticide applicator training materials, and by changes in provincial pesticide legislation to require an IPM approach.
- The new *Integrated Pest Management Act* and Regulation enacted in 2004 included an updated Excluded schedule of pesticides. It now includes a range of recently registered least-toxic pesticides (such as ferric phosphate for slug control and the herbicides based on fatty acids, acetic acid, and corn gluten). This gave landscapers access to a broader suite of least-toxic products to conduct their businesses.
- By the mid-1990s the major B.C. municipalities (notably Vancouver, Victoria, Burnaby, Coquitlam, North Vancouver) began to implement IPM programs and reduce pesticide use; some municipalities adopted policies to use only pesticides listed on the provincial Excluded (Exempted) Schedule.
- Many municipalities in Canada, including large cities such as Vancouver, have restricted pesticide use on private land through municipal bylaws. The bylaws restrict what an individual as well as professional services can use to a list of generally low-toxicity pesticides.

As more companies learn to manage pests with the least-toxic products on the Excluded list, and the list continues to expand as new low-toxicity products are registered in Canada, fewer companies will require licensing to use pesticides.

Phasing Out Toxic Home and Garden Pesticides

The following active ingredients previously registered for use in and around homes (i.e., for indoor pests, in flea collars) or residential landscapes and turf have been phased out or discontinued in recent years:

- Atrazine: residential and other uses (except in corn) expired 2006.
- Benomyl: all uses discontinued; last product expired 2004.
- Chlorpyrifos: last sale to retail 2001.
- Diazinon: all domestic and residential use on lawns phased out by 2003.
- Dimethoate: all domestic registered products expired 2004.
- Endosulfan: registrants withdrew all residential uses in 2004.
- Malathion: registrants discontinued turf and indoor uses; only labelled for mosquito control after 2003.
- Methoxychlor: all uses discontinued, last product expired 2005.
- Naled: pet collar uses expired 2003; turf uses expired 2004.
- Paraquat: all domestic, turf uses discontinued; last product expired 2005.
- Pirimicarb: all uses discontinued; last domestic products expire 2007.
- Sodium fluosilicate: all uses expired 2005.

Source: Pest Management Regulatory Agency Re-evaluation Summary Table: *www.pmra-arla.gc.ca/english/pdf/re-eval/summarytable-e.pdf* (updated May 2007).

Supplementary Information: Trends in Sales of Pesticide of Most Concern in the Georgia Basin

The 2003 provincial pesticide study (EC and BCMOE 2005) included an analysis of trends in reportable pesticide sales in the Georgia Basin. This study looked at 40 active ingredients that were included on lists of chemicals of concern by one or more of the following initiatives:

- The 1998 Nominating List of Toxic Substances in the Lower Fraser/Georgia Basin, developed under the Georgia Basin Ecosystem Initiative. It lists 44 substances, 13 of which were pesticide active ingredients (or groups of ingredients), with an emphasis on suspected endocrine-disrupting chemicals.

- A US National Oceanic and Atmospheric Administration list of contaminants of concern in the Puget Sound, developed for the Puget Sound/Georgia Basin Toxics Work Group. This list contains 48 pesticides, 26 of which were sold in Canada.
- A list of contaminants prepared by S.C.H. Grant and P.S. Ross of Fisheries and Oceans Canada (cited in Verrin et al. 2004) that could pose a health risk to southern resident killer whales. The list included 16 pesticide active ingredients that may persist in the environment and bioaccumulate.

In 2003, sales of these pesticides amounted to 95,446 kg, or 17.8% of all pesticides sold in the Georgia Basin that year. Eight pesticides appeared on two or more of the lists: atrazine, simazine, chlorpyrifos, malathion, metalachlor, endosulfan, trifluralin, and lindane. Together, they amounted to 5.7% (30,478 kg) of all pesticides sold in the Georgia Basin.

Table 10 shows the active ingredients registered for landscape uses that appeared on two or more lists of concern. Over the 12 years spanned by the provincial pesticide studies, use of chlorpyrifos (withdrawn in 2001), endosulfan, lindane, and trifluralin decreased to zero. Since then, uses of three landscape pesticides have been withdrawn: residential uses of endosulfan in 2004; turf uses of malathion by 2003; and all uses of lindane in 2006.

Table 10. Quantities of active ingredients on two or more lists of environmental concern used by landscape services in the lower mainland region of B.C., 1991–2003.

	Total used (kg)				
Active ingredient	1991	1995	1999	2003	Change from 1991 (kg)
Chlorpyrifos	15.4	20.0	16.3	0	-15.4
Endosulfan	8.0	3.3	0	0	-8.0
Lindane (gamma-BHC)	0.8	0.4	0	0	-0.8
Malathion	34.0	17.4	0	22.4	-11.6
Simazine	59.1	93.6	76.7	73.7	14.6
Trifluralin	3.5	0.4	0	0	-3.5

Source: Survey of Pesticide Use in BC: 2003 (EC and BCMOE 2005).

WHAT IS HAPPENING IN THE ENVIRONMENT?

A wide range of contaminants originating from a variety of human activities is detectable in the wider environment and in the tissues of wildlife and of people (c.f., Environmental Defence 2005). The indicators in this paper cover the impacts of contaminants and, for most of them, progress in controlling their release in the environment.

Key contaminants described in the indicators include the legacy POPs, PCBs, dioxins and furans, and DDE, all of which are persistent and bioaccumulative, and some organophosphorus pesticides, which are less persistent. Overall, the environmental concentrations of the legacy POPs have fallen as a direct result of regulatory controls instituted in the 1970s–1990s on release of these substances to the environment. Except at contaminated sites, the concentrations found in the air, water, and external environment are generally low. Through bioaccumulation and biomagnification, however, much higher concentrations of these persistent chemicals appear in the blood and tissue of animals near the top of the food chain, as shown in data from herons, cormorants, osprey, seals, and killer whales. Even though it has been 30 years since release of PCBs was prohibited in North America, PCB residues are still the most toxicologically significant of all POPs for animals at the top of the marine food chain. The decline in PCB concentrations in killer whales has been so slow that recent modelling suggests that it could be 60 years before residues decline enough to stop posing a health risk for southern resident killer whales (Hickie et al. 2007).

Adding to the tissue burden from the legacy POPs, are the PBDEs, which have been accumulating in the food chain since the 1970s, but have been only recently recognized as a concern. Environmental contamination with this new class of persistent contaminants has been rising rapidly. PBDE concentrations in the breast milk of Vancouver area mothers doubled every two and half years throughout the 1990s (Ryan et al. 2002). Concentrations have been doubling in marine mammals about every 5 years (Hites 2004) and in marine birds about every 5.7 years (Elliott et al. 2005). Although pentaBDE and octaBDE have been withdrawn from the market, decaBDE is still in use. It is distributed in commercial and consumer products to a greater extent than PCBs were, and there is evidence that it can break down into the more toxic penta- and octaBDE forms (research reviewed in Environment Canada 2006a). This means that residues will likely continue to increase for some time before controls on these substances bring about a decline.

Efforts to eliminate sources of risk from contaminants include: withdrawal of pesticide registrations, elimination of target industrial chemicals from use, cleanup of contaminated sites, and regulatory limits on food residues and exposure in the workplace or from consumer and industrial products. Despite regulations and voluntary controls, however, there are still sources of continuing input of these targeted industrial contaminants to the Canadian environment from the following sources:

- Release of decaBDEs from furniture, textiles, plastics, and other consumer goods.
- Local, industrial, and other activities that deposit small amounts of contaminants, such as dioxins and furans, in the local environment. Common examples are burning salt-laden wood waste, trash in backyard burn barrels, and open burning of wood waste (see “What You Can Do,” below).
- Breakdown processes in soils and sediments that are still releasing contaminants from past uses (such as DDE from past use of DDT).
- Accidental releases or spills. In the case of PCBs, there remains a risk that they may be released from controlled storage and landfill sites and from electrical equipment still in use.
- Transport of a variety of contaminants over long distances in the atmosphere from parts of the world where they are still in common use.

In addition to the POPs that were the subject of several of the indicators in this paper, other prominent contaminants, such as mercury, lead, and other heavy metals, were not covered. These have been, and continue to be, the target of long-running regulatory efforts to reduce their impacts on the environment and human health. Because there are often many possible sources for POPs and other contaminants, it is a challenge to make the links between the source and the effects to evaluate the success of mitigation efforts.

Other Contaminant Issues

Two major, emerging contaminant issues not addressed by indicators in this paper are: impacts of exposure to mixtures of contaminants and the release of reactive nitrogen into the global environment from human activity.

- In addition to the residues from earlier use of POPs, which will continue to persist in the global environment for decades, thousands of other substances are currently in use. In the course of daily living, people are exposed to a combination of chemicals (usually at extremely low levels) from many sources. These include widely used chemicals, such as phthalates and biphenol-A (in plastics) and human pharmaceuticals (in drinking water). Unlike drug interactions that have been well tested, the health effects of exposure to mixtures of contaminants are largely unknown. It would be impossible to test all possible combinations of substances, but researchers have begun to examine the effect of some mixtures. Studies on exposure to a combination of endocrine disrupting chemicals (present in plasticizers, sunscreen ingredients, cooling and insulating fluids) found that the resulting impact was additive. Although doses of each chemical were below the '"no effect levels," together their impact was the same as if the doses had been added together. This was shown both for chemicals that block activity of female hormones (e.g., Silva et al. 2002; Brian et al. 2007) and those that block activity of male hormones (e.g., Gray et al. 2006). Although it is not surprising that results were additive for chemicals that target the same pathways, it was surprising that mixtures of unrelated chemicals also produced additive effects (Gray et al. 2006).
- The impact of the reactive nitrogen (e.g., nitrates, ammonia and nitrogen oxides) that has been released into the global environment from human activity has been recognized as an international concern since the First International Nitrogen conference in 1998 (Erisman 2004). Today it is estimated that 70% of reactive nitrogen in the global environment comes from nitrogen fertilizer use and fossil fuel burning (reviewed in Hooper 2006). With effects that include acid rain, air and water pollution, climate warming, and eutrophication, reactive nitrogen has many and extremely complex effects.

When wider-scale monitoring data are available, indicators for emerging contaminants will likely be developed for future reporting. For example, concern about risks to health have driven recent interest in testing for contaminants in human tissue and blood. Statistics Canada is, for the first time, in the process of testing the blood of 5,000 Canadians as part of a comprehensive health survey to be completed in 2009; data from this study could be useful as a baseline for future indicator reporting.

WHAT IS BEING DONE ABOUT ENVIRONMENTAL CONTAMINANTS?

Government Initiatives

Internationally, Canada was the first country to ratify the Stockholm Convention on Persistent Organic Pollutants, in 2001. This international agreement calls for the elimination of: PCBs, dioxin and furans, hexachlorobenzene, and the pesticides DDT, dieldrin, aldrin, endrin, chlordane, heptachlor, toxaphene, and mirex. In 2000, Canada established the Canada Persistent Organic Pollutants Fund with a commitment of $20 million to help developing countries and those with economies in transition deal with POPs. For updates on National Implementation Plans for Canada's obligations under the Stockholm Convention, see *www.ec.gc.ca/cleanairairpur/CAOL/POPS/Stockholm/sum_e.html*.

In Canada, the *Canadian Environmental Protection Act* (CEPA) includes procedures for investigating and assessing substances, and for regulating substances that are, or might become, toxic as defined by CEPA. CEPA required the Minister of the Environment and the Minister of Health to "categorize" all of the approximately 23,000 substances on the Domestic Substances List (DSL) to identify those substances with the greatest potential for exposure or that are persistent or bioaccumulative and inherently toxic to humans and other living organisms. This led to the creation of two Priority Substances Lists, comprising a total of 69 substances or groups of substances. Under CEPA provisions, these were assessed to determine if they are toxic and whether there should be controls over production and release to the environment. A CEPA Environmental Registry provides information to the public and supports public participation in environmental decisions (*www.ec.gc.ca/CEPARegistry/*). The Registry provides access to toxic chemical assessments, inventories of substances and their toxicity, the industries they are associated with, and proposed management strategies and regulations.

At the provincial level, an updated B.C. *Environmental Management Act* (2003) introduced new provisions for toxic substances and waste management, including changes affecting contaminated sites, hazardous wastes, and waste discharge regulations. New sediment criteria incorporated in the Contaminated Sites Regulation provide a strong inducement for industry to avoid creating future contaminated sites. The Act covers a broad range of environmental regulations (see *www.qp.gov.bc.ca/statreg/stat/E/03053_00.htm*).

Under the Canada-wide Environmental Standards Sub-agreement between federal and provincial environment ministers, coastal pulp and paper mills were required to reduce their atmospheric emission of dioxins and furans from burning wood waste to less than 500 pg TEQ/m^3 by 2006 (CCME 2001).

The Canadian Health Measures Survey is a comprehensive health survey by Statistics Canada. It will test blood and urine samples of Canadians ages 6 to 79 to measure many aspects of disease and nutrition as well as environmental exposure to contaminants. The survey will be completed in 2009 and will give federal health officials a baseline on contaminant exposure along with the other results on the health of Canadians. For more information, see *www.statcan.ca/english/concepts/hs/measures.htm*.

WHAT CAN YOU DO?

Around the Home

Avoid releasing hazardous products to the environment:

- Use water-based, low-emission paints, paint removers, stains and varnishes, waxes, glues and adhesives, cleaners, etc. Use cleaning products with natural ingredients.
- Reduce and eliminate the use of toxic pesticides, paints and solvents, carpet and furniture cleaners, glues, and other household hazardous products around the home. If you must use hazardous products buy only enough to do the job to avoid having to store or dispose of them.
- Store hazardous products in their original, tightly closed containers in a well-ventilated area where children and pets cannot get at them. Never burn any household hazardous products in fireplaces or backyard fires.
- Dispose of waste in special household hazardous waste depots. More than 30 free dropoff locations for solvents, pesticides, and gasoline are operated in B.C. by Product Care. For information on acceptable products or to find a dropoff depot near you see: *www.productcare.org* or call the RCBC Recycling Hotline. Established in 1990, the RCBC Recycling Hotline (*www.rcbc.bc.ca/*) is a free, province-wide information service for recycling, pollution prevention, waste avoidance, disposal options, and regulations. In B.C. call toll-free: 1-800-667-4321; in the Lower Mainland call 604-732-9253; e-mail: *rcbc@rcbc.bc.ca*.

Several other disposal programs keep contaminants out of landfills and the environment:

- Batteries: Don't put used batteries from flashlights, clocks, toys, etc. in the garbage. There is a recycling program in B.C. for rechargeable batteries; for a dropoff location near you, see the Rechargeable Battery Recycling Corporation (*www.rbrc.org*) or call the RCBC Recycling Hotline. For alkaline (disposable) batteries there are some local and municipal programs; phone the RCBC Recycling Hotline for local disposal options.
- Motor oil, used oil filters: The B.C. oil recycling program is currently managed by the BC Used Oil Management Association. For your nearest dropoff location see *www.usedoilrecycling.com* or call the RCBC Recycling Hotline.
- Prescription medicines: Never flush away leftover medicines or over-the-counter drugs. Nearly all pharmacies in B.C. participate in the Medications Return Program to collect expired or unused medications for safe disposal. To find a drop-off location see the Residuals Management Association website (*www.medicationsreturn.ca*) or call the RCBC Recycling Hotline.
- Electronics: B.C.'s Return-It Electronics is a province-wide program available to all consumers and businesses in British Columbia. As of August 2007, you can drop off televisions, computers, printers, keyboards, and other products at designated collection sites without charge for proper recycling. For information visit the Encorp website: *www.encorp.ca/electronics/* or contact the RCBC Recycling Hotline.

Build a healthy house: Canada Mortgage and Housing Corporation (CMHC) provides free booklets and brochures and a low-priced book on building healthy homes and retrofitting existing homes to protect occupants from exposure to contaminants. See *www.cmhc.ca* or phone 1-800-668-2642. For healthy home publications click on "Order Desk" and follow links to "Your Health and Your Home."

Around the Yard

Avoid using pesticides (including insecticides, herbicides, fungicides, and other chemicals).

- Learn how to prevent pest problems and manage weeds without using pesticides. For information on Integrated Pest Management in B.C., see *www.env.gov.bc.ca/epd/epdpa/ipmp/* or local municipal websites, many of which have information on sustainable landscapes and gardens.
- For help with identification and advice on how to manage pests without toxic pesticides, consult Master Gardeners at clinics at your local garden centre and local gardening experts.
- Stop burning trash or yard waste. The US Environmental Protection Agency (EPA) found that the largest source of dioxin and furan emissions in the United States is now the burning of household trash (backyard burning). This source accounts for 10 times more emissions than the next highest sources, which are residential wood burning stoves and coal-fired utilities (FNB and IOM 2003). The health risk for people is from exposure through local food as the dioxins settle on plants, which are then eaten by meat and dairy animals. This source of contaminants would be eliminated by halting the practice of burning waste in open piles, burn barrels, or inefficient wood stoves. Many municipalities ban open burning as part of local smoke control regulations. Things you can do instead:
- Have waste picked up by a licensed waste removal company or take it to a local landfill or transfer station.
- Separate recyclables and drop them off at a local recycling centre. For information on recycling or disposal options, call the BC Recycling Hotline at 1-800-667-4321.
- Compost yard and garden waste, food, and leaves. Rent a chipper or hire a service to chip brush and wood to make mulch.
- For more information on avoiding backyard burning, see: *www.env.gov.bc.ca/air/*.

Find out More

- Environment Canada's What You Can Do website (*www.ec.gc.ca/eco/main_e.htm*) provides information on steps individuals can take to protect the environment. For suggestions for reducing your exposure to hazardous chemicals and ways to reduce the use of household hazardous waste and dispose of it safely, see *www.ec.gc.ca/eco/wycd/home6_e.html*.

- The Canadian Pollution Prevention Information Clearinghouse (CPPIC) is a searchable database of references and links to give Canadians access to information on pollution prevention, (*www.ec.gc.ca/cppic/en/index.cfm*).
- Greenpeace has been rating electronics companies according to their environmental record since 2005. They rate contaminants used in computers, cell phones and other equipment as well as manufacturing and disposal provisions. See Guide to Greener Electronics: *www.greenpeace.org/electronics/*.
- David Suzuki Foundation (*www.davidsuzuki.org*). Information on many aspects of environmental protection. For specific information on contaminants and human health see the 2007 report: Prescription for a Healthy Canada *www.davidsuzuki.org/Publications/Prescription_For_A_Healthy_Canada.asp*.

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