CANADIAN ENVIRONMENTAL PROTECTION ACT, 1999

ANNUAL REPORT TO PARLIAMENT FOR APRIL 2019 TO MARCH 2020

Environment and Climate Change Canada
Environnement et Changement climatique Canada

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Environment and Climate Change Canada Public Inquiries Centre
12th Floor, Fontaine Building 200 Sacré-Coeur Boulevard
Gatineau QC
K1A 0H3
Telephone: 819-938-3860 Toll Free: 1-800-668-6767 (in Canada only)
Email: ec.enviroinfo.ec@canada.ca

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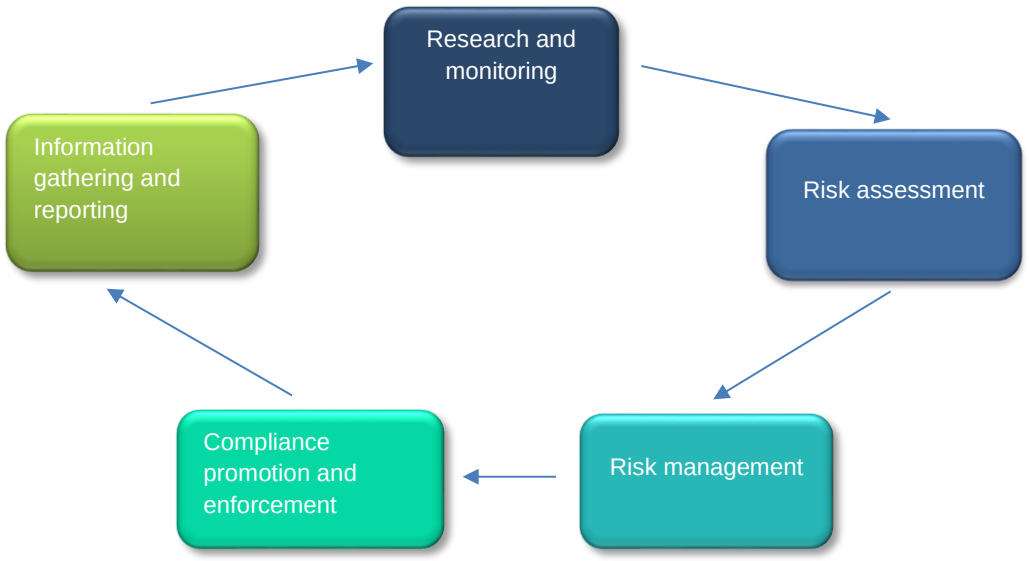
1 Introduction

This annual report provides an overview of the activities conducted and results achieved under the *Canadian Environmental Protection Act, 1999* (CEPA) from April 1, 2019, to March 31, 2020 by both Environment and Climate Change Canada (ECCC) and Health Canada (HC). It responds to the statutory requirement in Section 342 of the Act to provide annual reports to Parliament on the administration and enforcement of the Act.

CEPA provides authority for the Government of Canada to take action on a wide range of environmental and human health risks – from chemicals to pollution to wastes. For the most part, it functions as an enabling statute, providing a suite of instruments and measures for identifying, assessing and addressing risks.

The general steps followed to address each risk constitute a management cycle (see figure 1). At each stage of the cycle, stakeholders are engaged, the public has an opportunity to be involved and exercise their procedural rights, and the government works closely with domestic and international jurisdictions and agencies.

Figure 1: The CEPA management cycle



This report provides information on all stages of the management cycle. Section 2, "Monitoring the environment and human health", covers monitoring and surveillance activities that allow experts to determine levels and trends of chemicals, air pollutants and waste disposal affecting the environment and human health. Section 3, "Addressing key risks", covers information gathering, research and monitoring, risk assessment, and risk management for toxics, air pollution and greenhouse gases, water quality, and waste. Section 4, "Reporting programs and emission inventories", covers information on releases of pollutants and greenhouse gases. Section 5, "Administration and public participation", covers stakeholder engagement and inter-jurisdictional relationships. The report also includes Section 6, "Compliance promotion and enforcement" and Section 7, "Report of research".

This report includes the following mandatory information:

- Section 7 provides examples of the types of research initiatives and their key contributions in the reporting period.
- Section 5.1 describes the activities of the National Advisory Committee. There were no other committees established under paragraph 7(1) (a) of CEPA during the reporting period.
- Section 5.1 also describes the activities under federal-provincial agreements.
- There were no activities under the international air pollution provisions (Division 6 of Part 7) or the international water pollution provisions (Division 7 of Part 7) of CEPA during the reporting period.

The online CEPA Registry is a comprehensive source of information about activities taking place under the Act, including proposed and existing policies, guidelines, codes of practice, government notices and orders, agreements, permits, and regulations.

1.1 Review of the Act

In 2019-2020, work continued in both ECCC and HC in response to the 2017 report of the House of Commons Standing Committee on Environment and Sustainable Development entitled "*Healthy Environment, Healthy Canadians, Healthy Economy: Strengthening the Canadian Environmental Protection Act, 1999*" following its review of CEPA. ECCC and HC continued to move forward on commitments made in the government's June 2018 follow-up report to the Committee to strengthen protection of the environment and health of Canadians through policy and program improvements and future law reform.

They also continued engagement on key issues, such as renewal of the Chemicals Management Plan (CMP) Post-2020 and the environmental protection gap on First Nations reserve lands.

These efforts were consistent with the mandate given to the Minister of the Environment and Climate Change by the Prime Minister in December 2019 to work with the Minister of Health to better protect people and the environment from toxic substances and other pollution through various means, including strengthening CEPA.

2 Monitoring the environment and human health

2.1 Chemicals in our environment

Monitoring and surveillance activities are essential to identify and track levels and trends of chemicals in the environment and human exposure to those chemicals.

Monitoring activities also support Canada's contribution to international efforts, including the:

- Canada-United States Great Lakes Water Quality Agreement
- Great Lakes Herring Gull Contaminants Monitoring Program
- Arctic Council's Arctic Monitoring and Assessment Programme
- United Nations Economic Commission for Europe's Convention on Long-range Transboundary Air Pollution
- United Nations Environment Programme's Stockholm Convention on Persistent Organic Pollutants and the Minamata Convention on Mercury

A broad range of monitoring activities for chemicals was conducted to support a number of domestic programs including:

- the Chemicals Management Plan
- the Northern Contaminants Program
- the Freshwater Quality Monitoring Program
- the St. Lawrence Action Plan
- the Great Lakes Monitoring Program
- the Global Atmospheric Passive Sampling network (GAPS)
- the Northern Contaminants Program (NCP)

The CMP Environmental Monitoring and Surveillance Program involves the collection of data on the concentration of chemical substances in various environmental compartments at locations across Canada. Environmental compartments include surface water, sediment, air, aquatic biota and wildlife. Wastewater system influent, effluent and biosolids are also monitored at select locations representing a range of input

and treatment system types. These monitoring and surveillance activities provide data to inform the assessment and management of chemical substances in the environment.

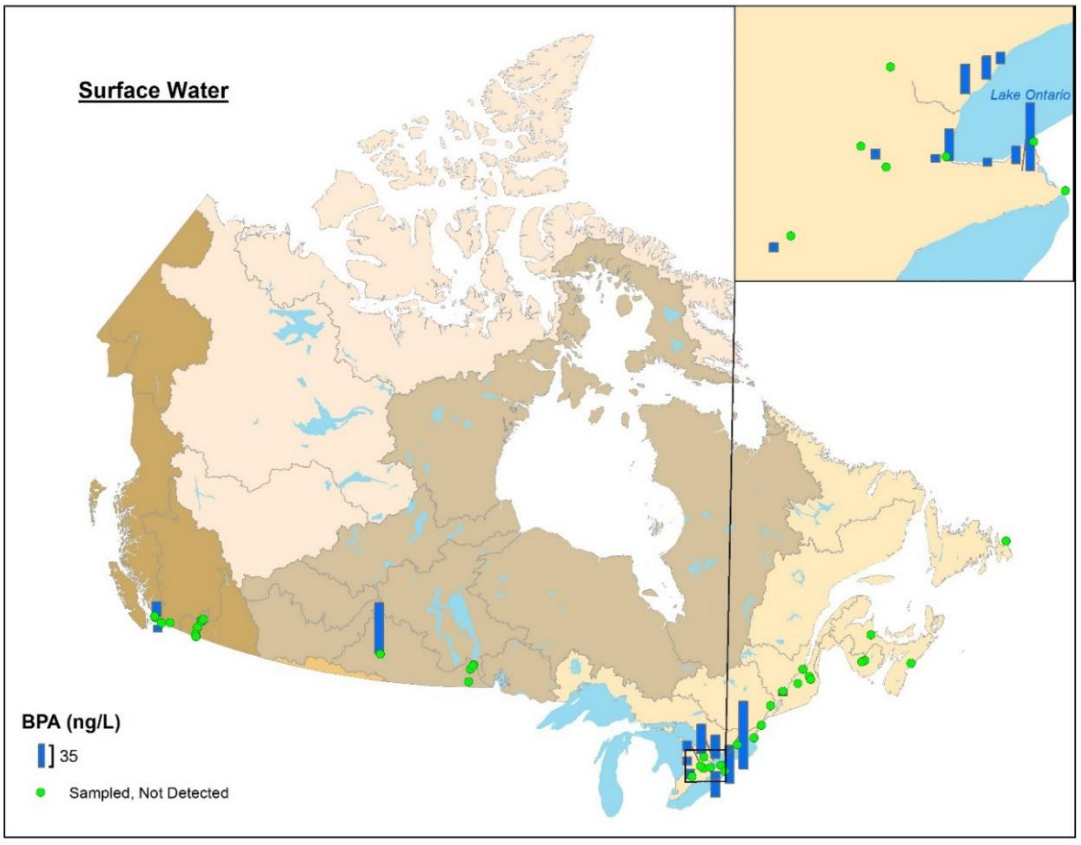
Priority substances monitored in 2019-2020 as part of the CMP Environmental Monitoring and Surveillance Program

- Per- and polyfluorinated alkyl substances (PFASs)
- Polychlorinated biphenyls (PCBs)
- Polychlorinated naphthalenes (PCNs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Polybrominated diphenyl ethers (PBDEs)
- Other flame retardants
- Priority rare earth elements
- Chlorinated alkanes
- Siloxanes
- Phthalates
- Nonylphenol and nonylphenol ethoxylates (NP/NPEs)
- Chlorhexidine salts
- Organotins
- Dioxins and furans
- Antioxidants
- Pharmaceuticals and personal care products (PPCPs)
- Dichlorodiphenyltrichloroethane (DDT) and metabolites
- Dichloromethane
- Metals (such as mercury, cobalt, lead, selenium)

Environmental Monitoring of Bisphenol A in Canada

Environmental monitoring activities were conducted for Bisphenol A at selected sites across Canada in surface water (2008 to 2018; figure 2), sediment (2011 to 2018), fish (2004 to 2009), bird eggs and plasma (2009 to 2015), wastewater (2008 to 2013), and landfill leachate (2008 to 2013). Results from these monitoring activities were summarized in the report entitled "Bisphenol A in the Canadian Environment". As described in the report, concentrations of BPA were generally higher near sources such as wastewater treatment plants (some of which receive landfill leachate), landfill sites and paper-recycling mills, and in large cities, compared to other sampling sites. This information was used as part of the "Evaluation of the Effectiveness of Risk Management Measures for Bisphenol A (BPA) – Ecological Component", which aims to evaluate the effectiveness of measures that have been put in place since 2012 to manage the risk posed by BPA to the environment.

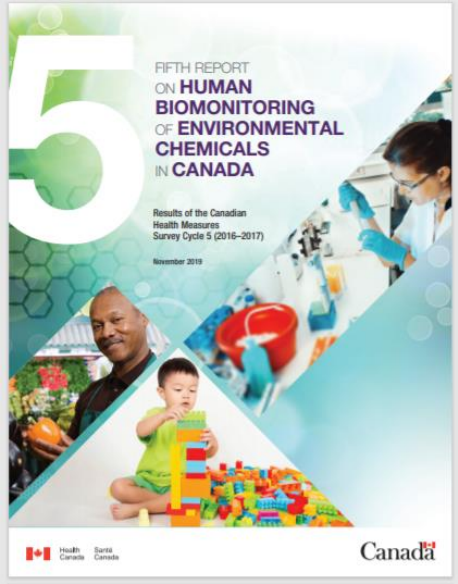
Figure 2: BPA concentrations in surface water samples collected across Canada, 2008 to 2018.



2.2 Chemicals in humans

Health Canada's human biomonitoring efforts continued in 2019-2020 with the national biomonitoring program conducted under the Canadian Health Measures Survey (CHMS), measuring environmental chemical exposures in blood and urine of a nationally representative sample of Canadians aged 3 to 79 years.

The *Fifth Report of Human Biomonitoring of Environmental Chemicals in Canada* that included data for 99 environmental chemicals (e.g. alternate plasticizers, pesticides, and VOCs) collected from approximately 5,800 Canadians aged 3 to 79 years in cycle 5 of the CHMS (2016-2017) was published in November 2019.



Other activities on the CHMS in 2019-2020 included:

- completion of the sample collection for cycle 6 (2018-2019) and finalization of analytical methods for certain chemicals prioritized for cycles 7
- publication by Health Canada researchers of a regional analysis of biomonitoring data from CHMS for the provinces of Quebec and Ontario and an updated evaluation of human biomonitoring data from CHMS in health-risk context[1]
- publication of 82 journal articles that used the CHMS data with 12 articles authored by Health Canada researchers and the remainder authored by external researchers

[1] Sarah Faure, Nolwenn Noisel, Kate Werry, Subramanian Karthikeyan, Lesa L Aylward, Annie St-Amand. Evaluation of human biomonitoring data in a health risk based context: An updated analysis of population level data from the Canadian Health Measures Survey Int J Hyg Environ Health. 2020 Jan;223(1):267-280. doi: 10.1016/j.ijheh.2019.07.009. Epub 2019 Sept 13.

- screening assessments of parabens, molybdenum, vanadium, zinc and its compounds using CHMS data

Health Canada (HC) continued analysis and publication of biomonitoring and research results from the Maternal-Infant Research on Environmental Chemicals (MIREC) Research Platform. In 2019-2020, 12 MIREC platform papers were published. This included studies of:

- environmental exposures and outcomes in children and infants (obesity, behavioral and cognitive outcomes, and endocrine disruption) and pregnant women (gestational hypertension, folate metabolism), and
- the importance of prenatal chemical exposures on child behavior and the relationship between environmental chemicals and child adiposity.
    - Notably, interesting sex differences in studies of child adiposity from the MIREC CD and CD Plus studies were found. Even at very low levels, lead may impact children's body mass index at ages 3 to 5 years. These associations were stronger in boys. Conversely, prenatal exposure to BPA was associated with an increase in body mass index in girls around age 3.

Monitoring in the North

Both ECCC and HC contribute to the Northern Contaminants Program (NCP) led by Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC). HC partners with CIRNAC on the human health component of the NCP, which addresses concerns about human exposure to elevated levels of contaminants in wildlife species important to the traditional diets of northern Indigenous peoples. In 2019-2020, HC supported four human biomonitoring and health projects under the NCP. These projects addressed exposure to contaminants and links to country foods and nutritional status in multiple northern regions (Yukon, Northwest Territories, Nunavik) and the development and evaluation of health communication tools.

ECCC has been a major contributor in monitoring abiotic media, aquatic biota and wildlife, as well as Arctic ecosystem health. ECCC monitors wildlife at numerous sites across the Canadian Arctic on a biennial or annual basis under the NCP, for a large suite of legacy and new Chemicals of Emerging Arctic Concern (CEACs), as well as metals, including mercury.

2.3 Air pollutants and greenhouse gases monitoring

Monitoring and reporting activities are important for identifying and tracking levels and trends of air pollutants that impact both the environment and human health, as well as greenhouse gases that impact climate change.

Air pollution

Ambient (outdoor) air quality monitoring informs air quality management in Canada, including tracking progress relative to the Canadian Ambient Air Quality Standards. The data is used for validation of numerical air quality prediction models, for evaluating the benefits and effectiveness of control measures, as well as for assessments of the impact of air pollution on Canadians and the environment.

ECCC monitors ambient air quality across the country through two complementary networks.

- The National Air Pollution Surveillance (NAPS) program which is managed by provincial and territorial governments in cooperation with ECCC, via an agreement, in order to provide long-term air quality data from populated regions of Canada.
- The Canadian Air and Precipitation Monitoring Network (CAPMoN) which provides information on regional patterns and trends of atmospheric pollutants in both air and precipitation at rural and remote sites.

Data collected through NAPS, CAPMoN and other provincial, territorial and municipal monitoring stations are used to calculate air quality indicators. The air quality indicators track ambient concentrations of fine particulate matter ($PM_{2.5}$), ground-level ozone (O_3), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), and volatile organic compounds (VOCs) at the national, regional and urban levels and at local monitoring stations.

Additional air pollutant monitoring carried out by ECCC includes:

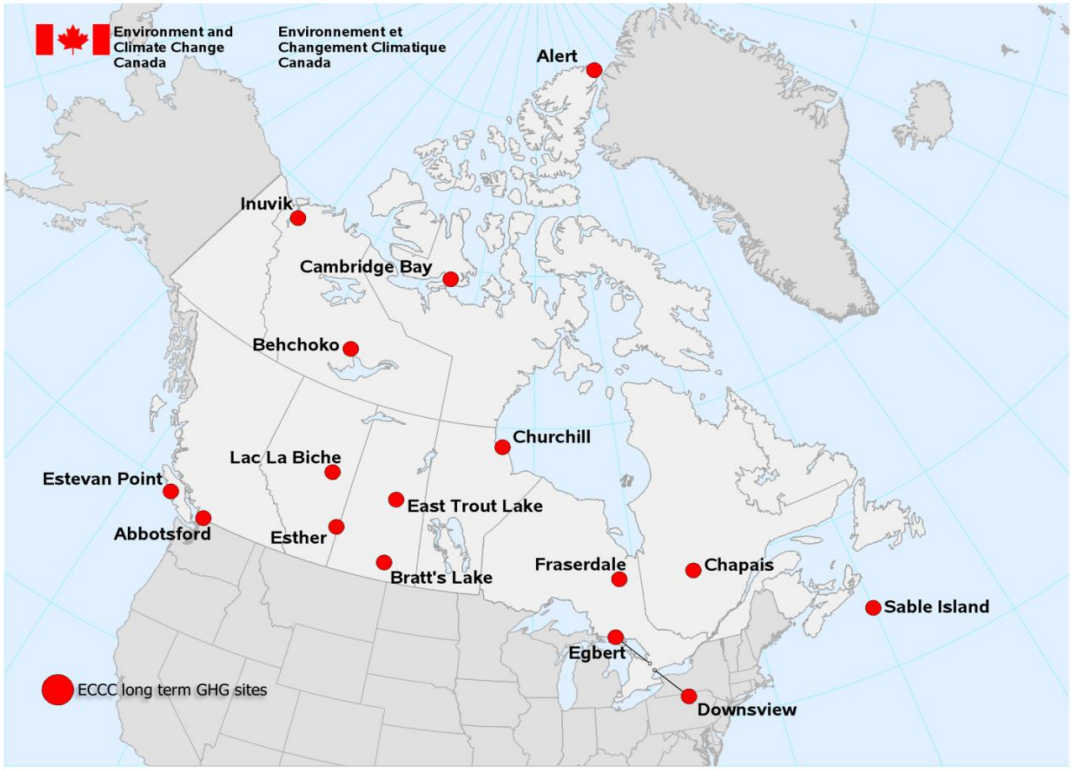
- AEROCAN, the Canadian sub-network of NASA's global AERONET satellite network, takes optical readings of solar radiation in order to measure atmospheric aerosols.
- The Canadian Brewer Spectrophotometer Network measures the total thickness of the ozone layer (known as total column ozone) and ultraviolet radiation (UV) at selected locations across Canada.

- The Canadian Ozonesonde Network measures vertical column ozone from ground level up to 36 km altitude by launching weekly ozonesondes affixed to balloons, providing long-term ozone data.

Greenhouse gases

The Canadian Greenhouse Gas Monitoring Program includes observations of carbon dioxide and other GHGs from 16 long-term measurement sites across Canada (figure 3). Among the sites is the Alert Global Atmosphere Watch Observatory. Alert serves as one of three global GHG inter-comparison sites to ensure consistent measurement of carbon dioxide (CO_2) and other greenhouse gas concentrations across the world.

Figure 3. Canadian Greenhouse Gas Measurement Program monitoring sites



ECCC makes its atmospheric monitoring data available to the public through national and international databases, including the Government of Canada Open Data Portal; World Meteorological Organization (WMO); World Data Centres for GHGs; WMO World Data Centre for Precipitation Chemistry; and the WMO World Ozone and Ultraviolet Data Centre, which is operated by the Meteorological Service of Canada.

MEASUREMENTS OF ATMOSPHERIC CO_2 AND CH_4 AT ALERT NUNAVUT

Measurements of atmospheric CO_2 began in March 1975 at Alert, Nunavut (figure 4). The annual average CO_2 value at Alert in 2019 was 412.0 parts per million (ppm), which is slightly higher than the annual average CO_2 values at Alert in 2018 and 2017 which were 409.5 ppm and 407.7 ppm, respectively.

ECCC began measuring atmospheric methane (CH_4) in August 1985 at Alert, Nunavut (figure 5). The annual average CH_4 value at Alert in 2019 was 1950.0 parts per billion (ppb). The rate of annual increase in CH_4 concentrations showed a steady decline in the late 1980s and hovered around zero from 1999 to 2006, reflecting a near global balance between emissions and removal by atmospheric chemical processes. However, since 2007, CH_4 has increased every year on average by 6 ppb per year.

Figure 4: Atmospheric carbon dioxide measured at Alert, Nunavut

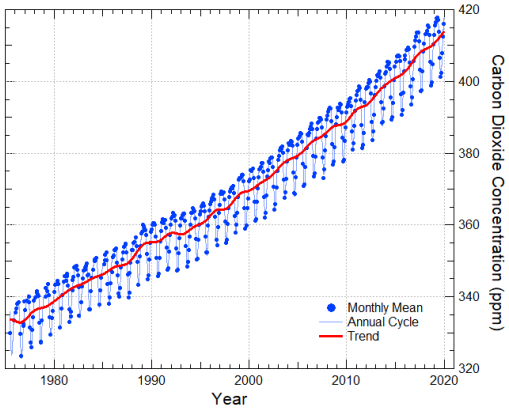
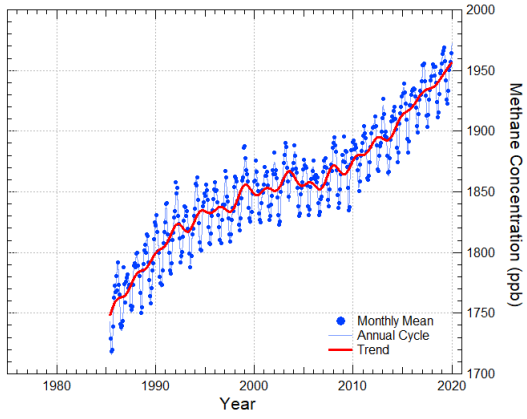


Figure 5: Atmospheric methane measured at Alert, Nunavut



2.4 Disposal at sea site monitoring program

By monitoring disposal sites, ECCC is able to verify that the permitting of disposals at sea is sustainable and that permit holders can have continued access to suitable sites. Where monitoring indicates a problem or where the site has reached its capacity over time, management action in the form of closing, moving or altering the site use can occur.

In 2019-2020, monitoring projects were completed at 12 ocean disposal sites nationally, one of which was a closed site. Monitoring at the 11 actively used sites amounts to monitoring 11% of the 104 actively used sites. Due to the timing of fieldwork and the length of time required for data analysis, some of the results of disposal at site monitoring projects are sometimes not available until at least a year after they are completed. This year, results are reported for 2018-2019 and 2019-2020 in Pacific and Quebec regions, and for 2019-2020 in Atlantic region.

Pacific region

In 2018-2019, four disposal sites were monitored off the coast of British Columbia (see table 1). In 2019-2020, one of those sites was monitored again, as well as an additional site. Monitoring at all of the sites consisted of sediment sampling and analysis for physicochemical parameters, toxicity testing, and sediment profile imaging (SPI) surveys to better understand the potential effects related to disposal activities. At the Sandheads and Point Grey sites, sediment samples were also analyzed for an extensive suite of chemicals, including polybrominated diphenyl ethers (PBDE) to generate new data in support of the Government of Canada's Whales initiative.

Sediment profile imaging

A camera is deployed to the seafloor to take a cross-sectional image of the sediment/water interface and near-surface sediment. This technique is used to image, measure and analyze physical and biological parameters at and around disposal sites.

Table 1: Results of monitoring disposal at sea sites in Pacific region

Disposal sites	Physico-chemical survey (sediment)	Toxicity testing (sediment)	Sediment profile imaging	Comments
Five Fingers Island (2018)	n/a	n/a	n/a	One-year study with Natural Resources Canada to install instrumentation to determine if the site is dispersive. Results showed site is non-dispersive.
Cape Mudge (2018)	Primarily sand. No concerns with sediment chemistry.	Not performed	No concerns	Sediment chemistry data interpretation for other parameters is still underway.
Newcombe Channel (2018)	Primarily sand. No concerns with sediment chemistry.	Passed	No concerns	Sediment chemistry data interpretation for other parameters is underway.
Sandheads (2018)	Primarily sand at disposal site, silt outside. No concerns with sediment chemistry at site.	Passed	No concerns	Sediment chemistry data interpretation for other parameters is underway. Exceedances of the PCB guideline developed specifically for Killer Whale Critical Habitat were found outside of the disposal site. Re-investigated in 2019.
Sandheads (2019)	Primarily sand-silt. No concerns with sediment chemistry at site.	Not performed as it was completed in 2018 and all passed.	n/a	Sediment chemistry data interpretation for other parameters is still underway. Exceedances of PCB guideline for Killer Whale Critical Habitat once again found outside of disposal site. Site will be monitored again in 2020-2021.
Point Grey (2019)	Primarily gravel-sand at disposal site, silt-clay outside. No concerns with sediment chemistry.	Passed	No concerns	Sediment chemistry data interpretation for other parameters still underway.

Quebec region

In 2018-2019, six disposal sites were monitored in the Gulf of the St. Lawrence off the coast of the province of Quebec. Post-disposal hydrographic surveys were conducted at all sites and compared to the results of the surveys completed in 2016, providing a before and after survey of the sea floor.

Hydrographic survey

A multibeam echo sounder from a ship is used to measure the depth of the sea floor. The resulting image allows for the interpretation of where and how sediment and disposal material has settled at disposal sites.

Table 2: Results of monitoring disposal at sea sites in Quebec: 2018-2019 Results

Disposal site	Results of hydrographic surveys	Comments
Sainte-Thérèse-de-Gaspé (ST-4)	No material detected at disposal site	Expected result - verified compliance with unused permit
L'Anse-à-Beaufils (AB-5)	No material detected at disposal site	Unexpected result - permittee reported that 5,160 m^3 of material had been disposed at this site*
L'Anse-à-Brillant (ABR-1)	Only 24% of deposited material detected	Unexpected result, as more than 24% should be detected*
Saint-Godefroi (SG-2)	No material detected at disposal site	Unexpected result - permittee reported that 5,880 m^3 of material had been disposed at this site*
Port-Daniel-Est (PD-6)	No material detected at disposal site	Unexpected result - permittee reported that 4,490 m^3 of material had been disposed at this site*
Dépôt E	Nearly 302,274 m^3 of the expected 420,038 m^3 of material (72%) remained in place	Loss of material not a cause for concern

*For these four sites, this round of monitoring revealed a pattern in this region of not being able to find the material that was disposed. This has raised concerns that the material is in fact being disposed outside of the disposal sites' boundaries. As a result, investigations and preliminary conversations with the permit holder have suggested that incorrect coordinates may have been entered in the GPS of the inexperienced contractor. The investigation continued in 2019-2020 to resolve the issue for future permits.

In 2019-2020, five disposal sites were monitored in the Gulf of the St. Lawrence, including specific follow-up hydrographic surveys of those sites that had unexpected results (see table 3). Two other sites were monitored off the coast of the Îles-de-la-Madeleine with the same objective.

Table 3: Results of monitoring disposal at sea sites in Quebec: 2019-2020

Disposal site	Results of hydrographic surveys	Comments
L'Anse-à-Beaufils (AB-5)	Nearly 3,911 m^3 of the expected 6,067 m^3 of material (64%) remained in place.	Result is a vast improvement over 2018-2019 and demonstrates that material was disposed of at the correct location.
L'Anse-à-Brillant (ABR-1)	Nearly 815 m^3 of the expected 1,325 m^3 of material (61%) remained in place.	Result is a vast improvement over 2018-2019 and demonstrates that material was disposed of at the correct location.
G-5	No material detected at disposal site.	Expected result - permit was not used.
Port-Daniel-Est (PD-6)	No material detected at disposal site.	Expected result - permit was not used.
Saint-Godefroi (SG-2)	No material detected at disposal site.	Unexpected result as a permittee reported that 2,394 m^3 of material had been disposed at this site. A supplementary hydrographic survey will be conducted at in 2020-2021 to investigate further.
IE-6	Nearly 7,374 m^3 of the expected 7,742 m^3 of material (95%) remained in place.	Expected result - no concerns at the site.
M-5	Nearly 6,483 m^3 of the expected 10,111 m^3 of material (64%) remained in place.	Expected result - no concerns at the site.

Note: The percentage of material that remains in place is site specific and depends on a number of factors, which include: a) the nature of the site and whether or not it is dispersive; b) the pattern of disposal of the sediments; c) the depth of the site and slope of the seafloor; d) the type of substrate of the seabed versus the nature of the material disposed; e) the conditions at the time of the hydrographic survey.

An additional site off the coast of the Îles-de-la-Madeleine, Dépôt D, was also monitored in 2019-2020 (see table 4). The site is 12 m deep and has been closed since 2006. The study's objectives were to evaluate the recovery of the site and its stability over time.

Table 4: Results of 2019-2020 monitoring at Dépôt D disposal site

Hydrographic survey	Physico-chemical survey (sediment)	Benthic community survey	Video survey	Comments
Appears there is some light flattening of the site since 2006, primarily due to the effects of winds and storms.	No contamination issues	Low abundance and diversity of organisms. Differences in methodologies did not allow for evaluation of recovery of the site.	Sandy seafloor. No differences observed between abundance and richness of epibenthic macrofauna at the disposal site versus the reference sites.	No major concerns were found at this site and it is closed

Atlantic region

In 2019-2020, monitoring was conducted at the Black Point and Les Aboiteaux disposal sites, both located in New Brunswick. Results are included in table 5.

For the Les Aboiteaux disposal site, a pilot monitoring study was conducted to assess a proposed monitoring approach and tools for the biological monitoring of DFO Small Craft Harbour sand bypass disposal sites located along the Gulf shore. The pilot study utilized a beam trawl (trawl net spread on a beam) to sample the biological communities that live on, in, or near the seabed (epibenthic/ hyperbenthic). Seven transects were sampled at two study sites (nearfield exposure and reference). Prior to the conduct of the sampling study, underwater video recordings of the transects were collected, to determine the efficacy of the beam trawl method in sampling the biological community.

Table 5: Results of monitoring disposal at sea sites in Atlantic region 2019-2020

Disposal site	Hydrographic survey	Physico-chemical survey (sediment)	Biological survey	Comments
Black Point (New Brunswick)	Little change, except for 1.32 metres of deposition found between the 2018 and 2019 surveys. Sediments spread along the sea-bottom towards the northwest site boundary and appear to extend beyond in places.	Data interpretation still underway.	Data interpretation still underway.	Hydrographic surveys show significant sediment build-up at the disposal site. No concerns regarding navigational or environmental impacts. Annual hydrographic surveys will be conducted. Assessment of the apparent exceedance of the northwest boundary will be conducted.
Les Aboiteaux (New Brunswick) – pilot project	n/a	n/a	The beam trawl sampling method used in the pilot study resulted in low efficacy as compared to the video recordings.	Research and consultation with experts is underway to explore the possible causes of the low efficacy of this method and whether modifications could result in a better sampling of the biological community.

2.5 Water quality monitoring

Freshwater quality monitoring has been a core ECCC program since the Department's inception in the early 1970s. The Department's monitoring and surveillance activities are critical for assessing and reporting on water quality status and trends in addition to fulfilling federal domestic and international commitments and legislative obligations. Much of the Program's monitoring is carried out through federal-provincial/territorial agreements, ensuring cost-effective and non-duplicative program delivery.

ECCC's Fresh Water Quality Monitoring program continues to implement a risk-based adaptive management framework in conjunction with statistical analyses to better target monitoring activities to the risks of contaminants and human activities in Canadian watersheds. The approach has been used to optimize monitoring locations and adjust monitoring frequencies relative to the environmental risks and

to report on changes in environmental condition. The program continues to monitor chemicals of concern in water, sediments and aquatic biota at national sites across Canada in support of the Chemicals Management Plan.

Please see the *Canada Water Act* Annual Report for an update on freshwater quality monitoring in Canada**.**

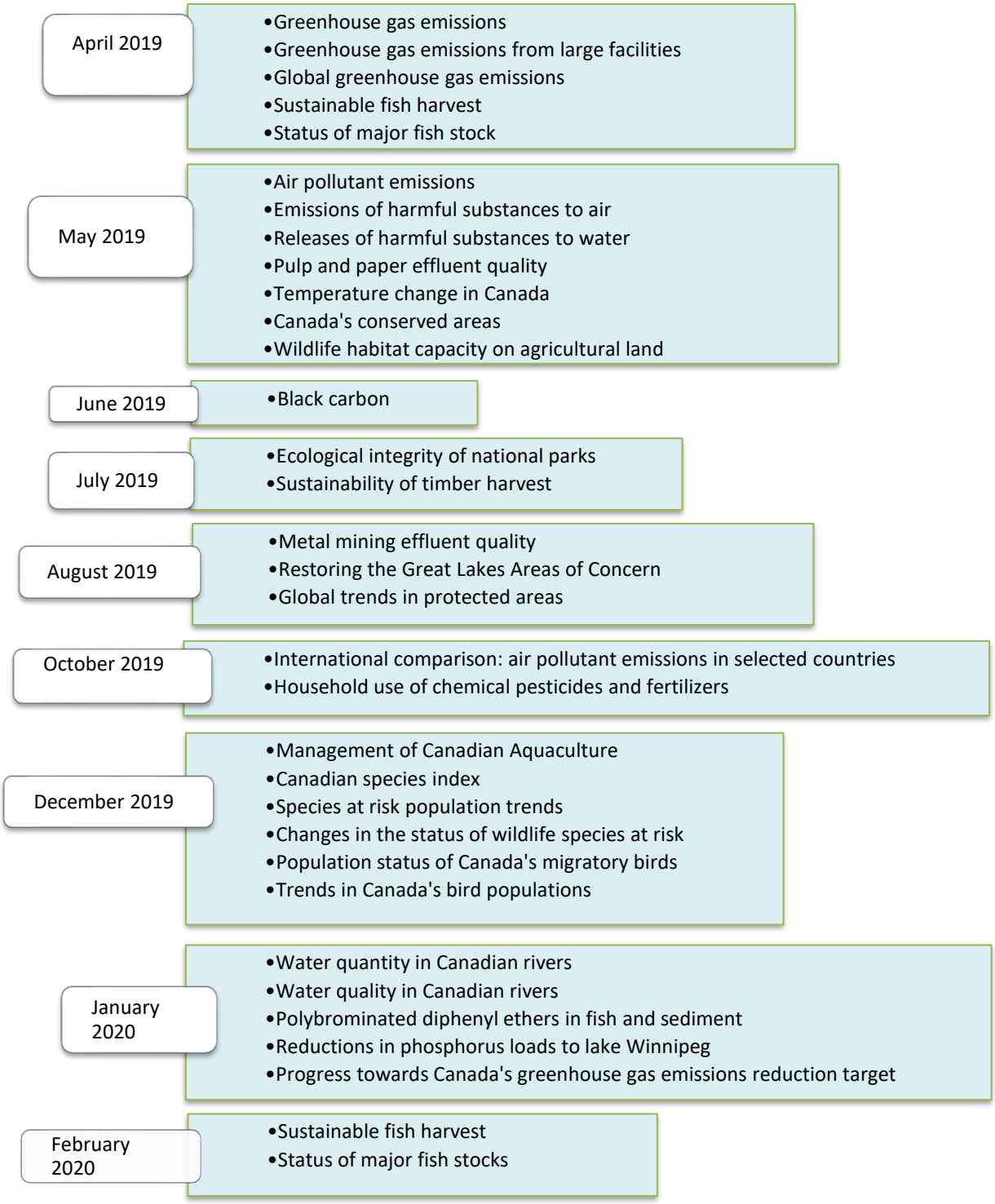
2.6 Canadian Environmental Sustainability Indicators

The Canadian Environmental Sustainability Indicators (CESI) program reports on key environmental sustainability issues including climate change, air quality, water quality and availability, wildlife, biodiversity, habitat, pollution, waste and toxic substances. It is designed to convey the state of Canada's environment, including historical trends, in a straightforward and transparent manner. CESI is used to inform citizens, Parliamentarians, policy makers and researchers with comprehensive, unbiased and authoritative environmental information. The CESI program responds to ECCC's commitments under CEPA and the *Department of the Environment Act* to report to Canadians on the state of the environment and is the prime instrument to measure progress of the Federal Sustainable Development Strategy.

ECCC prepares the indicators through close collaboration with science and data experts across the federal government, including Health Canada, Statistics Canada, Natural Resources Canada, Agriculture and Agri-Food Canada, and Fisheries and Oceans Canada, as well as relevant provincial and territorial counterparts. The data used to calculate indicators originate from a variety of sources, including surveys, measurement networks and other research initiatives that are expected to be maintained and updated for the foreseeable future.

The indicators are published on the CESI website showing national and regional results along with the methodology explaining each indicator and links to related socio-economic issues and information. CESI also has an interactive map that enables the user to quickly explore Canada's local and regional environmental indicators.

Table 6: Canadian Environmental Sustainability Indicators (CESI) updates and new releases in 2019-2020



3 Addressing key risks

3.1 Chemicals

Parts 4, 5 and 6 of CEPA include specific provisions for data collection, assessment and management of toxic substances. Substances include both chemicals and living organisms (specific information on living organisms begins in section 3.2).

There are two streams of risk assessment for substances in Canada based on when they enter into commerce. Substances on the Domestic Substances List (DSL) are referred to as **existing substances** and many have been in use in Canada for over three decades. Substances that are not on the DSL are considered **"new" substances.**

THE CHEMICALS MANAGEMENT PLAN UPDATE

The Chemicals Management Plan (CMP) is a program developed to protect Canadians and their environment from exposure to toxic substances. At its core is a commitment to assess, by 2020, approximately 4,300 substances of potential concern that were already in commerce in Canada. Under the CMP, the government also conducts pre-market assessments of health and environmental effects of approximately 400 substances that are new to Canada each year.

Since the launch of the CMP in 2006, the Government of Canada has managed potential risks to Canadians and their environment. As of March 31, 2020, the Government of Canada has:

- addressed 89% (3,894) of the 4,363 existing substances identified as priorities for attention by 2020-2021
- found 326 existing chemicals to be harmful to the environment and/or human health, for a total of 574 when including toxic conclusions prior to 2006
- implemented over 180 risk management actions for existing chemicals
- received and assessed approximately 6,288 notifications for new substances prior to their introduction into the Canadian market
- implemented 305 risk management actions for new chemicals

3.1.1 Information gathering

Mandatory surveys (or information gathering notices) issued under sections 46 and 71 of CEPA request commercial use information needed to support priority setting, risk assessment, or risk management activities.

In 2019-2020, the Government of Canada did not publish any mandatory notices. A summary of the information received in response to the 2017 inventory update (chemicals and polymers) was published via the Government of Canada Open Data Portal.

Targeted voluntary data-gathering activities also contribute to risk assessments and risk management activities. In 2019-2020, Health Canada issued two voluntary data requests for:

- 2-butanone, oxime and ethylbenzene to inform the performance measurement of the 2-butanone, oxime code of practice and potential development of Significant New Activity provisions for ethylbenzene, and
- certain alkylbenzene sulfonates and their derivatives/alkylbenzenes/sulfonate esters to inform risk assessment activities.

3.1.2 Existing substances risk assessment

ECCC and HC conduct risk assessments or screening assessments to determine whether existing substances, on the DSL, meet or are capable of meeting any of the criteria for toxicity as set out in section 64 of the Act. Draft screening assessments are published for a 60-day public comment period, which is followed by publication of the final screening assessments.

During 2019-2020 (see table 7), the Minister of the Environment and Minister of Health:

- published 28 draft screening assessment reports covering 282 substances
- published 9 final screening assessment reports covering 39 substances
- published 2 state of the science reports covering 3 substances
- concluded that 32 substances meet or are proposed to meet one or more of the toxicity criteria set out in section 64 of CEPA

Table 7: Summary of existing substance assessment decisions published from April 2019 to March 2020 (NFA – no further action)

Substances (and number of substances)	Meet s. 64 criteria	Proposed measure	Publication date of draft notice	Publication date of final notice
Isophorone diisocyanate (1)	No	NFA	March 3, 2018	April 27, 2019
Fatty Amides Group (3)	No	NFA	February 24, 2018	April 27, 2019
Diazenedicarboxamide (1)	No	NFA	April 20, 2019	
Triazines and Triazole Group (3)	No	NFA	April 13, 2019	
Substances identified as being of low concern using the ecological risk classification of inorganic substances and three human health science approaches (21)	No	NFA	April 13, 2019	
Used and Re-refined Oils Group (9)	No	NFA	April 6, 2019	
Phenol-Formaldehyde Resins Group (8)	No	NFA	April 6, 2019	
Organic flame retardant substances Group (4)	Yes	Add to Schedule 1	October 8, 2016	May 11, 2019
Copper and its compounds (37)	Yes	Add to Schedule 1	May 18, 2019	
Seven Hydrocarbon-based substances (7)	No	NFA	March 10, 2018	May 18, 2019
Gas Oils and Kerosenes Group (42)	No	NFA	May 11, 2019	
Epoxy Resins Group (4)	No	NFA	March 24, 2018	May 4, 2019
Zinc and its compounds (75)	Yes	Add to Schedule 1	June 29, 2019	
Chlorhexidine and its salts (4)	Yes	Add to Schedule 1	August 19, 2017	June 29, 2019
Alkyl Imidazolines Group (4)	No	NFA	June 22, 2019	
Acetonitrile (Nitriles Group) (1)	No	NFA	June 22, 2019	
Resins and Rosins Group (12)	Yes	Add to Schedule 1	June 22, 2019	
Organic Peroxides Group (2)	No	NFA	April 18, 2018	June 22, 2019
Heterocycles Group (3)	No	NFA	November 11, 2017	June 8, 2019
Siloxanes Group (6)	No	NFA	June 1, 2019	
Chlorocresol (1)	Yes	Add to Schedule 1	July 27, 2019	
Dimethoxymethane (1)	No	NFA	July 20, 2019	

Substances (and number of substances)	Meet s. 64 criteria	Proposed measure	Publication date of draft notice	Publication date of final notice
Acetic Acid (1)	No	NFA	July 20, 2019	
Phosphoric Acid Derivatives Group (3)	No	NFA	July 13, 2019	
Macrocyclic Lactones and Ketones, Ionones and Cyclohexanone Group (11)	No	NFA	May 19, 2018	July 6, 2019
Poly(alkoxylates-ethers) Group (21)	No	NFA	December 14, 2019	
Sodium cyclamate and cyclohexylamine (2)	No	NFA	December 14, 2019	
1-Nitropropane (1)	No	NFA	December 7, 2019	
Corn, steep liquor (1)	No	NFA	December 7, 2019	
Dicyclopentadiene (DCPD) (1)	No	NFA	December 7, 2019	
Lotus corniculatus extract (1)	No	NFA	December 7, 2019	
Sodium ortho-phenylphenate (SOPP) (1)	No	NFA	February 29, 2020	
Fluorescent brightener 367 (1)	No	NFA	February 22, 2020	
Heptamethylnonane (1)	No	NFA	February 1, 2020	
Acyclic, Monocyclic, and Bicyclic Monoterpenes Group (15)	Yes	Add to Schedule 1	March 14, 2020	
Salicylates Group (5)	Yes	Add to Schedule 1	March 14, 2020	
Parabens Group (7)	Yes	Add to Schedule 1	March 14, 2020	
Benzene, 1,3,5-tribromo-2-(2-propenyloxy)- (ATE) (1)	N/A	NFA	October 8, 2016	May 11, 2019
2-ethylhexyl-2,3,4,5 tetrabromobenzoate (TBB) (1)	N/A	NFA	October 8, 2016	May 11, 2019
Bis(2-ethylhexyl) 3,4,5,6-tetrabromophthalate (TBPH) (1)	N/A	NFA	October 8, 2016	May 11, 2019

Final decision by Ministers

Ministers may recommend the addition of a substance to Schedule 1 of CEPA if a screening assessment shows that a substance meets one or more of the toxicity criteria set out in section 64 of CEPA. The Governor in Council may then approve an Order specifying its addition to Schedule 1. The decision to recommend adding a substance to Schedule 1 obliges the Ministers to develop a "regulation or instrument respecting preventive or control actions" within specific time periods.

In 2019-2020, the Ministers proposed that two substances be added to Schedule 1 of CEPA as listed in table 8.

Table 8: Orders proposing adding substances to Schedule 1 of CEPA 1999 from April 2019 to March 2020

Substance	Proposed Order *
Benzene, 1,1′-(1,2-ethanediyl) bis [2,3,4,5,6- pentabromo-, which has the molecular formula $C_{14}H_4Br_{10}$	June 29, 2019
1,4:7,10-Dimethanodibenzo[a,e]cyclooctene, 1,2,3,4,7,8,9,10,13,13,14,14-dodecachloro-1,4,4a,5,6,6a,7,10,10a,11,12,12a-dodecahydro-, which has the molecular formula $C_{18}H_{12}Cl_{12}$	June 29, 2019

*Date of Publication in Canada Gazette Part I

In 2019-2020, six substances and one group of substances were added to Schedule 1 as listed in table 9.

Table 9: Orders adding substances to Schedule 1 of CEPA 1999 from April 2019 to March 2020

Substance	Final Order *
Benzene, 1,1′-methylenebis[4-isocyanato-, which has the molecular formula $C_{15}H_{10}N_2O_2$	May 15, 2019
Benzene, 1,1′-methylenebis[2-isocyanato-, which has the molecular formula $C_{15}H_{10}N_2O_2$	May 15, 2019
Benzene, 1-isocyanato-2-[(4-isocyanatophenyl)methyl]-, which has the molecular formula $C_{15}H_{10}N_2O_2$	May 15, 2019
Benzene, 1,1′-methylenebis[isocyanato- (non-isomeric-specific), which has the molecular formula $C_{15}H_{10}N_2O_2$	May 15, 2019

Substance	Final Order *
Isocyanic acid, polymethylenepolyphenylene ester, which has the molecular formula $C_{15}H_{10}N_2O_2•[C_8H_5NO]_n$ in which $0 \leq n \leq 4$	May 15, 2019
Cobalt and soluble cobalt compounds	June 26, 2019
N,N′-mixed phenyl and tolyl derivatives of 1,4-benzenediamine	June 26, 2019

*Date of publication in *Canada Gazette* Part II

Since 2014, ECCC and HC formalized their approach for the identification of risk assessment priorities (IRAP) for chemicals and polymers under CEPA. As a result of the IRAP process, substances may be considered for future risk assessment. The 2019 IRAP review took into consideration quantity and use information obtained through the 2017 DSL inventory update. Results of this IRAP review, along with results of the 2017-2018 IRAP review, will inform post-2020 assessment activities, including data gathering and problem formulation.

3.1.3 Existing substances risk management

Risk management instruments are put in place to reduce or eliminate risks to the environment and/or human health. They range from regulations, notices to require the preparation of pollution prevention plans, codes of practice, environmental performance agreements, release guidelines, to environmental quality guidelines.

Risk management scope and approach documents

In general, when a draft risk assessment proposes a conclusion that the substance is "toxic" under CEPA, a risk management scope document is developed and published at the same time as the draft assessment report. Risk management scopes are used as discussion documents to engage stakeholders on potential risk management actions. In 2019-2020, risk management scope documents were published for the following eight substances, or groups of substances:

- Chlorocresol
- Parabens group

- Certain terpenes and terpenoids within the Acyclic, Monocyclic and Bicyclic Monoterpenes Group
- Salicylates group
- Crude tall oil (CTO)
- Copper and its compounds
- Zinc and soluble zinc compounds
- Gas oils and kerosenes

When the final screening assessment report concludes that a substance is "toxic" under CEPA and is proposed for addition to Schedule 1 of the Act, a risk management approach document is developed and published at the same time as the final risk assessment report. The risk management approach document provides a more detailed description of the risk management being considered.

In 2019-2020, risk management approach documents were published for the following three substances, or substance groups:

- Chlorhexidine and its salts
- Benzene, 1,1'-(1,2-ethanediyl)bis [2,3,4,5,6-pentabromo- decabromodiphenyl ethane (DBDPE)
- 1,4:7,10-dimethanodibenzo[a,e]cyclooctene, 1,2,3,4,7,8,9,10,13,13,14,14-dodecachloro-1,4,4a,5,6,6a,7,10,10a,11,12,12a-dodecahydro- dechlorane plus (DP)

Final Regulations

On April 17, 2019, final ***Regulations Amending the Concentration of Phosphorus in Certain Cleaning Products Regulations*** were published in the *Canada Gazette*, Part II. These regulations limit the amount of phosphorus in certain cleaning products such as laundry, dishwasher detergents and household cleaners. The amendments exempted products in transit through Canada and revised laboratory accreditation provisions.

On April 17, 2019, the final ***Regulations Repealing the Chlor-Alkali Mercury Release Regulations*** were published in the *Canada Gazette*, Part II. The Regulations were no longer needed because the last chlor-alkali facility employing the mercury cell process closed in 2008. At the same time, the ***Regulations Amending the Regulations Designating Regulatory Provisions for Purposes of Enforcement (Canadian Environmental Protection Act, 1999)*** repealed the *Chor-Alkali Mercury Release Regulations* from the schedule.

Proposed Regulations

On June 15, 2019, ECCC published the proposed ***Regulations Amending the Ozone-depleting Substances and Halocarbon Alternatives Regulations.*** The proposed amendments would revise the Canadian hydrofluorocarbon (HFC) baseline value in accordance with the October 2018 Interim Order, before it was to expire in October 2020. In addition, the proposed amendments would allow the consumption of HCFC-123 (hydrochlorofluorocarbon) for the servicing of existing fire protection equipment until 2029, in accordance with recent adjustments to the Montreal Protocol on Substances that Deplete the Ozone Layer.

Regulatory administration

The *Ozone-depleting Substances and Halocarbon Alternatives Regulations* control the export, import, manufacture, sale and certain uses of ozone-depleting substances and hydrofluorocarbons, as well as certain products containing or designed to contain them.

- In 2019-2020, approximately 170 permits were issued under these Regulations. Additionally, in 2019 and 2020, consumption allowances for HFCs and HCFCs were issued to eligible companies. The lists of HCFC and HFC allowance holders are available online.

The *Federal Halocarbon Regulations, 2003* reduce and prevent emissions of halocarbons to the environment from refrigeration, air conditioning, fire extinguishing, and solvent systems that are located on Aboriginal or federal lands or are owned by federal departments, boards and agencies, Crown corporations, or federal works and undertakings.

- In 2019-2020, 12 permits to charge a fire-extinguishing system with a halocarbon and five permits to install a fire-extinguishing system with a halocarbon were issued under these Regulations.

Codes of Practice

In April 2019, a proposed *Code of Practice for Certain Methylenediphenyl Diisocyanates in Low-Pressure Two-Component Spray Polyurethane Foam Products* was published in the *Canada Gazette*, Part I, for a 60-day public comment period.

The third Progress Report regarding the *Code of Practice for the Management of Tetrabutyltin in Canada* was published on the Government Canada website in April 2019. The Department's review indicated that the sole facility covered had continued to implement the procedures and practices identified in the Code of Practice.

The complete list with status updates for all active Codes of Practice is available online.

Pollution Prevention Planning Notices

On June 15, 2019, the final *Notice requiring the preparation and implementation of pollution prevention plans in respect of reaction products of 2-propanone with diphenylamine (PREPOD), CAS RN 68412-48-6, in industrial effluents*, was published in the *Canada Gazette*, Part I. The Notice applies to persons who own or operate a facility within the chemical manufacturing and rubber sectors that has industrial effluent and that manufactures or uses PREPOD in quantities greater than 100 kg.

Progress under Pollution Prevention Planning notices is available online.

Environmental Performance Agreements

The fourth Progress Report on the Environmental Performance Agreement 2015–2020 Respecting the Use of Tin Stabilizers in the Vinyl Industry was published on the Government of Canada website in May 2019. The purpose of this agreement is to prevent the release of tin stabilizers into the environment through the continued implementation of effective stewardship practices by Canadian vinyl compounding facilities. The progress report indicates that all participating facilities have met the objective of the agreement.

On December 6, 2019, ECCC published a notice of the proposed renewal of the Environmental Performance Agreement Respecting the Use of Tin Stabilizers in the Vinyl Industry, for a one-month public comment period.

Results from four active EPAs and all completed EPAs are posted on the List of EPAs website.

Export Control List

The Export Control List, Schedule 3 of CEPA includes substances whose export from Canada is controlled because their use in Canada is prohibited or restricted, or because they are subject to an international agreement that requires notification or consent of the country of destination before the substance is exported from Canada.

A consultation on proposed amendments adding substances to the Export Control List was initiated in March 2020. The Consultation document (proposed amendments to Schedule 3) was made available to the public through the CEPA Registry.

In 2019-2020, 30 notices of proposed export were submitted to the Minister of the Environment. No export permits were requested or issued by the Minister.

Environmental quality guidelines

Environmental quality guidelines provide benchmarks for the quality of the ambient environment. They may be developed nationally through the Canadian Council of Ministers of the Environment (CCME) as Canadian Environmental Quality Guidelines (CEQGs) or federally under section 54 of CEPA as Federal Environmental Quality Guidelines (FEQGs).

Table 10 lists the CEQGs that were published or being developed nationally through CCME in 2019-2020.

Table 10: Canadian Environmental Quality Guidelines under development or finalized published in 2019-2020

Environmental compartment	Published	Under development
Water	Manganese	Nickel Neonicotinoid Pesticides (4) Alkyl substituted polycyclic hydrocarbons
Soils		Perfluorooctane sulfonate (PFOS)
Groundwater		Guidelines for n = 100 substances
Soil vapour		Guidelines for n = 100 substances

Table 11 lists the FEQGs for various CMP substances that were under development by ECCC in 2019-2020.

Table 11: Federal Environmental Quality Guidelines in 2019-2020

Environmental compartment	Under development
Water	Iron* Lead* Quinoline* Strontium* Aluminum D4 Siloxane Rare Earth Elements (REEs) Copper
Sediment	D4 Siloxane
Fish tissue	D4 Siloxane Selenium
Wildlife diet	D4 Siloxane
Bird egg	Selenium
Soil	Quinoline
Groundwater	Quinoline*

*Draft guidelines published for comments

Significant New Activity requirements

A Significant New Activity (SNAc) requirement is applied when a substance has been assessed and no current risk-based activities were identified, but there is a suspicion that new activities may pose a risk to human health and/or the environment. When it is applied, new uses or activities must be reported to the government. This ensures that departmental experts can evaluate whether the new use of a substance poses a risk to human health or the environment, and determine if risk management should be considered.

In 2019-2020, two SNAc Notices of intent were issued for 111 existing substances (table 12). The Notice of Intent published on July 27, 2019, was for 110 substances and resulted from the SNAc review initiative to ensure that current SNAc orders are aligned with current information, policies and approaches.

Table 12: Significant New Activity Notices of intent for existing substances from April 2019 to March 2020

Substance	Publication date
110 substances (see Appendix A for listing)	July 27, 2019
Benzene, 1-chloro-2-[2,2-dichloro-1-(4-chlorophenyl)ethyl]- (CAS RN 53-19-0)	February 1, 2020

3.1.4 New substances risk assessment

Substances that are new to Canada require notification to the government prior to beginning commercial activity in Canada. In 2019-2020, 409 new substance notifications were received pursuant to section 81 of CEPA and the *New Substances Notification Regulations (Chemicals and Polymers)*.

A new initiative to promote transparency was launched in 2018 to expand the practice of publishing summaries of new substance risk assessments. A total of 106 new substance risk assessment summaries were published online in 2019-2020.

During 2019-2020, 47 waivers of information requirements were granted and published in the *Canada Gazette* for new chemical and polymer substances.

Substances in products regulated under the *Food & Drugs Act* (FDA) are subject to the new substances provisions in CEPA for examination of potential risks to the environment and indirect exposure to humans. For new substances in products regulated under the FDA, 51 notifications for chemical/polymer substances and living organisms were received in 2019-2020.

3.1.5 New substances risk management

When the assessment of a new substance identifies a risk to human health or the environment, CEPA allows the Minister of the Environment to intervene prior to or during the earliest stages of its introduction into Canada. In this case, three actions may be taken. The Minister may:

a) permit the manufacture or import of the substance subject to specified conditions

b) prohibit the manufacture or import of the substance

c) request additional information considered necessary for the purpose of assessment

In 2019-2020, the Minister of the Environment issued seven Notices of Ministerial Conditions for five new substances (table 13).

Table 13: Notices of Ministerial Conditions for new substances from April 2019 to March 2020

Substance	Publication date*
Benzoic acid, 2-benzoyl-, methyl ester, (CAS RN 606-28-0)	April 27, 2019
Amides, tall-oil fatty, N-[3-(dimethylamino)propyl], CAS RN 68650-79-3)**	June 15, 2019
Amides, tall-oil fatty, N-[3-(dimethylamino)propyl], CAS RN 68650-79-3)**	June 15, 2019
Amides, tall-oil fatty, N-[3-(dimethylamino)propyl], CAS RN 68650-79-3)**	June 15, 2019
Amines, C36-alkylenedi- (CAS RN 68955-56-6)	August 17, 2019
9-octadecenoic acid (*Z*)-, compd. with (*Z*)-*N*-9-octadecenyl-1,3-propanediamine, (CAS RN 40027-38-1)	January 2, 2020
*N*1-(2-aminoethyl)-*N*2-[2-[(2-aminoethyl)amino]ethyl]-1,2-ethanediamine, alkane bis oxymethyleneoxirane, 4,4′-(1-methylethylidene)bis[phenol] and 2,2′-[(1-methylethylidene)bis(4,1-phenyleneoxymethylene)]bis[oxirane], reaction products with Bu glycidyl ether and 1-[[2-[(2-aminoethyl)amino]ethyl]amino]-3-phenoxy-2-propanol, acetates (salts), Confidential Substance Identity Number 13804-7	January 25, 2020

* The dates are those on which the Notices were published in the *Canada Gazette*, Part I.
** Different notifiers were identified in the three notices.

A Significant New Activity (SNAc) requirement is applied when a substance has been assessed and no current risk-based activities were identified, but there is a suspicion that new activities may pose a risk to human health and/or the environment. In 2019-2020, six SNAc Notices and one SNAc Order were issued for new substances (table 14).

Table 14: Significant New Activity Notices and Order for new substances issued from April 2019 to March 2020

Substance	Publication date*
Nonadecane, 9-methylene-, mixed with 1-decene, dimers and trimers, hydrogenated (CAS RN 1000172-32-6)	May 18, 2019
Aluminium magnesium vanadium oxide (CAS RN 170621-28-0)	May 18, 2019
2-propenoic acid, 2-methyl-, eicosyl ester, polymer with hexadecyl 2-methyl-2-propenoate, isooctyl 2-propenoate, octadecyl 2-methyl-2-propenoate and 2-propenoic acid (CAS RN 133167-76-7)	June 22, 2019
Ethanol, 2-amino-, reaction products with ammonia, by-products from, distn. residues (CAS RN 84238-53-9)	August 3, 2019
Ethanol, 2-amino-, reaction products with ammonia, by-products from (CAS RN 68910-05-4)	August 3, 2019
1,2-cyclohexanedicarboxylic acid, 1-butyl 2-(phenylmethyl) ester (CAS RN 1200806-67-2)	December 14, 2019
Pentane, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)- (CAS RN 132182-92-4)	March 18, 2020

* The dates are those on which the Final Notices or Orders were published in the *Canada Gazette*, Part I.

3.1.6 Communications activities

ECCC and HC work together to communicate information to Canadians on the environmental and human health risks of substances of concern. The Departments publish materials on the Canada.ca and Chemicals Management Plan web pages, and on ECCC and HC social media channels.

In 2019-2020, ECCC and HC increased their collaboration activities to raise awareness of the safe use and potential risks of chemicals. A large variety of communications material was developed and published to accompany the technical and scientific documents on chemicals. These products include information sheets, fact sheets, plain-language summary pages and social media campaigns. They provide supplemental and/or non-technical information about substances of concern, for stakeholders and the general public.

More specifically, the following communications activities relating to the health and environmental risks of chemicals were undertaken:

- Publication of 27 'Information sheet' webpage summaries of draft screening assessments and risk management scopes (where applicable)
- Publication of 13 'Information sheet' webpage summaries of final screening assessments and risk management approach documents (where applicable)
- Publication of two 'Information sheet' webpage summary updates for substances discussed in two final state of the science reports
- Publication of two 'Information sheet' webpage updates for risk management activities
- Publication of plain-language summaries and communications materials for selected substances of concern, including:
    - Publication of a news release and social media products related to the draft science assessment of plastic pollution
    - Publication of a news release, backgrounder and social media products related to the draft screening assessment for parabens
    - Publication of five plain language summaries for high profile substances that underwent a draft screening assessment (rose oil, salicylic acid, mandarin and tangerine oil, turpentine and turpentine oil, and parabens)
- Continued national roll out of the new Healthy Home social marketing campaign. The Healthy Home campaign includes a range of activities and messaging on webpages and through social media, to encourage Canadians to take action to protect themselves from the risks of chemicals found in and around the home.
    - Digital engagement: social media advertising promoting the campaign and driving traffic to the Healthy Home website, and a new video for the general public on asbestos.
    - Media outreach: Promoting the campaign in community publications across Canada by 477 media outlets.
- Publication of 106 new substances notification assessment summaries on Canada.ca

- Delivery of approximately 280 outreach activities across the country concerning the safe use of consumer products and cosmetics, and limiting exposure to toxic chemicals, to empower consumers and stakeholders to make informed decisions. The activities targeted intermediary groups such as early childhood educators, fire chiefs, and public health professionals. This allowed the information to reach subpopulations that may be more vulnerable to chemicals or have greater exposure, such as pregnant women children and youth, new Canadians, and Indigenous communities.

3.2 Living organisms

Products of biotechnology that are living organisms are regulated for health and safety purposes by a variety of federal departments and agencies across the government. CEPA sets the federal standard for assessment and risk management of new and existing living organisms that are new animate products of biotechnology. Other Canadian legislation meeting the CEPA standard is listed in Schedule 4 of the Act. Living organisms manufactured or imported for a use not covered by an Act listed on Schedule 4 are regulated under CEPA. These include naturally occurring and genetically modified organisms (such as bacteria, fungi, viruses, and higher organisms such as fish or pigs) used for various environmental, industrial and commercial purposes.

3.2.1 Risk assessment activities

Risk assessment of new animate products of biotechnology

During 2019-2020, 27 notifications of new animate products of biotechnology were received and 18 were assessed as new animate products under the *New Substances Notification Regulations (Organisms)*. All notifications that were accepted as new animate products were assessed within the statutory assessment period.

For new substances in products regulated under the *Food and Drugs Act*, 13 notifications for new animate products of biotechnology were received in 2019-2020.

Also during 2019-2020:

- 30 pre-notification consultations were held to help companies better understand the notification requirements for their specific organism before submitting a Notification, and
- 16 waivers of information requirements for new living organisms were granted and published in the *Canada Gazette*, Part I.

Risk assessment of new higher organisms

The *Voluntary Public Engagement Initiative* on the risk assessment of higher organisms (e.g., genetically modified plants and animals) was launched in 2018. This initiative promotes greater public engagement in the risk assessment of higher organisms. Two public comment periods were completed in April and July 2019 on three new genetically modified fishes to inform risk assessments.

Risk assessment of existing animate products of biotechnology

The Act requires that all living organisms (68) that were grandfathered to the DSL because they were in commerce between 1984 and 1986, undergo a screening assessment to determine whether the living organism is toxic or capable of becoming toxic. ECCC and HC jointly perform the screening assessment of micro-organisms listed on the DSL.

On August 29, 2019, a final screening assessment for two micro-organisms was published in the *Canada Gazette*, Part I (see table 15). Neither of these organisms met the toxicity criteria in section 64 of the Act.

Table 15: Summary of existing living organisms assessment decisions published from April 2019 to March 2019

Assessment	Publication date final
Aspergillus awamori (strain ATCC 22342) and *Aspergillus brasiliensis* (strain ATCC 9642)	August 24, 2019

Note: The date is that on which the notice was published in the *Canada Gazette*, Part I.

3.2.2 Risk management activities

The significant new activity (SNAc) provisions trigger an obligation for a person to provide the Government of Canada with information about a substance when proposing to use, import or manufacture the substance for a significant new activity. The government then assesses the substance for potential risks to human health and/or the environment. If risks are identified, the government may impose management measures.

Significant New Activity requirements

In 2019-2020, one SNAc Notice of Intent was issued for the DSL strains of *A. awamori* and *A. brasiliensis* (see table 16).

Table 16: Significant New Activity Notices of intent and Orders for existing living organisms from April 2019 to March 2020

Assessment	Number of strains	Notice of intent*	Final Order*
Aspergillus awamori (ATCC No. 223421)	1	August 24, 2019	TBD
Aspergillus brasiliensis (ATCC No. 9642)	1	August 24, 2019	TBD

* The dates are those on which the Notices of intent and final Orders were published in the *Canada Gazette*, Part I or Part II, respectively.

3.3 Air pollutants and greenhouse gases

Air pollutants and greenhouse gases (GHGs) originate from numerous domestic and international sources, such as industry and transportation. CEPA provides authorities to develop and administer regulatory and non-regulatory risk management instruments to reduce the releases of air pollutants and GHGs.

3.3.1 Risk assessment activities

Outdoor air quality

Health Canada (HC) assesses the overall impact of air pollution on the health of Canadians on an annual basis. Health and environmental risk assessments of air pollutants underpin air quality risk management decisions made by federal, provincial, territorial and municipal governments. Comprehensive risk assessments are completed in support of decisions to establish or update Canadian Ambient Air Quality Standards (CAAQS) and sector-based assessments are conducted to inform management and regulation of air pollution sources.

HC is completing science assessments of the health effects of particulate matter ($PM_{2.5}$); the exposure of Canadians to traffic-related air pollution (TRAP) and evaluation of the evidence linking it to asthma, allergies and changes to lung function; and the national population health impacts of wildfire smoke during the 2013-2018 period.

Indoor air quality

In 2019-2020, HC continued risk assessments on indoor carbon dioxide and acrolein. HC also continued work on a new round of risk assessments based on a recently completed prioritization process. Work on an assessment of xylenes and the reassessment of benzene is ongoing.

3.3.2 Risk management activities

Different regulatory and non-regulatory instruments are available under the authorities provided by CEPA to limit and reduce emissions of air pollutants and greenhouse gases from vehicles, engines and fuels, consumer and commercial products, and industrial sectors, as well as for establishing national ambient air quality objectives to drive air quality improvements.

Health Impacts of Air Pollution in Canada: Estimates of Morbidity Outcomes and Premature Mortalities, 2019 Report

Assessment of the annual population health impacts attributable to outdoor air pollution in Canada

Ambient concentrations of air pollutants (fine particulate matter, ozone and nitrogen dioxide) were estimated across the country from a combination of satellite measurements, ground measurements and air quality computer models. It is estimated that above-background air pollution causes 14,600 premature deaths per year in Canada, as well as 2.7 million asthma symptom days and other morbidities.* The total economic valuation of the health impacts attributable to air pollution in Canada is estimated at $114B per year (based on 2015 currency). Overall, this analysis indicates that despite improvements in air quality and the relatively low levels of air contaminants in Canada compared to other regions of the world, air pollution continues to have impacts on population health in Canada.

*Health Canada's computer model (the Air Quality Benefits Assessment Tool or AQBAT), which produces an estimate of the number of premature deaths and other health outcomes in Canada that are associated with a specified change in air pollution concentration, was used).

Cooperation among governments is key in managing air pollution. The Air Quality Management System (AQMS), agreed to by federal, provincial and territorial environment ministers in 2012, provides a collaborative approach to reducing air pollution and improving the health of Canadians and the environment. The AQMS includes:

- Canadian Ambient Air Quality Standards (CAAQS)
- local air zones and regional airsheds
- industrial emission requirements for major industries
- work to address emissions from mobile sources

- outdoor air pollutants monitoring program
- reporting to Canadians on the state of the air

CAAQS are environment- and health-based-standards that apply to the concentration of specific air pollutants in the outdoor air. They provide the drivers for air quality management actions across the country. ECCC and HC lead the process under the Canadian Council of Ministers of the Environment (CCME) to develop, review and amend CAAQS. Once agreed under the CCME, CAAQS are published as environmental quality objectives under CEPA. CAAQS have been developed for fine particulate matter ($PM_{2.5}$), ozone (O_3), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2).

On June 29, 2019, the Minister of the Environment and the Minister of Health published new CAAQS for ozone as environmental quality objectives under CEPA. The new ozone CAAQS will replace the 2020 standard and comes into effect on January 1, 2025. Work is underway on the review of the CAAQS for fine particulate matter ($PM_{2.5}$).

Industrial sector emissions requirements

The *Multi-Sector Air Pollutants Regulations* (MSAPR) came into force in 2016 and established nationally consistent industrial emissions performance standards. The MSAPR limit nitrogen oxides (NO_x) emissions from large industrial boilers and heaters, as well as from stationary spark-ignition engines, used in several industrial sectors, that burn gaseous fuels (such as natural gas). The MSAPR also limit NO_x and SO_2 emissions from kilns at cement manufacturing facilities. It is expected that the MSAPR will contribute significantly to reducing emissions that contribute to smog and acid rain, including 2,000 kilotonnes of NO_x emission reductions in the first 19 years.

On June 8, 2019, the proposed *Multi-Sector Air Pollutants Regulations Amendment Regulations (Part 1 — Biomass)* were published in the *Canada Gazette*, Part I. The proposed amendments to

Part 1 of the MSAPR would ensure that boilers and heaters that combust predominantly solid or liquid biomass are excluded from the MSAPR.

For stationary spark-ignition engines, an online reporting system is available for regulatees to register engines and submit compliance reports for modern engines. Registrations for approximately 100 modern and 5,100 pre-existing engines were received from over 100 regulated parties. Emissions requirements for the modern engines are in force with annual compliance reports due by July 1. Emission requirements for pre-existing engines begin to apply in 2021.

The first annual reports, due in June 2019, were submitted by all cement facilities subject to the MSAPR. Emission requirements for these facilities apply in 2020.

Oil and gas sector emission requirements

The first requirements under the *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)* came into force on January 1, 2020, in order to help fulfill Canada's commitment to reduce emissions of methane from the oil and gas sector by 40 to 45% below 2012 levels by 2025.

Regulatory requirements for facility production venting restrictions and venting limits for pneumatic equipment come into force on January 1, 2023.

Transportation sector emissions requirements

ECCC administers six vehicle and engine emission regulations and nine fuel regulations under CEPA.

ECCC and the U.S. Environmental Protection Agency (U.S. EPA) continued to collaborate closely through the United States-Canada Air Quality Committee towards the development of aligned

vehicle and engine emission standards, related fuel quality regulations and their coordinated implementation.

On May 27, 2019, an interim order was made by the Minister to delay the coming into force of the GHG emission standards for trailers in Canada under the *Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations* until May 27, 2020. On June 15, 2019 a Governor in Council *Order Approving the Interim Order Modifying the Operation of the Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations (Trailer Standards)* was published in the *Canada Gazette*, Part I. This allowed the department time to assess concerns received from Canada's trailer industry on potential adverse economic impacts if Canada proceeded to implement the trailer standards without the corresponding standards of the U.S. EPA being in force due to legal challenges.

In April 2019, ECCC published the final *Regulations Amending the Contaminated Fuel Regulations.* The Amendments exempt contaminated fuels in transit from the prohibition on imports and exports of contaminated fuels.

Regulatory administration of transportation and fuel quality regulations

ECCC administers a compliance program under the transportation and fuels regulations. This includes processing of regulatory reports and importation declarations; managing notice of defects and recalls; testing of selected vehicles and engines; analyzing fuel samples; reviewing recoding of fuel suppliers; and verifying compliance with the regulations.

Some transportation regulations require companies to submit annual compliance reports documenting fleet performance and the quantity of products. Fuel producers and importers are required to submit annual reports on the composition and volume of petroleum products, as well as corporate pool averages. During 2019-2020, the department received approximately 260 regulatory reports for vehicles and engines and over 550 reports for fuels. ECCC conducts an annual risk-based review of each fuel supplier based on the reports submitted. In 2019-2020,

ECCC assessed 83 fuels suppliers and took further action to address reporting issues with at least 59 companies.

In 2019-2020, ECCC processed about 300 Canada-unique[2] submissions and almost 2030 importation declarations for vehicles and engines. Additionally, the department processed 86 notices of defect and recall notifications covering almost 512,300 vehicles and engines. ECCC continues to post basic information summarizing notices of defect and other company notifications submitted to the department on the Government of Canada's Open Data portal.

The administration of the transportation and fuel quality regulations is supported by ECCC laboratory emissions testing on vehicles and engines, and fuel quality testing done in order to verify compliance with the regulations. Occasionally, private laboratories will be used by ECCC to conduct testing. In 2019-2020, the department conducted testing on 129 vehicles and engines, and conducted 169 analyses on 73 fuel samples.

During 2019-2020, ECCC responded to almost 1,500 inquiries regarding the vehicles and engines regulations and over 500 regarding the fuels regulations.

During 2019-2020, the department published the 2017 model year light-duty vehicle GHG performance report. This report, compiled from the annual compliance reports submitted by automobile companies, documents the overall fleet performance for each of the specified model years. The department also published three fuel quality reports covering data reported for gasoline and distillate fuels between 2013 and 2017. These reports summarized data, collected from fuel producers and importers, of benzene in gasoline, sulphur in liquid fuels, and renewable fuels. The corresponding aggregated fuel quality data was also published in 2019-2020 using the Open Data Portal.

[2]A Canada-unique vehicle or engine is a vehicle or engine that is specifically listed on a United States Environment Protection Agency (EPA) certificate and sold in Canada, but not sold in the United States; or a vehicle or engine that is not specifically listed on an EPA certificate.

More information on the Government of Canada's vehicle, engine and fuel regulations is available online.

Clean fuel standard

The government is developing a Clean Fuel Standard, a key part of the Pan-Canadian Framework on Clean Growth and Climate Change that will reduce the carbon intensity of fuels used in Canada. The Clean Fuel Standard aims to lower the carbon intensity of fossil fuels, resulting in significant GHG emissions reductions, while sending a market signal for investment and innovation in low carbon fuels and technologies and reducing compliance costs through a flexible regulatory design.

On June 28, 2019, ECCC released the document Clean Fuel Standard: Proposed Regulatory Approach. This document outlined the proposed design for the liquid fuel class regulations of the Clean Fuel Standard. It was developed through extensive engagement and consultations with provinces, territories and stakeholders. The document built on the Clean Fuel Standard: Regulatory Design paper, published in December 2018, as well as the Clean Fuel Standard Regulatory Framework, published in December 2017.

Consumer and commercial products

ECCC has been targeting the reduction of emissions of Volatile Organic Compounds (VOCs) from consumer and commercial products. VOCs are a contributing factor in the creation of air pollution. Control measures have been developed that set VOC content limits in some products, which in turn reduce their emissions.

On July 6, 2019, ECCC published the proposed *Volatile Organic Compound Concentration Limits for Certain Products Regulations* in the *Canada Gazette*, Part I, for a 75-day comment period. The proposed Regulations would establish VOC concentration limits for 130 product categories

including: personal care, automotive and household maintenance products; adhesives, adhesive removers, sealants and caulks; and other miscellaneous products. All comments received during the consultation period are currently under consideration.

Indoor air quality

In addition to the penetration indoors of outdoor pollutants, indoor air can be contaminated by emissions from building materials, products, and activities inside the home, and by the infiltration of naturally occurring radon from the soil under the building.

On June 29, 2019, the proposed *Formaldehyde Emissions from Composite Wood Products Regulations* were published. The proposed regulations would set formaldehyde emission limits for composite wood products that are for indoor use.

The Residential Indoor Air Quality Guidelines summarize the health risks posed by specific indoor pollutants, based on a review of the best scientific information available at the time of the assessment. HC also continued the implementation of a risk-based screening process for 60 semi-volatile organic compounds (SVOCs) in indoor air.

In 2019-2020, HC published fact sheets on indoor air quality including:

Ventilation and Indoor Air Quality

and

Indoor Sources of PM2.5

In 2019-2020, HC also conducted investigations that help to inform risk assessment and risk management processes for indoor environments. A study of air quality in ice arenas continued with the objective of developing broadly applicable risk management practices. Additionally, a multi-year study of the air quality in newly built homes in Ottawa was initiated.

3.4 Drinking water quality

Work on water quality under CEPA includes leadership on the development of guidelines for water quality.

HC works in collaboration with the provinces and territories to establish a list of priority contaminants for developing or updating Guidelines for Canadian Drinking Water Quality (GCDWQ) and their technical documents.

Health-based guidelines are developed for drinking water contaminants that are found or expected to be found in drinking water supplies across Canada and at levels that could lead to adverse health effects. All provinces and territories use the GCDWQ to establish their own regulatory requirements regarding the quality of drinking water in their jurisdictions to manage the risk from drinking water.

Priorities for guideline development are established approximately every four or five years, using exposure information from federal, provincial and territorial sources and up-to-date science, international actions, as well as taking into consideration jurisdictional needs. A process for prioritizing the development and update of GCDWQ was published in 2019. The list of priority contaminants will be finalized and form the basis for the future workplan for the Federal-Provincial-Territorial Committee on Drinking Water (CDW).

HC has also been modernizing its drinking water program to increase openness and transparency and further engage the Canadian public. New or updated GCDWQ are published in the *Canada Gazette*, Part I, while the technical document continues to be published on Health Canada's website. The final GCDWQ are also accompanied by a plain language summary to increase the public's access.

For increased transparency, each guideline contains a section dedicated to a comparison with standards of international agencies and other jurisdictions, including new or updated standards.

In some instances, drinking water values for specific contaminants vary internationally due to a number of considerations. All leading international agencies and jurisdictions consider the science that has been used by other agencies. However, each jurisdiction maintains its own considerations that are specific to climate, geology, industrial uses and other factors which are characteristic of the country, thus accounting for the potential for different values in different jurisdictions (whether higher or lower). An international comparison is more than choosing the most stringent value or lowest number for drinking water standards around the world.

Table 17 lists the guidelines finalized in 2019-2020 and those under development.

Table 17: Guideline documents for Canadian drinking water quality from April 2019 to March 2020

Published final guidelines	In progress*
Barium (January 2020)	Aluminum (June 2019)
Chloramines (February 2020)	Boron (January 2020)
Copper (June 2019)	E. Coli (June 2019)
Enteric Protozoa (April 2019)	Total coliforms (June 2019)
Enteric Viruses (April 2019)	Withdrawal of Select Guidelines (February 2020)
Manganese (May 2019)	
Quantitative Microbial Risk Assessment (July 2019)	
Strontium (May 2019)	
Uranium (May 2019)	

*In progress refers to guidelines published for consultation

3.5 Waste

Waste generally refers to any material, non-hazardous or hazardous, that has no further use, and is managed at recycling, processing or disposal sites or facilities. In Canada, the responsibility for

managing and reducing waste is shared between the federal, provincial, territorial and municipal governments.

ECCC exercises responsibilities with respect to disposal at sea of specified materials, as well as the international and interprovincial movements of hazardous waste and hazardous recyclable material.

Plastic that is discarded, disposed of, or abandoned in the environment outside of a managed waste stream is considered plastic pollution. Plastic pollution has been detected on shorelines, and in surface waters, sediment, soil, groundwater, indoor and outdoor air, drinking water and food.

On February 1, 2020, a draft science assessment of plastic pollution was published in the *Canada Gazette*, Part I, for a 60-day public comment period. The purpose of the report was to summarize the current state of the science regarding the potential impacts of plastic pollution on the environment and human health, as well as to guide future research and inform decision-making on plastic pollution in Canada.

In addition to the activities listed below, risk management actions described in section 3.1.3 on toxic substances also contribute to the overall improvement of waste management.

3.5.1 Disposal at sea

Part 7, Division 3 of CEPA imposes a general prohibition on the disposal at sea or onto sea ice of substances. Disposal at sea activities conducted under a permit from ECCC are exempt from this prohibition and permits are only available for a short list of low risk wastes. A permit is only granted after an assessment, and only if, disposal at sea is the environmentally preferable and practical option.

The 2018 agreement between ECCC and the Tsleil-Waututh Nation (TWN) is now in effect. The department and the TWN are working towards starting up the collaborative processes and mechanisms to begin to review permits and collaborate on shared environmental monitoring priorities. When implemented, the agreement will enable ECCC to meet its duty to consult TWN, including at the Point Grey disposal site, which is one of the most active sites in Canada.

International activities

The disposal at sea provisions of CEPA help Canada to meet its obligations as a party to the 1996 London Protocol, which is a more modern version of the 1972 London Convention. Canada reports the number of permits, quantities and types of wastes disposed, and results of disposal site monitoring to the London Protocol Secretariat each year.

At the London Protocol meetings in 2019, Canada led a group working to help other countries to monitor for effects of disposal in the marine environment, and supported workshops and technical assistance offered to bring implementation within reach of more countries. Canada completed a three-year term as Chair of the London Protocol Compliance Group, which encourages and supports compliance and ratification of the treaty.

Disposal at sea permits

In 2019-2020, 85 permits were issued in Canada for the disposal of 9.3 million tonnes of waste and other matter at sea (tables 18 and 19), compared to 93 permits for the disposal of 9.4 million tonnes in 2018-2019. While similar to the amount permitted in 2018-2019, this is significantly higher than the ten-year average, largely due to the permitting of a few major projects for port development and the continued need to remove dredged material from harbours and waterways to keep them safe for navigation. Also permitted was excavated native till (geological matter) that is disposed of at sea in the lower mainland of British Columbia, where on-land disposal options for clean fill are extremely limited. Fish-processing waste was also permitted in remote communities where there is no access to reuse-and-recycling opportunities.

Table 18: Disposal at sea quantities permitted (in tonnes) and permits issued in Canada from April 2019 to March 2020

Material	Quantity permitted	Permits issued
Dredge material	7,478,062	50
Fisheries waste	33,420	28
Geological matter	1,820,000	7
Vessels	0	0
Organic matter	0	0
Total	**9,331,482**	**85**

Note: Dredged material and geological matter were converted to tonnes using an assumed density of 1.3 tonnes per cubic metre.

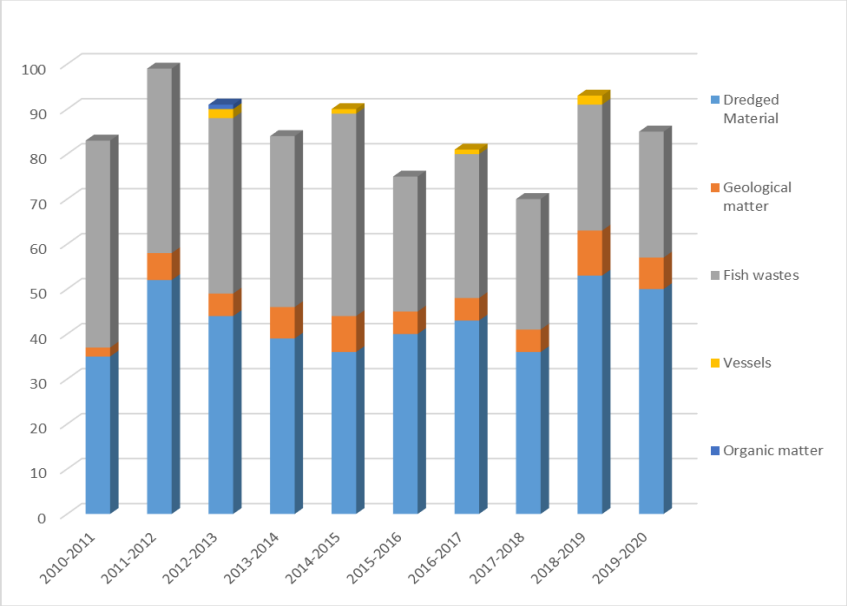
Table 19: Disposal at sea quantities permitted (in tonnes) and permits issued by region from April 2019 to March 2020

Material	Atlantic		Quebec		Pacific and Yukon		Prairie and Northern	
	Quantity	Permits	Quantity	Permits	Quantity	Permits	Quantity	Permits
Dredge material	1 490 450	13	85 800	10	5 862 812	26	39 000	1
Fisheries waste	32 270	25	1 150	3	--	--	--	--
Geological matter	--	--	--	--	1 820 000	7	--	--
Vessels	--	--	--	--	0	0	--	--
Organic matter	--	--	--	--	--	--	--	--
Total	**1 522 720**	**38**	**86 950**	**13**	**7 ,682 812**	**33**	**39 000**	**1**

Note: Dredged material and geological matter were converted to tonnes using an assumed density of 1.3 tonnes per cubic metre.

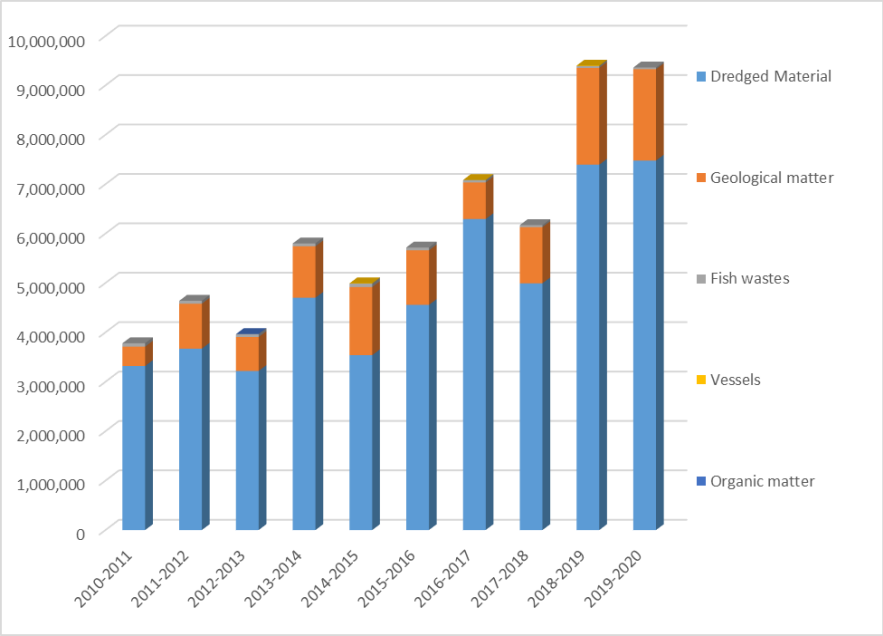
Figures 6 and 7 illustrate the trends in the number of permits issued over the last decade, as well as the trends in the quantities of the types of material disposed of at sea. The number of permits issued decreased in 2019-2020 (figure 6).

Figure 6: Number of disposal at sea permits issued in each fiscal year by type of material



The quantities permitted continue to fluctuate from year to year. Building of infrastructure led to a high quantity permitted for both dredged material and inert, inorganic geological matter (excavated material) this past fiscal year (figure 7), similar to the quantity in 2018-2019.

Figure 7: Annual disposal at sea quantities permitted (in millions of tonnes)



Further information on disposal at sea is available online.

3.5.2 Hazardous waste and hazardous recyclable material

With respect to managing the movement of hazardous waste and hazardous recyclable material, CEPA provides authority to:

- make regulations governing the export, import and transit of waste (including both hazardous and prescribed non-hazardous waste) and hazardous recyclable materials
- establish criteria for refusing an export, import or transit permit, should the hazardous waste or hazardous recyclable material not be managed in a manner that will protect the environment and human health
- make regulations governing movements of hazardous waste and hazardous recyclable materials between provinces and territories

Through the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations,* the *Interprovincial Movement of Hazardous Waste Regulations* and the *PCB Waste Export Regulations*, 1996, Canada implements its international obligations as a party to the:

- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention)
- Organization for Economic Co-operation and Development Decision on the Control of Transboundary Movement of Wastes Destined for Recovery Operations (OECD Decision)
- Canada-United States Agreement on the Transboundary Movement of Hazardous Waste

In 2019, ECCC processed 2,347 notices for proposed imports, exports and transits of hazardous wastes and hazardous recyclable materials under the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*.

The notices received covered 38,128 waste streams, which exhibited a range of hazardous properties such as being flammable, acutely toxic, oxidizing, corrosive, dangerously reactive and environmentally hazardous.

Of the notices received, 1,870 permits were issued. From these permits, at least 21,453 individual transboundary shipments of hazardous waste and hazardous recyclable material were reported in movement documents received by ECCC. Because not all movement data for 2019 was available at time of publication, care must be taken when analyzing this potential decrease. It should be noted that data are revised periodically as new information becomes available.

In 2019, almost all imports (99.7%) and exports (92.8%) of hazardous wastes and hazardous recyclable materials occurred between Canada and the United States. The remaining import exchanges occurred with Germany, France, Bahamas, Bolivarian Republic of Venezuela, United Arab Emirates, Brunei Darussalam, and Indonesia, while the remaining exports occurred with the Republic of Korea, Mexico, Germany, Belgium and Austria.

The quantity of hazardous wastes and hazardous recyclable materials imported into Canada was 276,410 metric tonnes (t) in 2019. This represents a decrease of 111,879 t or 29% compared to 2018.

Imported shipments destined for recycling totaled 178,046 t and represented about 64% of all imports in 2019. Imports of all hazardous wastes and hazardous recyclable materials in 2019 were shipped to authorized facilities in five provinces: Ontario, Quebec, British Columbia, New Brunswick and Alberta. Hazardous recyclable material imported into Canada in the greatest quantities were:

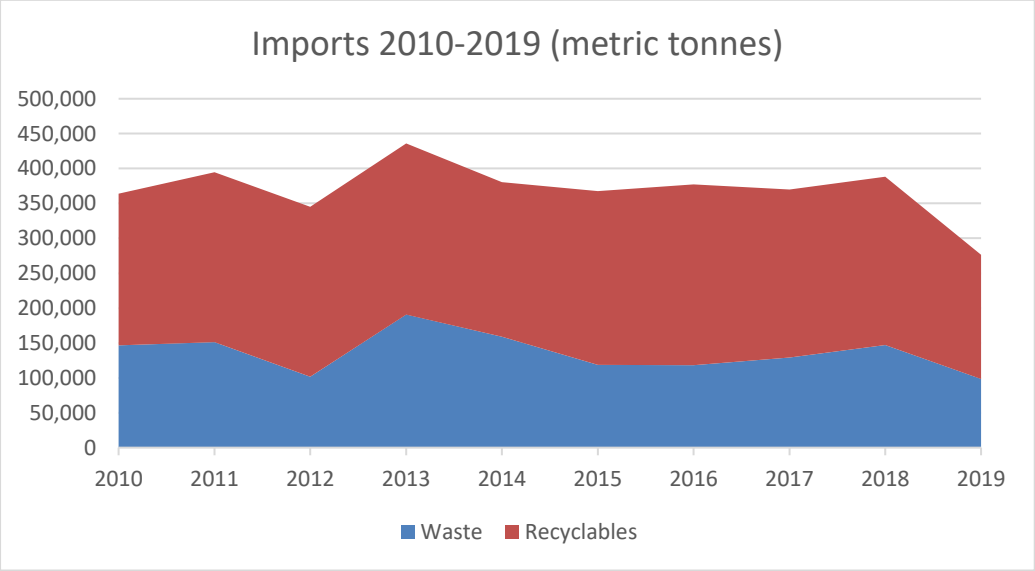
- spent batteries (lead-acid and lithium)
- hydraulic fluids (used oil)
- metal-bearing waste
- sulphuric acid, spent
- corrosive liquids
- flammable liquids

The remaining 98,364 t imported were hazardous wastes (about 36%) and were mostly composed of:

- metal-bearing waste having as constituents any of the following: metal carbonyls, hexavalent chromium compounds
- waste tarry residue from refining, distillation and pyrolytic treatment
- wastes from the production, formulation and use of biocides and phytopharmaceuticals, pesticides, and herbicides
- corrosive liquids
- waste consisting of or containing off specification or outdated chemicals

Figure 8 shows the trends in the quantities of hazardous wastes and hazardous recyclable materials imported from 2010-2019.

Figure 8: Hazardous waste and hazardous recyclable material, imports, 2010-2019 (Metric tonnes)



The quantity of hazardous waste and hazardous recyclable materials exported was 269,115 t in 2019. This represents a decrease of 109,200 t or 29% from 2018.

Shipments exported for recycling totaled 226,394 t and represented about 84% of all exports in 2019. Exports of hazardous recyclable materials in 2019 originated from eight provinces: Ontario, New Brunswick, Quebec, British Columbia, Alberta, Saskatchewan, Manitoba and Newfoundland. The majority of hazardous recyclable material exported abroad for recycling included:

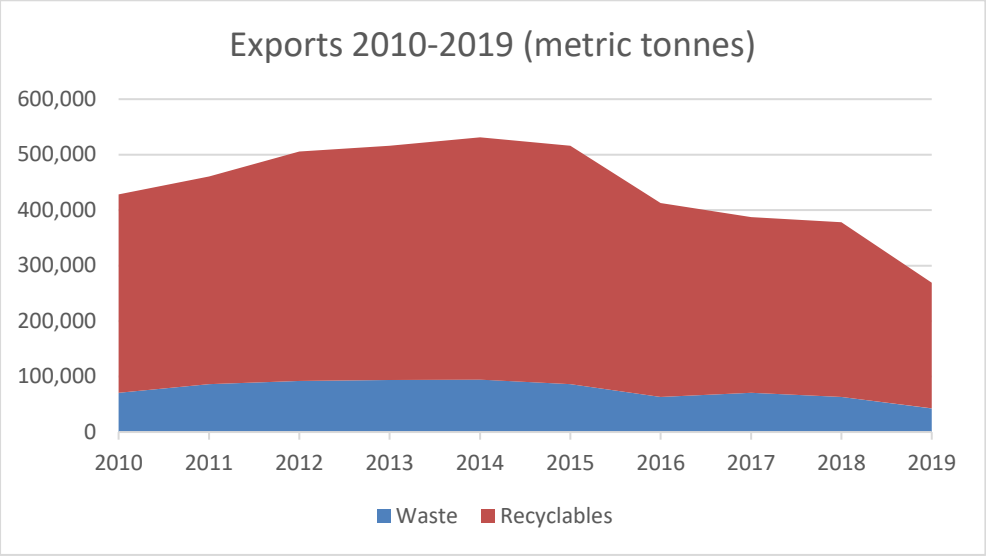
- sulphuric acid, spent
- batteries and other electrical cells
- waste oil/water, hydrocarbon/water mixtures, and emulsions (used oils)
- metal-bearing waste
- waste catalysts
- treated cork and wood wastes

The remaining 42,721 t exported were hazardous wastes (16%) and were mostly composed of:

- waste consisting of or containing off specification or outdated chemicals
- waste from industrial pollution control devices
- sulphuric acid, spent
- waste oil/water, hydrocarbon/water mixtures, and emulsions (used oils)
- clinical and related wastes
- metal-bearing waste

Figure 9 shows the trends in the quantities of hazardous wastes and hazardous recyclable materials exported from 2010-2019.

Figure 9: Hazardous waste and hazardous recyclable material, exports, 2010-2019 (Metric tonne)



Note: Data are revised periodically as new information becomes available. Therefore, information presented here may differ from information published in other reports.

3.6 Environmental emergencies

Part 8 of CEPA (Environmental Matters Related to Emergencies) addresses the prevention of, preparedness for, response to and recovery from uncontrolled, unplanned or accidental releases into the environment of substances that pose potential or immediate harm to the environment or danger to human life or health.

The Environmental Emergencies Division (EED) implements the departmental pollution incident notification system for persons required to notify federal and provincial/territorial governments of an environmental emergency or environmental occurrence (spill, release, etc.).

In the event of a significant pollution incident, the Division oversees that response actions are taken by the responsible party to repair, reduce or mitigate any negative effects on the environment or human life or health that result from the environmental emergency.

The National Environmental Emergencies Centre (NEEC) provides science-based expert advice 24 hours a day, seven days a week, in collaboration with other federal, provincial and territorial governments, municipalities, and stakeholders to inform actions that reduce the consequence of environmental emergencies.

In 2019-2020, NEEC recorded 350 notifications involving the release, uncontrolled, unplanned or accidental release of CEPA-regulated substances into the environment.

The new *Environmental Emergency Regulations, 2019* (E2 Regulations) came into force on August 24, 2019 and a new online reporting application was launched.

The Regulations require any person who owns, manages, or has the control of a regulated substance at a place in Canada, at or above the established threshold, to notify ECCC when this quantity threshold is met or when the maximum container capacity meets or exceeds this threshold.

If the total quantity and container capacity thresholds are both met, there is an additional requirement to prepare and exercise an environmental emergency (E2) plan for prevention, preparedness, response and recovery in the event of an environmental emergency.

The nine most commonly identified substances requiring E2 plans are propane, anhydrous ammonia, natural gas, petroleum, raw liquid mix, butane, natural gas condensates, ammonium nitrate solid, and gasoline.

More than 3,016 facilities from different sectors, subject to the Regulations, have registered in the new application and 2,150 have already informed ECCC that their E2 plan has been brought into effect.

In 2019-2020, ECCC's regional activities associated with the implementation of the E2 Regulations included conducting site visits, delivering presentations to the regulated community, and promoting and enforcing compliance with regulated persons.

3.7 Government operations and federal and Aboriginal land

On May 25, 2019, proposed administrative amendments to the *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations (Miscellaneous Program)* were published in the *Canada Gazette*, Part I. The proposed amendments are in response to concerns, comments and recommendations from the Standing Joint Committee for the Scrutiny of Regulations (SJCSR) regarding a lack of clarity and some inconsistencies in the regulatory text. These regulations establish technical standards for the design and installation of storage tank systems under federal jurisdiction and include requirements for operation, maintenance, removal, reporting and record keeping.

4 Reporting programs and emission inventories

4.1 Reporting programs

There are two mandatory reporting programs under CEPA, which require facilities to report on their releases or emissions of specified substances into the environment:

- National Pollutant Release Inventory
- Greenhouse Gas Reporting Program

Data for both programs is submitted through ECCC's Single Window Information Management (SWIM) system. Further information on the SWIM system is available online.

National Pollutant Release Inventory Reporting

The National Pollutant Release Inventory (NPRI), Canada's legislated, publicly accessible national inventory, collects information from Canadian industrial, commercial and institutional facilities on their releases (to air, water and land), disposals, and transfers of pollutants and other substances of concern. Since 1993, owners or operators of facilities that have met the NPRI reporting requirements have reported on an annual basis. NPRI data for the 2018 reporting year was submitted to ECCC by June 3, 2019 (see Emission and release inventories for reporting details). The publication of the 2018 data was delayed due to the COVID-19 pandemic.

In February 2020, the department published updated NPRI reporting requirements that take effect for the 2020 reporting year, including a number of changes that will improve the information available through the NPRI.

The NPRI Multi-Stakeholder Work Group is the primary consultation mechanism for the NPRI program, with representatives from industry associations, environmental groups and Indigenous

organizations providing input on changes to the requirements and other aspects of the program, such as tools to access the data. Consultations during 2019-2020 included a number of teleconferences and paper-based consultations, as well as a face-to-face meeting in June 2019. Consultations focused on proposed changes to the requirements for 2020 reporting, including changes to reporting of air pollutants to provide more information for air quality modelling and for the addition of certain substances such as PREPOD, BENPAT and azo disperse dyes.

In addition to the above-mentioned consultations, the NPRI program shares information and gathers ideas from stakeholders and the public. Activities include engaging users of NPRI data to get input on how to meet their needs; working collaboratively with other government programs and international organizations; and updating stakeholders regularly on the NPRI.

During 2019-2020, ECCC undertook a number of initiatives to better understand and respond to the needs of various users of NPRI data, including a survey and a workshop.

Greenhouse Gas Reporting Program

ECCC requires annual reporting of GHG emissions from facilities (mostly large industrial operations) through its Greenhouse Gas Reporting Program (GHGRP). The GHGRP is part of ECCC's ongoing effort to develop, in collaboration with the provinces and territories, a nationally consistent, mandatory GHG reporting system, in order to meet the GHG reporting needs of all jurisdictions and to minimize the reporting burden for industry and government.

Key objectives of the GHGRP are to provide Canadians with consistent information on facility-level GHG emissions, to support regulatory initiatives, and to support the National GHG Inventory. The data collected are also shared with provinces and territories.

In February 2020, a notice was published in the *Canada Gazette*, Part I, requiring the reporting of GHG emissions for the 2019 calendar year. The 2019 reporting cycle continues the additional requirements introduced in the first two phases of the expansion implemented in 2017 and 2018. The expansion includes enhanced reporting and methodological requirements for fourteen industry sectors as well as a drop in the reporting threshold (50,000 tonnes to 10,000 tonnes CO_2 equivalent). Information about the GHGRP is available online.

4.2 Emission and release inventories

ECCC compiles and maintains five inventories of substances released into the environment:

- National Pollutant Release Inventory
- Air Pollutant Emissions Inventory
- Black Carbon Emissions Inventory
- Facility Greenhouse Gas Emissions Overview
- National Greenhouse Gas Inventory

National Pollutant Release Inventory

NPRI information is a major starting point for identifying and monitoring sources of pollution in Canada, and in developing indicators for the quality of our air, land and water. The NPRI helps determine if regulatory or other action is necessary to ensure reductions, and if so, the form that action should take. Public access to the NPRI data through annual data highlights, an online data search tool, location-based data for use in mapping and downloadable datasets encourages industry to prevent and reduce pollutant releases, and improves public understanding about pollution and environmental performance in Canada.

In 2018, 7,699 facilities (figure 10) reported to the NPRI a total of approximately 5 million tonnes of pollutants covering over 320 substances (figure 11):

- 2.8 million tonnes of pollutants were released directly to the environment
- 1.37 million tonnes were disposed to landfills, applied to land or injected underground, either on the facility site or off-site
- 377,606 tonnes were transferred off the facility site for treatment prior to final disposal or for recycling and energy recovery

Figure 10: Location of facilities that reported to the NPRI for the 2018 reporting year

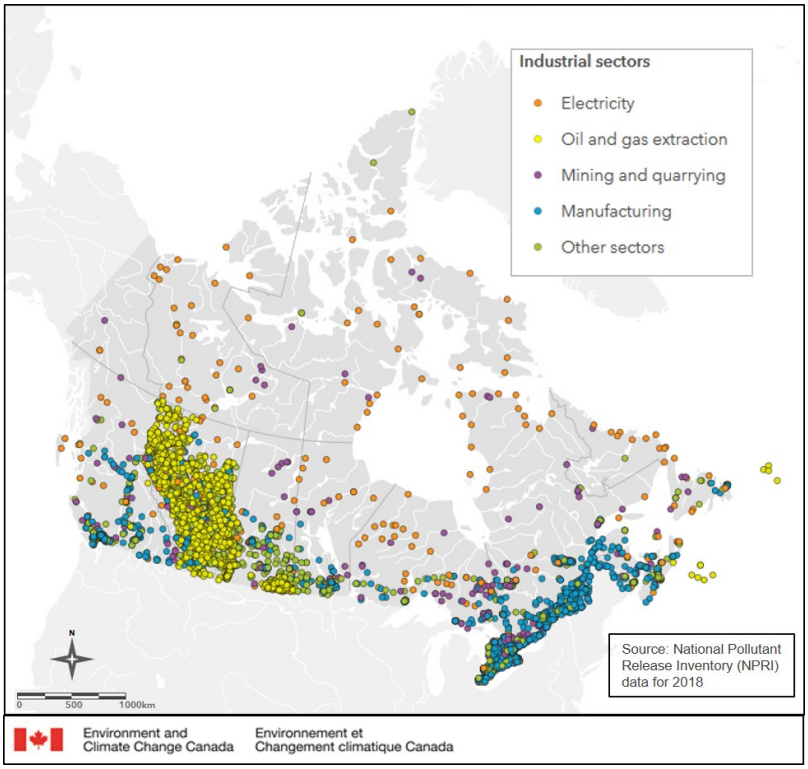
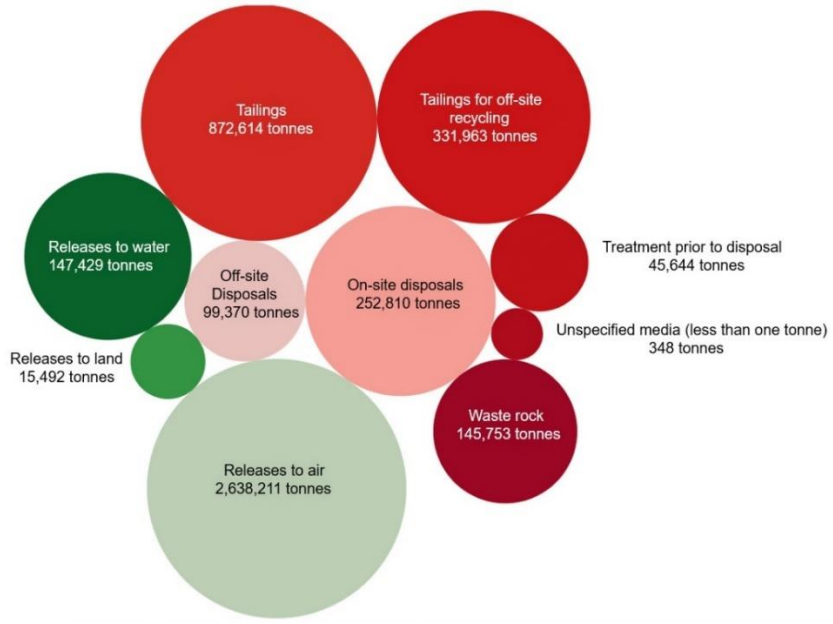


Figure 11: Breakdown of total quantities reported in 2018, by reporting category



Between 2009 and 2018, releases to the environment reported to the NPRI decreased by 794,771 tonnes. In particular:

- releases to air decreased by 831,528 tonnes
- releases to water increased by 28,005 tonnes
- releases to land increased by 9,492 tonnes
- releases of substances (i.e., unspecified media) where the total release quantity was less than one tonne decreased by 740 tonnes

Between 2009 and 2018, total disposals and transfers increased by 46,495 tonnes. In particular:

- off-site disposals decreased by 412,419 tonnes
- on-site disposals decreased by 14,629 tonnes
- off-site transfers for recycling decreased by 33,606 tonnes
- disposals of waste rock (rock removed to reach ore) increased by 133,761 tonnes
- disposals of tailings (materials left when minerals are removed from ore) increased by 352,366 tonnes

Pollution prevention data submitted to the NPRI is analyzed and outlined in the NPRI annual highlights. Pollution prevention activity data submitted by facilities is also summarized on the "How Canadian companies are preventing pollution" webpage, which provides an overview and examples of the implementation of the seven common pollution prevention techniques among Canadian facilities.

Air Pollutant Emissions Inventory

Canada's Air Pollutant Emissions Inventory (APEI) is a comprehensive inventory of air pollutant emissions at the national, provincial and territorial level primarily developed using two types of information: 1) facility-reported data primarily from the NPRI and 2) in-house estimates, including diffuse sources and other sources that are too numerous to be accounted for individually. Since 1990, the APEI has compiled emissions of 17 air pollutants contributing to smog, acid rain and reduced air quality.

This inventory serves many purposes including fulfilling Canada's international reporting obligations under the 1979 Convention on Long-Range Transboundary Air Pollution (CLRTAP) and the associated protocols ratified by Canada for the reduction of various types of emissions. These include sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), particulate matter (PM), cadmium (Cd), lead (Pb), mercury (Hg), dioxins and furans (D/F), and other persistent organic pollutants (POPs). The APEI also supports monitoring and reporting obligations under the Canada-U.S. Air Quality Agreement, the development of air quality management strategies, policies and regulations, provides data for air quality forecasting models, and informs Canadians about pollutants that affect their health and the environment.

According to the APEI, 14 of the 17 reported air pollutants show decreases compared to historical levels (see figure 12). A few key sources of pollutants account for a significant portion of the downward trends in emissions (see table 20).

Table 20: Percentage reductions of air pollutants from 1990-2018 from major sources.

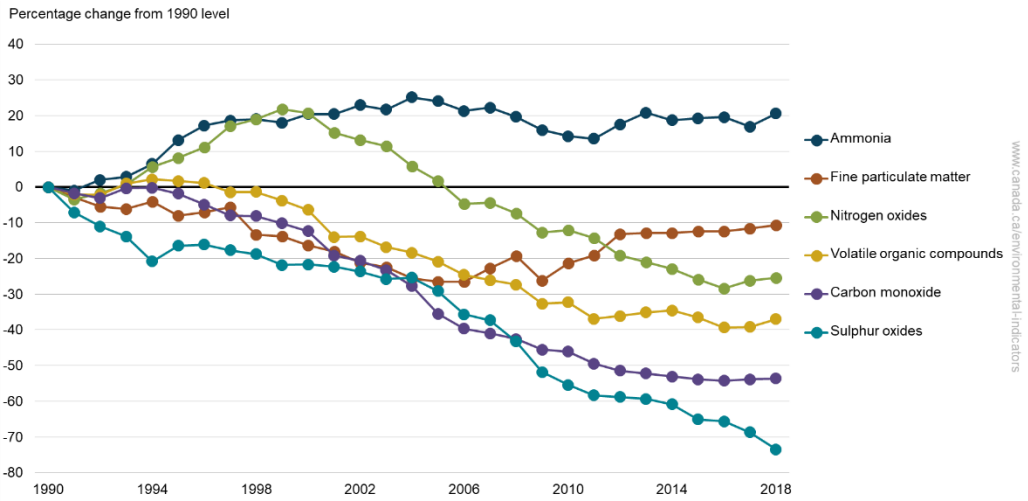
Source	Pollutant	Percentage decrease 1990-2018
Non-ferrous refining and smelting • major source of the these pollutants	SO_x	89%
	Pb	88%
	Cd	95%
	Hg	99%
	HCB (hexachlorobenzene)	60%
Home firewood burning • adoption of more modern wood combustion equipment	$PM_{2.5}$	39%
	VOC	36%
	CO (carbon monoxide)	29%
	D/F (dioxins and furans)	23%
	PAH (polycyclic aromatic hydrocarbons)	26%
Coal-fired electric power generation • closing of coal-fired power plants	SO_x	59%
	Hg	71%
	HCB	97%
Light-duty gasoline trucks and vehicles • effective fuel and engine regulations	NO_x	58%
	PAH	63%
Transportation associated with combustion of gasoline • effective fuel and engine regulations	VOC	66%
	CO	63%
Waste incineration • improvements in incineration technologies	HCB	93%
	D/F	94%

Despite significant decreases, emissions of some pollutants, including Pb and $PM_{2.5}$, have begun to rise again in recent years.

In addition, a 39% increase in total particulate matter (TPM) and 30% increase in PM_{10} emissions since 1990 contrast with the general trends described above; these increases are largely due to increased transportation on unpaved roads as well as construction operations. Another exception to the general downward trends is the steady increase in emissions of ammonia (NH_3), which were 21% above 1990 levels in 2018; the recent upward trend in NH_3 emissions is driven by fertilizer application. Historically, animal production contributed to increasing emissions until

2005, but this emission source has since decreased. Rising fertilizer emissions and decreasing animal emissions have resulted in relatively stable emissions over the past 10 to 15 years.

Figure 12: Emissions trends for selected air pollutants in Canada, 1990 to 2018



Inventory of black carbon emissions

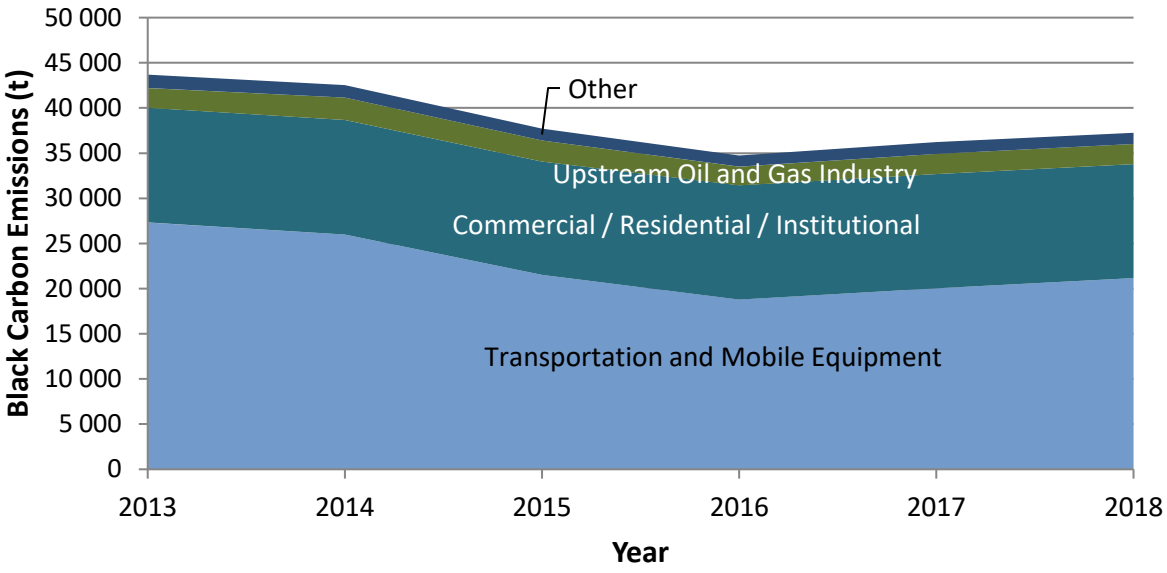
As a member of the Arctic Council Canada has committed to producing an annual inventory of black carbon emissions. The associated report serves to inform Canadians about black carbon emissions and provide valuable information for the development of air quality management strategies.

The data used to quantify black carbon emissions are based on fine particulate matter ($PM_{2.5}$) emissions from combustion-related sources, such as transportation and mobile equipment and home firewood burning, taken from the Air Pollutant Emission Inventory.

According to Canada's 2020 Black Carbon Emission Inventory report the following trends were observed (see figure 13).

- In 2018, approximately 37 kilotonnes (kt) of black carbon were emitted from human activities.
- Transportation and mobile equipment (notably diesel) and home firewood burning (in the Commercial/Residential/Institutional category) are the largest sources of black carbon, accounting for 21 kt (57%) and 11 kt (31%) respectively, of total emissions in 2018.
- Since 2013, black carbon emissions have decreased by 6.5 kt (15%), although emissions have increased by 2.5 kt (7%) since 2016.
- Trends in black carbon emissions are largely driven by transportation and mobile equipment, consistent with observed downward trends in emissions of fine particulate matter from combustion-related activities (upon which black carbon estimates are based).

Figure 13: Canada's black carbon emissions trends, 2013 to 2018



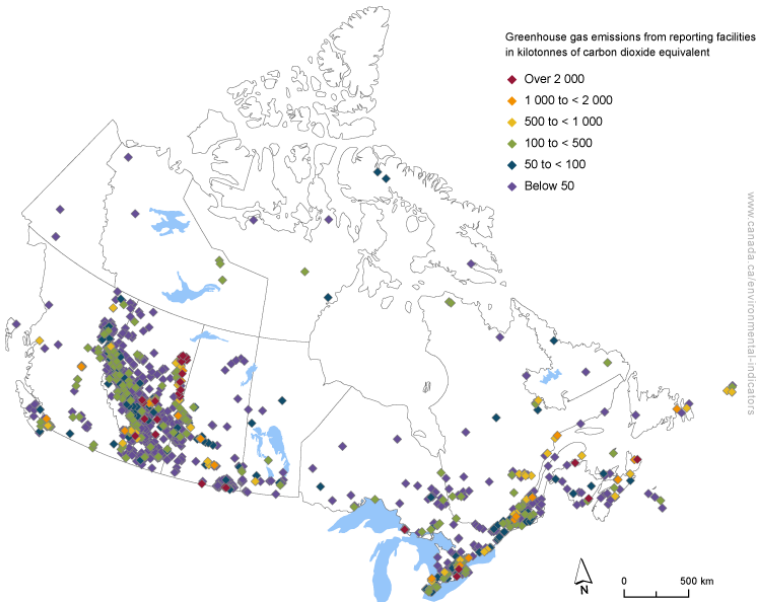
Facility Greenhouse Gas Emissions Overview

In 2018, 1,706 facilities reported their greenhouse gas (GHG) emissions (see figure 14), totalling 295 megatonnes (Mt) of carbon dioxide equivalent (CO_2 eq). The 2018 reporting cycle marks the

first year of Phase 2 of the expansion to the federal GHG reporting program (GHGRP) in which certain facilities in targeted sectors were also required to provide additional data. The reported emissions are largely distributed across three sectors: (1) Mining, Quarrying, and Oil and Gas Extraction (38%), (2) Manufacturing (30%), and (3) Utilities (25%).

The indicator for greenhouse gas emissions from large facilities provides consistent information on emissions from the largest emitting facilities in Canada and is published annually.

Figure 14: Greenhouse gas emissions in 2018 from large facilities



The latest indicator, based on data reported to the GHG Reporting Program, shows that emissions from the reporting facilities account for 40% of Canada's total GHG emissions in 2018.

National Greenhouse Gas Inventory

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) Canada is obligated to prepare and submit an annual national greenhouse gas (GHG) inventory covering anthropogenic emissions by sources and removals by sinks. ECCC is responsible for preparing Canada's official national inventory with input from numerous experts and scientists

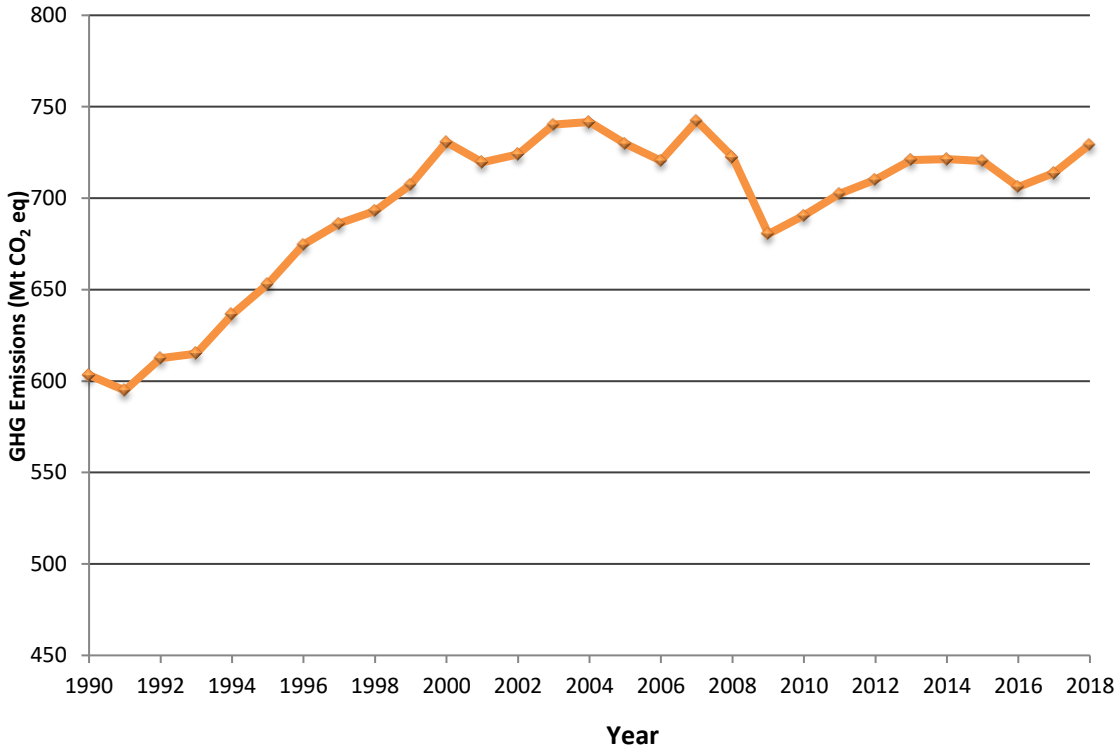
across Canada. The National Inventory Report (NIR) contains Canada's annual GHG emission estimates dating back to 1990. In addition to providing GHG emission data by mandatory reporting categories, the NIR also presents emission data by Canadian economic sectors, which support policy analysis and development.

The NIR, along with the Common Reporting Format (CRF) tables, comprise Canada's inventory submission to the UNFCCC and are prepared in accordance with the UNFCCC Reporting Guidelines on annual inventories.

The National GHG Inventory shows the following trends:

- After hovering between 700 and 720 megatonnes of carbon dioxide equivalent (Mt CO_2 eq) in recent years, in 2018 Canada's GHG emissions increased to 729 Mt CO_2 eq (see figure 15). This increase is attributed to higher fuel consumption for transportation, winter heating and oil and gas extraction.
- Over the long term, Canada's economy has grown more rapidly than its GHG emissions: the emissions intensity for the entire economy (GHG per Gross Domestic Product [GDP]) has declined by 36% since 1990 and 20% since 2005.
- Emission trends since 2005 remain consistent, with emission increases in the Oil and Gas and Transportation sectors being offset by decreases in other sectors, notably Electricity and Heavy Industry.

Figure 15: Canada's greenhouse gas emissions trend, 1990 to 2018



Further information on the National GHG Inventory is available online.

Please note that inventories mentioned above are available on the departmental data catalogue and the Open Data Portal.

5 Administration and public participation

5.1 Federal, provincial, territorial cooperation

National Advisory Committee

The National Advisory Committee (NAC) provides a forum for provincial, territorial and Aboriginal governments to advise the Ministers on certain actions being proposed under the Act, enable national cooperative action, and avoid duplication in regulatory activity among governments. The Committee was provided opportunities to advise and comment on initiatives under the Act.

To carry out its duties in 2019-2020, the CEPA NAC held a teleconference meeting in January 2020, and the NAC Secretariat corresponded regularly with committee members regarding various initiatives implemented under CEPA, including the publication of 27 draft screening assessments and 9 final screening assessment. The initiatives include those listed below.

Members were informed of risk management and other activities:

- Final regulations
  - *Regulations Amending the Concentration of Phosphorus in Certain Cleaning Products Regulations*
  - *Regulations Repealing the Chlor-Alkali Mercury Release Regulations*
  - *Regulations amending the Contaminated Fuel Regulations*

- Pollution prevention plan notices
  - Pollution prevention plan notice with respect to reaction products of 2-propanone with diphenylamine (PREPOD) in industrial effluents;

- An Order Declaring that the Reduction Of Carbon Dioxide Emissions from Coal-Fired Electricity Regulations do not apply in Saskatchewan;
- Three final orders which added the substances BENPAT, cobalt and it soluble compounds, and five methylenediphenyl diisocyantes to Schedule 1; and
- the *Notice with respect to the substances in the National Pollutant Release Inventory for 2020 and 2021*.

Members were provided with an opportunity to comment on:

- Draft Science Assessment of Plastic Pollution;
- Proposed Code of Practice for Methylenediphenyl Diisocyanates (MDIs)
- Proposed renewal of the Environmental Performance Agreement Respecting the Use of Tin Stabilizers in the Vinyl Industry; and
- applying the Significant New Activity (SNAc) provisions to Mitotane in addition to 105 substances and rescinding the significant new activity provisions for five substances.

Members were provided with an offer to consult on:

- Federal Environmental Quality Guidelines (FEQGS) for Certain Substances under Section 54 of CEPA – Iron, Lead, Quinoline and Strontium, as well as Copper.
- Proposed Regulations *Amending the Storage Tank Systems For Petroleum Products and Allied Petroleum Products Regulations* made under Section 209 of CEPA.

Members were provided with an offer to advise on proposed regulatory initiatives:

- proposed *Multi-Sector Air Pollutants Regulations Amendment Regulations* (Part 1 – Biomass);
- proposed *Formaldehyde Emissions from Composite Wood Products Regulations* ; and
- proposed *Volatile Organic Compound Concentration Limits for Certain Products Regulations*.

5.2 Federal-provincial/territorial agreements

Part 1 of the Act also allows the Minister of the Environment to negotiate an agreement with a provincial or territorial government, or an Aboriginal people, with respect to the administration of the Act. It also allows for equivalency agreements, which allow the Governor in Council to suspend the application of federal regulations in a jurisdiction that has equivalent regulatory provisions. The intent of an equivalency agreement is to eliminate the duplication of environmental regulations. Table 21 indicates the administrative and equivalency agreements in place under sections 9 and 10 of CEPA.

Table 21: Current administrative and equivalency agreements under CEPA by jurisdiction (New activity in 2019-2020 is indicated in bold).

Jurisdiction (s)	Agreement	Description
British Columbia	Canada-British Columbia Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016
	Agreement on the Equivalency of Federal and British Columbia Regulations Respecting the Release of Methane from the Oil and Gas Sector in British Columbia, 2020	Equivalency agreement (s.10) **Signed on February 26, 2020**, and comes into force pending the publication of a final Order under Section 10(3) of CEPA. On that date, the following CEPA regulations no longer apply in British Columbia: • *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*
Alberta	Canada-Alberta Equivalency Agreement 1994	Equivalency agreement in place since 1994 that applies to pulp and paper mills and secondary lead smelters **Alberta Environment reported no violations in 2019-2020 by the four pulp and paper mills regulated under the provincial regulations.**
	Canada-Alberta Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016

Jurisdiction (s)	Agreement	Description
Saskatchewan	Canada-Saskatchewan Administrative Agreement for the Canadian Environmental Protection Act	Administrative agreement in place since 1994 that deals with pulp and paper mills and ozone-depleting substances
	Canada-Saskatchewan Environmental Occurrences Notification Agreement*	Administrative agreement s.9 2016
	An Agreement on the Equivalency of Federal and Saskatchewan Regulations for the Control of Greenhouse Gas Emissions from Electricity Producers in Saskatchewan, 2020	Equivalency agreement (s.10) **Signed on May 3, 2019,** and came into force on January 1, 2020. When in force, the following CEPA regulations no longer apply in Saskatchewan: • *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations*
Manitoba	Canada-Manitoba Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016
Ontario	**Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health**	Administrative agreement (s.9) **New draft agreement published – July 6, 2019** Agreement outlines how the governments of Canada and Ontario will cooperate and coordinate their efforts to restore, protect and conserve the Great Lakes basin ecosystem. See the *Canada Water Act* Annual Report 2019-2020 for an update on progress under this Agreement.
	Canada-Ontario Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016
Nova Scotia	**An Agreement on the Equivalency of Federal and Nova Scotia Regulations for the Control of Greenhouse Gas (GHG) Emissions from Electricity Producers in Nova Scotia, 2020**	**Signed on November 14, 2019** and came into force on January 1, 2020. On that date, the following CEPA regulations continue to no longer apply in Nova Scotia: • *Reduction of Carbon Dioxide Emissions from Coal-fired Generation of Electricity Regulations*
Northwest Territories	Canada-Northwest Territories Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016

Jurisdiction (s)	Agreement	Description
Yukon	Canada-Yukon Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016
British Columbia, Manitoba, New Brunswick, Nova Scotia, Ontario, Quebec, Prince Edward Island, Newfoundland and Labrador, Saskatchewan, Northwest Territories, Nunavut, Yukon	National Air Pollution Program Memorandum of Understanding	Administrative agreement (s.9) renewed in 2018

*Purpose is to establish a streamlined notification system and reduce duplication of effort for persons required to notify federal and provincial/territorial governments of an environmental emergency or environmental occurrence, such as an oil or chemical release.

Memorandum of Understanding between Canada and Quebec

The Province of Quebec and the Government of Canada have been collaborating since 1994. The parties currently co-operate through a memorandum of understanding for data collection, whereby Quebec provides a single data-entry portal for regulatees for the following federal regulations:

- *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* made pursuant to CEPA
- *Pulp and Paper Mill Defoamer and Wood Chip Regulations* made pursuant to CEPA
- *Pulp and Paper Effluent Regulations* made pursuant to the *Fisheries Act.*

5.3 Public participation

CEPA Registry

Part 2 of CEPA (Public Participation) provides for the establishment of an environmental registry, whistleblower protection, and the right of an individual to request an investigation and pursue court action.

The CEPA Registry was launched on ECCC's website when the Act came into force on March 31, 2000. Continuous efforts are made to increase the Registry's reliability and ease of use. The Registry encompasses thousands of CEPA-related documents and references. It has become a primary source of environmental information for the public and private sectors, both nationally and internationally, and has been used as a source of information in university and college curricula.

From April 2019 to March 2020, the CEPA Registry website had 307,466 visits.

Public consultation

CEPA includes many requirements to provide the public with access to information, to provide comments on proposed initiatives and to provide access to justice. These provisions include a mandatory consultation and public comment periods for proposed Orders, Regulations and other statutory instruments; and requirements to publish information. Other provisions allow for a member of the public to bring civil actions against alleged offenders, to request reviews of existing laws and policies, as well as providing protection for whistle-blowers.

In addition, engaging stakeholders and the public is central to several programs under CEPA. For example, at each stage in the CMP management cycle, stakeholders are engaged and the public has the opportunity to be involved and comment on proposed assessments of substances or groups of substances.

There were 48 opportunities posted on the Registry between April 1, 2019 and March 31, 2020 for stakeholders and the members of the public to provide comments on proposed initiatives under CEPA. These included:

- 27 draft screening assessments
- 3 final assessments
- 1 draft science assessment
- 2 substances proposed for addition to the List of Toxic Substances
- 1 environmental quality guideline
- 6 proposed regulations
- 1 proposed regulatory approach
- 3 notices regarding amendments to the Domestic Substances List
- 1 proposed code of practice for substances
- 1 proposed amendment to the Export Control List
- 1 draft administrative agreement
- 1 proposed order related to an equivalency agreement

Please see the CEPA Registry public consultations, available online.

Pollution Prevention resource finder

Part 4 of CEPA provides the authority for the establishment of a national pollution prevention information clearinghouse to facilitate the collection, exchange and distribution of information regarding pollution prevention.

The Pollution Prevention resource finder (P2 finder) is Canada's largest publicly accessible database of links to practical resources that can help Canadians and Canadian organizations be more environmentally friendly. It received more than 16,500 views in 2019-2020. Users can

search by keyword and/or filters to find resources of interest. In 2019-2020, 93 new links were added to the P2 finder. The P2 finder contains links to resources for:

- Employees or volunteers
- Homeowners or renters
- Travelers
- Youths or educators
- Businesses (including non-profit organizations)
- Community groups
- Governments
- Health care facilities

CMP-related committees and activities

The CMP Science Committee supports a strong science foundation to CMP by providing external national and international scientific expertise to Health Canada and ECCC on scientific issues. Members met in June 2019 to discuss new approaches for integrating chemical fate and spatial and temporal scale in exposure assessment. Another meeting took place in February 2020 to discuss considerations for identifying potential risks from exposure to chemicals in the workplace. Members engaged in constructive discussions as they continued developing the Committee's scientific input for the Government of Canada. Meeting records and reports are made available online.

The CMP Stakeholder Advisory Council (CMP SAC) aims to obtain advice from stakeholders for implementing the CMP and to foster dialogue between stakeholders and government, and among different stakeholder groups. In May 2019, the government hosted a CMP SAC meeting to update on government initiatives related to chemicals management in Canada, with presentations and discussions on the following topics:

- National Pollutant Release Inventory (NPRI)

- Commissioner of the Environment and Sustainable Development (CESD) 2018 toxics audit follow-up and performance measurement
- Nanomaterials: update and next steps
- Progress towards CMP modernization
- Vulnerable populations (VPs) – Development of a framework for addressing populations at increased risk from chemicals
- Canada's Plastics Science Agenda (CaPSA) – Science to address plastic pollution
- Green chemistry – Industry lead
- Wastewater monitoring

6 Compliance promotion and enforcement

To achieve greater compliance with the Act and its risk management tools, both compliance promotion activities and enforcement measures are used.

The goal of compliance promotion is to increase awareness of and voluntary compliance with regulatory and non-regulatory instruments in an effort to limit harm to the environment and human health and consequential enforcement actions. Compliance promotion officers across Canada provide information to regulated communities on what is required to comply with CEPA, the benefits of compliance, and the consequences of non-compliance.

The goal of enforcement activities is to ensure enforcement of the Act is done in a fair, predictable and consistent manner. CEPA provides enforcement officers with a wide range of powers to enforce the Act, including the powers of a peace officer.

Enforcement activities are conducted in accordance with the Compliance and Enforcement Policy for CEPA and it is available online.

6.1 Compliance promotion priorities

Each year, ECCC develops a list of priorities for delivery of compliance promotion activities on issues such as chemical management, air pollutants, and greenhouse gas emissions. Factors that influence the identification of priority activities include the recent publication of new or amended regulatory and non-regulatory instruments, new requirements coming into force, level of compliance, and need to maintain awareness, understanding, or compliance for specific requirements. Resources are aligned with the identified compliance promotion priorities.

In 2019-2020, compliance promotion activities were carried out on 18 priority regulatory and non-regulatory CEPA instruments, namely:

- *Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations*
- *Code of Practice for the Environmental Management of Road Salts*
- *Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the Use of Cutback and Emulsified Asphalt*
- *Concentration of Phosphorus in Certain Cleaning Products Regulations*
- *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*
- *Federal Halocarbon Regulations, 2003*
- *Microbeads in Toiletries Regulations*
- *Multi-Sector Air Pollutants Regulations (MSAPR)—Part 2 (Engines)*
- *New Substances Notification Regulations (Organisms)*
- *PCB Regulations*
- *Products Containing Mercury Regulations*
- *Prohibition of Asbestos and Asbestos Products Regulations*
- *Prohibition of Certain Toxic Substances Regulations*
- *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*
- *Renewable Fuels Regulations*
- *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations*
- *Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements Regulations)*
- *Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations*

ECCC also worked on planning the implementation for 29 new or amended regulatory and non-regulatory instruments published in the *Canada Gazette*, Parts I and II.

6.2 Compliance promotion activities

Multiple compliance promotion approaches were used to reach the regulated communities, including workshops, information sessions, presentations, information package emails, mail-outs, articles, phone calls, and social media platforms. Many of these activities were carried out in collaboration with provincial and territorial governments, as well as non-governmental organizations and associations.

In 2019-2020, a total of 16,406 known or potential regulatees received compliance promotion material and 7,558 stakeholders were contacted by ECCC for clarification of regulatory requirements and/or additional information. Most enquiries and feedback were received by email, while the remainder came by fax, letter and telephone.

ECCC was particularly successful in launching a number of compliance promotion initiatives:

- Undertaking a regional-specific characterization study on asphalt industry practices and products to tailor messaging and improve awareness of the *Code of Practice for the Reduction of Volatile Organic Compound (VOC) Emissions from the Use of Cutback and Emulsified Asphalt*.
- Overcoming significant barriers (business turnover, small business sizes and language) to maintain awareness of the *Tetrachlorethylene (Use In Dry Cleaning And Reporting Requirements) Regulations* by providing tailored compliance promotion support and guidance in English, French, Korean and Chinese.
- Outlining permit requirements for exporting household waste to countries under the Basel Convention as specified in the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations* in light of high-profile international events.
- Creating an interactive online flowchart titled *5-Steps to Easy Reporting* to improve awareness of the reporting period for the *Products Containing Mercury Regulations*.
- Increasing awareness though ECCC's websites by using vanity URLs (shortened urls) and web analytics to determine proportion of web traffic directly linked to certain campaigns

such as the *Microbeads in Toiletries Regulations,* which experienced a 100% increase in website visits.

- Improving reporting under the s.46 notice with respect to certain quaternary ammonium compounds in Canadian commerce. Phase 1 reporting increased following direct communication with potential importers of reportable substances.
- Providing information and fact sheets and delivering webinars to inform stakeholders on topics including the provisions of the *Ozone-depleting Substances and Halocarbon Alternatives Regulations*, which entered into force on January 1, 2020 HFCs used in the refrigeration sector, as well as the import of HCFCs.

In 2019-2020, ECCC continued to expand its capacity to verify compliance with the transportation sector's emission regulations, including identifying devices to defeat the emission regulations. ECCC also conducted eight major inspections at fuels facilities, including detailed reviews of regulatory records. The expanded program increases opportunities to identify non-compliant regulatees and take enforcement action where required.

Promoting compliance to Indigenous people

In 2019-2020, the Compliance Promotion Program focused efforts to reach remote Indigenous communities for two CEPA regulations, namely the *PCB Regulations* and the *Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations*. Compliance Promotion Officers were able to address both regulations when visiting remote communities and to maintain/improve relationships while building upon networks with communities and influencers (such as Tribal Council, First Nations technical associations, Indigenous Services Canada and Circuit Riders).

6.3 Enforcement priorities

Each year, ECCC develops an Integrated Enforcement Plan (IEP) that sets out the enforcement activities to be carried out in that fiscal year, including activities to address non-compliance with CEPA. Factors that influence the identification of priority activities include the risk to the environment and human health represented by the regulated substance or activity, governmental and departmental priorities, suspected non-compliance, recent publication of new and amended regulations, and domestic and international commitments and obligations.

In 2019-2020, the IEP prioritized the following CEPA instruments:

- *Off-Road Compression-Ignition Engine Emission Regulations*
- *Benzene in Gasoline Regulations*, *Sulphur in Gasoline Regulations*, *Sulphur in Diesel Fuel Regulations* and *Renewable Fuels Regulations*
- *Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations*
- *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*

In addition to the planned inspections carried out under the IEP, enforcement activities also include a large number of inspections resulting from responses to complaints, notifications from partners, intelligence or departmental referrals, reported spills and incidents, or other information.

ECCC initiated a series of risk assessment in 2018-2019 to assess and determine the risk of non-compliance with its laws and regulations - including those under CEPA. In 2019-2020, a risk assessment on toxic substances was completed and the results were used to inform 2020-2021 planning. Additional risk assessments are currently ongoing and will inform decision-making processes and help to better align enforcement actions and resources to protect the environment and human health.

6.4 Enforcement activities

Enforcement activities undertaken between April 1, 2019 and March 31, 2020 are summarized in the following four tables.

- Table 22 provides the number of on-site and off-site inspections for each regulation
- Table 23 provides the breakdown of investigations for each regulation for which at least one investigation occurred or closed
- Table 24 provides the total number of enforcement measures resulting from inspections and investigations that were imposed for each regulation
- Table 25 provides the number of prosecutions for each regulation

6.4.1 Inspections

Inspections are defined as the active process of gathering information to verify compliance with legislation. This may include site visits, examining substances, products or containers, taking samples, and reviewing records. An on-site inspection involves visiting a site, such as a border crossing, an airport or a port of entry, to conduct any activity, operation, or analysis required to verify the regulatee's compliance with a regulation. An off-site inspection is normally undertaken at the officer's place of work or in another location that is not at the regulated site and is usually limited to documentation verification.

Table 22 details the 1,474 inspections under CEPA for fiscal year 2019-2020. The number of inspections relates to the number of times the regulation was inspected for compliance using the start date of the inspection for the reference period.

Table 22: Number of inspections under CEPA from April 1, 2019 to March 31, 2020

Instrument	Inspections*		
	On-site	Off-site	Total
Total	**1096**	**378**	**1474**
2-Butoxyethanol Regulations	13	-	**13**
Benzene in Gasoline Regulations	5	-	**5**

Instrument	Inspections*		
	On-site	Off-site	Total
CEPA - Section(s)	26	39	**65**
Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations	9	3	**12**
Concentration of Phosphorus in Certain Cleaning Products Regulations	6	-	**6**
Disposal at Sea Regulations	35	30	**65**
Environmental Emergency Regulations	108	35	**143**
Export of Substances on the Export Control List Regulations	2	-	**2**
Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations	170	8	**178**
Federal Halocarbon Regulations, 2003	46	69	**115**
Fuels Information Regulations, No. 1	5	2	**7**
Gasoline and Gasoline Blend Dispensing Flow Rate Regulations	23	-	**23**
Interprovincial Movement of Hazardous Waste Regulations	4	1	**5**
Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations	3	1	**4**
Multi-Sector Air Pollutants Regulations	-	2	**2**
Microbeads in Toiletries Regulations	7	-	**7**
National Pollutant Release Inventory	4	7	**11**
New Substances Notification Regulations (Chemicals and Polymers)	1	2	**3**
Off-Road Compression-Ignition Engine Emission Regulations	71	5	**76**
Off-Road Small Spark-Ignition Engine Emission Regulations	10	-	**10**
On-Road Vehicle and Engine Emission Regulations	4	-	**4**
Ozone-depleting Substances and Halocarbon Alternatives Regulations	28	3	**31**
Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations	2	-	**2**
PCB Regulations	141	12	**153**
Products Containing Mercury Regulations	6	-	**6**
Prohibition of Asbestos and Products Containing Asbestos Regulations	2	-	**2**
Prohibition of Certain Toxic Substances Regulations, 2012	7	-	**7**
Pulp and Paper Mill Defoamer and Wood Chip Regulations	-	6	**6**
Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations	2	12	**14**

Instrument	Inspections*		
	On-site	Off-site	Total
Renewable Fuels Regulations	24	1	**25**
Solvent Degreasing Regulations	3	1	**4**
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	153	30	**183**
Sulphur in Diesel Fuel Regulations	11	1	**12**
Sulphur in Gasoline Regulations	6	-	**6**
Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations	70	107	**177**
Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations	76	1	**77**
Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations	13	-	**13**

* Only those regulations under which an inspection occurred during the time period are listed in this table.

6.4.2 Investigations

An investigation involves gathering, from a variety of sources, evidence and information relevant to a suspected violation. An enforcement officer will conduct an investigation when he or she has reasonable grounds to believe that an offence has been committed under the Act and it has been determined that a prosecution is the appropriate enforcement action.

Table 23 describes the number of investigations under CEPA for fiscal year 2019-2020.

Table 23: Breakdown of investigations from April 1, 2019 to March 31, 2020

Instrument**	Investigations*		
	Started before 2019-2020 and still ongoing at the end of 2019-2020	Started in FY 2019-2020	Ended in FY 2019-2020
Total	**43**	**17**	**19**
2-Butoxyethanol Regulations	-	1	-
CEPA - Section(s)	12	5	8

Instrument**	Investigations*		
	Started before 2019-2020 and still ongoing at the end of 2019-2020	Started in FY 2019-2020	Ended in FY 2019-2020
Disposal at Sea Regulations	4	1	-
Environmental Emergency Regulations	2	-	1
Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations	-	-	1
Federal Halocarbon Regulations, 2003	1	1	-
Off-Road Compression-Ignition Engine Emission Regulations	1	3	2
Off-Road Small Spark-Ignition Engine Emission Regulations	1	-	-
On-Road Vehicle and Engine Emission Regulations	2	-	-
PCB Regulations	11	1	2
PCB Waste Export Regulations, 1996	-	-	1
Renewable Fuels Regulations	-	1	
Sulphur in Diesel Fuel Regulations	-	-	1
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	5	-	3
Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations	3	-	-
Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations	-	1	-
Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations	1	3	-

*****Investigations are tabulated by the number of investigation files at the regulation level, based on the start or end date of the investigation. One investigation may be counted under one or more regulations.

**Only those regulations under which an investigation occurred during the time period are listed in this table.

6.4.3 Enforcement measures

Enforcement measures available to address alleged violations of CEPA and its regulations include warnings to bring an alleged violation to the attention of an alleged offender, and if applicable, return to compliance. In addition, environmental protection compliance orders

(EPCOs) require action to be taken to stop an ongoing violation from continuing, or to prevent a violation from occurring, and administrative monetary penalties (AMP) provide a financial disincentive to non-compliance.

Table 24 sets out the number of written warnings, EPCOs, and AMPs issued under CEPA during fiscal year 2019-2020.

Table 24: Number of enforcement measures taken from April 1, 2019 to March 31, 2020

Instrument	Enforcement measures* from inspections and investigations			
	Written warnings**	Number of subjects involved in EPCOs***	EPCOs**	AMPs**
Total	**216**	**31**	**25**	**213**
2-Butoxyethanol Regulations	3	3	3	
Benzene in Gasoline Regulations	2			
CEPA - Section(s)	13	1	1	73
Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations	4			
Environmental Emergency Regulations	39	3	1	
Export of Substances on the Export Control List Regulations	1			
Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations	18			34
Federal Halocarbon Regulations, 2003	9			2
Fuels Information Regulations, No. 1	3			
Gasoline and Gasoline Blend Dispensing Flow Rate Regulations	5	1	1	
Gasoline Regulations	1			
Microbeads in Toiletries Regulations	1			
National Pollutant Release Inventory	6			
Off-Road Compression-Ignition Engine Emission Regulations	12	1	1	54
Off-Road Small Spark-Ignition Engine Emission Regulations	1			

Instrument	Enforcement measures* from inspections and investigations			
	Written warnings**	Number of subjects involved in EPCOs***	EPCOs**	AMPs**
Ozone-depleting Substances and Halocarbon Alternatives Regulations	3			
PCB Regulations	14	9	6	
Prohibition of Certain Toxic Substances Regulations, 2012	3	2	1	
Products Containing Mercury Regulations	4	1	1	
Renewable Fuels Regulations	5			6
Solvent Degreasing Regulations	1			
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	35	4	4	42
Sulphur in Diesel Fuel Regulations	4			2
Sulphur in Gasoline Regulations	2			
Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations	13	1	1	
Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations	11	2	2	
Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations	3	3	3	

*Enforcement measures that were issued between April 1, 2019 and March 31, 2020. Therefore, it is possible that the initial inspection was conducted in a different fiscal year than when the measure was issued.
**Written warnings, EPCOs, and AMPs are tabulated by number of measures issued at the regulation level. For example, if one warning was issued for two different regulations, the number of warnings would be two.
***The number of subjects involved in EPCOs is represented by the number of regulatees issued EPCOs, regardless of the number of sections. For example, if one regulatee was issued an EPCO for three sections of the PCB Regulations, the number of subjects involved is one.

6.5 Prosecutions, tickets and EPAMs

Enforcement measures also include tickets, prosecutions and environmental protection alternative measures.

For reporting purposes, prosecutions are all instances in which charges were laid against a person (individual, corporation, or government department). The decision to prosecute ultimately rests with the Director of Public Prosecution (DPP) of Canada or their delegated agent. While reviewing the data, it should be noted that prosecutions often continue through multiple fiscal years, so there may be more counts tabulated during a particular year than actual charges laid.

Tickets for offences under CEPA can be issued under the *Contraventions Act*, usually where there is minimal or no threat to the environment or human health. Where an offence has taken place and this offence is designated as ticketable, enforcement officers will issue a ticket, unless they have determined that, in accordance with the criteria of the Compliance and Enforcement Policy for CEPA, another enforcement measure is the appropriate response.

An Environmental Protection Alternative Measure (EPAM) is an agreement that is negotiated with the accused in order to return an alleged violator to compliance with CEPA. It can be used only after a charge has been laid and before the matter goes to trial, as an alternative measure to prosecution for an alleged violation of the Act.

Table 25 outlines the number of prosecutions and tickets under CEPA for fiscal year 2019-2020. No EPAMs were issued in 2019-2020.

Table 25: Number of prosecutions and tickets from April 1, 2019 to March 31, 2020

Instrument	Prosecutions				Tickets
	Charges laid in FY 2018-2019		Concluded in FY 2018-2019		
	Prosecuted subjects*	Counts**	Convicted subjects***	Guilty counts**	
Canadian Environment Protection Act, 1999 **- Total**	**33**	**235**	**5**	**70**	**3**
CEPA - Section(s)	16	69	5	6	-
Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations	2	6	0	0	1
Environmental Emergency Regulations	3	15	1	1	-
On-Road Vehicle and Engine Emission Regulations	1	58	1	58	-
Ozone-depleting Substances and Halocarbon Alternatives Regulations	-	-	-	-	1
PCB Regulations	13	59	0	0	-
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	2	18	0	0	-
Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations	2	10	1	3	1
Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations	0	0	1	2	-

* Prosecuted subjects are the number of subjects charged, where the charge date falls within the reporting period. This means that the number of prosecutions launched is counted, not the number of prosecutions concluded in the reporting year. As well, prosecuted subjects are counted by the number of parties charged. This means that if one case resulted in the prosecution of two different subjects, the number reported would be two. The number of prosecuted subjects does not necessarily correspond to the total at the legislative level, because one prosecution might be related to more than one instrument.

** Counts are the number of sections of legislation or regulations, for which there was a charge or conviction during the reporting period. For example, if one person is charged with two counts under CEPA, this is considered one charge laid against the subject and two counts.

*** Convicted subjects are the number of subjects convicted during the reporting period and are based on date sentenced.

6.6 Enforcement highlights

In 2019-2020, five subjects were convicted and sentenced for offences related to CEPA and its regulations and $197,411,000 in fines was directed to the Environmental Damages Fund (EDF).

The EDF is a specified purpose account, administered by ECCC, to provide a mechanism for directing funds received as a result of fines, court orders, and voluntary payments to priority projects that will benefit our natural environment.

Below are highlights of prosecutions that occurred under CEPA and its regulations in 2019-2020.

On-Road Vehicle and Engine Emission Regulations

On January 22, 2020, in the Ontario Court of Justice, Volkswagen Aktiengesellschaft (Volkswagen AG) was ordered to pay an unprecedented $196.5 million fine after pleading guilty to 60 charges for offences under the Act. Volkswagen AG pleaded guilty to 58 counts of contravening section 154 of CEPA and to two counts of providing misleading information, an offence under paragraph 272(1)(k) of the Act. The fine was directed to the EDF.

The investigation into a suspected violation of the federal *On-Road Vehicle and Engine Emission Regulations* revealed that between January 2008 and December 2015, the company imported into Canada nearly 128,000 two- and three-litre diesel engine Volkswagen and Audi vehicles equipped with defeat devices. It also revealed that the use of software to reduce the effectiveness of the emission control systems involved significant deception and showed that the company knowingly circumvented national vehicle emissions regulations.

Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations

On October 11, 2019, in Saint-Jérôme, Quebec, Les Entrepôts A.B. inc., a Terrebonne-based company, was fined a total of $564,000 after pleading guilty to three counts of contravening CEPA and the *Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations*. The total fines were directed to the EDF.

The investigation revealed that the company had imported, offered for sale, and sold automotive refinishing products that contained volatile organic compounds in excess of the allowable limit. The company also failed to comply with an EPCO issued by an enforcement officer. As a result, the company received two fines of $125,000 for importing and selling the products, respectively, totaling $250,000, and a fine of $150,000 for failing to comply with an EPCO. In addition to the fines on the three counts, the company received an additional $164,000 fine for financial gains. This amount represents the profits generated by the sale of non-compliant automotive refinishing products.

Environmental Emergency Regulations

On November 12, 2019, K-G Spray-Pak Inc. was ordered to pay a fine of $170,000 in the Ontario Court of Justice. The company pleaded guilty to two offences under CEPA, including one count of violating the *Environmental Emergency Regulations* and one count of failing to comply with an EPCO. The total fine was directed to the EDF.

In February 2017, an investigation was launched, which revealed that K-G Spray-Pak Inc., a manufacturer, marketer, and distributor of aerosol products, had failed to comply with an EPCO issued by ECCC, in July 2016. The company was subsequently charged when it failed to implement and test environmental emergency plans within the prescribed time limit specified in the compliance order.

Environmental Offenders Registry and Enforcement Notifications

The Environmental Offenders Registry contains information on convictions of corporations obtained under certain federal environmental laws including CEPA, since June 18, 2009. This tool allows the media and the public to search for corporate convictions using the name of the corporation, its home province, the province where the offence occurred, or the legislation under which the conviction was obtained.

The Enforcement Notifications contain information about successful prosecutions across Canada under the acts and regulations administered by ECCC or involving ECCC enforcement officers (including CEPA).

6.7 International enforcement cooperation

Enforcement-related activities are carried out under various international and domestic agreements and organizations. ECCC actively participates in INTERPOL's Pollution Crime Working Group, which brings together member countries to work collectively on pollution crime issues.

In 2019, ECCC participated in INTERPOL's Operation 30 Days at Sea, the first-ever global action aimed at combatting maritime pollution crime. During the Operation, ECCC conducted numerous vessel inspections and worked closely with Transport Canada, as well as the United States Coast Guard and the United States Department of Justice. The joint Canadian efforts were also supported by Canada's Department of Justice and the Public Prosecution Service of Canada.

7 Report on research

ECCC and HC conduct a wide range of research to help inform assessment and management of the risks associated with various substances to human health or the environment. This research is often done in collaboration with scientists in other agencies and universities across Canada and the world. This section provides highlights of the research published in 2019-2020.

7.1 Chemical substances

Research on chemical substances is designed primarily to:

- fill data gaps in risk assessment and risk management
- develop novel methods and approaches to improve priority setting, support risk assessment and work towards the goal of reducing animal testing
- evaluate the fate and the impact of toxic substances, complex environmental mixtures, and other substances of concern on the environment and human health
- determine the extent of ecological and human health exposure to contaminants
- investigate the toxicity of chemicals, including effects on endocrine systems

In addition, HC undertakes research to support the development of regulations, guidelines and air quality objectives with the goal of reducing population exposures to pollutants and improving human health.

During 2019-2020, research on chemicals was carried out by both departments under a number of programs, including the Chemicals Management Plan (CMP), the Northern Contaminants Program (NCP), the Strategic Technology Applications of Genomics in the Environment Program, Genome Canada and the Great Lakes Action Plan.

ENVIRONMENT AND CLIMATE CHANGE CANADA RESEARCH

In 2019-2020, 19 new CMP research projects were initiated at ECCC. Although these projects are only expected to be completed in March 2021, they have produced preliminary results and have led to the publication of over 40 journal articles addressing a range of topics related to CMP priority substances, including sources, fate, mode of action, hazard, as well as standard methods development. References to a selection of these articles are provided below as examples.

Chemicals in the Atmosphere

Sources and mechanisms of the transport and deposition of mercury

Focus of research: Investigation of the sources and mechanisms of the transport and deposition of mercury from the atmosphere to the surface.

Results: Atmospheric Hg dry deposition through vegetation uptake is the primary source of mercury in surface soil. This in turn suggests that climate change will have a significant impact on the cycling of mercury in the environment, as it influences vegetative development. Also, chemical reactions of bromine atoms enhance deposition of mercury from the atmosphere to the surface.

Publications: St Louis, V.L., Graydon, J.A., Lehnherr, I., Amos, H.M., Sunderland, E.M., St Pierre, K.A., Emmerton, C.A., Sandilands, K., Tate, M., Steffen, A., Humphreys, E.R., *Atmospheric Concentrations and Wet/Dry Loadings of Mercury at the Remote Experimental Lakes Area, Northwestern Ontario, Canada*, Environmental Science and Technology, 2019, 53, 14, 8017–8026, 10.1021/acs.est.9b01338.

Wang, X., Yuan, W., Lin, C.-J., Zhang, L., Zhang, H., Feng, X., *Climate and Vegetation as Primary Drivers for Global Mercury Storage in Surface Soil*, Environ. Sci. Technol. 2019, 53, 18, 10665-10675, 10.1021/acs.est.9b02386.

Wang, S., McNamara, S.M., Moore, C.W., Obrist, D., Steffen, A., Shepson, P.B., Staebler, R.M., Raso, A.R.W., Pratt, K.A., *Direct detection of atmospheric atomic bromine leading to mercury and ozone depletion*, Proceedings of the National Academy of Sciences of the United States of America, Volume 116, Issue 29, July 2019, 14479-14484, 10.1073/pnas.1900613116.

Polycyclic aromatic compounds in urban air

Focus of research: Passive air sampling in Toronto and the Greater Toronto Area from 2016 to 2017 was used to investigate ambient levels of polycyclic aromatic compounds (PACs) associated with different source types.

Results: Traffic emission was a major contributor to PACs in the atmosphere of Toronto. This study highlights the importance of traffic as an emission source of PACs to urban air and the relevance of PAC classes other than just unsubstituted PAHs that are important but currently not included in air quality guidelines or for assessing inhalation cancer risks.

Publication: Jariyasopit, N., Tung, P., Su, K., Halappanavar, S., Evans, G.J., Su, Y., Khoomrung, S., Harner, T., *Polycyclic aromatic compounds in urban air and associated inhalation cancer risks: A case study targeting distinct source sectors*, Environmental Pollution, Volume 252, September 2019, 1882-1891, 10.1016/j.envpol.2019.06.015.

Chemicals in the Arctic

Prevalence, transport, fate and behavior of certain toxic substance families in the Arctic

Focus of research: Understanding the prevalence, transport, fate and behavior of certain toxic substance families.

Results: Hexachlorobutadiene (HCBD) has been measured in Arctic air collected from monitoring stations in Finland and Canada. PAHs in the Canadian and Norwegian Arctic are likely to have originated in the northern hemisphere – predominantly from Western Russia, northern Europe, and North America.

Publications: Balmer, J.E., Hung, H., Yu, Y., Letcher, R.J., Muir, D.C.G., *Sources and environmental fate of pyrogenic polycyclic aromatic hydrocarbons (PAHs) in the Arctic*, Emerging Contaminants, Volume 5, 2019, 128-142, 10.1016/j.emcon.2019.04.002.

Balmer, J.E., Hung, H., Vorkamp, K., Letcher, R.J., Muir, D.C.G., *Hexachlorobutadiene (HCBD) contamination in the Arctic environment: A review*, Emerging Contaminants, Volume 5, 2019, 116-122, 10.1016/j.emcon.2019.03.002.

Muir, D., Bossi, R., Carlsson, P., Evans, M., De Silva, A., Halsall, C., Rauert, C., Herzke, D., Hung, H., Letcher, R., Rigét, F., Roos, A., *Levels and trends of poly- and perfluoroalkyl substances in the Arctic environment – An update*, Emerging Contaminants, 5, 2019, 240-271, doi.org/10.1016/j.emcon.2019.06.002.

Perfluoroalkyl Substances and Organophosphate Ester Flame Retardants in the High Arctic

Focus of research: To discern the sources and transport of PFAS to remote freshwater ecosystems in the High Arctic and To investigate the distribution of 14 OPEs in a High Arctic aquatic ecosystem and to explore the input and outputs of OPEs from glacial rivers to a large lake.

Results: Annual atmospheric deposition is a major source of PFAS that undergo complex cycling in the High Arctic. Perfluoroalkyl carboxylic acids (PFCA) in snowpacks display odd-even concentration ratios characteristic of long-range atmospheric transport and oxidation of volatile precursors. This study highlights long-range transport of OPEs, their deposition in Arctic glaciers, landscapes, and lakes.

Publications: MacInnis, J.J., Lehnherr, I., Muir, D.C.G., St. Pierre, K.A., St. Louis, V.L., Spencer, C., De Silva, A.O.‡ 2019. *Fate and Transport of Perfluoroalkyl Substances from Snowpacks into a Lake in the High Arctic of Canada.* Environ. Sci. Technol. 53: 10753–10762.

Sun, Y., De Silva, A.O., St. Pierre, K.A., Muir, D.C.G., Spencer, C., Lehnherr, I., MacInnis, J.J. 2020. *Glacial Melt Inputs of Organophosphate Ester Flame Retardants to the Largest High Arctic Lake,* Environ. Sci. Technol. 2020, 54: 2734-2743.

Atmospheric transport pathways for microplastics

Focus of research: To determine the extent of sources and atmospheric transport pathways for microplastics, particularly as related to impacts in the Arctic.

Results: Microplastics were found across the studied marine systems of the eastern Canadian Arctic and Hudson Bay, and it was concluded that microplastics likely undergo long-range transport via oceanic and air currents, and via riverine systems to reach the Arctic, as well as coming from local sources.

Publication: Adams, J., Jantunen, L., Diamond, M. L., Finkelstein, S. A., Rochman, C. M., Bernstein, S., Stern, G., *Understanding sources and transport of microplastic pollution to the Canadian Arctic*, Conference paper, SETAC Europe, Helsinki Finland, May 2019.

Other Substances

Exposure of workers at e-waste dismantling facilities to flame retardant chemicals

Focus of research: Levels and exposure of workers to flame retardant chemicals at Canadian e-waste dismantling facilities.

Results: Levels of some flame retardants were found to be one to two orders-of-magnitude higher than in residential homes, and some air and dust concentrations as well as some estimated exposures exceeded those from informal e-waste facilities located in low and middle income countries.

Publications: Stubbings, W.A., Nguyen, L.V., Romanak, K., Jantunen, L., Melymuk, L., Arrandale, V., Diamond, M.L., Venier, M., *Flame retardants and plasticizers in a Canadian waste electrical and electronic equipment (WEEE) dismantling facility*, Science of the Total Environment, Volume 675, July 2019, 594-603, 10.1016/j.scitotenv.2019.04.265.

Nguyen, L.V., Diamond, M.L., Venier, M., Stubbings, W.A., Romanak, K., Bajard, L., Melymuk, L., Jantunen, L.M., Arrandale, V.H., (2019), *Exposure of Canadian electronic waste dismantlers to flame retardants*, Environment International, 95-104, 10.1016/j.envint.2019.04.056

A novel group of persistent chemicals; liquid crystal monomers

Focus of research: The cytotoxic and transcriptomic effects of a novel group of persistent chemicals, liquid crystal monomers (LCM), were determined. These substances are found in liquid crystal display screens including TVs, personal computers and most importantly, cell phones.

Results: Following exposure to mixtures of LCM collected from 6 LCD devices, significant modulation of 5 genes, *CYP1A4*, *PDK4*, *FGF19*, *LBFABP*, and *THRSP*, was observed in vitro. LCMs were detectable in 47% of analyzed indoor dust samples,

Publication: Su, H., Shi, S., Zhu, M., Crump, D., Giesy, J.P., Letcher, R.J., Su, G. 2019. *Persistent, Bioaccumulative and Toxic Properties of Liquid Crystal Monomers (LCMs) and their Detection in Indoor Residential Dust*. Proc. Nat. Acad. Sci 116(52): 26450-26458.

Research Methods

Acute Transcriptomic Dose-Response Analysis in Adults Fish and Fish Embryos for BPA, DEHP and Related Compounds

Focus of research: Resource limitations often require risk assessors to extrapolate chronic toxicity from acute tests using assessment factors. Transcriptomic dose-response analysis following short-term exposures may provide a more reliable and biologically-based alternative for estimating chronic toxicity. This study applies cutting edge genomics techniques to estimate concentrations that can cause low-dose long-term toxicity in fish exposed to estrogenic chemicals (bisphenol A (BPA), diethylhexylphthalate (DEHP), and several proposed BPA- and DEHP-replacement compounds).

Results: Using genomics in adult fish following short-term exposure to BPA-related compounds, doses that would cause low-dose long-term toxicity were estimated (i.e. the point-of-departure, POD). The genomics-based PODs were highly correlated to and protective of (i.e. within 10-fold) PODs determined using traditional methods. A meta-analysis of genomics data in a multi-species study also found that a genomics-based POD was highly correlated to a traditionally determined POD.

Publications: Pagé-Larivière F, Crump D, O'Brien J. 2019. *Transcriptomic points-of-departure from short-term exposure studies are protective of chronic effects for fish exposed to estrogenic chemicals.* Toxicology and Applied Pharmacology. 378: 114634.

New method for studying metabolism of triphenyl phosphate (TPHP) in biota

Focus of research: TPHP has been detected in a wide range of environmental samples, especially in indoor dust samples and may have possible health effects. This study investigated the metabolism of the flame retardant and plasticizer chemical, triphenyl phosphate (TPHP), in a rat liver microsome-based *in vitro* assay with glutathione (GSH) in order to elucidate metabolic pathways leading to formation of conjugates.

Results: A highly sensitive and efficient method developed for the detection and characterization of GSH reactive metabolites revealed that certain GSH conjugates may be valuable candidate biomarkers for monitoring TPHP exposure in biota.

Publication: Chu, S.-G., Letcher , R.J. 2019. *In vitro metabolic activation of triphenyl phosphate leading to the formation of glutathione conjugates by rat liver microsomes.* Chemosphere 237: 124474. DOI: 10.1016/j.chemosphere.2019.124474

Distribution of halogenated flame retardants in herring gull tissue and eggs

Focus of research: Polybrominated diphenyl ethers (PBDEs) and other halogenated flame retardants (HFRs) continue to be an environmental concern. This study examined the distribution of HFRs within the tissues and eggs of an upper trophic level Great Lakes species, the herring gull.

Results: Among the 25 PBDEs and 23 non-PBDE HFRs assessed, only six BDE congeners, hexabromocyclododecane (HBCDD), and Dechlorane Plus (*syn*- and *anti*-DDC-CO) were frequently detectable and quantifiable. Maternal transfer rates of PBDEs and non-PBDE HFRs were low (~4.7 and ~2.9 % respectively), suggesting that *in ovo* transfer is not a significant mode of depuration for these compounds.

Publication: Smythe, S.A., Mattioli, L.C., Letcher, R.J. 2020. *Distribution behaviour in body compartments and in ovo transfer of flame retardants in North American Great Lakes herring gulls (Larus argentatus).* Environ. Pollut. 262: 114306. DOI: 10.1016/j.envpol.2020.114306

Trends of novel flame retardants in herring gull eggs in the Great Lakes

Focus of research: The occurrence of the environmentally novel tetrabromobisphenol-A-bis(2,3,-dibromopropyl ether) (TBBPA-BDBPE) flame retardant contaminant is generally unknown in wildlife. We developed a highly sensitive method of detection and report on temporal and spatial trends in herring gull eggs across the Laurentian Great Lakes of North America.

Results: Typical of many alternate flame retardants in wildlife, TBBPA-BDBPE levels in the gull samples were low with a few high values and increasing prevalence through time. They appear to be associated with terrestrial versus aquatic food sources.

Publication: Gauthier, L.T., Laurich, B., Hebert, C.E., Drake, C., Letcher, R.J. 2019. *Tetrabromobisphenol-A-bis (dibromopropyl ether) flame retardant in eggs, regurgitates and feces of herring gulls (Larus argentatus) from multiple North American Great Lakes locations.* Environ. Sci. Technol. 53: 9564-9571. DOI: 10.1021/acs.est.9b02472

Bioaccumulation and biomagnification of PFAS in liver tissues of polar bear and ringed seals

Focus of research: The objective of the present study was to investigate the prey to predator relationships of per-/poly-fluoroalkyl substance (PFAS) bioaccumulation and biomagnification of established and newer perfluorinated sulfonate (PFSA) and perfluorinated carboxylic acid (PFCA)

contaminants, and several important PFSA precursors in blubber and liver tissues of polar bears and ringed seals.

Results: The bioaccumulation and biomagnification of 22 major PFAS were investigated in tissues of polar bears and their major prey species, the ringed seal. In both polar bears and seals, concentrations of PFSAs in liver were much higher than in fat. There were differences in distribution of short and long chain PFCAs between liver and fat in both species. Biomagnification factors (which indicate the accumulation of contaminants from prey to predator) from seal blubber to bear liver best reflect the dietary exposure relationship of PFAS between bears and seals.

Publication: Boisvert, G., Sonne, C., Rigét, F.F., Dietz, R., Letcher, R.J., 2019. *Bioccumulation and biomagnification of perfluoroalkyl acids and major precursors in East Greenland polar bears and their ringed seal prey.* Environ. Pollut. 252: 1335-1343. DOI: 10.1016/j.envpol.2019.06.035

Priority Perfluroalkyl Substances and Wildlife: Uptake, bioaccumulation and toxic effects in terrestrial and marine birds

Focus of research: The goal of this research was to characterize the exposure of raptors and tree swallows to high-priority perfluorinated compounds, and to determine the possible effects to the birds of these chemicals and to model chemical movements through the terrestrial food web. This research was done to support work under the CMP and the Stockholm Convention.

Results: Several perfluoroalkyl acids and sulfonamides (PFAAs) were found in the majority of peregrine falcon eggs and nestlings across the Laurentian Great Lakes Basin. The shorter-chain perfluorinated carboxylic acids (PFCAs) were dominant in nestling plasma and the longer-chain ones in eggs. Egg concentrations of PFCAs and perfluorinated sulfonic acids were related to maternal foraging locations, whereas concentrations in nestling blood were related to the trophic position of prey in the nestlings' diet. Results suggested that compared to rural nestling peregrines, urban nestlings may be exposed to higher PFCAs and prone to their potential physiological impacts given their poorer body condition. Preliminary investigations with tree swallows suggest that PFAAs and microfibers are nearly ubiquitous for these birds in this region.

Publications: *Fremlin, K., J. Elliott*, D. Green, K. Drouillard, T. Harner, A. Eng, and F. Gobas. 2020. *Trophic magnification of legacy persistent organic pollutants in an urban terrestrial food web.* Science of the Total Environment. 714:137646. https://doi.org/10.1016/j.scitotenv.2020.136746

Marteinson, S.C, Guigueno, M.F., Fernie, K.J., Head, J.A., Chu, S., Letcher, R.J. 2020*. Uptake, deposition and metabolism of triphenyl phosphate in embryonated eggs and chicks of Japanese quail (Cortunix japonica)*. Environ. Toxicol. Chem. 39: 565-573. https://doi.org/10.1002/etc.4637

Guigueno, M.F., Head, J.A., Letcher, R.J., Karouna-Renier, N., Peters, L., Hanas, A.M., Fernie, K.J. 2019. *Early life exposure to triphenyl phosphate affects thyroid function, growth, and resting*

metabolic rate, of Japanese quail (Coturnix japonica) chicks. Environ. Poll. 253:899-908. https://doi.org/10.1016/j.envpol.2019.05.110

Exposure of rainbow trout to benzotriazole UV stabilizers

Focus of research: Benzotriazole ultraviolet-stabilizers (BZT-UVs) are commonly used as additives to protect from light-induced degradation in a variety of consumer goods. Despite their widespread presence in aquatic ecosystems, information on the effects of these compounds remains largely unknown.

Results: Individual compounds induced specific transcriptional changes and revealed potentially distinct modes of action; UV-328 impacted immune response-related genes, and UV-234 affected genes involved in glucose and cholesterol metabolism; both compounds regulated iron homeostasis genes in opposite ways. The mixture of both BZT-UVs did not produce significant evidence of additive or synergistic effects.

Publication: Giraudo, M., Colson, T.-L.L., De Silva, A.O., Lu, Z., Gagnon, P., Brown, L., Houde, M. 2020. Food-borne exposure of juvenile rainbow trout (*Oncorhynchus mykiss*) to benzotriazole UV stabilizers alone and in mixture induces specific transcriptional changes. *Environmental Toxicology and Chemistry* 39:852-862. https://doi.org/10.1002/etc.4676

Chemicals in Wastewater

Concentrations of Scotchgard™ derived side-chain fluorinated polymer surfactants in biosolids generated from Canadian wastewater treatment plants

Focus of research: To determine if Scotchgard™ derived side-chain fluorinated polymer components found in soil were derived from biosolids that were land-applied. The objectives of the study were to: 1) assess the occurrence of these Scotchgard derived side-chain fluorinated polymer surfactants in biosolids generated from Canadian wastewater treatment plants (WWTPs), and 2) examine the relationships between the locations and the type of WWTP processes and the levels of these side-chain polymer components in biosolids.

Results: High concentrations of the main components in Scotchgard fabric protector products (pre-2002 and post-2002; side-chain fluorinated polymer surfactants, S1 and S2, respectively) were detected in biosolids samples from twenty pan-Canadian WWTPs. S1 concentrations and S2 concentrations were much higher than that of other commonly monitored perfluoroalkyl substances (PFAS). A negative linear correlation was observed between concentrations of S1 (or S2) with the volume of WWTP treated wastewater per day per person (m3/person/day). The total concentrations of 22 other PFAS were approximately thirty times lower than S1 and S2

concentrations. PFAS concentrations in biosolids are likely underestimated without consideration of S1 and S2.

Publication: Letcher, R.J., Chu, S.-G., Smyth, S.A. 2020. *Side-chain fluorinated polymer surfactants in biosolids from wastewater treatment plants.* J. Hazard. Mat. 388: 122044. DOI: 10.1016/j.jhazmat.2020.122044

Nanomaterials

Environmental fate, effects and bioaccumulation of priority nanomaterials in soil

Focus of research: The effect of metal nanomaterials (nano copper (II) oxide and nano cerium (IV) oxide) on soil invertebrate species and indigenous microorganisms in agricultural soil were examined, with and without biosolid amendment. This also included an evaluation of the bioaccumulation potential in earthworms over time at sublethal levels.

Results: This project determined the conditions and concentrations at which selected metal nanomaterials exert adverse effects on different aspects of the soil ecosystem: soil microbial growth, activity and diversity; plant growth; and soil invertebrate health and reproduction. The research demonstrated the utility of alternate metrics used to measure bioavailability and toxicity.

Publications: Samarajeewa, A.D., Velicogna, J.R., Schwertfeger, D.M., Jesmer, A.H., Subasinghe, R.M., Princz, J.I., Scroggins, R.P., Beaudette, L.A. 2019. *Effect of silver nanoparticle contaminated biosolids on the soil microbial community*. NanoImpact 14:100157.

Velicogna, J., Schwertfeger, D., Beer, C., Jesmer, A., Kuo, J., Chen, H., Scroggins, R., Princz, J. 2019. *Phytotoxicity of copper oxide nanoparticles in soil with and without biosolid amendment*. Nanoimpact 17:100196.

Understanding the Atmospheric Fate and Toxicity of Engineered Nanoparticles through Transformation Studies

Focus of research: This research investigated the chemical and toxicity changes occurring in engineered nanoparticles when exposed to the atmosphere. Testing was conducted on the impacts of various atmospheric coatings on the oxidative potential of engineered nanoparticles.

Results The health risk of airborne nanoparticles is strongly related to the length of time they undergo atmospheric chemical reaction, and accounting for the impacts of atmospheric processing should be considered critical for making accurate risk assessments.

Publication: Liu, Q, Shahpoury, P, Liggio, J, Harner, T, Li, K, Lee, P, Li, SM. 2019. *Understanding the Key Role of Atmospheric Processing in Determining the Oxidative Potential of Airborne Engineered Nanoparticles.* Environmental Science and Technology Letters, 7 (1), pp. 7-13. DOI: 10.1021/acs.estlett.9b00700

HEALTH CANADA RESEARCH

HC funded 31 CMP research projects in 2019-2020. These projects address departmental and international priorities and cover a number of subjects such as characterization of nanomaterials, toxicological response to nanomaterials, carcinogenic potential of chemicals, genetic toxicity assessment, hazard characterization and identification of biotechnology microbes.

Methods

In vitro to in vivo extrapolation (IVIVE) Toxicokinetics of CMP Chemicals

Focus of research: The goal of this research was to develop better *in-vitro* toxicokinetic (TK) data and consistent biological extrapolation models to predict realistic doses *in-vivo* where potential toxicological effects would be anticipated based on measures from high throughput *in-vitro* assay toxicity databases. Tests and models focus on substances recently used as replacements for plasticizers, flame retardants and perfluorinated chemicals.

Results: The project resulted in the development of a new software platform to screen and model high throughput screening (HTS) data. The platform, named DREAM-TK, allows data users to analyze and visualize HTS toxicity and in-vitro TK data. The collected in vitro data was sorted and treated before being compiled for model predictions of daily dose exposure values. An application of the approach using a fire retardant (hexabromocycldodecane) *in vitro* data was presented in a publication. This tool helps in identifying chemicals considered safe and/or to trigger additional testing.

Publication: Moreau M, Nong A. *Evaluating hexabromocyclododecane (HBCD) toxicokinetics in humans and rodents by physiologically based pharmacokinetic modeling*. Food Chem Toxicol. 2019 Nov;133:110785. doi: 10.1016/j.fct.2019.110785.

Development and validation of rapid methods to assess endocrine toxicity

Focus of research: There are growing concerns that exposures to commercial chemicals cause harm by interfering with the hormonal control of growth and development of the brain, reproductive tract and lead to metabolic and stress-related problems. Developing rapid methods to identify chemicals posing these hazards is a critical need for safety assessment. This project will 1) identify and characterize the molecular target(s) mediating toxicity of organophosphate flame retardants and 2) establish methods to screen for molecules that impair thyroid hormone signaling.

Results: Enzyme targets of flame retardant toxicity were identified in all affected organs. Detailed structure activity studies of enzyme inhibition have been completed for liver target and for human homolog enzyme. This project contributes to a global initiative to characterize the molecular targets influenced by hazardous substances and to develop validated, high throughput methods to rapidly screen chemicals for toxicity and to set priorities for further assessment.

Publications: Hongyan Dong, Marlena Godlewska and Michael G. Wade. *A Rapid Assay of Human Thyroid Peroxidase Activity*. 2020. Toxicol In Vitro. 2019 Oct 16;62:104662. DOI: 10.1016/j.tiv.2019.104662

Wade MG, Kawata A, Rigden M, Caldwell D, Holloway AC. 2019. *Toxicity of Flame Retardant Isopropylated Triphenyl Phosphate: Liver, Adrenal, and Metabolic Effects.* Int J Toxicol. 2019 May 27:1091581819851502. DOI: 10.1177/1091581819851502

Dong H, Atlas E, Wade MG. 2019. *Development of a non-radioactive screening assay to detect chemicals disrupting the human sodium iodide symporter activity*. Toxicol. In Vitro. 57:39-47. doi: 10.1016/j.tiv.2019.01.021

Gouesse R, Lavoie M, Dianati E, Wade M, Hales B, Robaire B, Plante I. 2019. *Gestational and Lactational Exposure to an Environmentally-relevant Mixture of Brominated Flame Retardants Down-regulates Junctional Proteins, Thyroid Hormone Receptor α1 Expression and the Proliferation- Apoptosis Balance in Mammary Glands Post Puberty.* Toxicol Sci.171(1) 13-31. DOI: 10.1093/toxsci/kfz147

Developing in vitro screening methods for metabolic disruptors in adipocytes

Focus of research: There is increased concern that chemicals can act as endocrine disruptors and contribute to the development of endocrine cancers, as well as metabolic disease. The adipose tissue is an endocrine organ responsible for the energy homeostasis of the organism, in part via the secretion of molecules called adipokines. This project employs cell-based models to investigate chemical effects on adipose mass and functional changes in the adipocyte that may

indicate broader metabolic effects, such as diabetes, and to investigate the effects of chemicals on the initiation and progression of endocrine cancers such as breast cancer.

Results: Data suggests that bisphenol-A analogs, such as bisphenol S, can act as endocrine disruptor chemicals and affect the mammary gland. The data also suggests that flame-retardants i.e. dechlorane plus, and polychlorinated biphenyls can also act as metabolic disruptors.

Publications: Atlas E, Dimitrova V. 2019. *Bisphenol S and Bisphenol A disrupt morphogenesis of MCF-12A human mammary epithelial cells.* Sci Rep. doi: 10.1038/s41598-019-52505-x.

Tremblay-Laganière C, Garneau L, Mauger JF, Peshdary V, Atlas E, Nikolla AS, Chapados NA, Aguer C. 2019 *Polychlorinated biphenyl 126 exposure in rats alters skeletal muscle mitochondrial function.* Environ Sci Pollut Res Int. doi: 10.1007/s11356-018-3738-8.

Peshdary V, Calzadilla G, Landry A, Sorisky A, Atlas E. 2019 *Dechlorane Plus increases adipogenesis in 3T3-L1 and human primary preadipocytes independent of peroxisome proliferator-activated receptor γ transcriptional activity.* Int J Obes (Lond). 43(3):545-555. doi: 10.1038/s41366-018-0072-7.

GeneTox21 - An Integrated, High-throughput (HT) Platform for In Vitro Genetic Toxicity Assessment of New and Existing Chemicals

Focus of research: Genetic damage is associated with numerous human diseases. Chemical screening programs routinely assess a chemical's ability to damage genetic material (i.e., genetic toxicity). Traditional assessment tools (i.e., bioassays) are laborious and not conducive to high-throughput (HT), high-content chemical screening using tools that employ cultured cells (i.e., *in vitro* bioassays). This project is developing a NAM (New Approach Methodology) comprised of an integrated, multi-assay, high(er) throughput (HT) platform for the assessment of chemically-induced genetic toxicity. The HT platform, which is called GeneTox21, will be internationally promoted to encourage its adoption for robust genetic toxicity assessment of new and existing substances.

Results: Progress to date includes advancement towards validation of the MutaMouse FE cell *in vitro* mutagenicity assay, and the development of an *in vitro* mutagenicity assay based on cultured murine liver cells. For the former, a miniaturized protocol was developed to rapidly assess the effects of various treatment times and post-exposure sampling times. The results obtained includes multi-assay assessments of numerous reference compounds, and numerous data-poor priority substances. Additional work developed a beta version of a bioinformatics tool to integrate, visualise and interpret complex, multi-assay genetic toxicity assessment data. The tool is called IATGA – Integrated Analysis Tool for Genotoxicity Assessment.

Publications: Cox, J.A., Zwart, E., Luijten, M. 2019. *The development and pre-validation of an in vitro mutagenicity assay based on MutaMouse primary hepatocytes, Part II: Assay performance for the identification of mutagenic chemicals*. Environmental and Molecular Mutagenesis. 60:348-360

Cox, J.A. and P.A. White. 2019. *The mutagenic activity of select azo compounds in MutaMouse target tissues in vivo and primary hepatocytes in vitro*. Mutation Research. 844:25-34.

Tran, YK, Juick, JK, Keir, JLA, Williams, A, Swartz, CD, Recio, L, White, PA, Lambert, IB and CL Yauk. 2019. *Integrated in silico and in vitro genotoxicity assessment of thirteen data-poor substances.* Reg Toxicol Pharm. 107:104427

Madia, F, Kirkland, D, Morita, T, White, PA Asturiol, D and R Corvi. 2020. EURL ECVAM *Genotoxicity and Carcinogenicity Database of Substances Eliciting Negative Results in the Ames Test: Construction of the Database.* Mutation Research 854-855:503199.

Refining and Deploying a Quantitative Framework for the Analysis and Regulatory Interpretation of Genetic Toxicity Dose-Response Data

Focus of research: This project is using data collected from the scientific literature to improve the scientific foundation for quantitative use of genetic toxicity dose-response data for risk assessment and regulatory decision-making. More specifically, the work is determining the levels of genotoxic effects (e.g., genetic mutations) that should be considered adverse, and refining the uncertainty factor values required for determination of human exposure limit values, e.g., Tolerable Daily Intake.

Results: A formal context was developed to justify quantitative interpretation of genetic toxicity dose-response data for regulatory decision-making. Published dose-response data were collected and curated; ongoing analyses is determining the response level that should be considered as an adverse health effect. Additional analyses of information published in the scientific literature is being used to establish the uncertainty factors required to extrapolate from experimental animal data, i.e., animal-to-human inter-species adjustment and adjustment for variability in human sensitivity. The results obtained are being applied to case studies of genotoxic chemicals of concern (e.g., alkylnitrosamines and benzene). Collectively, the results obtained are being used to develop a formal framework for quantitative use of genetic toxicity data for regulatory evaluations of new and existing chemicals.

Publications: Heflich, RH, Johnson, GE, Zeller, A, Marchetti, F, Douglas, GR, Witt, KL, Gollapudi, BB and PA White. 2019. *Mutation as a toxicological endpoint for regulatory decision-making*, Environmental and Molecular Mutagenesis 61:34-41. https://doi.org/10.1002/em.22338

Luijten, M, Ball, NS, Dearfield, KL, Gollapudi, BB, Johnson, GE, Madia, F, Pfuhler, S, Settivari, RS, ter Burg, W, van Benthem, J and PA White. 2020. *Utility of a next generation framework for*

assessment of genomic damage: a case study using the industrial chemical benzene. Environmental and Molecular Mutagenesis 61:94-113. doi: 10.1002/em.22346

White, PA, Long, AS and GE Johnson. 2020. *Quantitative Interpretation of Genetic Toxicity Dose-Response Data for Risk Assessment and Regulatory Decision-Making: Current Status and Emerging Priorities.* Environ Molec Mutagen, 61:66-83.

An integrated testing strategy to assess somatic and germ cell mutations using the OECD's transgenic rodent test guideline TG 488 and the MutaMouse model

Focus of research: The objective is to harmonize the experimental design to identify somatic and germline mutations at a single time point. This integrated approach will significantly reduce the number of animals that are needed for the testing of chemicals for regulatory purposes.

Results: Data generated by this project have been used by the Organisation for Economic Cooperation and Development (OECD) to update the recommended experimental design in one test guideline that is routinely used to assess the ability of chemicals to induce mutations (i.e., changes in the sequence of the DNA).

Publications: Heflich HR, Johnson GE, Zeller A, Marchetti F, Douglas GR, Witt KL, Gollapudi BB, White PA (2020) *Mutation as a toxicological endpoint for regulatory decision-making*. Environmental and Molecular Mutagenesis, 61:34-41. Epub: October 10, 2019

Marchetti F, Douglas GR, Yauk CL (2020) *A return to the origin of the EMGS: rejuvenating the quest for human germ cell mutagens and determining the risk to future generations*. Environmental and Molecular Mutagenesis, 61:42-54. Epub: August 31, 2019.

Godschalk RWL, Yauk CL, van Benthem J, Douglas GR, Marchetti F (2020) *In utero exposure to genotoxins leading to genetic mosaicism: an overlooked window of susceptibility in genetic toxicology testing?* Environmental and Molecular Mutagenesis. 61:55-65. Epub: November 19, 2019.

Development and application of novel tools and new approach methodologies (NAM)

Focus of research*:* HC and ECCC continue to increase efforts in support of the progressive advancement of risk science through the exploration, development and application of computational tools and new approach methodologies (NAM) to effectively leverage and integrate existing and emerging data.

Results: In 2019-2020, the focus was on building risk-based science approaches and illustrative examples for the application of NAM, including predictive models and *in vitro* high-throughput screening assays, to rapidly and effectively identify and assess the potential for hazard and/or

risk in support of assessment modernization. This and ongoing work is being done through strong partnerships and collaborations between the research and regulatory communities within the Government of Canada and internationally to ensure alignment and increase global confidence in application.

Publications: Paul Friedman K., Gagne M., Loo, L-H., Karamertzanis, P., Netzeva, T., Sobanski, T., Franzosa, J., Richard, A., Lougee, R., Gissi, A., Lee, J-Y, Angrish, M., Dorne. J-L., Foster, S., Raffaele, K., Bahadori, T., Gwinn, M., Lambert, J., Whelan, M., Rasenberg, M., Barton-Maclaren, T., Thomas, RS. 2020. *Examining the Utility of In Vitro Bioactivity as a Conservative Point of Departure: A Case Study*. Toxicol Sci. 173(1):202-225. doi: 10.1093/toxsci/kfz201.

Webster, F., Gagné, M., Patlewicz, P., Pradeep, P., Trefiak, N., Judson, R., Tara S. Barton-Maclaren, TS. 2019. *Predicting Estrogenicity of a Group of Substituted Phenols: An Integrated Approach to Testing and Assessment Case Study*. Reg Tox Pharm Aug;106:278-291.

Barton-Maclaren TS, Gwinn, MR., Thomas, RS., Rasenberg, M., Kavlock, RJ. 2019. Insights: *New Approaches to Chemical Assessment- A progress Report.* Bloomberg Environment.

Kienzler A., Connors, K.A., Bonnell, M., Barron M., Beasley A., Inglis C., Norbert-King T., Martin T., Sanderson H., Vallotton N., Wilson P., Embry M. 2019. *Mode of Action (MOA) classifications in the EnviroTox Database: Analysis and implementation of a consensus MOA classification.* Environ. Toxicol. Chem. 38(10): 2294-2304. DOI: 10.1002/etc.4531

Nanomaterials

The impact of dissolution behaviour of metal oxide nanomaterials on toxicological response

Focus of research: The toxicological behavior of nanomaterials (NMs) is closely associated with their distinct physical-chemical properties. This research is investigating the influence of dissolution behaviour of NMs on their toxic potential.

Results: Experimental results showed that the dissolution behaviour of three nano-metal oxides and their bulk analogues (nickel, zinc and copper) was different in cell culture medium compared to distilled water. By participating in an international validation exercise led by Germany under Project 1.4 of the Working Group of the National Coordinators for the Test Guidelines Programme (WNT), the HC research team contributed to the development of an OECD Test Guideline on Particle Size Distribution.

Publication: Avramescu, M-L., Chénier, M., Palaniyandi, S., Rasmussen, P.E. (2020) *Dissolution behaviour of metal oxide nanomaterials in cell culture medium versus distilled water.* J. Nanoparticle Research, Vol. **22**, 222 DOI: 10.1007/s11051-020-04949-w

Relative toxic potency of silica and titanium dioxide nanoparticle variants

Focus of research: The objective is to assess composition, size and surface coating characteristics of nanomaterial (NMs), and test toxicity in lung cells including cells from biopsy samples from healthy lungs and those affected by pulmonary diseases (e.g., cystic fibrosis).

Results: Comparison of silica and titanium dioxide nano particles showed different responses based on size and surface-modifications. Also, silica nanoparticles were relatively more cytotoxic than titanium oxide nanoparticles, and atmospheric changes appeared to alter these toxicities. Furthermore, internalization of nanoparticles into exposed cells and effects on cellular organelles, namely mitochondrial functioning and cellular energy production were examined. Silica nanoparticle exposures affected key mitochondrial protein levels relevant to oxidative stress and cellular energy production. This work will advance understanding on the health consequences of exposure to NMs and assist in the design of less toxic NMs.

Publications: Liu, Q., Liggio, J., Breznan, D., Thomson, EM., Kumarathasan, P., Vincent, R., Li, K., Li, SM. *Oxidative and Toxicological Evolution of Engineered Nanoparticles with Atmospherically Relevant Coatings*. Environ Sci Technol. 2019 Mar 19;53(6):3058-3066. doi: 10.1021/acs.est.8b06879

7.2 Living organisms

Government research on living organisms focuses on developing novel and contemporary methods for determining the hazardous characteristics and the pathogenicity potential of various existing and emerging biotechnology microbes in order to support regulatory risk assessments. The research is jointly coordinated between regulators at HC and ECCC.

Research at ECCC on living organisms in 2019-2020 included the following study on methods for assessing microbial-based products.

Viable pathogen identification using DNA sequencing technology in microbial risk assessment

Focus of research: Through the application of genomics tools, methods are developed to ensure that commercial microbial-based products are safe for the environment and for Canadians.

Results: DNA sequencing technology is the preferred screening method to determine if a commercial microbial-based product contains pathogens, however, other definitive

microbiological methods may need to be applied to confirm the identity of the microbial species.

Publications: Subasinghe, R.M., Samarajeewa, A.D., Meier, M., Coleman, G., Clouthier, H., Crosthwait, J., Tayabali, A.F., Scroggins, R., Shwed P.S., Beaudette, L.A.. 2018. *Bacterial and fungal composition profiling of microbial based cleaning products*. Journal of Food and Chemical Toxicology 116:25-31.

Subasinghe, R.M., Samarajeewa A.D., Scroggins, R., Beaudette, L.A.. 2019. *Evaluation of denaturing gradient gel electrophoresis (DGGE) and next generation sequencing (NGS) in combination with enrichment culture techniques to identify bacteria in commercial microbial-based products*. Journal of Microbiological Methods 161:118-130.

7.3 Air pollutants and greenhouse gases

Air quality research efforts help quantify priority air pollutants and determine trends, improve and validate air quality predictions both in the near term and into the future within the national and global context. These efforts also enhance understanding of the impacts of air pollution on Canadians and the environment. The research also tackles emerging issues and underpins and informs evidence-based policy and regulatory development.

Ongoing research continued on a wide range of air pollutants, including short lived climate pollutants, ammonia, nitrogen oxides (NO_x), sulphur dioxide (SO_2), volatile organic compounds (VOCs), ozone, and particulate matter/aerosols. Over 67 research papers were published in peer-reviewed scientific journals in 2019-2020. The following are representative examples of that body of work.

ECCC RESEARCH

Understanding air pollutant emissions and atmospheric concentrations

Focus of research: Improve understanding of air pollutant emissions and atmospheric concentrations, and the contribution of specific sources such as on-road traffic and the oil sands.

Results: A review of monitoring data from 22 North American sites indicated that atmospheric ammonia concentrations have increased, and that this increase could not be reconciled with reported decreases in emissions. The influence of traffic-related $PM_{2.5}$ and PAH emissions on air pollution near roads depends more on the proportion of large trucks in the fleet than the total traffic volume.

Publications: Islam, S.M.N., Jackson, P.L., Kharol, S.K., McLinden, C.A., *Impact of natural gas production on nitrogen dioxide and sulphur dioxide over Northeast British Columbia, Canada*, Atmos. Environ. December 2019, 10.1016/j.atmosenv.2019.117231.

Yao X., Zhang L., *Causes of Large Increases in Atmospheric Ammonia in the Last Decade across North America,* ACS Omega 2019, 4, 22133−22142, 10.1021/acsomega.9b03284.

Dammers, E., McLinden, C. A., Griffin, D., Shephard, M. W., Van Der Graaf, S., Lutsch, E., Schaap, M., Gainairu-Matz, Y., Fioletov, V., Van Damme, M., Whitburn, S., Clarisse, L., Cady-Pereira, K., Clerbaux, C., Coheur, P. F., and Erisman, J. W.: *NH3 emissions from large point sources derived from CrIS and IASI satellite observations*, Atmos. Chem. Phys., 19, 12261–12293, https://doi.org/10.5194/acp-19-12261-2019, 2019.

Shephard, M. W., Dammers, E., Cady-Pereira, K. E., Kharol, S. K., Thompson, J., Gainariu-Matz, Y., Zhang, J., McLinden, C. A., Kovachik, A., Moran, M., Bittman, S., Sioris, C. E., Griffin, D., Alvarado, M. J., Lonsdale, C., Savic-Jovcic, V., and Zheng, Q.*: Ammonia measurements from space with the Cross-track Infrared Sounder: characteristics and applications*, Atmos. Chem. Phys., 20, 2277–2302, https://doi.org/10.5194/acp-20-2277-2020, 2020.

Hilker, N., Wang, J. M., Jeong, C.-H., Healy, R. M., Sofowote, U., Debosz, J., Su, Y., Noble, M., Munoz, A., Doerksen, G., White, L., Audette, C., Herod, D., Brook, J. R., and Evans, G. J.: *Traffic-related air pollution near roadways: discerning local impacts from background,* Atmos. Meas. Tech., 12, 5247–5261, https://doi.org/10.5194/amt-12-5247-2019, 2019.

Whaley, C. H., Galarneau, E., Makar, P. A., Moran, M. D., and Zhang, J., *How much does traffic contribute to benzene and polycyclic aromatic hydrocarbon air pollution? Results from a high-resolution North American air quality model centred on Toronto, Canada*, Atmos. Chem. Phys., 20, 2911–2925, 10.5194/acp-20-2911-2020, 2020.

Dabek-Zlotorzynska E., Celo V., Ding L., Herod D., Jeong C.-H., Evans G., Hilker N., *Characteristics and sources of $PM_{2.5}$ and reactive gases near roadways in two metropolitan areas in Canada.* Atmos. Environ. Sept 2019, Vol. 218, 10.1016/j.atmosenv.2019.116980

Measurement of carbon dioxide (CO_2) emissions

Focus of research: Using aircraft- and satellite-based instruments to measure carbon dioxide (CO_2) emissions.

Results: CO_2 emission intensities for oil sands facilities are larger than those estimated using publically available data, and overall greenhouse gas emissions may be 30% higher than those reported using existing internationally recommended bottom-up estimation methods. Also, fossil-fuel CO_2 emissions and their trends in eight U.S. megacities during 2006–2017 are inferred by combining satellite-derived NO_X emissions with bottom-up city-specific NO_X-to-CO_2 emission ratios. CO_2 emissions calculated from NO_2 satellite measurements were found to be in good agreement with existing CO_2 emissions data from ground-based measurements.

Publications: Liggio, J., Li, S.-M., Staebler, R.M., Hayden, K., Darlington, A., Mittermeier, R.L., O'Brien, J., McLaren, R., Wolde, M., Worthy, D., Vogel, F., *Measured Canadian oil sands CO_2 emissions are higher than estimates made using internationally recommended methods*., Nature Communications, Volume 10, Issue 1, December 2019, 10.1038/s41467-019-09714-9.

Goldberg, D.L., Lu, Z., Oda, T., Lamsal, L.N., Liu, F., Griffin, D., McLinden, C.A., Krotkov, N.A., Duncan, B.N., Streets, D.G., Exploiting OMI NO_2 satellite observations to infer fossil-fuel CO_2 emissions from U.S. megacities, Science of the Total Environment, Volume 695, December 2019, 10.1016/j.scitotenv.2019.133805

Alignment of carbon and nitrogen cycles with livestock and crop production in GHG emission inventories from agriculture

Focus of research: ECCC scientists worked with Agriculture and Agri-Food Canada (AAFC) scientists towards the improvement of the representation and alignment of emissions and removals of carbon, and the cycling of nitrogen and emission of nitrous oxide on farms, through livestock and crop production systems.

Results: These studies have improved the relationship between precipitation and nitrous oxide emissions and refined the Canadian nitrous oxide model, quantified the relationship between carbon in perennial soils and beef production and quantified the increase in soil carbon associated with increasing crop productivity and variations in manure application.

Publications: Liang, B.C., A.J. VandenBygaart, J.D. MacDonald, D. Cerkowniak, B.G. McConkey, R.L. Desjardins, D.A. Angers. (2020). *Revisiting no-till's impact on soil organic carbon storage in Canada.* Soil Till Res. 198, Article number 104529.

Liang, B.C., J.D. MacDonald, B.G. McConkey, C. Flemming, D. Cerkowniak, A. Blondel, and R.L. Desjardins. (2020). *Grazing based cattle production systems impacts on soil organic carbon storage in Canada.* Sci Total Env. 718, Article number 137273.

Fan, J., McConkey, B.G., Liang, B.C, Angers, D.A, Janzen, H.H, Kröbel, R, Cerkowniak, D.D, Smith, W.N. *(2019) Increasing crop yields and root input make Canadian farmland a large carbon sink.* Geoderma *336, 49-58*

HEALTH CANADA RESEARCH

In 2019-20, HC continued to conduct research on human exposure to indoor and outdoor air pollutants and their health impacts in order to guide actions to address air pollution by governments, industries, other organizations and individuals. HC scientists published approximately 53 articles in peer reviewed scientific journals. These addressed issues such as the effect of air pollutants on birth outcomes and on the development of diseases such as asthma, diabetes, and autism, the risks associated with elevated exposure to traffic and industrial pollutants, and the mechanisms by which air pollutants affect health. Other studies investigated determinants of air pollution exposure in various environments and provided information of use to local air quality management and population health studies.

The following includes a list of some of the projects in which Health Canada was engaged during 2019-20.

ATOUSSA – Assessing Toxicity of Organics in Urban Source Sectors for Air

Focus of research: This study investigates potential human health risks associated with exposure to chemical mixtures in urban air. The objective is to identify various toxic organics and characterise their relative concentrations at different sites in urban Toronto influenced by different types of emission sources.

Results: The project generated knowledge of the chemical composition of eight different sites indicative of different sources in the Toronto urban area and how the chemical composition changes from season to season. Several toxicity assays were optimised to determine the most sensitive assays that will enable differentiation of site-specific responses that can be linked to

specific chemical components and their respective concentrations in the mixtures. The current study provided a level of comparison with and between various sources in the Toronto region.

Publications: Eftade O. Gaga, Tom Harner, Ewa Dabek-Zlotorzynska, Valbona Celo, Greg Evans, Cheol-Heon Jeong, Sabina Halappanavar, Narumol Jariyasopit, Yushan Su. *Polyurethane Foam (PUF) Disk Samplers for Measuring Trace Metals in Ambient Air.* Environ. Sci. Technol. Lett.2019,6,9, 545-550. DOI10.1021/acs.estlett.9b00420

Role of non-chemical stressors and stress susceptibility in modifying the effects of air pollutants on health

Focus of research: Non-chemical stressors are important determinants of health that may also modify or contribute to the adverse health effects associated with air pollution. The objective is to assess the extent to which non-chemical stressors and inter-individual differences in stress response modify health effects of air pollution.

Results: The study produced the first evidence that individual differences in stress reactivity are associated with differential sensitivity to pulmonary impacts of ozone. The first national profile of allostatic load, a measure of cumulative physiological dysfunction associated with chronic exposure to stressors, was published. Results identified a spatial association between psychological distress and ambient air pollution levels in Canada. This work provides insight into factors governing susceptibility to inhaled pollutants. The allostatic load profile provides a tool for assessing combined and cumulative impacts of exposure to multiple stressors.

Publication: Thomson EM, Kalayci H, Walker M. 2019. *Cumulative toll of exposure to stressors in Canadians: an allostatic load profile.* Health Reports 30(6):14-21.

Role of stress and stress reactivity in mediating impacts of air pollutants on the brain and lungs

Focus of research: Exposure to air pollution is associated with increased risk of neurological and mental health disorders, but underlying mechanisms are unclear. The brain is exquisitely sensitive to stress, and chronic stress exerts profound biochemical and structural effects on the brain that contribute to local and systemic disease processes. This project investigates the role of stress responses in mediating impacts of pollutant inhalation on the brain and lungs, using *in vivo* and *in vitro models*, a human chamber study, and a birth cohort.

Results: Study findings directly link pollutant-induced release of stress hormones with effects in the brain, substantiating the hypothesis that activation of the stress axis is involved in mediating adverse central nervous system impacts of air pollutants. By linking results from experimental models to humans, ongoing work will provide mechanistic support for the causal basis of epidemiological associations, and inform effective risk assessment and management strategies through identification of characteristics that underlie vulnerability.

Publications: Thomson EM. *Air pollution, stress, and allostatic load: linking systemic and central nervous system impacts.* Journal of Alzheimer's Disease, 2019; 69(3):597-614. DOI: 10.3233/JAD-190015

Thomson EM, Filiatreault A, Guénette J. *Stress hormones as potential mediators of air pollutant effects on the brain: Rapid induction of glucocorticoid-responsive genes.* Environmental Research. 2019 Nov;178:108717. doi: 10.1016/j.envres.2019.108717. Epub 2019 Sep 4.

Air Quality Health Index and other Communications Tools

Focus of research: The Air Quality Health Index (AQHI) is the Government of Canada's tool to communicate daily air quality conditions and forecasts to Canadians. It was developed by Health Canada as a means to convey to the public the health risk associated with the air pollution mixture and to guide actions by individuals and organizations to address episodes when the risk is elevated. In order to remain accurate and relevant ongoing scientific research is needed to evaluate, update and improve the AQHI.

Results: The AQHI was originally formulated based on the association of three air pollutants with increased risk of all-cause mortality. Further investigations have demonstrated that the index also reflects other health outcomes such as emergency department visits. Wildfires smoke present specific circumstances for the deterioration in air quality and communication tools to specifically address these conditions are needed. Other studies have considered the relationship between short term variability in air quality and diverse health outcomes and different approaches to communicating air pollution health risks.

Publications: Szyszkowicz M. *The Air Quality Health Index and all emergency department visits*. Environ Sci Pollut Res Int. 2019 Aug;26(24):24357-24361. Epub 2019 Jun 22. DOI: 10.1007/s11356-019-05741-7.

Yao J, Stieb DM, Taylor E, Henderson SB. *Assessment of the Air Quality Health Index (AQHI) and four alternate AQHI-Plus amendments for wildfire seasons in British Columbia*. Canadian Journal of Public Health. 2020 Feb;111(1):96-106.

Szyszkowicz M. *Use of two-point models in "Model choice in time-series studies of air pollution and mortality"*. Air Quality, Atmosphere & Health. 2020 Feb;13(2):225-32.

Masselot P, Chebana F, Lavigne É, Campagna C, Gosselin P, Ouarda TB. *Toward an Improved Air Pollution Warning System in Quebec*. International journal of environmental research and public health. 2019 Jan;16(12):2095.

Stieb DM, Huang A, Hocking R, Crouse DL, Osornio-Vargas AR, Villeneuve PJ. *Using maps to communicate environmental exposures and health risks: Review and best-practice recommendations*. Environmental research. 2019 Sep 1;176:108518.

Effectiveness of the Air Quality Health Index for patients with implanted cardioverter defibrillators

Focus of research: The AQHI is a risk communication tool intended to provide information to the public on current and forecasted air quality conditions. The primary objective is to evaluate the actual effectiveness of the AQHI as an intervention in reducing health risks of patients wearing implantable cardioverter defibrillator (ICD). The secondary objective is to study the associations between daily exposure to outdoor O_3, NO_2 and $PM_{2.5}$ as well as AQHI and variations in arrhythmia parameters and other cardiovascular outcomes in this panel of cardiac patients.

Results: The results suggest that air pollution was associated with adverse changes in cardiovascular measures in ICD patients. Advice to avoid exposure to outdoor air pollution based on AQHI may help reduce adverse impacts on cardiovascular measures. Daily mild exercise may benefit cardiovascular function in this cohort of ICD patients.

Publication: Ling Liu, Bruce Urch, Kumaraswamy Nanthakumar, Li Chen, Marc Smith-Doiron, Jeffrey R. Brook, Mary Speck, Frances Silverman, and David M. Stieb. *Air pollution, physical activity and cardiovascular function of patients with implanted cardioverter defibrillators: A randomized controlled trial of indoor versus outdoor activity.* J. Occup. Environ. Med. December 2019, 62(4):263-271. DOI: 10.1097/JOM.0000000000001795

The association between pregnancy exposure to air pollution and autism in children

Focus of research: The number of children diagnosed with autism spectrum disorder (ASD) has been increasing. Previous studies suggested potential association between pregnancy air pollution exposure and ASD. This project is designed to test two hypotheses: (1) prenatal exposure to air pollution is associated with the risk of ASDs in children; and (2) the impact of exposure to air pollution varies according to gestational periods.

Results: The first phase of this project was a systematic review and meta-analysis of previous publications and is intended to summarize the association between maternal exposure to outdoor air pollution and ASD in children by trimester based on recent studies. The review found some evidence for $PM_{2.5}$, weak evidence for NO_2 and little evidence for PM_{10} and ozone. However, patterns in associations over trimesters were inconsistent among studies and among air pollutants.

Publications: Chun H, Leung C, Wen SW, McDonald J, Shin HH. *Maternal exposure to air pollution and risk of autism in children: A systematic review and meta-analysis*. Environmental Pollution. 2020 Jan 1;256:113307

Health effects of exposure to ultrafine particles (UFPs)

Focus of research: This study investigates long-term exposure to UFPs on the risk of developing lung, breast and prostate cancers using data from three case-control studies. As well, it investigates pregnancy exposure to UFPs on the risk of term low birth weight (<2,500g), preterm birth and small for gestational age using a provincial birth registry in Ontario for births in the city of Toronto.

Results: Three scientific manuscripts have been published based on findings relating UFPs to childhood asthma, congenital heart defects and brain tumours in adults. More specifically, UFP exposures during a critical periods of pregnancy were associated with an increased risk of ventricular septal defect and the onset of asthma in children. Ambient UFPs may also represent a previously unrecognized risk factor for incident brain tumors in adults.

Publications: Lavigne E, Lima I, Hatzopoulou M, Van Ryswyk K, Decou ML, Luo W, van Donkelaar A, Martin RV, Chen H, Stieb DM, Crighton E. *Spatial variations in ambient ultrafine particle concentrations and risk of congenital heart defects.* Environment international. 2019 Sep 1;130:104953.

Lavigne E, Donelle J, Hatzopoulou M, Van Ryswyk K, Van Donkelaar A, Martin RV, Chen H, Stieb DM, Gasparrini A, Crighton E, Yasseen III AS. *Spatiotemporal variations in ambient ultrafine particles and the incidence of childhood asthma.* American journal of respiratory and critical care medicine. 2019 Jun 15;199(12):1487-95.

Weichenthal S, Olaniyan T, Christidis T, Lavigne E, Hatzopoulou M, Van Ryswyk K, Tjepkema M, Burnett R. *Within-city Spatial Variations in Ambient Ultrafine Particle Concentrations and Incident Brain Tumors in Adults.* Epidemiology (Cambridge, Mass.). 2020 Mar;31(2):177.

Spatial modelling to support health studies

Focus of research: Health Canada carries out intensive ambient air pollution monitoring, and develops land-use regression (LUR) models that allow for the prediction of concentrations of pollutants at a neighbourhood or household level. LUR models are being used to support local- and national-scale health studies investigating air pollution impacts on respiratory, cardiovascular (e.g. stroke), developmental (e.g. birth outcomes, gestational diabetes), autoimmune diseases and cancer outcomes.

Results: Land-Use Regression models and other exposure data developed by Health Canada's Air Program are now available through several venues including The Canadian Urban Environmental Health Research Consortium (CANUE).

Publication: Goldberg MS, Villeneuve PJ, Crouse D, To T, Weichenthal SA, Wall C, Miller AB. *Associations between incident breast cancer and ambient concentrations of nitrogen dioxide from a national land use regression model in the Canadian National Breast Screening Study*. Environment international. 2019 Dec 1;133:105182.

Central Experimental Farm Greenspace Effects

Focus of research: Air pollution, traffic related noise and local temperatures are all influenced by features of the urban built environment. In Ottawa, the Central Experimental Farm (CEF) likely plays a prominent role in influencing these exposures, but to date there have been few efforts to evaluate these impacts. The purpose of this study was to characterize air pollution, noise and ambient temperature on and around the CEF, and to determine if the farm has a mitigating impact on these exposures.

Results: Three seasonal sampling campaigns were conducted in and around the CEF. The spatial variability of nitrogen dioxide, fine particulate matter, ultra-fine particles, black carbon, volatile organic compounds, ambient temperature, and noise within this area was characterized. The study produced evidence that this large green space can mitigate levels of heat and air pollution in the surrounding area.

Publication: Van Ryswyk K, Prince N, Ahmed M, Brisson E, Miller JD, Villeneuve PJ. *Does urban vegetation reduce temperature and air pollution concentrations? Findings from an environmental monitoring study of the Central Experimental Farm in Ottawa, Canada*. Atmospheric Environment. 2019 Dec 1;218:116886.

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Multi-City Multi-Country (MCC) Collaborative Research Network

Focus of research: Numerous studies have examined the associations between short-term PM exposures and daily mortality. However, most evidence has been obtained from studies in single cities, regions, or countries, and there are challenges in comparing these results and in synthesizing effect estimates because of different modeling approaches and potential publication bias. The Multi-City Multi-Country (MCC) Collaborative Research Network was designed to address these limitations by performing international, multicenter studies that adopt the same analytic protocol and model specifications to estimate globally representative associations of ozone, PM_{10} and $PM_{2.5}$ exposures with daily mortality.

Results: Two research papers were published. One paper showed independent associations between short-term exposure to PM_{10} and $PM_{2.5}$ and daily all-cause, cardiovascular, and

respiratory mortality in more than 600 cities across the globe. The second paper reported on data analyzed from more than 400 locations in twenty countries and provided evidence on the short term association between ozone and mortality

Publications: Liu C, Chen R, Sera F, Vicedo-Cabrera AM, Guo Y, Tong S, Coelho MS, Saldiva PH, Lavigne E, Matus P, Valdes Ortega N. *Ambient particulate air pollution and daily mortality in 652 cities.* New England Journal of Medicine. 2019 Aug 22;381(8):705-15.

Vicedo-Cabrera AM, Sera F, Liu C, Armstrong B, Milojevic A, Guo Y, Tong S, Lavigne E, Kyselý J, Urban A, Orru H, et al. *Short term association between ozone and mortality: global two stage time series study in 406 locations in 20 countries.* BMJ. 2020 Feb 10;368.

Air Pollution Exposure linked to the Ontario Population Health and Environment Cohort

Focus of research: The Ontario Population Health and Environment Cohort (ONPHEC) is a large, retrospective cohort in the province of Ontario, created in 2014 by linking multiple large-scale health administrative databases. It is comprised of virtually the entire Canadian-born population of Ontario who were 35 years or older in 1996 (~ 4.9 million), with follow-up until 2014. The primary objectives of ONPHEC are to investigate the independent and combined effects of environmental stressors (such as air pollution, traffic-related noise) on the incidence of chronic diseases and their interactions with 'healthy' environmental factors (e.g. green areas).

Results: Five research papers were published. One paper reported that air pollution exposure increased risk of stroke, a second found an association between exposure to air pollutants and heart failure and acute myocardial infarction (heart attack). Further analysis found that consideration of the chemical components that make up $PM_{2.5}$ may increase the estimate of the effect of $PM_{2.5}$ heart attacks and cardiovascular mortality by 10% to 27%. A fourth paper presented links between air pollution and the incidence of diabetes and diabetes related mortality. Finally, another paper reported that long term exposure to traffic noise increases risks of diabetes and hypertension and that this effect was independent of the effects of air pollution.

Publications: Shin S, Burnett RT, Kwong JC, Hystad P, van Donkelaar A, Brook JR, Goldberg MS, Tu K, Copes R, Martin RV, Liu Y. *Ambient air pollution and the risk of atrial fibrillation and stroke: a population-based cohort study.* Environmental health perspectives. 2019 Aug 26;127(8):087009.

Chen H, Zhang Z, van Donkelaar A, Bai L, Martin RV, Lavigne E, Kwong JC, Burnett RT. *Understanding the Joint Impacts of Fine Particulate Matter Concentration and Composition on the Incidence and Mortality of Cardiovascular Disease: A Component-Adjusted Approach*. Environmental Science & Technology. 2020 Feb 26;54(7):4388-99.

Bai L, Shin S, Burnett RT, Kwong JC, Hystad P, van Donkelaar A, Goldberg MS, Lavigne E, Copes R, Martin RV, Kopp A. *Exposure to ambient air pollution and the incidence of congestive heart*

failure and acute myocardial infarction: A population-based study of 5.1 million Canadian adults living in Ontario. Environment international. 2019 Nov 1;132:105004.

Shin S, Bai L, Oiamo TH, Burnett RT, Weichenthal S, Jerrett M, Kwong JC, Goldberg MS, Copes R, Kopp A, Chen H. *Association between road traffic noise and incidence of diabetes mellitus and hypertension in Toronto, Canada: a population-based cohort study.* Journal of the American Heart Association. 2020 Mar 17;9(6):e013021.

Paul LA, Burnett RT, Kwong JC, Hystad P, van Donkelaar A, Bai L, Goldberg MS, Lavigne E, Copes R, Martin RV, Kopp A. The impact of air pollution on the incidence of diabetes and survival among prevalent diabetes cases. Environment international. 2020 Jan 1;134:105333.

Air Pollution Health Effects observed in the Canadian Community Health Survey

Focus of research: The Canadian Community Health Survey (CCHS) is a national cross-sectional survey of the Canadian population that collects information related to health status, health care utilization, and health determinants. The survey has been used to create a cohort with detailed air pollution exposure data and information on a number of important individual-level behavioural risk factors that can be used to investigate the relationships between air pollution and various health outcomes.

Results: The Canada wide coverage of the cohort allowed the investigation of effect of air pollution on population mortality even when pollutant concentrations were low. The results showed that a significant effect and supralinear concentration response at low $PM_{2.5}$ concentrations. The CCHS data was also applied to an investigation of causal mediators of the relationship between air pollution and dementia. The study found a relationship between long term exposure to air pollutants and increased incidence of dementia and suggested that the effect of air pollution exposure on cardiovascular disease may contribute to the effect on dementia.

Publications: Christidis T, Erickson AC, Pappin AJ, Crouse DL, Pinault LL, Weichenthal SA, Brook JR, van Donkelaar A, Hystad P, Martin RV, Tjepkema M. *Low concentrations of fine particle air pollution and mortality in the Canadian Community Health Survey cohort.* Environmental Health. 2019 Dec 1;18(1):84.

Ilango SD, Chen H, Hystad P, van Donkelaar A, Kwong JC, Tu K, Martin RV, Benmarhnia T. *The role of cardiovascular disease in the relationship between air pollution and incident dementia: a population-based cohort study.* International Journal of Epidemiology. 2020 Feb 1;49(1):36-44.

Traffic Related Air Pollution

Focus of research: Traffic-related air pollution (TRAP) is one of the major sources of exposure in urban areas and has been associated with a wide range of adverse human health effects. Much of the Canadian population is regularly exposed to TRAP as a result of daily activities (e.g., commuting) and a significant portion of the population resides in close proximity to major roadways.

Results: Health Canada conducted a scoping review to develop an evidence map of the epidemiological literature of the human health effects of exposure to TRAP, to support future reviews and assessments**.**

Publication: Matz CJ, Egyed M, Hocking R, Seenundun S, Charman N, Edmonds N. *Human health effects of traffic-related air pollution (TRAP): a scoping review protocol.* Systematic reviews. 2019 Dec 1;8(1):223.

Health Impacts of Early Life Exposure to Air Pollution

Focus of research: Exposure to air pollution in-utero and throughout childhood is believed to contribute to many adverse health outcomes including immune related diseases. Several approaches are being undertaken to elucidate this relationship using different methods to characterizing air pollution exposure and retrospective birth and child cohorts.

Results: Air pollution was seen to increase the risk of adverse health outcomes at birth and in early childhood development across several different research methods and considering pollutants from different sources. Ozone exposure was associated with asthma and eczema in children, while other studies showed complex profiles and source characteristics that were linked to health effects.

Publications: Serrano-Lomelin J, Nielsen CC, Jabbar MS, Wine O, Bellinger C, Villeneuve PJ, Stieb D, Aelicks N, Aziz K, Buka I, Chandra S. *Interdisciplinary-driven hypotheses on spatial associations of mixtures of industrial air pollutants with adverse birth outcomes*. Environment international. 2019 Oct 1;131:104972.

Buteau S, Shekarrizfard M, Hatzopolou M, Gamache P, Liu L, Smargiassi A. *Air pollution from industries and asthma onset in childhood: A population-based birth cohort study using dispersion modeling*. Environmental Research. 2020 Jan 25:109180.

To T, Zhu J, Stieb D, Gray N, Fong I, Pinault L, Jerrett M, Robichaud A, Ménard R, van Donkelaar A, Martin RV. *Early life exposure to air pollution and incidence of childhood asthma, allergic rhinitis and eczema*. European Respiratory Journal. 2020 Feb 1;55(2).

Methods

Outdoor Pollution Exposure Risk Assessment (OPERA)

Focus of research: Outdoor Pollution Exposure and Risk Assessment (OPERA) represents a new paradigm in how to conduct burden of disease studies to support evidence-based decision making in climate and air quality management. The project consists of two main components: construction of multi-pollutant concentration response functions for different health outcomes; and estimation of disease burden by source of pollution and geographic area.

Results: Improved air pollution exposure methodologies were applied to Canadian and global cohorts and found associations between air pollution exposure for a range of health outcomes including diabetes, preterm birth and mortality. A large international collaboration has made a significant contribution to the estimation of the global burden of disease associated with air pollution.

Publications: Erickson AC, Brauer M, Christidis T, Pinault L, Crouse DL, van Donkelaar A, Weichenthal S, Pappin A, Tjepkema M, Martin RV, Brook JR. *Evaluation of a method to indirectly adjust for unmeasured covariates in the association between fine particulate matter and mortality*. Environmental research. 2019 Aug 1;175:108-16.

Pappin AJ, Christidis T, Pinault LL, Crouse DL, Brook JR, Erickson A, Hystad P, Li C, Martin RV, Meng J, Weichenthal S. *Examining the Shape of the Association between Low Levels of Fine Particulate Matter and Mortality across Three Cycles of the Canadian Census Health and Environment Cohort.* Environmental health perspectives. 2019 Oct 22;127(10):107008.

Crouse DL, Erickson AC, Christidis T, Pinault L, van Donkelaar A, Li C, Meng J, Martin RV, Tjepkema M, Hystad P, Burnett R. *Evaluating the Sensitivity of PM2. 5–Mortality Associations to the Spatial and Temporal Scale of Exposure Assessment.* Epidemiology. 2020 Mar 1;31(2):168-76.

Methods to Pool Non-Linear Concentration-Response Models

Focus of research: New evidence is emerging that relationships between outdoor concentrations of air pollutants and health may not all be best characterized by linear risk models. This project will develop mathematical methods to combine results from several studies with non-linear associations between air pollution exposure and health.

Results: This study investigates the association between ambient air pollution concentration levels and emergency department visits for personality disorders, acute reaction to stress, and disturbance of conduct. The study suggested an impact of urban air pollution on human behaviour. This study resulted in the development of a method pooling non-linear risk functions

named the Global Exposure Mortality Model (GEMM) for non-accidental deaths. This new approach is used worldwide to determine the impact of fine particulate matter on mortality.

Publications: Szyszkowicz M. *Urban air pollution and behavioural disorders*. Int Arch Subs Abuse Rehabil 2019 (1):1-7. DOI: 10.23937/iasar-2017/1710005

Szyszkowicz M. *Case-Crossover Method with a Short Time-Window*. Int J Environ. Res. Public Health 2020, 17(1) 202: DOI: 10.3390/ijerph17010202

7.4 Water quality

Both ECCC and HC continued their water quality research activities.

ECCC RESEARCH

Trends in flame retardants in Great Lakes Fish

Focus of research: To assess temporal changes in concentrations of polybrominated diphenyl ethers (PBDEs) flame retardants in top predator fish in the Great Lakes.

Results: Both Canadian and the US researchers analyzed trends in five major PBDE congeners (BDE-47, 99, 100, 153, and 154) in lake trout and walleye in all five Great Lakes from 1979 to 2016. Total PBDE concentrations (age-adjusted) increased from 1990 to 2000 (16.3% per year) followed by a rapid decreasing trend from 2000 to 2007 (−19.5% per year). This decrease is associated with the voluntary phasing out of production and use of PBDEs beginning in 2000. Since 2007, the decreasing trend has become smaller (less than −5.5% per year) and relatively unchanged from 2011 to 2015. While BDE-47 continues to decline in most lakes, the concentration of the four higher brominated congeners appears to be increasing post 2007. These results indicate increasing fish uptake and bioaccumulation of higher brominated BDE congeners may be related to the transformation of BDE-209 to lower brominated BDE compounds in the Great Lakes environment or food web.

Publication: Zhou, C., Pagano, J., McGoldrick, D.J., Chen, D., Crimmins, B.,S., Hopke, P.K., Milligan, M.S., Murphy, E.W., Holsen, T.M. 2019. *Legacy Polybrominated Diphenyl Ethers (PBDEs) Trends in Top Predator Fish of the Laurentian Great Lakes (GL) from 1979 to 2016: Will Concentrations Continue to Decrease?* Environ. Sci. Technol. 53: 6650-6659 255. DOI: 10.1021/acs.est.9b00933

Trends in Perfluoroalkyl Acids (PFAAs) in Great Lakes precipitation and surface waters

Focus of research: To assess temporal changes in concentrations of perfluoroalkyl acids in wet precipitation and surface water between 2006 and 2018 in the Canadian Great Lakes in relation to regulatory changes.

Results: Perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) concentrations generally decreased in precipitation, likely in response to phase-outs/regulatory actions. In comparison, concentrations of shorter-chained PFAA, which are not regulated in Canada did not decrease and those of perfluorohexanoate and perfluorobutanoate (PFBA) recently increased, which could be due to their use as replacements, as the longer-chained PFAAs are being phased-out by industry. Our results suggest that source control of shorter-chained PFAAs may be slow to be reflected in environmental concentrations due to emissions far from the location of detection and continued volatilization from existing in-use products and waste streams.

Publication: Gewurtz, S.B., Bradley, L.E., Backus, S., Dove, A., McGoldrick, D.J., Hung, H., Dryfhout-Clark, H. 2019. *Perfluoroalkyl Acids in Great Lakes Precipitation and Surface Water (2006-2018) Indicate Response to Phase-outs, Regulatory Action, and Variability in Fate and Transport Processes*. In Environ. Sci. Technol. 53: 8543-8552.
https://pubs.acs.org/doi/10.1021/acs.est.9b01337

Spatial and temporal trends of bisphenol A in Canadian surface waters

Focus of research: Studies have shown that BPA, an industrial chemical used in plastics production, is entering the environment through wastewaters, washing residues, physical–chemical breakdown of end products during disposal and recycling, and has been found in some leachate from landfills. Freshwater samples were collected and analysed for Bisphenol A (BPA), at 44 sampling sites in Canada from 2012 to 2018.

Results: The resultant concentrations of PBA in the samples ranged from 3.05 to 1888.51 ng/L, with concentrations of BPA in 64% of the samples under the detection limit of the laboratory. In comparison, the Federal Environmental Quality Guideline for the protection of aquatic life is 3500 ng/L. Detections of BPA in water samples were more frequent in urban and municipal wastewater treatment plants-associated sites. Additionally, there does not seem to be a statistically significant temporal (upward or downward) or spatial trend in BPA concentrations in Canadian surface waters from 2012 to 2018. Overall, Canadian BPA results are of similar concentrations to that of other countries in Asia and Europe.

Publication: Lalonde B., Garron C. 2020. *Spatial and Temporal Distribution of BPA in the Canadian Freshwater Environment.* Arch of Env. Contam and Toxicol. 78: 568-578
https://link.springer.com/article/10.1007/s00244-020-00721-2

Fate, transport and bioaccumulation of emerging and legacy perfluoroalkyl substances

Focus of research: The focus of this research is to contribute environmental fate data on emerging and legacy perfluoroalkyl substances (PFAS), from various sources including Lake Ontario sediment and wastewater influent and effluent.

Results: In a Lake Ontario sediment core that was sectioned, dated, and analyzed for perfluoroalkyl substances (PFAS), a deposition profile was constructed for individual PFAS congeners from 1950 to 2017. Perfluoroalkane sulfonic acids (PFSA) and perfluoroalkyl carboxylic acids (PFCA) were detected in all samples 1950 -2017. PFOS increased exponentially from the 1950s until 2008, followed by a decline. The 2nd and 3rd highest concentrations were attributed to perfluorooctanoate (PFOA) and (PFUnDA). PFOA increased until 1996 followed by decline and a plateau from 2000 to the present. Perfluoroundecanoate (PFUnDA) and other long chain PFCA do not display a decline and have increased in deposition since 2000.

PFAS were analyzed in raw wastewater influent sampled from 14 different wastewater treatment plants in Canada with a variety of treatment approaches: primary treatment with chemical addition, facultative lagoon, advanced secondary treatment, and advanced biological nutrient removal. Total PFAS (20 congeners) in influent ranged from 11 ng L^{-1} to 444 ng L^{-1}(91 ± 100 ng L^{-1}) with a median value of 42 ng L^{-1}. In effluent, total PFAS ranged from 20 ng L^{-1} to 239 ng L^{-1} (66 ± 59 ng L^{-1}) with a median value of 42 ng L^{-1}. However, on an individual PFAS congener basis, greater concentrations of certain PFAS in effluent suggests their production via transformation of organofluorine precursors in the WWTP process.

Publication: Pickard, H.M., Criscitiello, A.S., Persaud, D., Spencer, C., Muir, D.C.G., Lehnherr, I., Sharp, M.J., De Silva, A.O., Young, C.J. 2020. *Ice Core Record of Persistent Short-Chain Fluorinated Alkyl Acids: Evidence of the Impact from Global Environmental Regulations*, Geophys. Res. Lett., 47, e2020GL087535.

Aquatic toxicology of silver nanoparticles

Focus of research: Silver nanoparticles (nAg) represent one of the most popular nanomaterials owing to their antibacterial properties. The increased use of nAg has raised concerns on potential impacts to aquatic ecosystems. The influence of surface coatings, size and the form of silver nanoparticles on the bioavailability and toxicity in fish were examined.

Results: The surface coatings influenced bioavailabilty and toxicity of silver nanoparticles. Silver nanoparticles coated with polyvinylpyrolidone were the most bioavailable in fish compared to citrate, silicate and bis-polyethyleneimine coatings. The toxicity of the form of silver nanoparticles of similar size and coating was greater with cubic nanomaterials compared to spherical and prismatic nano-silver. In this approach, polystyrene nanoparticles were used as inert surrogates where crowding effects could be measured in tissues without the reactivity of silver.

Publications: Auclair J, Turcotte P, Gagnon C, Peyrot C, Wilkinson KJ, Gagné F. 2019. *The influence of surface coatings on the toxicity of silver nanoparticle in rainbow trout.* Comp Biochem Physiol C Toxicol Pharmacol. 226: 108623.

Auclair J, Turcotte P, Gagnon C, Peyrot C, Wilkinson KJ and F, Gagné 2019. *The Influence of Surface Coatings of Silver Nanoparticles on the Bioavailability and Toxicity to Elliptio complanata Mussels*. Journal of Nanomaterials e ID 7843025.

Availability and biophysical effects of polystyrene nanoparticles

Focus of research: The presence of nanoplastics in various products and from the weathering of released plastic materials are of concern for the environment's safety. The purpose of this study was to examine the biophysical effects of polystyrene nanoparticles on cnidarian and freshwater mussels.

Results: Polystyrene NPs were detected in the digestive gland and produced biophysical effects in the digestive gland of freshwater mussel such as anisotropy, viscosity, and changes in glucose metabolism enzyme dissipative activities and time-dependent viscosity. An additional studied concluded that NPs are bioavailable to hydra and lead to lipid peroxidation (LPO) and lipid mobilization in hydra.

Publications: Auclair J, Quinn B, Peyrot C, Wilkinson KJ, Gagné F. 2020. *Detection, biophysical effects, and toxicity of polystyrene nanoparticles to the cnidarian Hydra attenuata.* Environ Sci Pollut Res Int. 27: 11772-11781.

Auclair J, Peyrot C, Wilkinson KJ, F., Gagné, 2020. *Biophysical effects of polystyrene nanoparticles on Elliptio complanata mussels.* Environ Sci Poll Res. https://doi.org/10.1007/s11356-020-08920-

Fate, transformation and bioavailability of metal-based nanoparticles in the aquatic environment

Focus of research: To evaluate the environmental transformation and fate of metal-based nanomaterials *(NP Bi2O3, CeO2, CuO, MnO2, NiO, Ag, ZnO, ZrO2)* in natural waters. The fate of nanomaterials such as cerium, copper and zinc oxides and silver nanoparticles (NPs) released from municipal wastewaters and their toxicity in exposed fish and bivalves were assessed.

Results: Silver nanoparticles and transformation products were evaluated in Canadian municipal wastewater effluents as potential additional silver sources in natural waters. The bioavailability and toxicity of CeO_2 and Ag NPs and transformed products to different aquatic organisms were documented and environmental exposure was characterized as influenced by the nature and size of particles. The transformation of CuO and ZnO NPs was significant and key information for environmental exposure assessment (persistence and bioaccumulation).

Publications: Auclair, J., Turcotte, P., Gagnon C., Gagné F. 2020. *Toxicity of copper oxide nanoparticles to rainbow trout juveniles.* Current Topics Toxicol. 16: 1-11.

Auclair J, André C, Peyrot C, Wilkinson KJ, Turcotte P, Gagnon C, Gagné F. 2019. *Combined effects of surface waters and CeO nanoparticle in zebra mussels.* Invert. Surv. J. 16: 153-163.

Auclair J, Turcotte P, Gagnon C, Peyrot C, Wilkinson KJ, Gagné F. 2019. *The influence of surface coatings of silver nanoparticles on the bioavailability and toxicity of freshwater mussels*. J. Nanomaterials, ID 7843025, 10 p. doi.org/10.1155/2019/7843025.

Gagné F, Auclair J, Turcotte P, Gagnon C, Peyrot C, Wilkinson KJ. 2019. *The influence of surface waters on the bioavailability and toxicity of zinc oxide nanoparticles in freshwater mussels*. Comp Biochem Physiol - Part C. 219:1-11.

Toxicity of tire particle leachates to embryonic fish

Focus of research: ECCC scientists assessed the aquatic toxicity of leachates from particles of tires. Tire particles are a class of microplastics that enter the environment. Tires lose up to 1 kg per year of rubber (per car, with normal driving), and these small bits of rubber are washed from road surfaces into drains, often ending up in rivers.

Results: The effects of leachates from tire particles were assessed by exposing embryonic fish. Leachates from tire particles were toxic to fish. Toxicity was greater if the tire particles were leached at higher temperatures (34 °C compared to 25 °C) and if tire particles were leached with vigorous stirring (simulating high rainstorm turbulence). The leachates decreased fish embryo hatch success, and any surviving hatched fish were smaller. The study is continuing in order to assess which chemicals in the tire particles were harming the fish.

Publications: Kolomijeca A, Parrott J, Khan H, Shires K, Clarence S, Sullivan C, Chibwe L, Sinton D, Rochman CM. 2020. Increased temperature and turbulence alter the effects of leachates from tire particles on fathead minnow (*Pimephales promelas*). Environmental Science & Technology. 54(3):1750-1759.

8 Additional information

Further information on CEPA and related activities can be found online.

- CEPA Environmental Registry
- Environment and Climate Change Canada
- Health Canada
- CMP chemical substances section of the Canada.ca

For more information, contact the Environment and Climate Change Canada's Inquiry Centre.

Environment and Climate Change Canada
Public Inquiries Centre
7th Floor, Fontaine Building
200 Sacré-Coeur Boulevard
Gatineau QC K1A 0H3

Telephone: 819-938-3860

Toll Free: 1-800-668-6767 (in Canada only)

Email: ec.enviroinfo.ec@canada.ca

The following media relations contacts are also available to provide information.

Environment and Climate Change Canada

Toll-free within Canada: 1-888-908-8008

Outside Canada: 1-819-934-8008

Email: ec.media.ec@canada.ca

Health Canada

Telephone: 613-957-2983

Substance	Publication date
10*H*-Phenothiazine, 2-chloro-10-[3-(4-methyl-1-piperazinyl)propyl]- (CAS RN 58-38-8)	July 27, 2019
Phenol, 4,4′-(3*H*-2,1-benzoxathiol-3-ylidene)bis[2,6-dibromo-3-methyl-, S,S-dioxide (CAS RN 76-60-8)	July 27, 2019
Urs-12-en-28-oic acid, 3-hydroxy, (3β)- (CAS RN 77-52-1)	July 27, 2019
Benzamide, 3,5-dibromo-*N*-(4-bromophenyl)-2-hydroxy- (CAS RN 87-10-5)	July 27, 2019
1,4-Benzendiamine, *N*,*N*′-di-2-naphthalenyl- (CAS RN 93-46-9)	July 27, 2019
Phenol, 4,4′-thiobis[2-(1,1-dimethylethyl)-6-methyl- (CAS RN 96-66-2)	July 27, 2019
9*H*-Carbozole-3-carboxamide, *N*-(4-chlorophenyl)-2-hydroxy- (CAS RN 132-61-6)	July 27, 2019
Benzenethiol, pentachloro- (CAS RN 133-49-3)	July 27, 2019
Benzene, 1-(1,1-dimethylethyl)-3,4,5-trimethyl-2,6-dinitro- (CAS RN 145-39-1)	July 27, 2019
10*H*-Phenothiazine, 10-[3-(4-methyl-1-piperazinyl)propyl]-2-(trifluoromethyl)-, dihydrochloride (CAS RN 440-17-5)	July 27, 2019
Benzenamine, 4,4′,4″-methylidynetris[*N*,*N*-dimethyl- (CAS 603-48-5)	July 27, 2019
Phenol, pentabromo- (CAS RN 608-71-9)	July 27, 2019
Tetrasiloxane, 1,1,3,3,5,5,7,7-octamethyl- (CAS RN 1000-05-1)	July 27, 2019
1-Naphthalenemethanol, α,α-bis[4-(dimethylamino)phenyl]-4-(methylphenylamino)- (CAS RN 1325-85-5)	July 27, 2019
C.I. Sulphur Orange 1 (CAS RN 1326-49-4)	July 27, 2019
2H-Benzimidazik-2-one, 1-[1-[4,4-bis(4-fluorophenyl)butyl]-4-piperidinyl]-1,3-dihydro- (CAS RN 2062-78-4)	July 27, 2019
Benzo[*b*]thiophen-3(2*H*)-one, 5-chloro-2-(5-chloro-4,7-dimethyl-3-oxobenzo[*b*]thien-2(3*H*)-ylidene)-4,7-dimethyl- (CAS RN 2379-75-1)	July 27, 2019
Anthra[9,1,2-*cde*]benzo[*rst*]pentaphene-5,10-diol, 16,17-dimethyoxy-, bis(hydrogen sulfate), disodium salt (CAS RN 2538-84-3)	July 27, 2019
Heptanoic acid, 2-[4-[3-[2-(trifluoromethyl)-10H-phenothiazin-10-yl]propyl]-1-piperazinyl]ethyl ester (CAS RN 2746-81-8)	July 27, 2019
1,3,5-Triazine, 2,4-dimethoxy-6-(1-pyrenyl)- (CAS RN 3271-22-5)	July 27, 2019
3*H*-Indol-3-one, 5-bromo-2-(9-chloro-3-oxonaphtho[1,2-b]thien-2(3*H*)-ylidene)-1,2-dihydro- (CAS RN 3687-67-0)	July 27, 2019
9,10-Anthracenedione, 1-amino-4-(2-benzothiazolylthio)- (CAS RN 3767-68-8)	July 27, 2019
[1,1′-Biphenyl]-4-ol, 3,4′,5-tris(1,1-dimethylethyl)- (CAS RN 6257-39-2)	July 27, 2019
Benzo[*b*]thiophen-3(2*H*)-one, 5,7-dichloro-2-(6-chloro-4-methyl-3-oxobenzo[*b*]thien-2(3*H*)-ylidene)-4-methyl- (CAS RN 6371-23-9)	July 27, 2019

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Naphth[2,3-*c*]acridine-5,8,14(13*H*)-trione, 6,10,12-trichloro- (CAS RN 6373-31-5)	July 27, 2019
9,10-Anthracenedione, 1-(methylamino)-4-[(3-methylphenyl)amino]- (CAS RN 6408-50-0)	July 27, 2019
2-Anthracenecarboxaldehyde, 1-amino-9,10-dihydro-9,10-dioxo-, 2-[(1-amino-9,10-dihydro-9,10-dioxo-2-anthracenyl)methylene]hydrazine (CS RN 6409-68-3)	July 27, 2019
Naphth[2,3-c]acridine-10-carboxamide, *N*-[5-(benzoylamino)-9,10-dihydro-9,10-dioxo-1-anthracenyl]-5,8,13,14-tetrahydro-5,8,14-trioxo- (CAS RN 6417-38-5)	July 27, 2019
9,10-Anthracenedione, 1-[[4-(phenylsulfonyl)phenyl]amino]- (CAS RN 15958-61-9)	July 27, 2019
21*H*,23*H*-Porphine, 5,10,15,20-tetra-4-pyridinyl- (CAS RN 16834-13-2) (CAS RN 16834-13-2)	July 27, 2019
Benzoxazolium, 2-[3-[5,6-dichloro-1-ethyl-1,3-dihydro-3-(3-sulfopropyl)-2H-benzimidazol-2-ylidene]-1-propenyl]-3-ethyl-, hydroxide, inner salt (CAS RN 19163-98-5)	July 27, 2019
9H-Carbazole-1-carboxamide, N-(4-chlorophenyl)-2-hydroxy- (CAS RN 23077-61-4)	July 27, 2019
1*H*-Imidazole, 1-[2-[(4-chlorophenyl)methoxy]-2-(2,4-dichlorophenyl)ethyl]-, mononitrate (CAS RN 24169-02-6)	July 27, 2019
Hexanedioic acid, bis[2-[[4-(2,2-dicyanoethenyl)-3-methylphenyl]ethylamino]ethyl] ester (CAS RN 25857-05-0)	July 27, 2019
9,10-Anthracenedione, 1-amino-4-[(methoxyphenyl)amino]- (CAS RN 27341-33-9)	July 27, 2019
1H-Benzimidazolium, 5,6-dichloro-2-[3-(5,6-dichloro-1,3-diethyl-1,3-dihydro-2H-benzimidazol-2-ylidene)-1-propenyl]-1-ethyl-3-(3-sulfobutyl)-, hydroxide, inner salt (CAS RN 28118-10-7)	July 27, 2019
Benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, ethyl ester (CAS RN 36294-24-3)	July 27, 2019
[1,1'-Biphenyl]-4-ol, 3,4'-bis(1,1-dimethylethyl)- (CAS RN 42479-88-9)	July 27, 2019
9,10-Anthracenedione, 2,2'-(1,3,4-oxadiazole-2,5-diyl)bis[1-amino- (CAS RN 52591-25-0)	July 27, 2019
9,10-Anthracenedione, 2,2'-[1,4-phenylenebis(1,3,4-oxadiazole-5,2-diyl)]bis[1-amino- (CAS RN 52671-38-2)	July 27, 2019
Phosphorous acid, (1-methylethylidene)di-4,1-phenylene tetrakis[(3-ethyl-3-oxetanyl)methyl] ester (CAS RN 53184-75-1)	July 27, 2019
Propanedinitrile, [[4-[[2-(2-cyclohexylphenoxy)ethyl]ethylamino]-2-methylphenyl]methylene]- (CAS RN 54079-60-6)	July 27, 2019
9,10-Anthracenedione, 1-amino-4-hydroxy-2-(4-methoxyphenoxy)- (CAS RN 54243-60-6)	July 27, 2019
Benzenediazonium, 2-methoxy-4-nitro-, salt with naphthalenedisulfonic acid (2:1) (CAS RN 56307-70-1)	July 27, 2019
Anthra[9,1,2-*cde*]benzo[*rst*]pentaphene-5,10-dione, diamino- (CAS RN 58019-27-5)	July 27, 2019
Carbamic acid, (3,4-dichlorophenyl)-, 2-[butyl[4-(2,2-dicyanoethenyl)-3-methylphenyl]amino]ethyl ester (CAS RN 59583-77-6)	July 27, 2019
3-Pyridinecarbonitrile, 5-[[2-chloro-4-(methylsulfonyl)phenyl]azo]-4-methyl-2,6-bis[[3-(2-phenoxyethoxy)propyl]amino]- (CAS RN 63281-10-7)	July 27, 2019

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1(2*H*)-Quinolinepropanamide, 6-(2,2-dicyanoethenyl)-3,4-dihydro-2,2,4,7-tetramethyl-*N*-phenyl- (CAS RN 63467-15-2)	July 27, 2019
9,10-Anthracenedione, 1-amino-2-bromo-4-[[4-[(1-methylethyl)amino]-6-phenyl-1,3,5-triazin-2-yl]amino]- (CAS RN 64086-95-9)	July 27, 2019
9,10-Anthracenedione, 2-acetyl-1-amino-4-[[4-[(1-methylethyl)amino]-6-phenyl-1,3,5-triazin-2-yl]amino]- (CAS RN 64086-96-0)	July 27, 2019
Cytidine, *N*-benzoyl-5'-*O*-[bis(4-methoxyphenyl)phenylmethyl]-2'-deoxy- (CAS RN 67219-55-0)	July 27, 2019
Benzenesulfonic acid, 2-[[9,10-dihydro-4-[(4-methylphenyl)amino]-9,10-dioxo-1-anthracenyl]amino]-5-methyl-, monoammonium salt (CAS RN 68227-79-2)	July 27, 2019
Siloxanes and Silicones, 3-cyanopropyl Me, di-Me (CAS RN 68938-51-2)	July 27, 2019
Benzenemethanol, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-, reaction products with 1,3,5-trimethylbenzene (CAS RN 68910-11-2)	July 27, 2019
9,10-Anthracenedione, 1-amino-4-[[3-[(dimethylamino)methyl]phenyl]amino]-, monohydrochloride (CAS RN 69695-75-6)	July 27, 2019
5-Isobenzofurancarboxylic acid, 3-[4-(diethylamino)-2-ethoxyphenyl]-3-(1-ethyl-2-methyl-1*H*-indol-3-yl)-1,3-dihydro-1-oxo-, ethyl ester (CAS RN 69898-66-4)	July 27, 2019
5-Isobenzofurancarboxylic acid, 1-[4-(diethylamino)-2-ethoxyphenyl]-1-(1-ethyl-2-methyl-1*H*-indol-3-yl)-1,3-dihydro-3-oxo-, ethyl ester (CAS RN 69898-67-5)	July 27, 2019
Methylium, [4-(dimethylamino)phenyl]bis[4-(ethylamino)-3-methylphenyl]-, chloride (CAS RN 72102-56-8)	July 27, 2019
Methylium, bis[4-(dimethylamino)phenyl][4-(ethylamino)-3-methylphenyl]-, chloride (CAS RN 72102-64-8)	July 27, 2019
Phenol, [[[3-(dimethylamino)propyl]amino]methyl]-, isobutylenated (CAS RN 72318-87-7)	July 27, 2019
Benzenesulfonic acid, [(9,10-dihydro-9,10-dioxo-1,4-anthracenediyl)diimino]bis[(1,1-dimethylethyl)-, sodium salt (CAS RN 72749-91-8)	July 27, 2019
Methylium, bis(4-amino-3,5-dimethylphenyl)(2,6-dichlorophenyl)-, phosphate (1:1) (CAS RN 72812-39-6)	July 27, 2019
1-Propanaminium, 3-[[9,10-dihydro-4-[(4-methylphenyl)amino]-9,10-dioxo-1-anthracenyl]amino]-*N*,*N*,*N*-trimethyl-, methyl sulfate)CAS RN 728-93-4)	July 27, 2019
Pyridine, 4-(3-chloro-5-propylphenyl)- (CAS RN 73398-86-4)	July 27, 2019
Pyridine, 4-(4-chloro-3-propylphenyl)- (CAS RN 73398-87-5)	July 27, 2019
Benzenesulfonic acid, oxybis[(1,1,3,3-tetramethylbutyl)-, dipotassium salt (CAS RN 75908-83-7)	July 27, 2019
Methanesulfonamide, 1-chloro-*N*-[2,3,4-trichloro-6-(2,4-dichlorophenoxy)phenyl]-, sodium salt (CAS RN 83721-47-5)	July 27, 2019
Methanesulfonamide, 1-chloro-*N*-[2,3,4,5-tetrachloro-6-(2,4-dichlorophenoxy)phenyl]-, sodium salt (CAS RN 83271-48-6)	July 27, 2019
9,10-Anthracenedione, 1-amino-4-[[3-[(dimethylamino)methyl]phenyl]amino]-, monoacetate	July 27, 2019
Xanthylium, 9-(2-carboxyphenyl)-3,6-bis(diethylamino)-, salt with mono-C10-14-alkylbenzenesulfonic acid (1:1) (CAS RN 85186-47-6)	July 27, 2019

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3*H*-Indol-3-one, 5,7-dibromo-2-(5-bromo-7-chloro-1,3-dihydro-3-oxo-2*H*-indol-2-ylidene)-1,2-dihydro- (CAS RN 85702-64-3)	July 27, 2019
Butanamide, 2-[2,4-bis(1,1-dimethylpropyl)phenoxy]-*N*-[4-(2-formylhydrazino)phenyl]- (CAS RN 86551-61-3)	July 27, 2019
Carbonic acid disodium salt, reaction products with aniline, 4-nitrobenzenamine, *p*-phenylenediamine, sodium sulfide, sulfur and *p*-toluidine (CAS RN 90268-98-7)	July 27, 2019
[2,6'-Bibenzothiazole]-7-sulfonic acid, 2'-(4-aminophenyl)-6-methyl-, diazotized, coupled with diazotized 4-aminobenzenesulfonic acid and resorcinol, sodium salts (CAS RN 91696-90-1)	July 27, 2019
Naphthalenesulfonic acid, reaction products with formaldehyde and hydroxybenzenesulfonic acid, ammonium salts (CAS RN 93384-84-0)	July 27, 2019
Carbamic acid, cyclohexyl-, nitrilotri-2,1-ethanediyl ester (CAS RN 93918-79-7)	July 27, 2019
Methanesulfonamide, 1-chloro-*N*-(2-phenoxyphenyl)-, pentachloro deriv., sodium salt (CAS RN 94248-26-7)	July 27, 2019
Fatty acids, tallow, hydrogenated, [6-[bis(methoxymethyl)amino]-1,3,5-triazine-2,4-diyl]bis[[(methoxymethyl)imino]methylene] ester (CAS RN 103331-97-1)	July 27, 2019
Fatty acids, tallow, hydrogenated, hexaesters with 2-[[[4-[[[2-hydroxy-1-(hydroxymethyl)ethoxy]methyl](hydroxymethyl)amino]-6-[(hydroxymethyl)(methoxymethyl)amino]-1,3,5-triazin-2-yl](methoxymethyl)amino]methoxy]-1,3-propanediol (CAS RN 103331-98-2)	July 27, 2019
Formaldehyde, reaction products with branched nonylphenol and xylenol, ethoxylated (CAS RN 104376-69-4)	July 27, 2019
1*H*-Imidazole-1-ethanol, α-(2,4-dichlorophenyl)-α-[2-(2,4-dichlorophenyl)cyclopropyl]-, [1α(R*),2β]- (CAS RN 108004-27-9)	July 27, 2019
Alkenes, C12-14, hydroformylation products, distn. residues, ethoxylated propoxylated, dihydrogen phosphates, sodium salts (CAS RN 113089-51-3)	July 27, 2019
Formaldehyde, reaction products with sulfonated 1,1'-biphenyl and sulfonated terphenyl, sodium salts (CAS RN 113163-36-3)	July 27, 2019
Phosphine oxide, (butylphenyl)bis(2,6-dichlorobenzoyl)- (CAS RN 117310-64-2)	July 27, 2019
Alkenes, C12-14, hydroformylation products, distn. residues, ethoxylated, dihydrogen phosphates, sodium salts (CA RN 119209-64-2)	July 27, 2019
Benzenesulfonic acid, hydroxydinonyl-, branched, monoammonium salt (CAS RN 223777-68-2)	July 27, 2019
9,10-Anthracenedione, 1-amino-4-(phenylamino) (CAS RN 4395-65-7)	July 27, 2019
1-Propanaminium, 3-[[4-[(2,4-dimethylphenyl)amino]-9,10-dihydro-9,10-dioxo-1-anthracenyl]amino]-*N*,*N*,*N*-trimethyl-, methylsulfate (CAS RN 60352-98-9)	July 27, 2019
Benzenesulfonic acid, [(9,10-dihydro-9,10-dioxo-1,4-anthracenediyl)bis(imino-4,1-phenyleneoxy)]bis-, disodium salt (CAS RN 70161-19-2)	July 27, 2019
Benzenesulfonic acid, 2,2'-[(9,10-dihydro-5,8-dihydroxy-9,10-dioxo-1,4-anthracenediyl)diimino]bis[5-(1,1-dimethylethyl)-, disodium salt (CAS RN 83006-67-1)	July 27, 2019
Benzamide, 3,5-dichloro-*N*-(3,4-dichlorophenyl)-2-hydroxy- (CAS RN 1154-59-2)	July 27, 2019

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Benzoic acid, 2-[(3,5-dibromo-4-hydroxyphenyl)(3,5-dibromo-4-oxo-2,5-cyclohexadien-1-ylidene)methyl]-, ethyl ester (CAS RN 1176-74-5)	July 27, 2019
Adenosine, *N*-benzoyl-5'-*O*-[bis(4-methoxyphenyl)phenylmethyl]-2'-deoxy- (CAS RN 64325-78-6)	July 27, 2019
Amines, C18-22-*tert*-alkyl, ethoxylated (CAS RN 68443-10-7)	July 27, 2019
2-Butanone, 4-[[[1,2,3,4,4a,9,10,10a-octahydro-1,4a-dimethyl-7-(1-methylethyl)-1-phenanthrenyl]methyl](3-oxo-3-phenylpropyl)amino]-, [1R-(1α,4aβ,10aα)]- (CAS RN 70776-86-2)	July 27, 2019
1-Naphthalenemethanol, α,α-bis[4-(diethylamino)phenyl]-4-(ethylamino)- (CAS RN 1325-86-6)	July 27, 2019
Benzene, 1,3,5-tribromo- (CAS RN 626-39-1)	July 27, 2019
Benzene, 1,2,3,4-tetrachloro-5,6-dimethoxy- (CAS RN 944-61-6)	July 27, 2019
Benzo[*h*]benz[5,6]acridino[2,1,9,8-*klmna*]acridine-8,16-dione (CAS RN 475-71-8)	July 27, 2019
Spiro[isobenzofuran-1(3*H*),9'-[9*H*]xanthen]-3-one, 2',4',5',7'-tetrabromo-3',6'-dihydroxy-, lead salt (CAS RN 1326-05-2)	July 27, 2019
Benzo[*b*]thiophen-3(2*H*)-one, 4,7-dichloro-2-(4,7-dichloro-3-oxobenzo[*b*]thien-2(3*H*)-ylidene)- (CAS RN 14295-43-3)	July 27, 2019
Benzoic acid, 4-[1-[[(2,4-dichlorophenyl)amino]carbonyl]-3,3-dimethyl-2-oxobutoxy]- (CAS RN 58161-93-6)	July 27, 2019
Bismuthine, triphenyl- (CAS RN 603-33-8)	July 27, 2019
Benzene, 1,1'-(chlorophenylmethylene)bis[4-methoxy- (CAS RN 40615-36-9)	July 27, 2019
Phenol, 2-phenoxy-, trichloro derivatives (CAS RN 64111-81-5)	July 27, 2019
Phenol, 4,4-(1-methylethylidene)bis-, reaction products with hexakis(methoxymethyl)melamine (CAS RN 125328-28-1)	July 27, 2019
1*H*-indene, 2,3-dihydro-1,1,3,3,5-pentamethyl-4,6-dinitro- (CAS RN 116-66-5)	July 27, 2019
Ethanamine, *N*-ethyl-*N*-hydroxy-, reaction products with hexamethylcyclotrisiloxane, silica and 1,1,1-trimethyl-*N*-(trimethylsilyl)silanamine (CAS RN 68583-58-4)	July 27, 2019
Pyridine, 2-[3-(3-chlorophenyl)propyl]- (CAS RN 101200-53-7)	July 27, 2019