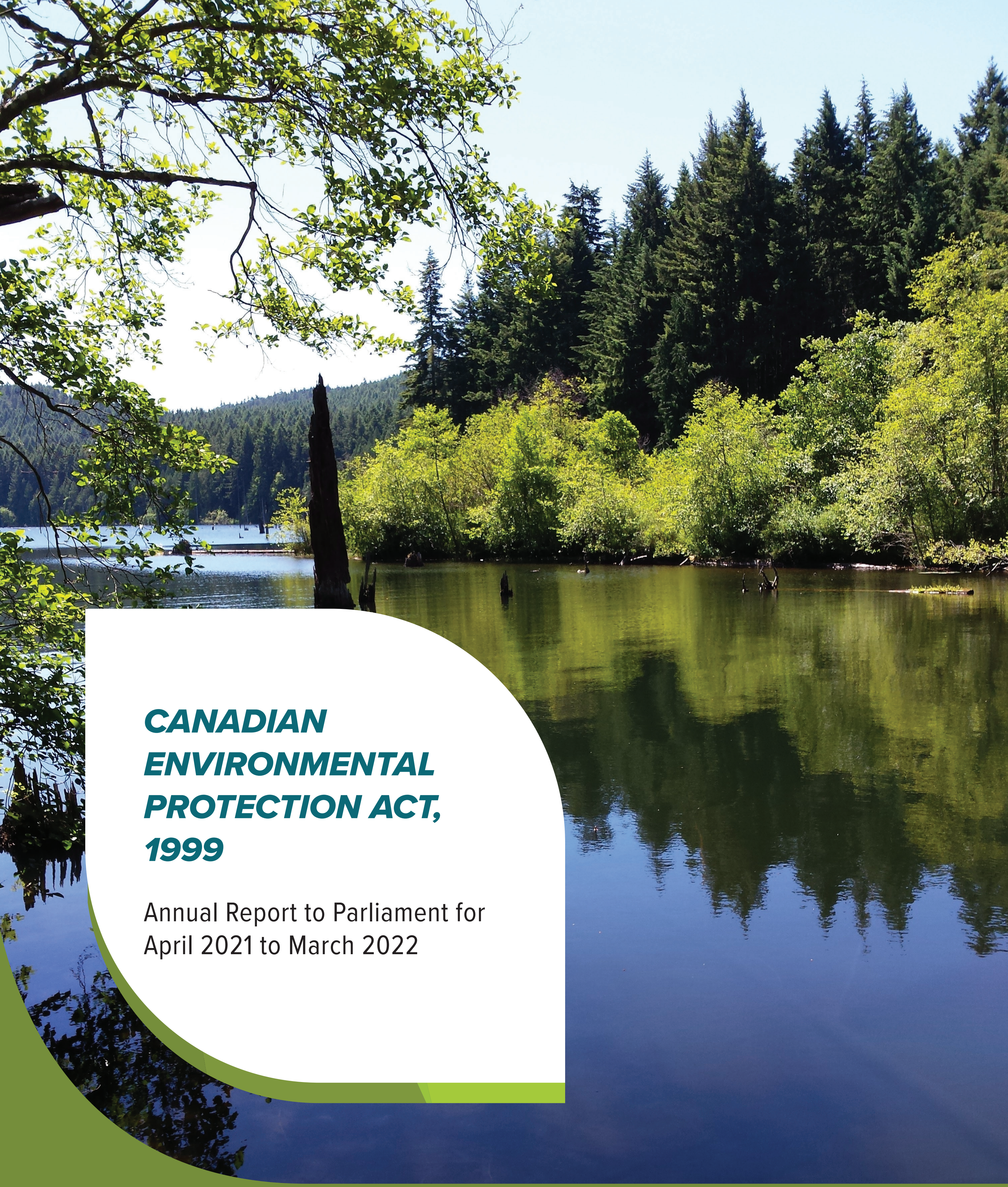

CANADIAN ENVIRONMENTAL PROTECTION ACT, 1999

Annual Report to Parliament for April 2021 to March 2022

Environment and Climate Change Canada
Environnement et Changement climatique Canada

Canada

Cat. No.: En81-3E-PDF
ISSN: 1492-0212
EC22152

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1. Introduction

Preventing pollution and protecting the environment and human health lies at the heart of the *Canadian Environmental Protection Act, 1999* (CEPA), (the Act). The Government relies on it to deliver many of the environmental and health protection programs administered by Environment and Climate Change Canada (ECCC) and Health Canada (HC), such as the Chemicals Management Plan (CMP), the National Environmental Emergencies Center or the Air Quality Program. CEPA is also the legislative basis to implement several regulations and risk management instruments related to waste, disposals at sea, fuels, and emissions from vehicles, engines and equipment, as well as Canada's obligations under numerous international environmental agreements, such as the Basel Convention and the London Protocol.

This annual report provides an overview of the activities conducted and results achieved under CEPA from April 1, 2021, to March 31, 2022 by both ECCC and HC. It responds to the statutory requirement in Section 342 of the Act to provide an annual report to Parliament on its administration and enforcement.[1]

1.1 CEPA Management Cycle

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. The Act provides a suite of instruments and measures to identify, assess and address these risks.

The steps taken to address each risk constitute a **management cycle** (see Figure 1). At each stage of the cycle:

- industries, individuals, interest groups and others are invited to participate in the public consultations and decision-making processes
- the Government works closely with their partners in domestic and international jurisdictions and agencies

Figure 1. The CEPA management cycle

1 CEPA requires the annual report to include the following mandatory information: s.342(s) report on research (found in section 7); s.8 activities of the National Advisory Committee (found in section 5.1); enforcement activities (found in section 6) and activities under administrative and equivalency agreements (found in section 5.1).
The Act also requires the inclusion of activities under the international air pollution provisions, the international water pollution provisions and any committees established under section 7(1)(a) in the annual report. However, there were no activities under any of these sections during the reporting period.

This report provides information on all stages of the management cycle:

- **Monitoring & Research** (sections 2 and 7) covers the 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.
- **Addressing key risks: risk assessment and risk management** (section 3) covers information gathering, risk assessment, and risk management for substances, air pollution and greenhouse gases, water quality, and waste.
- **Compliance promotion and enforcement** (section 6) provides information on the planned activities undertaken to increase awareness, understanding and compliance with the Act and regulations.
- **Reporting programs and emission inventories** (section 4) covers information on releases of pollutants and greenhouse gases.
- **Administration and public participation** (section 5) covers stakeholder engagement and inter-jurisdictional relationships.

The CEPA Registry is an accessible online source of current information relating to the Act. It gives Canadians the opportunity to learn how the federal government administers the Act and is a comprehensive source of information on a variety of CEPA-related tools, including proposed and existing policies, guidelines, codes of practice, government notices and orders, agreements, permits, and regulations. The Registry invites industries, individuals, interest groups and others to participate in the public consultations and decision-making processes that take place under the Act.

1.2 Proposed Changes to CEPA

On February 9, 2022, the Government introduced Bill S-5, *Strengthening Environmental Protection for a Healthier Canada Act*. This Bill is consistent with the mandate given to the Minister of ECCC in December 2021 to work with the Minister of Health to provide better protection for people and the environment from toxic substances and other pollution through various means, including strengthening CEPA. Bill S-5 is almost identical to Bill C-28, which was introduced in the House of Commons on April 13, 2021 but died on the *Order Paper* upon dissolution of the 43rd Parliament, 2nd Session, on August 15, 2021.

Bill S-5 introduces a right to a healthy environment for the first time in a Canadian federal statute. If the Bill becomes law, the framework to implement this right would be developed with the participation of Canadians. This right would lead to strong protections for all Canadians, emphasizing the protection of populations more vulnerable to exposure to harmful chemical. If passed, the Bill would also require the development of a new plan of chemicals management priorities and would propose a new regime to manage toxic substances of highest risk. With the proposed amendments, CEPA would require that risk assessments consider real-life exposure to the cumulative effects of substances on Canadians or the environment. Proposed amendments would also lead to the creation of a new publicly available Watch List so Canadians and businesses could see which substances they may wish to avoid.

2. Monitoring the environment and human health

Monitoring changes in the environment and human health trends is essential for assessing the impact of toxic substances. It is also essential for assessing the effectiveness of measures put in place to minimize environmental harm and reduce current and potential threats to human life.

2.1 Chemicals

2.1.1 Chemicals in our environment

Monitoring programs contribute to efforts domestically and abroad. The following programs contributed to national monitoring activities:

- the Chemicals Management Plan (CMP) Environmental Monitoring and Surveillance Program
- the Northern Contaminants Program (NCP)
- the Freshwater Quality Monitoring Program
- the St. Lawrence Action Plan
- the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health (COA)
- the Great Lakes Basin (GLB) Monitoring and Surveillance Program
- the Global Atmospheric Passive Sampling network (GAPS)
- the Whales Initiative: monitoring and research on contaminants

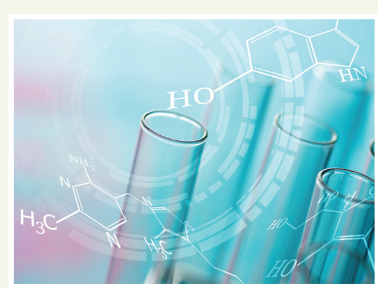
Monitoring activities support Canada's contribution to international efforts, including:

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

In particular, the CMP Environmental Monitoring and Surveillance Program involves the collection of data on the concentration of chemical substances in various environmental media across Canada. Environmental media include surface water, sediment, air, aquatic biota and wildlife. Wastewater system influent, effluent and biosolids are also monitored across a range of input and treatment system types. These activities provide data to inform the assessment and management of chemical substances in the environment.

Examples of priority substances monitored in 2021-2022 as part of the CMP Environmental Monitoring and Surveillance Program

- Per- and polyfluorinated alkyl substances (PFASs)
- Polychlorinated biphenyls (PCBs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Polybrominated diphenyl ethers (PBDEs)
- Other flame retardants
- Organochlorine pesticides
- Chlorinated alkanes
- Bisphenols
- Metals, including mercury
- Organotins
- Triclocarban



Numerous papers on the presence of chemicals in the environment were published by ECCC scientists in 2021-2022; a few of them are highlighted below as examples.

Perfluoroalkyl Substances (PFASs) in the Canadian Freshwater Environment	
Focus of Study	To determine concentrations and trends in multiple PFAS compounds in Canadian surface waters
Results	Thirteen PFAS chemicals were measured in 566 Canadian freshwater samples from 2013 to 2020 with concentrations ranging from below the laboratory detection limit (LOD range: 0.4–1.6 ng/L) to a maximum of 138 ng/L (for PFBS). While concentration of the legacy PFOS and PFOA compounds were found to be declining significantly over time, other newer compounds such as PFPeA and PFBA were found to have increased significantly over 2013–2020. Overall, the range of concentrations found in this study was similar to that of other Canadian and international studies; however, this study revealed more frequent detections of newer replacement PFAS chemicals compared with older Canadian studies.
Publication	Lalonde, B., Garron, C. Perfluoroalkyl Substances (PFASs) in the Canadian Freshwater Environment. *Arch Environ Contam Toxicol* 82, 581–591 (2022), DOI: 10.1007/s00244-022-00922-x

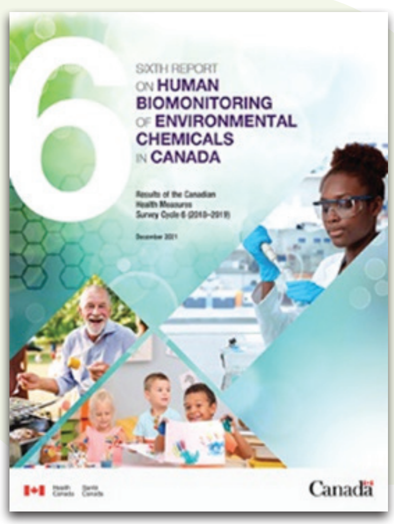
Bioaccumulation of volatile methylsiloxanes in the St. Lawrence River	
Focus of Research	Volatile methylsiloxanes (VMS) are anthropogenic substances used in a wide range of commercial applications. High usage of VMS in personal care products and commercial applications can lead to high concentrations in the environment, especially near city wastewater systems.
Results	VMS were detected in significant concentrations in the foodweb downstream of the wastewater effluent plume of the Montreal municipal wastewater treatment plant. Concentrations were highest in suspended sediments, but were also found in predator and prey fish, and macroinvertebrates. Caged mussels bio-accumulated 43x more total siloxanes than PBDEs, demonstrating that siloxanes are often a substantial component of the contaminant body burden.
Publications	Pelletier et al. 2021. Influence of wastewater effluents on the bioaccumulation of volatile methylsiloxanes in the St. Lawrence River. STOTEN 806(part 4): 151267; corrigendum to "Influence of wastewater effluents on the bioaccumulation of volatile methylsiloxanes in the St. Lawrence River" STOTEN 836:151267, DOI:10.1016/j.scitotenv.2021.151267 Corrigendum to: Pelletier, M., Isabel, L. Armellin, A., McDaniel, T., Martin, P., McGoldrick, D., Clark, M., Moore, S. 2022. Influence of wastewater effluents on the bioaccumulation of volatile methylsiloxanes in the St. Lawrence River. STOTEN 836: 155431. DOI:10.1016/j.scitotenv.2022.155431

Complementarity between targeted and non-targeted screening of halogenated organic pollutants in Great Lakes fish	
Focus of Research	The exposure to and impacts of mixtures of contaminants on organisms in the environment is a growing concern. However, characterizing mixtures is challenging. This study explored the complementarity between targeted (TS) and non-targeted screening (NTS) based on liquid and gas-phase chromatography coupled to (high-resolution) mass spectrometry (LC-/GC-(HR)MS) for the characterization of organohalogen fingerprints within a set of Lake Ontario lake trout samples.
Results	Concentrations of 86 legacy, emerging and novel halogenated compounds, were determined through 4 targeted approaches while 195 halogenated mass spectral features were characterized based on non-targeted high resolution mass spectrometry. Only 21 of the compounds highlighted by targeted analysis were identified by non-targeted screening.
Publications	Simonnet-Laprade, C., Bayen, S., McGoldrick, D., McDaniel, T., Hutinet, S., Marchand, p., Vénisseau A, Cariou, R., Le Bizec, B., Dervilly, G. 2022. Evidence of complementarity between targeted and non-targeted analysis based on liquid and gas-phase chromatography coupled to mass spectrometry for screening halogenated persistent organic pollutants in environmental matrices. Chemosphere. 293:133615. DOI:10.1016/j.chemosphere.2022.133615

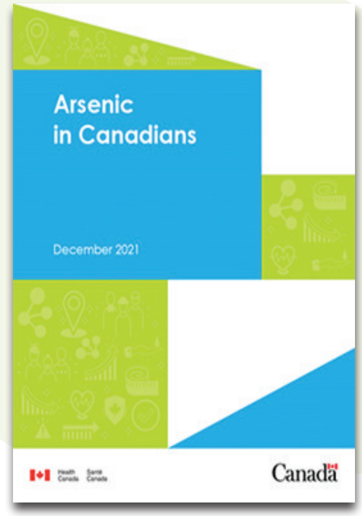
2.1.2 Chemicals in humans

HC human biomonitoring efforts continued in 2021-2022 with the national biomonitoring program conducted under the Canadian Health Measures Survey (CHMS), measuring environmental chemical exposures in a nationally representative sample of Canadians aged 3 to 79 years. Collection of data for cycle 7 of the CHMS experienced delays due to modernization efforts at Statistics Canada and subsequently the COVID-19 outbreak. However, the national biomonitoring program used samples collected in previous years and stored in a Biobank to measure priority substances, and initiated a second Biobank project to measure additional priority chemicals in previously collected samples.

In December 2021, the Sixth Report on Human Biomonitoring of Environmental Chemicals in Canada – Results of the Canadian Health Measures Survey Cycle 6 (2018–2019) was released. Along with a description of objectives, survey design, methods, and chemical summaries, this report presents data for 79 environmental chemicals in 132 data tables showing measured concentrations for the total Canadian population and sub-divided by age group and sex for CHMS cycles 1 through 6 (2007-2019).



Also, in December 2021, 8 fact sheets were published for: Arsenic, Mercury, Cadmium, Lead, BPA, Parabens, PFAS, and DEHP. Biomonitoring fact sheets are a new resource that summarizes key CHMS findings for CMP priority chemicals. These fact sheets also feature graphical representations of trends over time and comparisons between the general population and vulnerable sub-populations, including data from other biomonitoring initiatives in Canada and the U.S.



Activities of the CHMS in 2021-2022 included:

- laboratory analyses of samples from the CHMS biobank. These samples will provide the first data for some chemicals (such as glyphosate, BPA replacements), and time trends for other priority chemicals (such as fluoride).
- undertaking a feasibility study for collaboration between the national biomonitoring program and a longitudinal biomonitoring survey (CARTaGENE). A longitudinal survey design allows for the measurement of an individual's exposure levels and health effects over time, providing unique and important biomonitoring information that cannot be derived from a cross-sectional design.
- time trends in environmental chemical exposures in Canadians for 39 chemicals measured in at least three-time points between 2007 and 2017 (CHMS cycles 1-5) were published and made available for use by Health Canada and other scientific communities.
- CHMS biomonitoring data continues to inform Health Canada's risk assessment and management activities. For example, CHMS cycle 1, 2, and 5 data were used in a DEHP performance evaluation report published in June 2021, which demonstrated noticeable declines in DEHP exposure after implementing risk management tools.
- creation of a Biomonitoring Guidance Value Database and Comparison Tool that compiles currently available human biomonitoring guidance values developed by international organizations and jurisdictions. This tool was made available online and is now actively used by individuals from many countries interested in biomonitoring guidance values.
- international networks were strengthened, and information-sharing was facilitated by two meetings of the International Human Biomonitoring Working Group (i-HBM) in November 2021 and January 2022, organized by the national biomonitoring program.

The Maternal-Infant Research on Environmental Chemicals (MIREC) Study was established in 2007 to obtain national biomonitoring data for pregnant women and their infants, and to examine possible adverse health effects of prenatal exposure to environmental chemicals on pregnancy and infant health. There are several follow-up studies under the MIREC Research Platform, including:

- the MIREC-ID (Infant Development) study
- the MIREC-CD3 (Child Development at 3 years) and MIREC-CD Plus (Early Childhood Biomonitoring and Neurodevelopment) studies
- the MIREC-ENDO (Pubertal Timing, Endocrine and Metabolic Function) study

HC continued analysis and publication of biomonitoring and research results from the MIREC Research Platform. These included novel assessments of prenatal and early-childhood exposure to chemicals and the establishment of national estimates of maternal and fetal exposures (see section 7.1.2.1 for publications).

In 2021-2022, progress was made on the follow-up study, MIREC-ENDO, initiated in 2018 to study the effects of prenatal exposure to environmental chemicals on puberty and metabolic function in children and maternal health. In 2021-2022, participant recruitment and questionnaire-based data collection were completed for Phase 1, with 589 families recruited. Phase 2 is underway with participant recruitment and in-person visits set to start in 2022.

The MIREC Biobank, created at the beginning of the MIREC study in 2008, has grown with each follow-up study. The Biobank stores all the data and biological specimens collected since the inception of MIREC. Novel measures added to the Biobank in 2021-2022 include biomarkers of the metabolic, immune system, and endocrine function in mothers and children and biomarkers of metals and perfluoroalkyl substances in children. In 2021-2022, 31 Biobank access requests were received and reviewed.

Monitoring in the North

Both ECCC and HC contributed 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 2021-2022, HC supported 7 human biomonitoring and health projects under the NCP in several Arctic regions including the Yukon, Inuvialuit Settlement Region and in Nunavik. These projects addressed: exposure to contaminants and links to country foods; understanding dietary decision-making and supporting the development of communication materials; and, the integration of information on country foods, nutrition, food security, and health messaging.

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.

2.2 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.

2.2.1 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 are used to validate numerical air quality prediction models, evaluate the benefits and effectiveness of control measures, and assess the impact of air pollution on Canadians and the environment.

ECCC monitors ambient air quality across the country through 2 complementary networks.

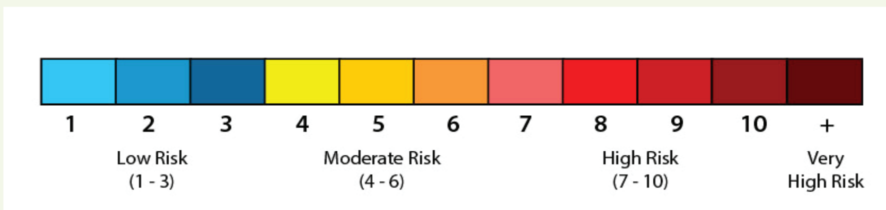
- The National Air Pollution Surveillance (NAPS) program provides long-term air quality data from populated regions of Canada. This program is managed through a formal agreement between the provincial and territorial governments and ECCC.
- The Canadian Air and Precipitation Monitoring Network (CAPMoN) 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 the following networks:

- AEROCAN, the Canadian sub-network of NASA's global AERONET satellite network, takes optical readings of solar radiation 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.

The Air Quality Health Index (AQHI)



Data collected through these programs determine the AQHI. The AQHI is a health protection tool designed to help people understand what the air quality around them means to their health. The AQHI is calculated based on the relative risks of a combination of the following common air pollutants known to harm human health:

- Ozone (O_3) at ground level
- Particulate matter ($PM_{2.5}$/PM_{10})
- Nitrogen dioxide (NO_2)

2.2.2 Greenhouse gases

The Canadian Greenhouse Gas Measurement Program includes observations of carbon dioxide and other GHGs from 16 long-term measurement sites across Canada (Figure 2). Among the sites is the Alert Global Atmosphere Watch Observatory. Alert serves as one of 3 global GHG inter-comparison sites to ensure consistent measurement of carbon dioxide (CO_2) and other greenhouse gas concentrations across the world.

Figure 2. 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, the World Meteorological Organization (WMO), World Data Centres for GHGs, the 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 3). The annual average CO_2 value at Alert in 2021 was 417.4 parts per million (ppm), which is slightly higher than the annual average CO_2 values at Alert in 2020 and 2019 which were 414.9 ppm and 412.0 ppm, respectively.

ECCC began measuring atmospheric methane (CH_4) in August 1985 at Alert, Nunavut (Figure 4). The annual average CH_4 value at Alert in 2021 was 1981.0 parts per billion (ppb). Annual CH_4 concentrations are now increasing following the relatively stable period from about 1999 to 2007. The annual average values of CH_4 at Alert in 2020 and 2019 were 1967.7 ppb and 1950.0 ppb, respectively.

Figure 3. Atmospheric carbon dioxide measured at Alert, Nunavut

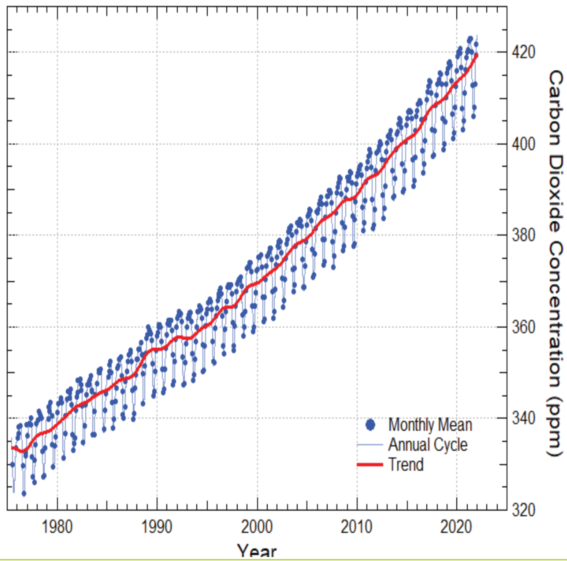
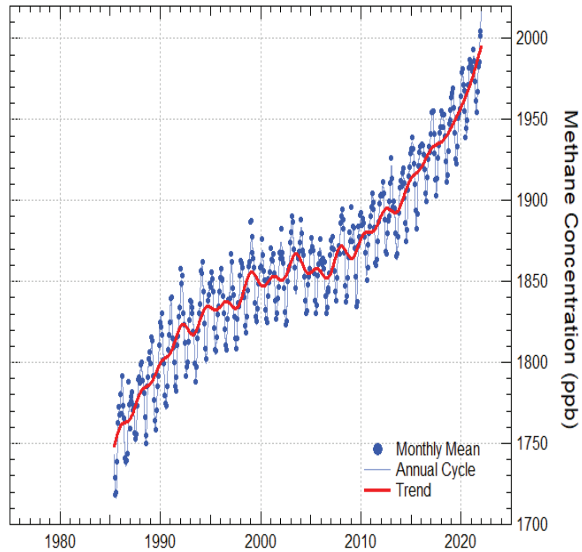


Figure 4. Atmospheric methane measured at Alert, Nunavut



2.3 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 the site, moving the site, or altering the site use can occur.

In 2021-2022, monitoring projects were completed at 14 ocean disposal sites nationally, which amounts to monitoring 23% of the 61 actively used sites. Due to the ongoing restrictions on fieldwork resulting from the COVID-19 pandemic, many field-monitoring projects were cancelled or postponed.

Pacific region

Given the ongoing restrictions on fieldwork resulting from the COVID-19 pandemic, a reduced field program was delivered in Pacific Region in 2021-2022, focusing on priority activities that could be carried out safely. Work continued on sediment contaminant monitoring in and around the Point Grey and Sand Heads disposal sites, in support of the Government of Canada's Whales Initiative. The Disposal at Sea program's participation in this five-year initiative (2018 to 2022), including data analysis, is ongoing and results will be reported when data analysis is completed.

Data collection began on the seasonal current velocity and directional information 1 m above the seafloor at the Sand Heads disposal site, part of an ongoing effort to increase understanding of the movement of sediments at disposal sites. Natural Resources Canada is leading this work and results will be reported when data analysis is complete.

ECCC collaborated with the Canadian Hydrographic Survey to complete multibeam bathymetric surveys at the Kitimat Arm 2016 and Point Grey disposal sites. Multibeam bathymetric surveys measure the water depths and map the seafloor topography to delineate the disposal footprint. The Kitimat Arm 2016 disposal site is a new non-dispersive site that was used for the disposal of dredged material resulting from dredging operations in Kitimat Harbour. The Point Grey disposal site is one of the oldest, largest, and most frequently used non-dispersive sites in Canada. Results of the multibeam hydrographic survey from both of these sites confirmed the hypotheses that disposed material remains within the authorized area of each site, which was expected of these non-dispersive sites.

Based on these results, ECCC did not identify the need to modify management practices at the Kitimat Arm 2016 or Point Grey disposal sites.

Table 1. Results of monitoring disposal at sea sites in Pacific region in 2021-2022

Disposal Site	Results	Comments
Sand Heads	Analysis of results in progress	Full results will be reported in the 2022-23 CEPA annual report.
Point Grey	Disposed material remains within the authorized area. No concerns identified.	ECCC will continue monitoring the site on a routine basis, scaled in accordance with the frequency of usage, total volume disposed at the site, and concerns raised during consultation on permits, to ensure site conditions remain the same. ECCC will also continue working with Indigenous groups, the public, and other stakeholders to ensure early and meaningful opportunities for engagement on proposed disposal activities and integration of recommendations and concerns as appropriate into site management measures.
Kitimat Arm 2016		

Quebec region

In 2021-2022, a total of 6 disposal sites were monitored in the Gulf of the St. Lawrence off the coast of the province of Quebec; 4 in the Gaspé region and 2 near the Magdalen Islands (see Table 2). Post-disposal hydrographic surveys were conducted at these sites and compared to the results of previous surveys, providing a “before and after” survey of the sea floor.

The 6 sites in the Gaspé and Magdalen Islands regions were monitored with the objectives of verifying compliance with permit conditions, establishing the height of the material deposited (i.e. mounds) for navigation safety purposes and to verify the dispersion of sediments. Hydrographic surveys in recent years at the disposal sites in the Gaspé region have given some perplexing results, where not all of the material reported as deposited could be located at the site. The hydrographic surveys in 2021 also aimed to evaluate whether this situation was persisting or if compliance promotion efforts had led to improvements. Preliminary results indicate that only 1 site, Saint-Godefroi, remains problematic, although results were inconclusive at L’Anse à Brillant due to the low volume of material disposed. A full analysis of the results (Saint-Godefroi site) and consideration of next steps (both sites) is underway.

Table 2. Results of monitoring disposal at sea sites off the coast of Quebec in 2021-2022

Disposal Site	Results of hydrographic surveys	Comments
Gaspé		
Port-Daniel-Est (PD-6)	2720 m^3 of material was disposed of at the site and approximately the same volume at the correct coordinates was detected with the hydrographic survey.	No concerns have been identified; a full analysis of the results is still underway.
Saint-Godefroi (SG-2)	No material detected at disposal site.	Despite a reported disposal volume of 2366 m^3, the material was not detected at the disposal site. This site remains problematic and a full analysis of the results and consideration of next steps is underway.

Disposal Site	Results of hydrographic surveys	Comments
L'Anse à Brilliant (ABR-1)	The reported disposal volume, 1500 m^3, is too small to be detected at the site with the methods used in the hydrographic survey.	Consideration of next steps is underway.
L'Anse à Beaufils (AB-5)	5994 m^3 of material was disposed of at the site and approximately the same volume at the correct coordinates was detected with the hydrographic survey.	No concerns have been identified; a full analysis of the results is still underway.
Îles-de-la-Madeleine		
Millerand (M-5)	Preliminary results indicate that the correct disposal amounts were disposed of at the correct coordinates.	No concerns have been identified; a full analysis of the results is still underway.
Pointe-Basse (PBCM-1)		

Arctic region

ECCC, in partnership with the Canadian Hydrographic Service, monitored the Frobisher Bay disposal site in the Arctic region for the first time, in the eastern Arctic in Nunavut (see Table 3). The objectives of this hydrographic survey was to verify compliance with permit conditions, establish the height of the material deposited, i.e. mound, for navigation safety purposes and to verify the dispersion of sediments.

Table 3. Results of monitoring disposal at sea sites off the Arctic coast in 2021-2022

Disposal Site	Results of hydrographic surveys	Comments
Frobisher Bay (FB-01)	Analysis of results in progress	Full results will be reported in the 2022-2023 CEPA annual report.

Atlantic region

In 2021-2022, 3 sites were monitored in the Atlantic region. Hydrographic monitoring surveys were conducted at the Black Point and Shippagan Gully disposal sites off the coast of New Brunswick and an optical monitoring survey was conducted at the Charlottetown, Labrador fish waste disposal site.

The Black Point disposal site was initially believed to be dispersive; however, repetitive hydrographic surveys have shown significant sediment build-up. Subsequent studies have determined an average net retention rate of disposed material of 29.1%. Given this accumulation, ECCC is now assessing the elevation of the accumulated material annually as per the site management plan to determine whether it is less than 7 m above the 1959 baseline elevation. The 7 m threshold was selected as a conservative navigational criterion.

In 2020, ECCC observed that disposed material accumulation was nearing or exceeding 7 m in height throughout most of the seabed under the 2017-2020 release zone. Based on these observations, ECCC decided to move disposal activities to a new release zone commencing in January 2021. In order to better assess possible changes to the disposed material footprint, the area surveyed in 2021 was increased beyond that of the 2020 survey. ECCC compared the 2021 survey data to the 2020 survey and the historical survey data from 1959. Preliminary results indicate that the site is stable from 2020 to 2021 and a full analysis of the data is underway.

Monitoring at the Shippagan Gully disposal site is driven by the need to monitor the fate of disposed materials following disposal activities and to contribute to the verification of the rate of dispersion predicted by the model. Three bathymetric surveys were run in 2021 (spring, summer and fall) following the completion of disposal activities. These surveys will be compared to each other and to the 2020 baseline survey. The results of the hydrographic surveys will also be shared with Saint Mary's University, to be used in their proposed research program on the beneficial re-use of the dredged material and effectiveness of mitigation measures related to the Piping Plover Recovery Strategy. Analysis of these results is underway.

The Charlottetown disposal site on the southeast coast of Labrador receives waste from shrimp processing facilities. An optical monitoring program was completed in 2021 for the first time at this site to ensure all regulations and permit conditions have been followed, as well as to verify the scientific assumptions made during the permit review and site selection process. The optical monitoring survey was completed using a remotely operated vehicle (ROV) in May 2021. Based on a preliminary analysis, there were no visual signs of fish waste build-up or environmental impacts resulting from disposal activities. A strong tidal flow was observed on the ROV during the physical survey and given that there were no signs of fish waste accumulating on the seafloor, it is assumed that the site has a natural ability to disperse material. Full analysis of the data is still underway.

Table 4. Results of monitoring disposal at sea sites in Atlantic region in 2021-2022

Disposal Site	Results	Comments
Black Point	Preliminary data analysis suggests the site is stable between 2020 and 2021; however, full interpretation of the results is still underway.	Full results will be reported in the 2022-2023 CEPA annual report.
Shippagan Gully	Analysis of results in progress	
Charlottetown	Based on preliminary analysis of the ROV footage, there are no visual signs of fish waste accumulation on the seafloor; however, full interpretation of the results is still underway.	

2.4 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 Freshwater 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 (CMP).

In 2021-2022, ECCC's Freshwater Quality Monitoring and Surveillance (FWQMS) program completed an analysis of arsenic concentrations and trends in sediments, water, and fish. This analysis supports performance measurement and reporting for the CMP across Canada. Also in 2021-2022, ECCC's FWQMS program published an analysis of perfluoroalkyl substances (PFAS) in Canadian surface waters, which identified reductions in environmental concentrations of some compounds and concurrent increases in others.

Please see the *Canada Water Act* Annual Reports for updates on freshwater quality monitoring in Canada.

2.5 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 provide 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 on the Federal Sustainable Development Strategy.

The indicators published on the CESI website show 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. The indicators and their corresponding datasets are also published in the Government of Canada Open Data Portal (see Table 5 for CESI updates and new releases in 2021-2022).

3. Addressing key risks: risk assessment and risk management

Risk assessments help to identify the sources of pollution that pose the greatest risk to the environment and human health. While risk assessment is the prelude to, and informs, the **risk management** stage for all programs under CEPA, the Act provides explicit direction on the assessment of toxic substances and the assessment of wastes and other matters that are destined for disposal at sea.

3.1 Chemicals

CEPA includes specific requirements for the assessment and management of substances currently existing in commerce or being released to the environment in Canada. The Minister of the Environment and the Minister of Health jointly administer this part of the Act.

There are two streams of risk assessment for substances in Canada:

- existing substances: substances which have been in use in Canada for over 3 decades and have been included on the Domestic Substances List (DSL)
- new substances: substances (chemicals, polymers or living organisms) being introduced into the Canadian marketplace that are not on the DSL

Progress under the Chemicals Management Plan

The Chemicals Management Plan (CMP) is a program aimed at reducing the risks posed by chemical substances to Canadians and the environment. Through the CMP, the Government of Canada assesses and manages risks to human health and the environment posed by chemical substances that can be found in food and food products, consumer products, cosmetics, drugs, drinking water and industrial releases. Included is a commitment to finish addressing approximately 4300 existing substances of potential concern that were already in commerce in Canada between 1984 and 1986. The Government also conducts pre-market assessments of health and environmental effects of approximately 400 new substances to Canada each year.

Chemicals Management Plan Update

Since the launch of the CMP in 2006, the Government of Canada has been managing potential risks to Canadians and the environment. As of March 31, 2022, the Government of Canada has:

- addressed **94%** (**4139**) of the 4363 **existing substances** identified as priorities in 2006
- found **342** existing substances to be harmful to the environment and/or human health, for a total of **591** when including toxic substances identified prior to 2006
- implemented over **200 risk management actions** for existing substances
- assessed approximately **6645 notifications for new substances** prior to their introduction into the Canadian market
- implemented **320 risk management actions** for new substances

3.1.1 Information gathering

Mandatory notices issued under CEPA are used to gather information needed to inform priority-setting, risk assessment and risk management activities, as well as decision making for chemical substances. The following notices and requests were issued in 2021-2022:

- Voluntary requests on longchain aliphatic amines (including DPDAB CAS RN 68479-04-09), and on 2-mercapto-benzothiazole (MBT) and its precursors, to inform the selection and development of risk management actions if deemed necessary. (ECCC, July 14, 2021).
- Targeted data request to previous section 71 respondents for zinc oxide and titanium dioxide nanomaterials to support risk assessment activities. (HC, October 27, 2021).
- Information gathering Notice under section 71 of the Act with respect to bisphenol A (BPA) and BPA structural analogues and functional alternatives to inform further prioritization decisions, risk assessment activities and risk management, if needed. (ECCC, November 13, 2021).
- Information gathering notice under section 71 of the Act concerning certain substances on the Revised In Commerce List (R-ICL).[2] The information collected will be used to update the commercial status of the substances, identify stakeholders with a commercial interest, support decisions to remove substances from the R-ICL, or support screening risk assessments by providing information on use patterns and quantities manufactured or imported. (ECCC, March 12, 2022).
- Voluntary request to industry stakeholders for information on barriers to supply chain transparency for chemicals to help the Government design and prepare for the launch of national consultations on supply chain transparency and labelling for chemicals in products. Structured as a series of national workshops and interactive events in a policy lab format, the consultations support the collaborative development of innovative approaches to enhancing the availability of information on chemicals in products for consumers, businesses, and governments. (ECCC, March 2022).

3.1.2 Existing substances

3.1.2.1 Risk assessment of existing substances

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, followed by the publication of the final screening assessments.

During 2021-2022, the Minister of Environment and Climate Change and the Minister of Health (see Table 6):

- published 10 draft screening assessment reports covering 166 substances
- published 12 final screening assessment reports covering 25 substances
- published a proposed Approach for a subset of organic and inorganic substances prioritized under the Chemicals Management Plan
- published an additional risk characterization document in support of the draft screening assessment report for zinc
- proposed that 15 substances meet one or more of the toxicity criteria set out in section 64 of CEPA
- concluded that 9 substances meet one or more of the toxicity criteria set out in section 64 of CEPA
- published 6 risk management scope documents
- published 4 risk management approach documents

2 The *R-ICL* is comprised of substances which were in products that were regulated under the *Food and Drugs Act* and that were in Canadian commerce between January 1,1987 and September 13, 2001.

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. In 2021-2022:

- the Ministers proposed that 2 substance groups (coal tars and their distillates and talc) be added to Schedule 1 of CEPA (see Table 6)
- 1 substance group (selenium and its compounds) was added to Schedule 1 of CEPA (see Table 6)[3]

Identifying Risk Assessment Priorities

Since 2014, ECCC and HC have formalized their approach to the identification of risk assessment priorities (IRAP) for chemicals and polymers under CEPA. As part of this approach, both departments compile new information on substances, evaluate this information, and then subsequently determine if further action on the substance(s) may be warranted. Results from past IRAP review cycles (2015, 2016, 2017-2018 and 2019) are available online and continue to inform post-2020 risk assessment activities, including data gathering.

In March 2022, ECCC published for a 60-day public comment period a science approach document, *Ecological risk classification of organic substances version 2.0 (ERC2)*, which presents the application of a set of computational tools and new approach methodologies to approximately 12,200 substances specified on the Domestic Substances List in order to classify their relative ecological risk based on hazard and exposure profiles for each substance. Results will assist the Government of Canada in identifying and addressing organic substances that may be of ecological concern in a more effective manner.

3.1.2.2 Risk management of existing substances

Risk management instruments are put in place to reduce or eliminate risks to the environment and/or human health after a substance has been concluded toxic. Risk management instruments may take the form of regulations, pollution prevention plans, release guidelines or codes of practice, environmental performance agreements, and environmental quality guidelines. The risk management scope is published to outline the Government of Canada's early thinking on risk management. If the final screening assessment maintains the toxic conclusion, the risk management approach is published and outlines in more detail the Government of Canada's plan for risk management.

Risk management scope and approach documents

When a draft risk assessment proposes a conclusion that the substance is "toxic" under CEPA, meaning that the substance has met one or more of the criteria in section 64, a **risk management scope document** is developed and published at the same time as the draft assessment report.

- In 2021-2022, 6 risk management scope documents were published for substances or groups of substances that were proposed to have met one or more of the toxicity criteria set out in section 64 of CEPA (see Table 6).

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.

- In 2021-2022, 4 risk management approach documents were published for substances, or groups of substance that met one or more of the toxicity criteria set out in section 64 of CEPA (see Table 6).

3 For the Order adding plastic manufactured items to Schedule 1, see section 3.5.1 on plastic pollution.

Regulations

Proposed regulations are published in the *Canada Gazette, Part I* and are linked to the CEPA Registry.

- On July 3, 2021, the proposed *Prohibiting the Manufacture and Import of Wheel Weights Containing Lead in Canada Regulations* were published. The proposed Regulations aim to reduce human and environmental exposure to lead by prohibiting the manufacture and import of lead wheel weights destined for the Canadian market, which would help reduce the adverse health impacts resulting from lead exposure, and help improve air, water and soil quality.

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 these substances.

- In 2021-2022, approximately 140 permits were issued under these Regulations. Additionally, consumption allowances for hydrofluorocarbons (HFC) and hydrochlorofluorocarbons (HCFCs) were issued to eligible companies and granted 25 requests for transfer of allowances. The Department publishes the list of HFC and HCFC allowance holders as well as holders of essential purpose permits.

The *Export of Substances on the Export Control List Regulations* apply to the export of substances listed on Schedule 3 of CEPA (known as the Export Control List) and to the export of products containing these substances.

- In 2021-2022, 17 notices of proposed export were submitted to the Minister of the Environment. No export permits were requested.

Codes of Practice

The fourth progress report of the Code of practice for management of tetrabutyltin was published on March 30, 2022. This progress report indicates that the facility continues to implement the code of practice.

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

Environmental Performance Agreements

An environmental performance agreement (agreement) is a voluntary and non-statutory instrument that allows parties with common goals to address a particular environmental or human health issue, such as reducing the use or release of chemicals, promoting product stewardship or conserving sensitive habitats. These agreements may be used to complement a regulation, a code of practice or a pollution prevention planning notice under CEPA.

- On October 29, 2021, ECCC informed Indigenous communities located near the Grand River in Southern Ontario of the Government's intent to publish the proposed *Environmental Performance Agreement for the Formulation of Chlorhexidine Products* and offered the communities an overview (via webinar) of the proposed Agreement. One Indigenous community accepted the offer and a meeting on the proposed Agreement was held on November 25, 2021.
- On February 14, 2022, the proposed *Environmental Performance Agreement for the Formulation of Chlorhexidine Products* was published for a 60-day public comment period. This agreement aims to protect the aquatic environment by minimizing participating companies' releases of chlorhexidine and its salts, from their facilities that formulate chlorhexidine-based products.
- The first progress report for the *2020 to 2025 Environmental Performance Agreement Respecting the Use of Tin Stabilizers in the Vinyl Industry* was published on February 11, 2022. This progress report indicates that all participating facilities continue to meet the objective of the agreement.

Pollution Prevention Planning Notices

In December 2021, the Government published a Performance Report for the Pollution prevention (P2) planning notice for halocarbons used as a refrigerant. All of the 9 companies that became subject to the P2 notice when it was published in May 2016 reported having successfully implemented their pollution prevention plan. Another company that became subject to the P2 notice in October 2018 has submitted its Declaration of preparation in accordance with the requirements of the notice and is currently implementing its P2 plan. Since 2016, this P2 notice has prevented he release of more than 585 tonnes of halocarbons into the environment. The P2 notice remains in effect for halocarbons and will apply to any new companies that undertake the activities captured by the P2 notice.

The complete list with status updates for all active P2 notices is available online.

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, found in Table 7) or federally under section 54 of CEPA as Federal Environmental Quality Guidelines (FEQGs, found on Table 8). In addition, an FEQG summary table is available online as of Feb 2021.

Significant New Activity requirements

A Significant New Activity (SNAc) requirement is applied when an existing substance has been assessed and no risks were identified with current activities, 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 2021-2022, 2 SNAc Notices of Intent were issued covering 56 existing substances (see Table 9). These Notices of Intent resulted from the SNAc review initiative to ensure that current SNAc orders are aligned with current information, policies and approaches.
- In 2021-2022, 1 SNAc Order was issued for Benzene, 1-chloro-2-[2,2-dichloro-1-(4-chlorophenyl)ethyl (Table 10).

Risk Management Performance Measurement Evaluation

Performance measurement evaluations provide Canadians with information on the effectiveness of risk management actions for substances found to be toxic under CEPA. The risk management, human health and environmental objectives are systematically evaluated using robust data and expert analysis.

- In 2021-2022, a performance measurement evaluation report for the substance Bis(2-ethylhexyl) phthalate (DEHP) was published.

3.1.3 New substances

3.1.3.1 Risk assessment

Substances that are new to Canada require notification to the government prior to being imported into or manufactured in Canada.

In 2021-2022:

- **328 New Substances Notifications were assessed** pursuant to section 81 of CEPA and the New Substances Notification Regulations (Chemicals and Polymers).
- **49 new substances risk assessment summaries** (for notifications where control measures are applied) were published online.

- **57 waivers of information requirements** were published in the Canada Gazette for new chemical and polymer substances.
- **40 pre-notification consultations** were held to help companies better understand the notification requirements for their specific chemical or polymer before submitting a New Substances Notification.

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.

- Of the 328 New Substances Notifications that were assessed in 2021-2022, 57 were for new substances in products regulated under the FDA.

New substances in COVID-19 vaccines and treatments

The environmental and indirect human health risk assessments of new substances in COVID-19 vaccines and treatments were prioritized by HC and ECCC to match accelerated timelines for clinical trial applications and new drug submissions. Furthermore, HC expedited the assessments of all new substances in COVID-related products to meet supply demands in various sectors. To accomplish this objective without compromising the integrity of its assessments, HC developed a new information sharing process to facilitate the assessment of information as it came in and contacted drug sponsors at the earliest possible opportunity to provide tailored guidance.

- In 2021-2022, the assessments of 4 New Substances Notification (NSNs) for new substances in COVID-19 vaccines and treatments were prioritized and either completed within accelerated timelines or expedited and completed early.

When the assessment of a new substance identifies a risk to human health or the environment, CEPA allows the Minister of Environment and Climate Change to intervene prior to or during the earliest stages of its introduction into Canada. In this case, 3 actions may be taken. The Minister may:

1. permit the manufacture or import of the substance subject to specified conditions
2. prohibit the manufacture or import of the substance
3. request additional information considered necessary for the purpose of assessment

In 2021-2022, the Minister of Environment and Climate Change issued 5 Notices of Ministerial Conditions for 5 new substances (see Table 11).

A Significant New Activity (SNAc) requirement can be applied when a substance has been assessed and no risks were identified with current activities but there is a suspicion that significant new activities may pose a risk to human health and/or the environment.

- In 2021-2022, 2 previously published SNAc Notices relating to new substances were varied (see Table 12)

3.1.4 Communication activities

Communications and outreach activities provide Canadians with timely and credible information about the CMP and its achievements, and how to protect themselves from the risks of chemical substances and pollutants.

In 2021-2022, ECCC and HC continued to work collaboratively to raise awareness of the safe use and potential risks of chemical substances and pollutants. A variety of communications materials were developed and published on Canada.ca and on ECCC and HC social media channels to accompany the technical and scientific documents on chemical substances and pollutants. These outreach products include information sheets, fact sheets, plain-language summary pages, social media campaigns, brochures/postcards, and short, illustrated, empowering articles made available for publication in community papers, blogs, websites and newspapers. They provide supplemental and/or non-technical information about aspects of the program and about substances, for stakeholders and the general public.

The following communications activities and products relating to the health and environmental risks of chemicals were published:

- 2 new fact sheets as part of the Fact Sheet Series on Topics in risk assessment of substances under CEPA (totaling 14 fact sheets):
  - Use of margins of exposure and risk quotients in risk assessment
  - Canadian exposure factors used in human health risk assessments
- 11 information sheet webpage summaries of draft screening assessments and risk management scopes (where applicable), including 1 for an additional risk characterization document in support of a draft assessment
- 12 information sheet webpage summaries of final screening assessments and/or risk management approach documents (where applicable)
- 1 information sheet webpage update for a performance measurement evaluation
- 7 information sheet webpage updates for risk management activities and proposed or final orders listing substances to Schedule 1
- 13 plain language summaries for high profile substances
  - 9 draft screening assessment summaries (flame retardants, alkyl halides, methanol, 1-butanol, benzyl alcohol, methyl acetate, clove oil, guaiazulene, sandalwood)
  - 4 final screening assessment summaries (talc, chlorocresol, coal tars, solvent violet 13)
- 49 new substances notification assessment summaries on Canada.ca
- 4 regional postcards and brochures distributed to 160 000 Canadians living in rural areas

Implementation of the new Healthy Home social marketing campaign continued. The campaign aims to empower Canadians to take action to protect themselves from the risks of chemical substances and pollutants in and around the home. A mix of both traditional and digital marketing and communication tactics have been utilized.

- Digital engagement:
  - posted 150 social media posts on Facebook, Twitter and LinkedIn (1 076 808 impressions), which promoted the campaign and drove traffic to the Healthy Home website
  - reached 970 449 Canadians through a digital influencer campaign
    - 20 influencers engaged Canadians on Healthy Home messaging
    - comments and feedback were positive at 97% with an engagement rate of 2.12%, (above the industry average of 1-2%)

- developed the first phase of an interactive on-line game to help inform Canadians about the risks of certain chemicals and pollutants in the home
- published 4 new Healthy Home videos on the website in both English and French

The Healthy Home Sessions were launched as a platform to deliver virtual and in-person outreach to the public. These sessions, delivered by Health Canada regional offices, were designed to increase Canadians' awareness of health risks posed by chemicals and pollutants in and around the home, and to provide information for them to take action to protect their health and that of vulnerable populations. In 2021-2022,

- 90 in-person and virtual outreach activities were delivered across the country, including Healthy Home sessions, train-the-trainer collaborations, and exhibits at virtual trade shows, science fairs, and conferences.
- activities targeted intermediary groups such as caregivers, early childhood educators, health care providers, and parents/guardians who act as influencers and further disseminate messaging through their professional networks, which allowed the information to reach subpopulations that may be more vulnerable to chemicals or have greater exposure, such as Indigenous communities, new Canadians, seniors, pregnant women, children and youth.
- public outreach activities continued to be enhanced by Health Canada through the development of innovative tools including:
    - action-based learning activities for schools and a children's activity book (ages 7-9)
    - research on game-based learning solutions
    - digital and in-person exhibits that minimize public health concerns accessible virtual outreach materials

3.2 Living organisms

Living organisms, defined in CEPA as animate products of biotechnology (CEPA section 104), 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 animate products of biotechnology. Other Canadian acts meeting the federal standard set by CEPA are 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 of living organisms

The Act requires that all 68 living organisms grandfathered to the DSL (i.e. those 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 have completed joint assessments for 45 of those living organisms to date. The remaining 23 living organisms have since been or will be removed from the DSL (e.g. see below). In addition, ECCC and HC jointly perform the assessment of living organisms that are new to the Canadian marketplace and require notification to the government prior to being imported into or manufactured in Canada.

Risk assessment of existing living organisms

On July 7, 2021, a Ministerial Order deleting 22 masked strains from the DSL was published in the *Canada Gazette, Part II*, as these living organisms do not meet the criteria set out in subsection 105(1) of the Act (see Table 13).

Also during 2021-2022:

- An Order amending the Domestic Substances List to apply the SNAc provisions of CEPA to Trichoderma reesei strain ATCC 74252 was published on August 18, 2021.

- A Notice of Intent to amend the Domestic Substances List (DSL) CEPA to remove one complex consortium was published in the Canada Gazette, Part I, on January 8, 2022.

Risk assessment of new living organisms

During 2021-2022, 37 notifications for new animate products of biotechnology were assessed under the *New Substances Notification Regulations (Organisms).* Of these, 22 were for new substances in products regulated under the *Food and Drugs Act*.

Also during 2021-2022:

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

Risk assessment of new higher organisms

Environment and Climate Change Canada and Health Canada are promoting more public engagement in the risk assessment of higher organisms (such as genetically modified plants and animals) conducted by the New Substances (NS) program.

The voluntary public engagement initiative was launched in 2018. The NS program publishes summaries of New Substances Notifications submitted for higher organism and invites stakeholders to share scientific information and test data related to potential risks to the environment or human health from the new living organisms. Information that could be shared to inform the risk assessment process includes:

- environmental fate information
- ecological effects information
- human health effects information or
- exposure information (including sources and routes of exposure)

A public comment period was initiated in February 2022 on 4 new genetically modified fish to inform risk assessments. Further information on past engagement initiatives may be found online.

3.2.2 Risk management

A Significant New Activity (SNAc) requirement is applied when an existing substance has been assessed and no risks were identified with current activities, but there is a suspicion that new activities may pose a risk to human health and/or the environment. The 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 SNAc. When the assessment of a new living organism 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. The Minister may either permit a person to manufacture or import a substance subject to conditions or may prohibit the manufacture or import of a substance.

In 2021-2022, the Minister of Environment and Climate Change issued 2 SNAc Notices for 2 new living organisms (see Table 14). The Minister also issued 2 SNAc Notices of Intent proposing to vary or rescind SNAc provisions related to 15 living organisms (see Table 15).

These Notices of Intent resulted from the SNAc review initiative to ensure that current SNAc orders are aligned with current information, policies and approaches.

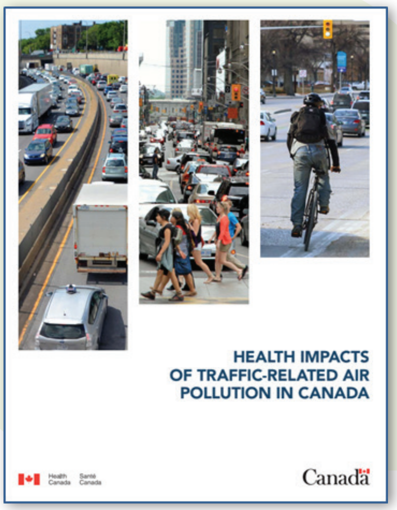
In 2021-2022, 1 SNAc Order was issued for an existing living organism (see Table 16).

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

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.



In March 2022, HC published an estimate of the health impacts of traffic-related air pollution (TRAP) in Canada, reporting that TRAP contributed to 1200 premature deaths in Canada in 2015 along with 210 000 asthma symptom days per year and 2.7 million acute respiratory symptom days. The total economic cost of all health impacts attributable to TRAP in 2015 was $9.5 billion (2015 CAD).

In March 2022, HC published a health risk assessment of TRAP on childhood leukemia, adult lung cancer, and adult breast cancer. Risk assessments of associations between exposure to TRAP and other health endpoints is ongoing. In addition, HC published an assessment of Canadian exposure to TRAP through analysis of population proximity to roadways. HC also published a systematic review and meta-analysis of the association between $PM_{2.5}$ exposure and lung cancer in Canada. This assessment will support HC's Air Quality Benefit Assessment Tool (AQBAT) and evaluation of health risks for Impact Assessments.

In March 2022, HC published the Canadian Health Science Assessment for Fine Particulate Matter ($PM_{2.5}$), a document that supports the review of the CAAQS for $PM_{2.5.}$ In addition, HC began development of Health Based Air Quality Objectives (HBAQOs). For the first cycle, the prioritized pollutants in outdoor air for HBAQO development include arsenic, carbon monoxide, formaldehyde, benzene and PM_{10}.

3.3.2 Risk management

Different regulatory and non-regulatory instruments are available under the authorities provided by CEPA to limit and reduce emissions of air pollutants and/or 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.

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 several industrial sectors

- work to address emissions from mobile sources
- outdoor air pollutants monitoring program
- reporting to Canadians on the state of the air

Canadian Ambient Air Quality Standards (CAAQS) are health and environment-based air quality objectives that apply to the concentration of specific air pollutants in the outdoor air. They provide the drivers for local 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 approved by the CCME, CAAQS are published by the Minister of the Environment and the Minister of Health as objectives under CEPA. CAAQS have been developed for $PM_{2.5}$, ground level ozone (O_3) sulphur dioxide (SO_2) and nitrogen dioxide (NO_2).

▸ **In 2021-2022, work continued to advance the review of the 2020 CAAQS for $PM_{2.5}$.**

Industrial sector emissions

The *Multi-Sector Air Pollutants Regulations* (MSAPR) came into force in 2016 and established nationally consistent industrial emissions performance standards. The MSAPR limit nitrogen oxide (NO_x) emissions from large industrial boilers and heaters, as well as from stationary sparkignition engines, used in several industrial sectors, that burn gaseous fuels (such as natural gas).

For stationary spark-ignition engines covered by the MSAPR, emission requirements for modern engines are in force, with annual compliance reports due by July 1. Emission requirements for pre-existing engines began to apply on January 1, 2021, with the first annual compliance report due on July 1, 2022.

The MSAPR also limit NO_x and SO_2 emissions from kilns at cement manufacturing facilities. More specifically, the MSAPR limits NO_x and SO_2 releases for 14 grey cement facilities in Canada under Part 3 of the regulations. Every June 1st, 14 facilities report on their compliance with the MSAPR. As of the end of 2021, all facilities are meeting the SO_2 limit and 11 of the 14 facilities are meeting the NO_x emission limits as defined in the MSAPR. The three facilities not meeting the NO_x emissions limits have implemented, or are in the process of implementing, a selective non-catalytic reduction system to reduce their NO_x emissions and meet the NO_x limit as set out in the regulation.

Oil and gas sector emissions

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. The remaining requirements will come into force on January 1, 2023.

A review of Canada's methane regulations for the upstream oil and gas sector was published in December of 2021. This report concluded that Canada is on track to meet its 2025 target for methane reductions from the oil and gas sector, while acknowledging that more work is needed to drive further reductions in this sector. ECCC published in March 2022 the discussion paper, *Reducing methane emissions from Canada's oil and gas sector*, to inform the development of new federal regulations and other measures needed to achieve at least a 75% reduction in methane emissions from the oil and gas sector from 2012 levels by 2030.

In 2021, Canada committed to achieving at least a 75% reduction in methane emissions from its oil and gas sector from 2012 levels by 2030. In March 2022, ECCC launched public consultations through a discussion paper to inform the development of more stringent regulations to achieve further methane emission reductions in the oil and gas sector. ECCC will continue to engage Indigenous organizations, industry, research organizations and civil society on regulatory options and complementary measures. ECCC plans to publish proposed regulations in the first half of 2023 and final regulations in 2024.

Electricity Generation

ECCC published the discussion paper, *A clean electricity standard in support of a net-zero electricity sector*, in March 2022 to inform the development of regulations to support a net-zero electricity grid by 2035. The publication also launched a collaborative process to ensure that the design of the regulations provides a clear and workable basis for provinces and territories to be able to plan and operate their grids in a way that will continue to deliver clean, reliable and affordable electricity to Canadians.

Vehicle and engine emissions and fuels

ECCC collaborates with the California Air Resources Board, as per their Memorandum of Understanding, to promote and carry out cooperative activities on policy and regulatory measures that reduce emissions from greenhouse gases and air pollutants including from vehicles, engines, and fuels. In addition, ECCC and the U.S. Environmental Protection Agency (U.S. EPA) continue to collaborate closely through the Canada-United States Air Quality Agreement towards the development of aligned vehicle and engine emission standards, related fuel quality regulations, and their coordinated implementation, including collaborative research and testing projects.

- **ECCC administers 6 vehicle and engine emission regulations and 9 fuel regulations under CEPA.**

On June 4, 2021, the *Off-road Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emission Regulations* came into force. These regulations set performance-based emissions standards for air pollutants from new stationary off-road diesel engines and mobile large spark-ignition engines. These Regulations repealed and replaced the *Off-Road Compression-Ignition Engine Emission Regulations*. Emission standards applicable to mobile off-road diesel engines remain unchanged although some new administrative and compliance flexibilities were introduced for certain applications.

On December 18, 2021, the *Regulations Amending Certain Regulations Made Under the Canadian Environmental Protection Act, 1999* were published in the *Canada Gazette, Part I*. These regulatory amendments were proposed to maintain alignment with the amendments published by the U.S. Environmental Protection Agency (EPA) in June, 2021. The U.S. EPA amendments related to vehicles and engines were to improve accuracy, reduce testing burden, and make a number of housekeeping changes to their regulations. Maintaining alignment with U.S. EPA emission standards for vehicles and engines minimizes the overall regulatory burden for companies operating in the integrated Canada–U.S. market and maintains fair regulatory conditions for importers and manufacturers. Most changes made by the U.S. EPA apply automatically in Canada due to the use of incorporation by reference in the various vehicle and engine emission regulations. However, minor changes were needed for three of the Canadian regulations, including modifying definitions and regulatory text and updating some references to the U.S. regulations. The proposed changes are not anticipated to have adverse economic or environmental impacts in Canada and do not affect the stringency of emission standards.

Early consultations were launched in December 2021 on new commitments related to zero emission vehicles that were supported by the following discussion papers:

- *Achieving a zero-emission future for light-duty vehicles*
- *Discussion paper on heavy-duty vehicles and engines in Canada: transitioning to a zero-emission future*

In the March 2022 Emissions Reduction Plan, ECCC committed to develop zero-emission vehicle requirements to implement new targets of at least 20% zero-emissions vehicle (ZEV) sales by 2026, 60% ZEV sales by 2030 and 100% ZEV sales by 2035. These requirements for light duty ZEVs will be implemented through CEPA regulations. In addition, the Emissions Reduction Plan committed ECCC to develop regulations to require 100% of medium and heavy-duty vehicle sales to be ZEVs by 2040 for a subset of vehicle types based on feasibility, with interim 2030 regulated sales requirements that would vary for different vehicle categories based on feasibility, and explore interim targets for the mid-2020s.

ECCC published the *Final Decision Document on the Mid-Term Evaluation of the Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations* on February 12, 2021. The Department determined that the standards for light-duty vehicles, which were aligned with the standards in the United States for up to model year 2026, were not stringent enough at the time of the release of the discussion document to meet Canada's emission reduction and climate goals and that Canada should work with the U.S. to develop more stringent standards. Since then, more stringent standards have been included in the Final Rulemaking which were published in the U.S. in December 2021. These more stringent standards automatically apply in Canada as the U.S. standards are incorporated into Canada's regulations by reference.

Regulatory administration of vehicle, engine and fuel quality regulations

ECCC administers a compliance program under the vehicle and engine regulations, as well as the 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 production and import records of fuel suppliers; and verifying compliance with the regulatory prohibitions and reporting requirements.

- During 2021-2022, under the vehicle and engine regulatory administration, ECCC:
  - received approximately 136 regulatory reports for vehicles and engines
  - responded to 1230 inquiries regarding the vehicles and engines regulations
  - conducted testing on 90 vehicles and engines
  - processed about 715 Canada-unique[4] submissions, 124 temporary importation submissions, and
  - 74 102 importation declaration entries representing 2 268 684 vehicles and engines.
  - processed 86 notices of defect and recall notifications covering almost 334 178 vehicles and engines. ECCC continues to provide basic information summarizing notices of defect and other company notifications received.
- ECCC conducts an annual risk-based review of each fuel supplier based on the reports submitted. During 2021-2022, under the fuels regulatory administration, ECCC
  - received over 2500 reports and notices for fuels
  - responded to over 450 inquiries by email and phone, in both official languages regarding the fuels regulations
  - assessed 85 fuels suppliers and worked directly with 29 of those suppliers to address their reporting and administrative issues
  - ECCC conducted 238 analyses on 95 fuel samples in order to verify compliance with the regulations. A number of inspections were also undertaken.

During 2021-2022, the department published the Greenhouse gas emissions performance for the 2019 model year light-duty vehicle fleet and the 2018 and 2019 model year light-duty vehicle air pollutant report. These reports, compiled from the annual compliance reports submitted by automobile companies, document the overall fleet performance for all model years since the regulations were first introduced in 2010 (with the 2011 model year) for GHGs and the 2004 model year for air pollutants up to the titular model year. The Department also made available aggregated data related to 4 fuel quality regulations (*Fuels Information Regulations, No. 1*; *Benzene in Gasoline Regulations*; *Sulphur in Diesel Fuel Regulations*; *Renewable Fuels Regulation*s) reported by the regulated community for the 2019 and 2020 calendar years.

4 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 and data related to certain regulations is available online.

Regulatory administration of the *volatile organic compound (petroleum sector) regulations*

As of January 1, 2022, the *Reduction in the Release of Volatile Organic Compounds Regulations (Petroleum Sector)* require the implementation of comprehensive leak detection and repair programs at Canadian petroleum refineries, upgraders and certain petrochemical facilities to reduce fugitive emissions of VOCs from process equipment. In addition, these facilities are required to monitor and report on the concentrations of certain VOCs in the air, at the fenceline.

To ensure compliance with the regulations, ECCC developed bilingual compliance promotion materials and reporting templates for the regulated community. During 2021-2022, the Department received and addressed 61 emails and phone calls related to the regulations and sent out 3 bilingual compliance promotion packages.

Clean Fuel Regulations

ECCC worked toward the finalization of the *Clean Fuel Regulations*[5] in 2021-2022. The Regulations require gasoline and diesel primary suppliers (i.e. producers and importers) to reduce the lifecycle carbon intensity (CI) of the gasoline and diesel they produce in, and import into, Canada from 2016 CI levels by 3.5 grams of carbon dioxide equivalent per megajoule (gCO_2e/MJ) in 2023, increasing to 14 gCO_2e/MJ in 2030. The Regulations also establish a credit market whereby the annual lifecycle CI reduction requirement could be met via three main categories of credit-creating actions: (1) actions that reduce the CI of the fossil fuel throughout its lifecycle, (2) supplying low-CI fuels, and (3) supplying fuel and energy in advanced vehicle technologies. Parties that are not fossil fuel primary suppliers would be able to participate in the credit market as voluntary credit creators (e.g. low-CI fuel producers and importers) by completing certain actions. In addition, the Regulations repeal the *Renewable Fuels Regulations* (RFR) but retain the minimum volumetric requirements (at least 5% low CI fuel content in gasoline and 2% low CI fuel content in diesel fuel) currently set out in the RFR.

Consumer and commercial products emissions

On January 5, 2022, the final *Volatile Organic Compound Concentration Limits for Certain Products Regulations* were published in the *Canada Gazette, Part II*: The regulations apply to manufacturers and importers and establish concentration limits for volatile organic compounds (VOCs) in approximately 130 product categories and subcategories. VOCs are an important contributor to the formation of ground-level ozone, a key component of smog. The objective of the regulations is to protect the environment and health of Canadians from the effects of air pollution by reducing VOC emissions.

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.

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 and propose evidence-based strategies to reduce exposure.

HC's air quality program also provided support to the Public Health Agency of Canada in developing guidance on using ventilation to reduce aerosol transmission of COVID-19 in residences and in long-term care homes.

5 The *Clean Fuel Regulations* (SOR/2022-140) were finalized outside of the scope of this report and were published in the *Canada Gazette, Part II*, Vol. 156, No.14 on July 7, 2022.

On July 7, 2021, the final *Formaldehyde Emissions from Composite Wood Products Regulations* were published in the *Canada Gazette, Part II*. The regulations help reduce exposure of Canadians to formaldehyde emissions in indoor air from composite wood products sold, offered for sale or imported into Canada. The regulations place limits on the amount of formaldehyde that composite wood products can emit. Further to the requirements to meet emission limits, the regulations would impose requirements on industry for record keeping, labelling, and reporting. They also align Canadian requirements for composite wood products with similar requirements in the United States (U.S.), thereby minimizing the burden on businesses operating in Canada and the U.S.

3.4 Drinking water quality

Work on water quality under CEPA includes leadership on the development of guidelines for water quality. HC collaborates 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 at levels that could lead to adverse health effects. All provinces and territories use the GCDWQ to establish regulations and policy for the quality of drinking water in their jurisdictions.

Priorities for guideline development are established every four to five years by examining exposure information from federal, provincial and territorial sources, current science, international actions, and jurisdictional needs. The process for prioritizing the development and updating of GCDWQ was updated in November 2020. The list of priority contaminants was also finalized, forming the basis for the workplan of the Federal-Provincial-Territorial Committee on Drinking Water.

New or updated GCDWQ are published in the *Canada Gazette, Part I*, while supporting technical documents are published on Health Canada's website. The draft GCDWQ undergo a 60-day public consultation period and the final GCDWQ are accompanied by a plain language summary to increase the public's access.

Table 17 lists the guidelines finalized in 2021-2022 and those under development.

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.

► **In addition to the activities listed below, risk management actions described in section 3.1.2.2 on toxic substances also contribute to the overall improvement of waste management.**

3.5.1 Plastic pollution

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.

Based on the findings and recommendations of the *Science Assessment of Plastic Pollution* published on October 7, 2020, the Government listed plastic manufactured items on Schedule 1 of CEPA in May 2021. The listing followed a 60-day public comment period on a draft of the listing from October to December 2020. A summary of comments received and stakeholder engagement efforts can be found in the Regulatory Impact Analysis Statement of the listing Order.

A discussion paper published by the Government in October 2020 (entitled, "*A proposed integrated management approach to plastic products*") presented a framework to manage risks to the environment posed by single-use plastics. The Government used this framework, drawing from the best available evidence to identify the six categories of single-use plastic items to be banned or restricted. In December 2021, the Government published a draft of the *Single-use Plastics Prohibition Regulations*. These regulations would ban six categories of single-use plastic items that were found to be prevalent in the environment, harmful to wildlife, difficult to recycle, and where viable alternatives were available. The publication of the draft Regulations was followed by a 70-day comment period.

In February 2022, the Government of Canada published a Notice of Intent in the *Canada Gazette, Part I* and a technical issues paper on the development of proposed regulations that would set minimum recycled content requirements for certain plastic manufactured items. Comments will be considered as the proposed regulations are developed.

These efforts are part of Canada's comprehensive zero plastic waste agenda that includes a range of complementary actions across the lifecycle, to transition to a circular economy for plastics.

3.5.2 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.

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 *London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972*. 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 2021, Canada led a group working to help other countries select suitable sites for disposal at sea, and supported technical assistance to bring implementation within reach of more countries. Canada continues to serve as a member of the London Protocol Compliance Group, which encourages and supports compliance and ratification of the treaty. Canada is also a member of technical working groups seeking to address marine plastic pollution and to promote the re-use of materials disposed of at sea.

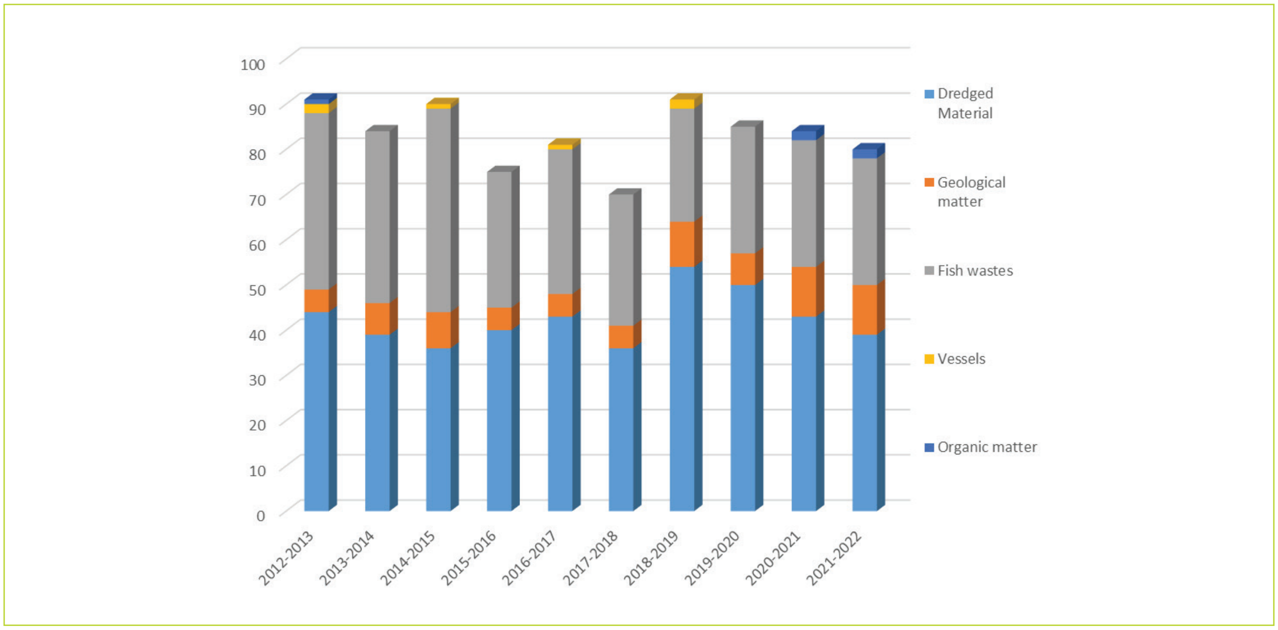
Disposal at sea permits

From April 1, 2021 to March 31, 2022 , 80 permits were issued in Canada for the disposal of 5.6 million tonnes of waste and other matter at sea (see Table 18), compared to 84 permits for the disposal of 8.4 million tonnes in 2020-2021.

Both the total number of permits and quantity of waste permitted has decreased from the previous year. The total amount of dredge material dropped by more than 2.7 million tonnes and the total number of permits by 4. The COVID-19 pandemic saw many large non-essential projects postponed or downscaled, while routine dredging for navigation safety was required to continue. This is evident in that the number of permits issued is closer to the 10-year average.

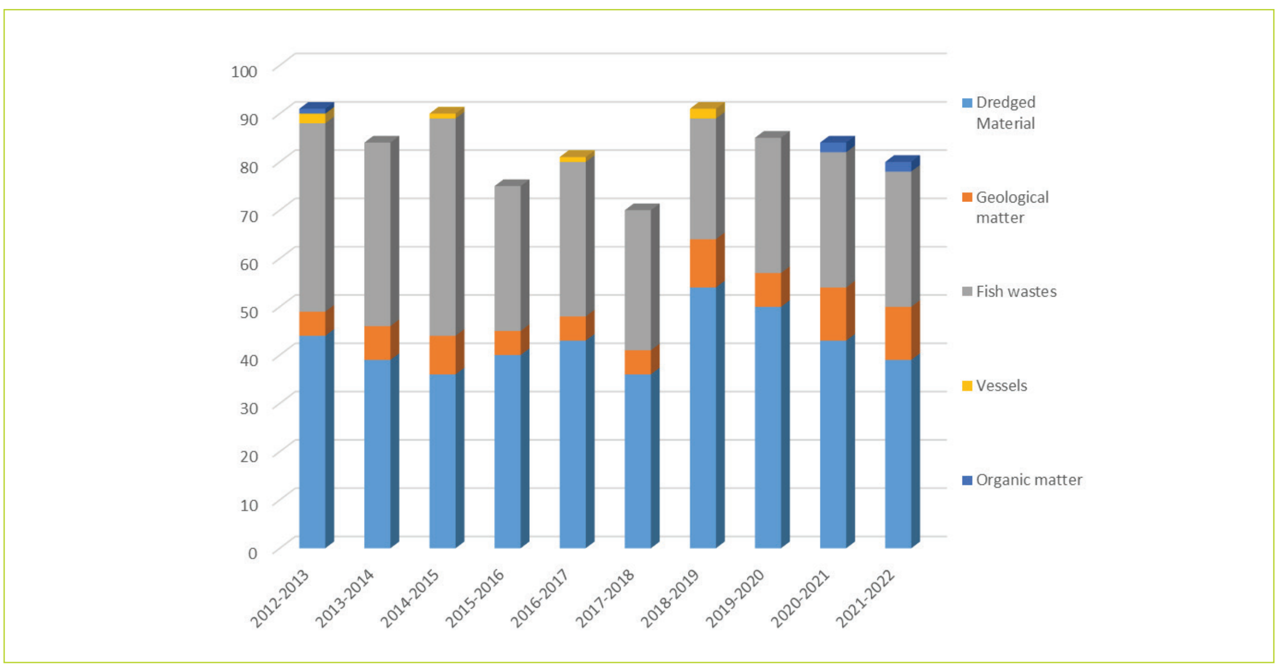
The trends in the number of permits issued over the last decade is illustrated in Figure 5, with the number of permits issued remaining consistent in 2021-2022 with the previous year.

Figure 5. Number of disposal at sea permits issued in each fiscal year by type of material



The trends in the quantity of material permitted each year is illustrated in Figure 6. The quantities permitted continue to fluctuate from year to year. From 2019 to 2020, building of infrastructure led to a high quantity permitted for both dredged material and inert, inorganic geological matter (excavated material). This fiscal year we saw a large drop in the quantity of dredged waste permitted.

Figure 6. Annual disposal at sea quantities permitted (in millions of tonnes)



Further information on disposal at sea is available online.

3.5.3 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

On March 26, 2021, the final *Cross-border Movement of Hazardous Waste and Hazardous Recyclable Material Regulations* (XBR) were published in *Canada Gazette, Part II* and came into force on October 31, 2021. These regulations repealed and replaced three current regulations (*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*). These new Regulations ensure greater clarity and consistency of the regulatory requirements, while maintaining the core permitting and movement tracking requirements of the former regulations. Permits issued in 2021 were delivered under the *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations*.

The implementation of the XBR enables Canada to meet its obligations under the following instruments:

- The United Nations Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention)
- The Decision OECD/LEGAL/0266 of the Council of the Organisation for Economic Co-operation (OECD) Concerning the Control of Transboundary Movements of Wastes Destined for Recovery Operations (OECD Decision)
- The Canada-USA Agreement on the Transboundary Movement of Hazardous Wastes (Canada-US Agreement)
- The Canada-USA Arrangement concerning the Environmentally Sound Management of Non-Hazardous Waste and Scrap Subject to Transboundary Movement

In 2021, ECCC processed 2879 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*. From the notices received, 2674 permits were issued.

Restrictions due to the COVID-19 pandemic impacted the compilation of data on the transboundary shipments of hazardous waste and hazardous recyclable material for both 2020 and 2021. Sufficient data for the transboundary shipments that took place in 2020 and 2021 was not available at the time of publication but will be provided in future annual reports as it becomes available. For the most recent information, please see section 3.5.3 Hazardous waste and hazardous recyclable material in the 2020-2021 CEPA annual report.

- **The notices received covered 44 748 waste streams, which exhibited a range of hazardous properties such as being flammable, acutely toxic, oxidizing, corrosive, dangerously reactive and environmentally hazardous.**

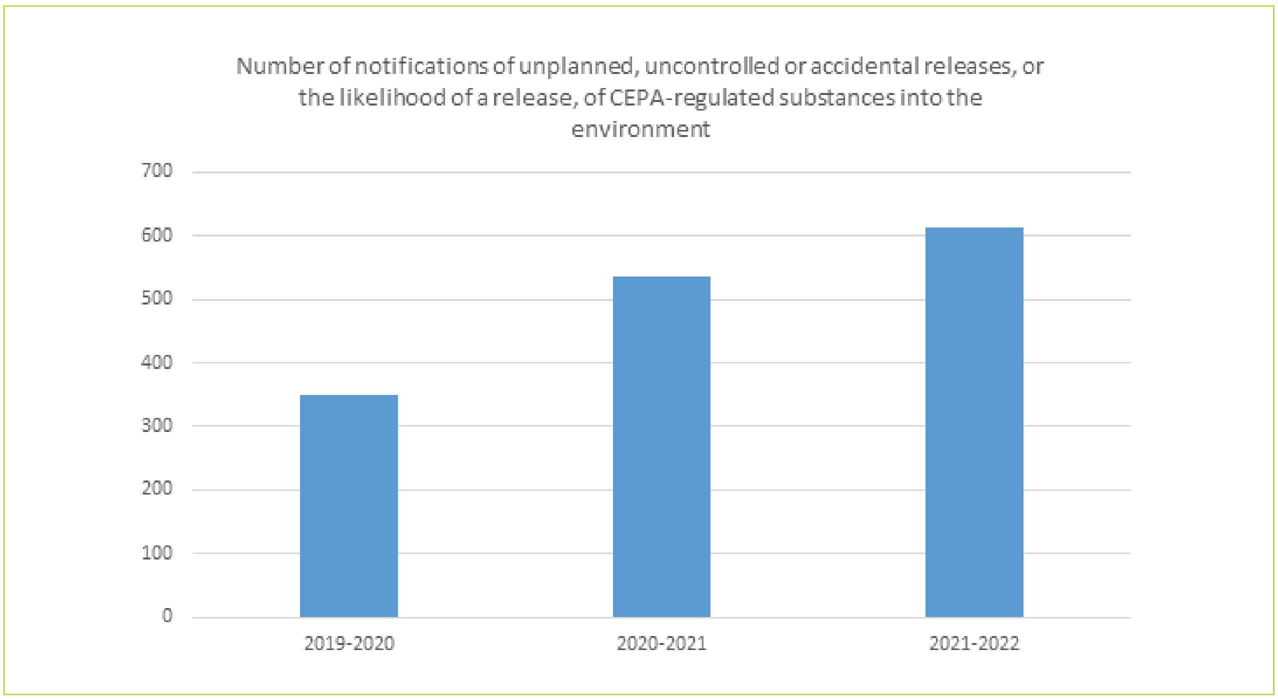
3.6 Environmental emergencies

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.

In the event of a significant pollution incident, the National Environmental Emergencies Centre (NEEC) 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.

- NEEC provides science-based expert advice 24 hours a day, 7 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 2021-2022, NEEC recorded 613 notifications involving an uncontrolled, unplanned or accidental release of CEPA-regulated substances into the environment.

Figure 7. Number of notifications involving uncontrolled, unplanned or accidental release of CEPA-regulated substances



The *Environmental Emergency Regulations, 2019* 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.

- A new electronic reporting system was introduced at the same time the *Environmental Emergency Regulations, 2019* came into effect. More than 3922 facilities from different sectors, subject to the Regulations, have registered in the new application and 2658 have already informed ECCC that their E2 plan has been brought into effect.

3.7 Government operations on federal and aboriginal land

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 2021-2022, 16 permits to charge fire-extinguishing systems with a halocarbon were issued under the *Federal Halocarbon Regulations, 2003.*

ECCC continued to work on the modification of the *Federal Halocarbon Regulations, 2003*. The final *Federal Halocarbon Regulations, 2022*[6] will repeal and replace the *Federal Halocarbon Regulations, 2003*. The scope of the *Federal Halocarbon Regulations, 2022* remains the same as the *Federal Halocarbon Regulations, 2003*. The final Regulations will clarify definitions and requirements, reduce administrative costs for the regulated community, remove or update obsolete provisions and enhance regulatory alignment with other jurisdictions.

6 The *Federal Halocarbon Regulations, 2022* (SOR/2022-110) were finalized outside of the scope of this report and were published in the *Canada Gazette, Part II*, Vol. 156, No.12 on May 20, 2022.

4. Reporting programs and emission inventories

There are 2 mandatory programs under CEPA, which require facilities to report on their releases or emissions of specified substances into the environment:

- Greenhouse Gas Reporting Program
- National Pollutant Release Inventory

Data for both programs is submitted through ECCC's Single Window Information Management (SWIM) system.

The most recent reports on Canada's National Pollutant Release Inventory and Facility-reported greenhouse gas data are available online.

ECCC compiles and maintains 5 inventories of substances released into the environment using the information reported through these programs. These are the:

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

Greenhouse Gas Reporting Program

Under CEPA section 46, facilities (mostly large industrial operations) are required to report the amounts of greenhouse gases released to the air through its Greenhouse Gas Reporting Program (GHGRP). Any facility emitting a combined total quantity of greenhouse gases above the equivalent of 10 000 tonnes of carbon dioxide must report their information each June. The GHGRP is part of ECCC's ongoing effort to maintain and continuously enhance, in collaboration with various provinces, 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 inform the development of the National Greenhouse Gas Inventory, and to support regulatory initiatives. The data collected are also shared with provinces and territories.

- Facilities submitted their information on greenhouse gas emissions for 2020 by June 1, 2021. ECCC undertook its yearly review of the submitted data to assess and resolve compliance or data quality issues. The reviewed data was prepared for public release on April 14, 2022 (see below for details on the data).
- On December 18, 2021, ECCC published a notice in the Canada Gazette, Part I requiring the reporting of greenhouse gas emissions for the 2021 calendar year. Requirements largely reflected those issued for 2020 data (in February 2021).
- The 2021 reporting cycle continued the additional requirements (introduced in 2017) as part of an expansion to the GHG Reporting Program to include enhanced reporting and methodological requirements for 14 industry sectors. ECCC will continue to assess the need for further expansion in future years.

National Pollutant Release Inventory

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 requirements have reported on an annual basis.

- NPRI data for the 2020 reporting year was submitted to ECCC by September 30, 2021 (details on the data follows below). Reviewed data for 2020 was published on March 2, 2022. The deadline for reporting of 2020 data and its publication was delayed due to the COVID-19 pandemic and associated delays in the launch of the modernized NPRI reporting application.

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 2021-2022 included a number of virtual meetings and consultations on proposals for specific changes that would take effect for reporting of 2022 data. After taking into account input received during these consultations, ECCC published the updated NPRI requirements for 2022 to 2024 reporting in the *Canada Gazette, Part I* on February 12, 2022. Key changes included the addition of chlorhexidine (and its salts) and the reporting requirements for air pollutants and VOCs that will improve the information available for air quality modelling and other data users.

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.

National Pollutant Release Inventory (NPRI) information is also 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.

The most recent NPRI data available at the time of publication is for the 2020 reporting year. In 2020, 7168 facilities (Figure 8) reported to the NPRI approximately 4.98 million tonnes of pollutants covering over 320 substances (Figure 9):

- 2.81 million tonnes of pollutants were released directly to the environment
- 1.83 million tonnes were disposed to landfills, applied to land or injected underground, either on the facility site or off-site
- 338 638 tonnes were transferred off the facility site for treatment prior to final disposal or for recycling and energy recovery

Figure 8. Location of facilities that reported to the NPRI for the 2020 reporting year

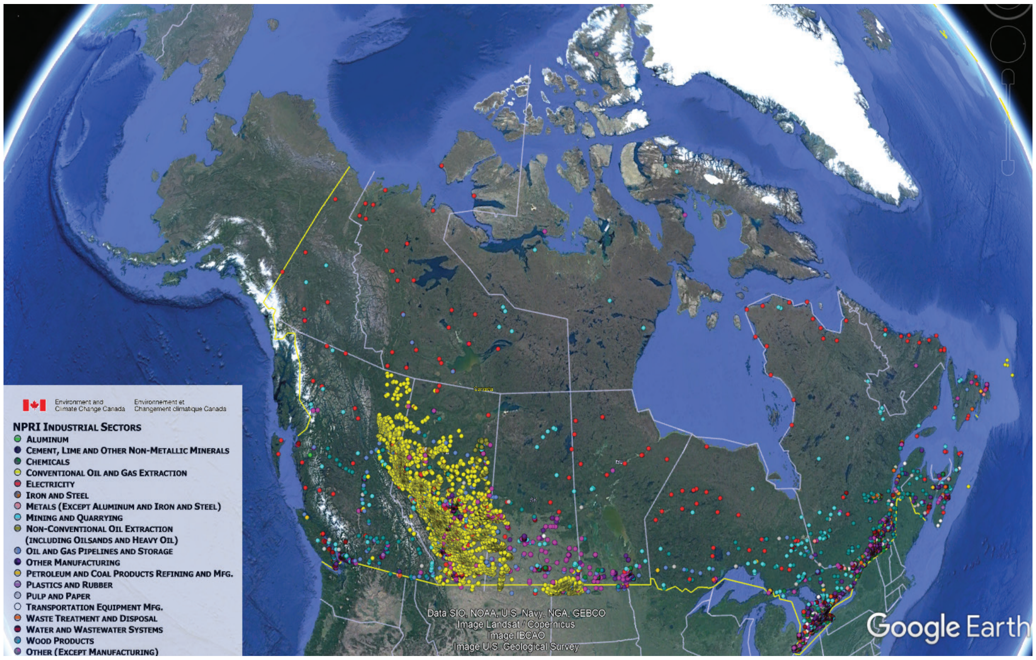
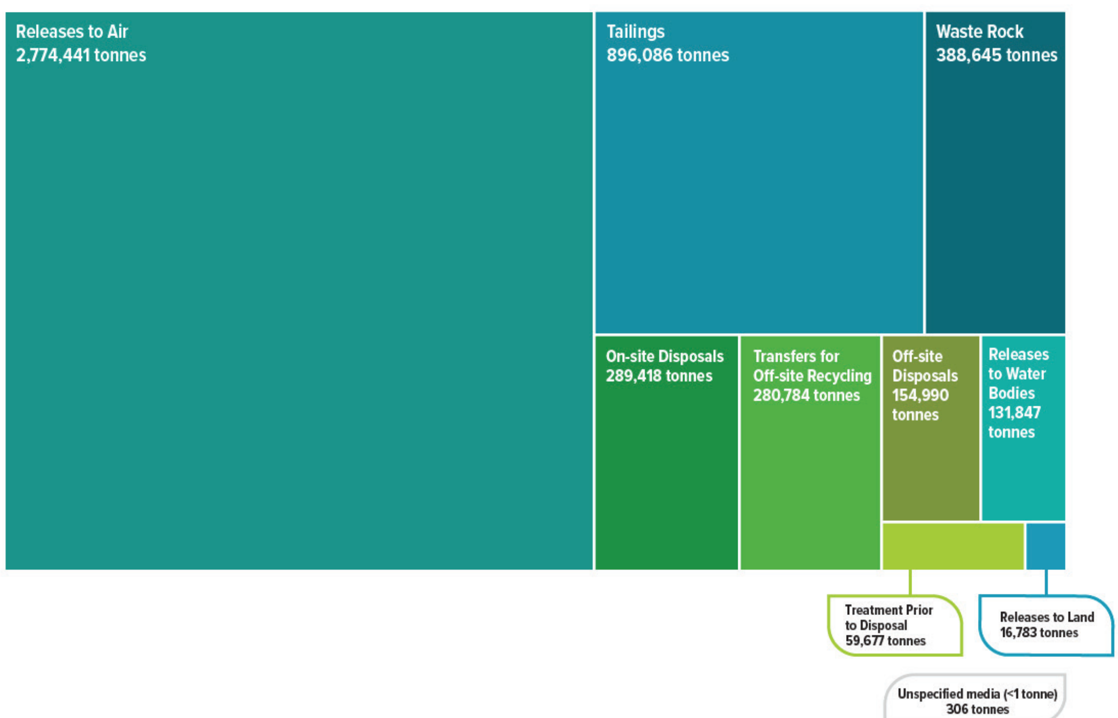


Figure 9. Breakdown of total quantities reported to NPRI for 2020, by reporting category



Between 2011 and 2020, releases to the environment to all media reported to the NPRI **decreased** by 640 085 tonnes. In particular:

- releases to air decreased by 650 630 tonnes
- releases to water increased by 3333 tonnes
- releases to land increased by 7213 tonnes
- releases of substances (i.e., unspecified media) where the total release quantity was less than 1 tonne decreased by 62 tonnes

Between 2011 and 2020, total disposals and transfers **increased** by 119 388 tonnes. In particular:

- off-site disposals decreased by 215 792 tonnes
- on-site disposals (excluding tailings and waste rock) decreased by 76 391 tonnes
- off-site transfers for recycling decreased by 320 043 tonnes
- disposals of waste rock (rock removed to reach ore) increased by 370 219 tonnes
- disposals of tailings (materials left when minerals are removed from ore) increased by 361 395 tonnes

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 2 types of information:

- facility-reported data primarily from the NPRI
- in-house estimates, including diffuse sources and other sources that are too numerous to be accounted for individually

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 air pollutant emissions. These emissions include sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), fine particulate matter ($PM_{2.5}$), cadmium (Cd), lead (Pb), mercury (Hg), dioxins and furans, and other persistent organic pollutants (POPs). The APEI also reports emissions of additional air pollutants including ammonia (NH_3), carbon monoxide (CO), coarse particulate matter (PM_{10}) and total particulate matter (TPM).

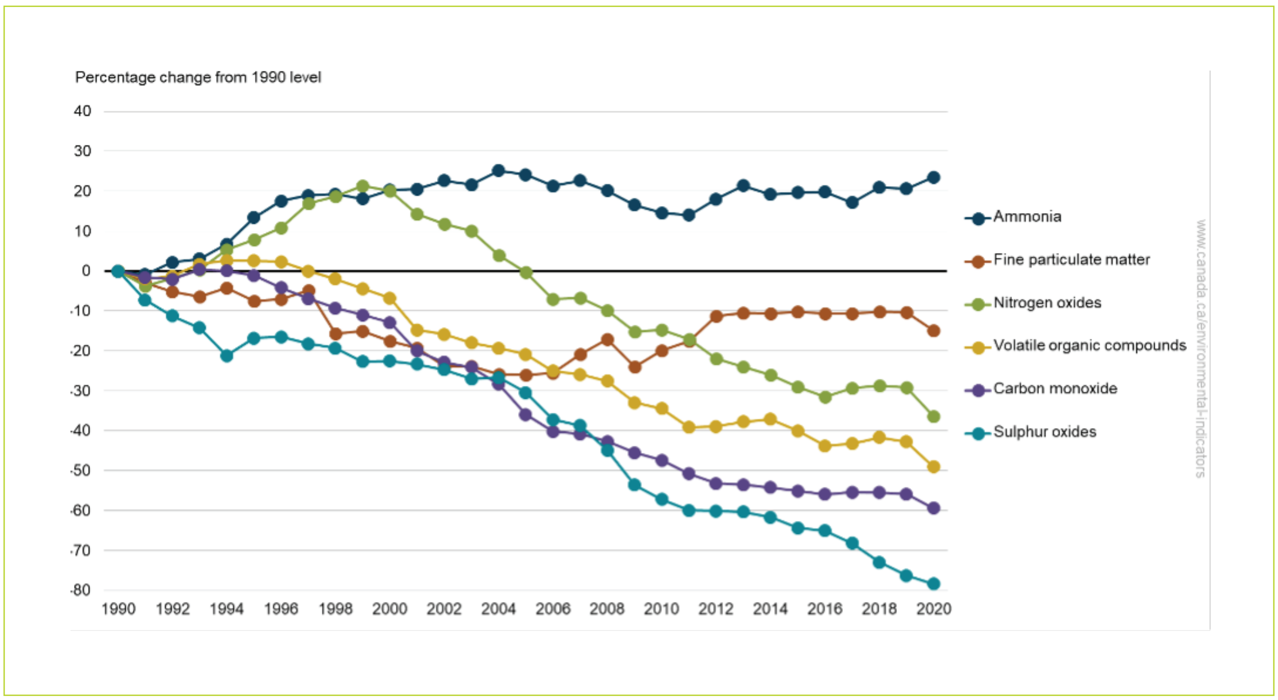
- **Since 1990, the APEI has compiled emissions of 17 air pollutants contributing to smog, acid rain and reduced air quality.**

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.

This edition of the APEI Report summarizes the most recent estimates of air pollutant emissions for 1990 to 2020, as of February 2022. The inventory indicates that emissions of 14 of the 17 reported air pollutants are decreasing compared to historical level (see Figure 10). A few key sources of pollutants account for a significant portion of the downward trends in emissions (see Table 19).

The most recent year for which data are available for this report, 2020, was marked by the COVID-19 pandemic. This coincides with observed emission decreases between the years 2019 and 2020 for almost all pollutants with the exception of particulate matter and NH_3. Indeed, despite significant decreases in emissions of most pollutants since 2005, emissions of particulate matter have risen by 33% (TPM), 29% (PM10) and 15% ($PM_{2.5}$). These increases are coming largely from dust emissions associated with transportation on unpaved roads as well as construction operations. Another exception to the genera downward trends is the steady increase in emissions of NH_3, which in 2020 were 24% above 1990 levels, although 1% below 2005 levels. The upward trend in NH_3 emissions is driven primarily by the use of inorganic nitrogen fertilizer.

Figure 10. Emissions trends for selected air pollutants in Canada, 1990 to 2020



Black carbon emissions inventory

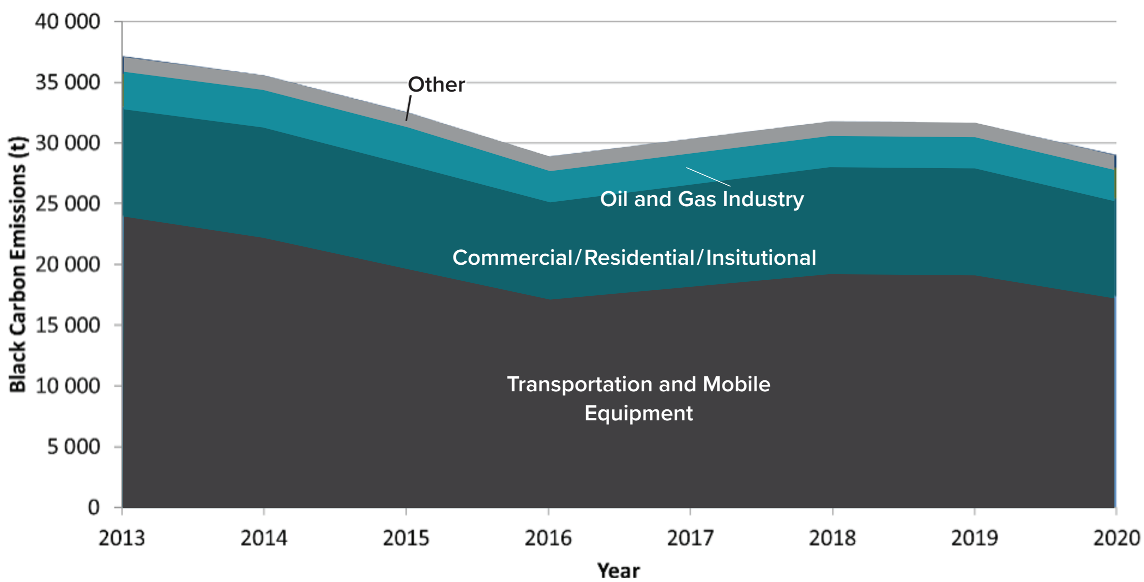
Canada produces an annual report, as well as an associated report, as part of its commitments under the Arctic Council Framework for Action on Enhanced Black Carbon and Methane Emissions Reductions. The report serves to inform Canadians about black carbon emissions, to provide valuable information on domestic actions to reduce emissions, and to help track action and progress towards the Arctic Council collective goal to reduce emissions of black carbon by 25-33% below 2013 levels by 2025.

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, and taken from the Air Pollutant Emissions Inventory.

According to Canada's 2022 Black Carbon Inventory Report, the following trends are notable (see Figure 11).

- In 2020, approximately 29 kilotonnes (kt) of black carbon were emitted from vehicles, equipment, and combustion of fuel related to human activities.
- The largest sources of black carbon emissions are transportation and mobile equipment (notably diesel engines from on-road and off-road transport) and Commercial/Residential/Institutional category fuel combustion, most notably from home firewood burning, accounting for 17 kt (60%) and 8.0 kt (28%) respectively, of total emissions in 2020.
- Since 2013, black carbon emissions have decreased by 8.1 kt (22%).
- The most recent year for which data are available for this report, 2020, was marked by the COVID-19 pandemic, coinciding with an observed overall decrease in emissions of 2.6 kt or 8.2% between the years 2019 and 2020. This decrease is most notable in transportation and mobile equipment. There were less off-road diesel engines in use in 2020 relative to 2019, and they consumed less diesel fuel.
- 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 11. Canada's black carbon emissions trends, 2013 to 2020



Facility-level greenhouse gas emissions inventory

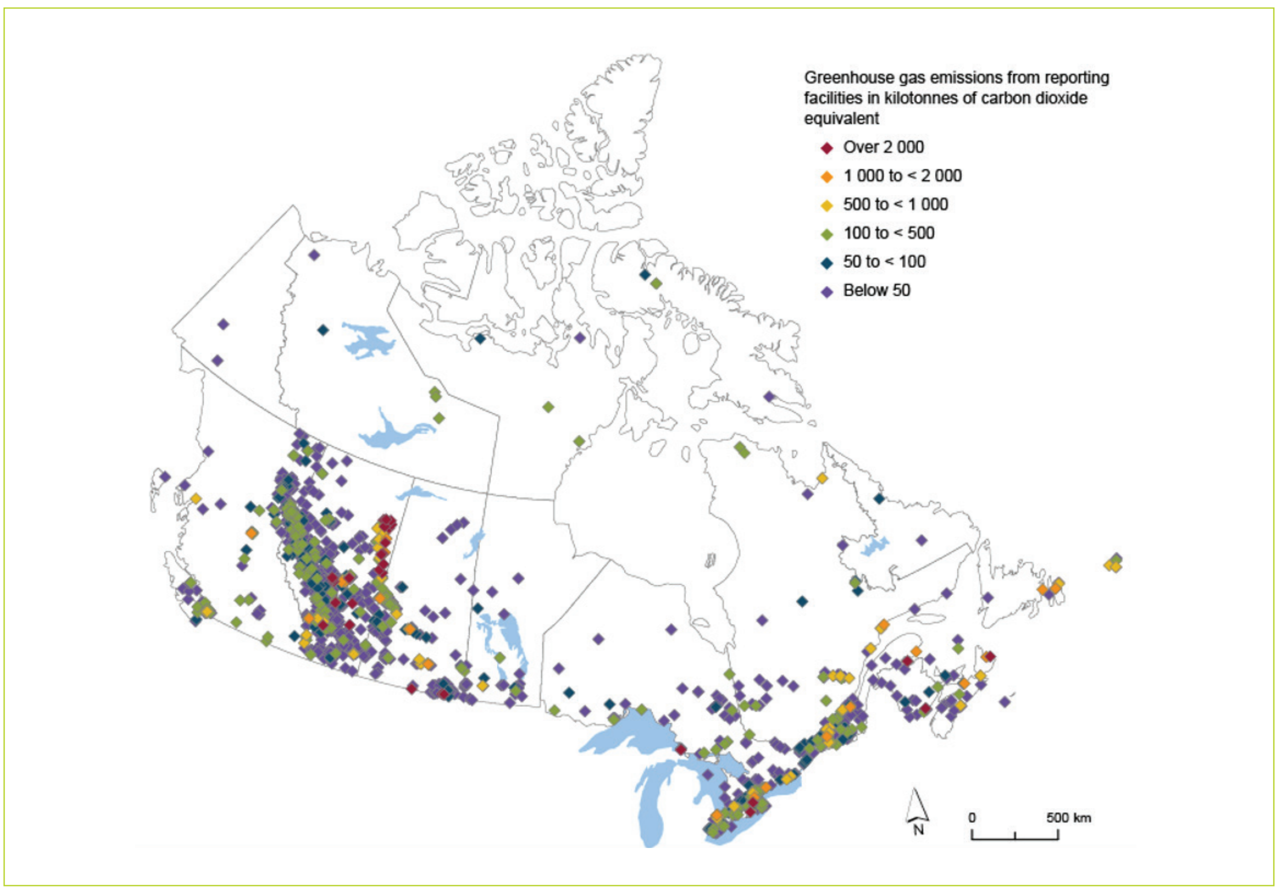
Accurate and consistent tracking of greenhouse gas emissions from individual facilities contributes to ECCC's efforts to monitor environmental performance and develop policies related to climate change by providing a more precise picture of emission levels from large emitters in Canada. The most recent data available, collected under the Greenhouse Gas Reporting Program, is for the 2020 reporting year.

- In 2020, 1704 facilities reported their greenhouse gas emissions (see Figure 12), totaling 273 million tonnes (Mt) of carbon dioxide equivalent (CO_2 eq). The reported emissions are largely distributed across 3 sectors: Mining, Quarrying, and Oil and Gas Extraction (41%); Manufacturing (30%); and Utilities (22%).
- Total facility-reported emissions were 7% less than the reported total in 2019 (293 Mt) due mainly to reduced emissions in the electricity generation and manufacturing sectors. Factors contributing to reduced emissions in 2020 stem from a number of drivers such as lower coal consumption, production slowdowns and impacts on facility operations associated with the COVID-19 pandemic.

The complete data set of greenhouse gas emissions from facilities and the corresponding indicator provides consistent information on emissions from the largest emitting facilities in Canada and is published annually.

The latest data reported to the GHGRP shows that emissions from the reporting facilities account for 41% of Canada's total GHG emissions in 2020.

Figure 12. Location of facilities reporting greenhouse gas emissions in 2020



National Greenhouse Gas Inventory

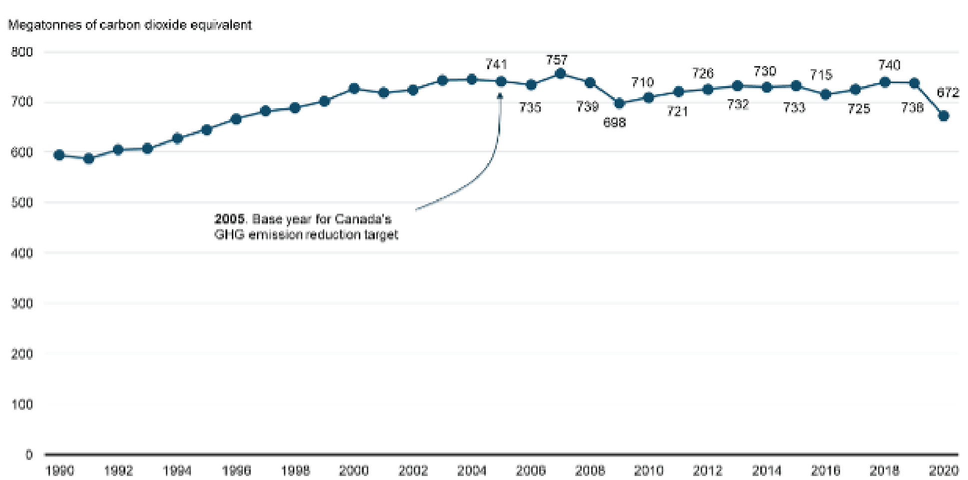
As a signatory to the *United Nations Framework Convention on Climate Change* (UNFCCC) Canada is obligated to prepare and submit an annual national greenhouse gas (GHG) inventory covering anthropogenic emissions by sources and removals by sinks. ECCC is responsible for preparing Canada's official national 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 NIR published in 2022 provides data up to 2020.

The National Greenhouse Gas Inventory shows the following trends:

- After fluctuations in recent years, Canada's GHG emissions in 2020 decreased to 672 megatonnes of carbon dioxide (Mt CO_2 eq) (see Figure 13), net decreases of 66 Mt or 8.9% from 2019 and 69 Mt CO_2 eq or 9.3% from 2005 emissions.
- During the period covered by this inventory (1990-2020), 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 39% since 1990 and 26% since 2005.
- The year 2020 was marked by the COVID-19 pandemic, coinciding with a decrease in emissions of 66 Mt, or 8.9%, across numerous sectors. Notable examples include: Transport (-27 Mt or -12%), largely due to fewer kilometres driven and a decrease in air traffic; and, Public Electricity and Heat Production (-7.4 Mt or -11%) due to decreased coal consumption partially offset by an increase in natural gas consumption.
- Emission trends since 2005 remain consistent with previous editions of the NIR, with emission increases in the Oil and Gas and Transportation sectors being offset by decreases in other sectors, notably Electricity and Heavy Industry.

Figure 13. Canada's greenhouse gas emissions trend, 1990 to 2020



Further information on the National GHG Inventory is available online. Please note that inventories mentioned above are available on the Open Data Portal.

5. Administration and public participation

Administration and public participation covers stakeholder engagement and inter-jurisdictional relationships.

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, enables national cooperative action, and seeks to avoid duplication in regulatory activity among governments. The committee was provided opportunities to advise and comment on initiatives under the Act. More information on the committee is available online.

To carry out its duties in 2021–2022, the CEPA NAC held 2 teleconference meetings on April 21, 2021 and February 17, 2022. The NAC Secretariat corresponded regularly with committee members regarding various initiatives implemented under CEPA, including to inform members of actions taken under the Act and to provide them with opportunities to comment and advise on proposed regulatory and policy measures.

Members were provided an opportunity to comment on:

- 10 draft screening assessments, 4 of which included a risk management scope document
- 4 risk management approach documents associated with final screening assessments
- 2 proposed orders (1 adding coal tars and their distillates and 1 adding talc) adding substances to Schedule 1
- 2 proposed regulations (*Regulations Amending Certain Regulations Made Under the Canadian Environmental Protection Act, 1999*; *Regulations Amending the Regulations Designating Regulatory Provisions for Purposes of Enforcement (Canadian Environmental Protection Act, 1999*))
- 4 Notices of Intent to vary or rescind the SNAc Provisions for 56 existing substances and 15 living organisms
- 1 proposed environmental performance agreement (*Environmental Performance Agreement for the Formulation of Chlorhexidine Products*)

Members were provided with an offer to consult on:

- draft *Federal Environmental Quality Guidelines for Certain Substances* (FEQGs) under section 54 of the Act

Members were provided with an opportunity to advise on:

- 2 proposed regulations to be made under subsection 93(1) of the Act (*Single-Use Plastics Prohibition Regulations*; *Prohibiting the Manufacture and Import of Wheel Weights Containing Lead in Canada Regulations*)

Members were also informed of:

- 8 final screening assessments
- 2 final orders, adding plastic manufactured items and selenium and its compounds to Schedule 1 of the Act
- the publication of 3 regulations (*Regulations Amending Certain Regulations Made Under the Canadian Environmental Protection Act, 1999; Volatile Organic Compound (VOC) Concentration Limits for Certain Products Regulations; Formaldehyde Emissions from Composite Wood Products Regulations)*
- 2 orders amending the Domestic Substances List to apply the SNAc provisions to trichoderma reesei strain ATCC 74252 and mitotane
- the publication of a notice of removal of substances with no commercial activity from the Revised In Commerce List (R-ICL) under the *Food and Drugs Act*

- the publication of a socio-economic and environmental study on remanufacturing and other value-retention processes (VRPs) in Canada
- the publication of FEQGs for copper
- a notice of intent to address the broad class of per- and polyfluoroalkyl substances (PFAS)
- 2 information gathering notices published under section 71 of the Act
- reviewed 2020 National Pollutant Release Inventory (NPRI) data
- NPRI reporting requirements for 2022 to 2024

5.2 Federal-provincial/territorial agreements

Part 1 of the Act 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 20 indicates the administrative and equivalency agreements in place under sections 9 and 10 of CEPA and the activities under them during 2020-2021.

Memoranda of Understanding between Canada and Quebec

In order to maximize the effectiveness of regulatory efforts and reduce the administrative burden on the pulp and paper industry, 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*

▶ The Memorandum of Understanding continued to provide ECCC with real time access to historical and current data during 2021-2022.

On January 30, 2021, a new Memorandum of Understanding (MOU) between the federal government and the government of Quebec was published in the *Canada Gazette, Part I*. The MOU sets out the terms of cooperation and the respective responsibilities to ensure the continuity in the transmission of air quality data and air quality forecast and smog warnings production for Quebec's Info-Smog Program.

5.3 Public participation

CEPA Registry & Public Consultation

Part 2 of CEPA (Public Participation) provides for the establishment of an environmental registry.

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 2021 to March 2022, the CEPA Registry website had 40 790 visits and 83 527 page views.

CEPA also has many provisions requiring consultation and public comment periods for proposed orders, regulations and other statutory instruments, and requirements to publish information to the Registry.

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

There were 34 opportunities posted on the Registry between April 1, 2021 and March 31, 2022 for stakeholders and the members of the public to provide comments on proposed initiatives under CEPA. These include:

- 13 screening assessments
- 1 final decision on assessments
- 4 results of investigations
- 2 orders adding a Toxic Substance to Schedule 1
- 1 amendment to the Domestic Substances List
- 5 proposed guidelines
- 2 proposed Regulations
- 2 amendments to existing Regulations
- 4 independent publications

Please see the CEPA Registry public consultations, available online.

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 HC and ECCC on scientific issues.

- The Committee held its final meeting of its mandate online on February 17-19, 2021 to discuss the evolution of risk assessment under CEPA. Meeting records and reports are available online, including the Second term report, published in February 2022.

The goal of the CMP Stakeholder Advisory Council (CMP SAC) was to obtain advice from stakeholders and Indigenous partners for implementing the CMP and to foster dialogue with the government, and among different groups.

- In 2021-2022, the government hosted a final virtual CMP SAC meeting to reflect on an evaluation of SAC Members' experiences throughout the current mandate, as well as to seek insight on some forward looking considerations. The formal mandate of the SAC ended March 31, 2021. Health Canada and ECCC are currently developing a new Engagement Strategy with a view to modernizing the approach to engaging with CMP stakeholders in the future.

Also in 2021-2022, ECCC and HC launched the National Consultations on Supply Chain Transparency, including labelling to engage Canadians in identifying, developing, prioritizing, and testing innovative solutions, for consumer products. The objective of this work is to mprove supply chain transparency and enhance mandatory labeling for certain consumer products, to give Canadians greater access to information about the substances to which they are exposed. The consultations are in a policy lab approach, which includes a series of workshops and interactive events, during which participants are brought together to collaboratively develop and test innovative solutions. In addition, ECCC collaborated with Innovation, Science and Economic Development Canada and industry partners to support the development and testing of distributed ledger (“block chain”) technology solutions for the secure sharing of data about chemicals within supply chains.

As part of the CMP renewal under Budget 2021, funding was provided to Health Canada for a new CMP Engagement and Outreach Contribution Program. This Contribution Program will better equip the CMP to address government priorities, namely reconciliation, GBA+, and protection of Canada’s vulnerable populations confronted by systemic barriers. It also facilitates the engagement of a wider breadth of stakeholders and partners to help navigate an increasingly complex chemicals management landscape that requires a range of knowledge and perspectives for effective program decision-making. The Contribution Program is composed of three funding streams: Outreach (public awareness and education), Public Participation and Indigenous Participation.

6. Compliance promotion and enforcement

6.1 Compliance promotion

Compliance promotion relates to planned activities undertaken to increase awareness, understanding and compliance with the law and its regulations. Through these activities, compliance promotion officers provide information to regulated communities on what is required to comply with the law, the benefits of compliance and the consequences of non-compliance. The goal is to achieve desired environmental results more efficiently through education and awareness-building, which helps mitigate consequential enforcement actions.

Tools used to promote compliance include:

- information sessions
- conferences and workshops
- facts sheets
- manuals
- guidelines
- reports
- Canada Gazette notices

6.1.1 Compliance promotion priorities

Each year, ECCC establishes priorities for compliance promotion activities. These priorities are among regulatory and non-regulatory CEPA instruments that address issues such as chemical management, air pollutants, and greenhouse gas emissions. To determine the priorities, ECCC considers a number of factors to assess the need or promoting compliance of the instrument. These include whether the instrument is new or amended, has new requirements coming into force, has a low level of compliance, or there is a need to maintain awareness, understanding, or compliance. ECCC's Compliance Promotion Program then aligns resources to priority instruments and carries out compliance promotion activities in collaboration with the managers responsible for the instruments and enforcement personnel.

In 2021-2022, compliance promotion activities were carried out on the following prioritized 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*
- *Cross-border Movement of Hazardous Waste and Hazardous Recyclable Material Regulations*
- *Export of Substances on the Export Control List Regulations*
- *Federal Halocarbon Regulations, 2003*
- *Formaldehyde Emissions from Composite Wood Products Regulations*
- *Microbeads in Toiletries Regulations*
- *Multi-Sector Air Pollutants Regulations (MSAPR)*
- *New Substances Notification Regulations (Organisms)*
- *Off-road Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emission Regulations*

- *PCB Regulations*
- *Products Containing Mercury Regulations*
- *Prohibition of Asbestos and Asbestos Products Regulations*
- *Prohibition of Certain Toxic Substances 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*
- *Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations*

6.1.2 Compliance promotion activities

The COVID-19 pandemic restrictions preventing in-person contact resulted in limited opportunities to hold meetings, site visits, conferences, multi-instrument sessions, or training. The majority of compliance promotion activities focused on virtual events aimed at reaching larger audiences such as virtual conferences and webinar events, email campaigns, article publications and phone calls. Many of these activities were carried out in collaboration with other government departments, or non-governmental organizations and associations.

In 2021-2022, 34 150 known or potential regulatees received compliance promotion material and 1423 stakeholders contacted ECCC by email, fax, letter and telephone to get clarification of regulatory requirements and/or additional information .

During 2021-2022, ECCC launched the following compliance promotion initiatives:

- collaborated with Health Canada to increase the reach of an awareness campaign regarding the *Prohibition of Certain Toxic Substances Regulations, 2012*, among relevant stakeholders
- developed and distributed a simplified factsheet written for members of the regulated community that do not have a scientific background, to help determine whether the *Prohibition of Certain Toxic Substances Regulations, 2012*, applies to their business activities
- maximized outreach to regulated sectors by distributing guidance material to influencers (companies that have regulatees as their client) and encouraging influencers to share the information with clients that may be subject to the *Prohibition of Certain Toxic Substances Regulations, 2012*
- developed an interactive online business reply form to replace paper forms, which allows interested stakeholders to efficiently update their company information, thereby facilitating easier communication with ECCC regarding the *Products Containing Mercury Regulations*
- delivered campaigns to stakeholders involved in transboundary movements of certain substances which integrated information about the Export of Substances on the *Export Control List Regulations*
- updated webpage content and added keywords to enhance visibility in search engine results which increased the accessibility of information related to *New Substances Notification Regulations (Organisms)*, and the broader New Substances Program
- disseminated a targeted reminder to rural and remote facilities that may face challenges in scheduling equipment replacement ahead of the *PCB Regulations* end-of-use deadline
- increased the visibility of the *Storage Tank Systems for Petroleum Products* and *Allied Petroleum Products Regulations* informational video *Identification of Storage Tank Systems*, through updates to guidance material and promotion on social media

6.2 Enforcement

CEPA provides enforcement officers with a wide range of powers to enforce the Act, including the powers of a peace officer. Enforcement officers can carry out inspections to verify compliance with the Act; enter premises, open containers, examine contents and take samples; conduct tests and measurements; obtain access to information (including data stored on computers); stop and detain conveyances; search, seize and detain items related to the enforcement of the act; secure inspection warrants to enter and inspect premises that are locked and/or abandoned or where entry has been refused; seek search warrants; and arrest offenders.

Enforcement activities are conducted in accordance with the Compliance and Enforcement Policy for CEPA (1999).

6.2.1 Enforcement priorities

Each year, ECCC develops an Integrated Enforcement Plan that sets out the enforcement activities to be carried out in that fiscal year, including activities to address non-compliance with CEPA. This risk-based approach allows the department to target entities where evidence indicates an offence is likely to occur and where significant environmental or conservation damage would result from an offence. 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 2021-2022, the Integrated Enforcement Plan gave priority to the following CEPA instruments:

- *2-Butoxyethanol Regulations*
- *Environmental Emergency Regulations*
- *Off-Road Compression-Ignition Engine (Mobile and Stationary) and Large Spark-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 Automotive Refinishing Products Regulations*
- *Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations / Cross-Border Movement of Hazardous Waste and Hazardous Recyclable Material Regulations*
- *Prohibition of Asbestos and Products Containing Asbestos Regulations*
- *Prohibition of Certain Toxic Substances Regulations, 2012*
- *Microbeads in Toiletries Regulations*

In addition to the planned inspections carried out under the Integrated Enforcement Plan, enforcement activities under CEPA also include a large number of unplanned 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 assessments in 2018-2019 to assess and determine the risk of noncompliance with its laws and regulations - including those under CEPA. In 2019-2020, a threat risk assessment on toxic substances was completed and the results were used to inform planning. In 2020-2021, a series of risk-based projects were launched based on the results of the threat risk assessments. These projects continued into 2021-2022 and focused on increased inspections for ammonia, siloxane D4, metallurgical projects, and textile mill effluent. 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.

6.2.2 Enforcement activities

Enforcement activities undertaken between April 1, 2021 and March 31, 2022 are summarized in Tables 21 and 22 and found in the Appendix.

- Table 21 provides the number of on-site and off-site inspections for each regulation, the breakdown of investigations for each regulation for which at least 1 investigation occurred or closed, and the total number of enforcement measures resulting from inspections and investigations that were imposed for each regulation
- Table 22 provides the number of prosecutions for each regulation

6.2.2.1 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 21 details the 669 inspections conducted under CEPA for fiscal year 2021-2022. The number of inspections relates to the number of times the regulation or other instrument was inspected for compliance, using the start date of the inspection for the reference period.

6.2.2.2 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.

Table 21 describes the 42 investigations conducted under CEPA during 2021-2022.

Two of these investigations started and ended in 2021-2022.

6.2.3 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 (AMPs) provide a financial disincentive to noncompliance.

Table 22 sets out the number of written warnings, EPCOs, and AMPs issued under CEPA during fiscal year 2021-2022. Only those regulations or other instruments under which enforcement measures were issued during the time period are listed in this table.

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 prosecutions tabulated during a particular year than actual charges laid.

> ▶ **Enforcement measures also include tickets, prosecutions and environmental protection alternative measures (EPAMs).**

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 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 22 outlines the number of prosecutions and tickets under CEPA for fiscal year 2021-2022. Only those regulations or other instruments under which prosecutions or tickets resulted during the time period are listed in this table. No EPAMs were issued in 2021-2022.

Environmental Damages Fund

In 2021-2022, $161 000 was directed to the Environmental Damages Fund (EDF) through the issuance of Administrative Monetary Penalties (AMPs). Table 22 includes a breakdown of the regulations under which these AMPs were issued.

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.

6.2.4 Enforcement highlights

From April, 2021 to March, 2022 Enforcement issued $161,000 in AMPs under seven CEPA regulations. There were no prosecutions during this period because of reduced operations caused by the COVID pandemic.

6.2.5 Environmental Offenders Registry and Enforcement Notifications

The Environmental Offenders Registry contains information on convictions of corporations obtained under certain federal environmental laws, including CEPA, from June 18, 2009 to the present. This tool allows the media and the public to search for corporate convictions using keywords such as the name of the corporation or the legislation under which the conviction was obtained.

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

6.3 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 October 2021, ECCC participated in the World Customs Organization (WCO) Demeter VII operation, which focused on addressing illegal waste. Enforcement officers, working with the Canada Border Services Agency, stopped the export of a total of 15 containers containing approximately 196 000 kilograms of plastic waste and 101 000 kilograms of other wastes.

7. Report on research

Scientists from ECCC and HC conduct a wide range of research to inform the assessment and management of risks associated with various substances to human health or the environment. Frequently, scientists from other agencies and universities across Canada and the world collaborate with this research.

This section provides highlights of the research published in 2021-2022. The digital object identifier (DOI) or the International Book Standard Number (ISBN) has been provided for each research publication. To obtain online access to a particular publication, copy and paste the DOI (for example, DOI:17.1019/acs.est.1q03279) or ISBN into the search bar of your search engine. A comprehensive list of all research published in 2021-2022 has been included in the Annex.

7.1 Chemical substances

Research on chemical substances is designed to primarily:

- 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
- investigate the health effects of chemicals on human health

HC also undertakes research to support the development of regulations and guidelines, with the goal of improving human health by reducing population exposure to pollutants.

During 2021-2022, 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 (STAGE) Program, Genome Canada and the Great Lakes Protection Initiative.

7.1.1 Environment and Climate Change Canada research

Environment and Climate Change Canada (ECCC) conducted research activities under the CMP as part of 21 projects. These projects were either new projects or a continuation of existing projects delayed by the pandemic and related suspension of laboratory and fieldwork. Some of the latter work was able to progress for those research projects conducted in partnership with universities that only experienced short shutdown periods. Municipal effluent studies included the characterization of toxic discharges related to textile mill inputs and the assessment of Selective Serotonin Reuptake Inhibitors (SSRIs) exposure to organisms in the receiving environment. Field and laboratory assessments of priority chemical substances including perfluoroalkyl substances, alkylbenzene sulfonates and lead in crustaceans, fish, mussels and frogs were also initiated. Significant progress was made for all research projects in terms of data analysis and publication of manuscripts. A selection of the papers related to chemicals in the environment published by ECCC scientists in 2021-2022 are referenced below.

7.1.1.1 Chemicals in the environment

Organic flame retardants and other priority substance	
Focus of Research	Global scale studies were conducted of the sources, levels and behavior in air, and risks to human health of organophosphate flame retardants and bisphenol A (BPA).
Results	A new methodology was presented for assessing the risks of airborne chemicals that includes the risks of any new products created by atmospheric chemical reactions of the parent chemical. It found that the transformation products of organophosphate flame retardants are distributed globally, representing a previously unrecognized exposure risk for the world's urban populations. Risk assessments of commercial chemicals should consider these atmospheric transformations. Due to their low volatility, BPA and its analogues are mainly present in air associated with particles; this has important implications for their persistence in air and the role of particulate matter (especially microplastics) in their transport and deposition.
Publications	Liu, Q., Li, L., Zhang, X., Saini, A., Li, W., Hung, H., Hao, C., Li, K., Lee, P., Wentzell, J.J.B., Huo, C., Li, S.-M., Harner, T., Liggio, J. *Uncovering global-scale risks from commercial chemicals in air,* Nature, 600 (7889), pp. 456-461, DOI:10.1038/s41586-021-04134-6, 2021 Vasiljevic, T., Harner, T. *Bisphenol A and its analogues in outdoor and indoor air: Properties, sources and global levels*, Science of the Total Environment, 789, 48013, DOI: 10.1016/j.scitotenv.2021.148013, 2021

Microfibers and microplastics in the Canadian Arctic	
Focus of Research	The first Canadian Arctic-wide study of manmade particles in marine sediments collected from 14 sites between 2014 and 2017.
Results	Analysis of microfibers determined that 69% could be confirmed as manmade; of this 82% were microfibers (synthetic or modified cellulose such as from clothing material) and 15% were microplastics. The concentrations of manmade particles in dry sediment ranged from 0.6 to 4.7 particles per gram, which may exceed some concentrations recorded in urban areas near sources of plastic pollution, indicating that the Canadian Arctic is a "sink" where manmade fiber pollution collects.
Publication	Adams, J.K., Dean, B.Y., Athey, S.N., Jantunen, L.M., Bernstein, S., Stern, G., Diamond, M.L., Finkelstein, S.A. *Anthropogenic particles (including microfibers and microplastics) in marine sediments of the Canadian Arctic* (2021) Science of the Total Environment, 784, art. no. 147155, DOI: 10.1016/j.scitotenv.2021.147155

Mercury	
Focus of Research	Describing mercury concentration trends over time, tracing racing mercury sources, transport and deposition and assessing the total mercury mass balance in the Arctic, highlighting the concerns of climate change on mercury in the Arctic environment and cryosphere, and assessing the impact of oils sands emissions on mercury levels.
Results	Over 98% of atmospheric mercury found in the Arctic is emitted outside of the region, and approximately 80 tonnes of mercury is transferred into the Arctic Ocean via rivers and coastal erosion per year. Atmospheric mercury deposition to the ocean and sedimentation may be underestimated by up to 100%. It was determined that sea ice melting, sea ice dynamics, thawing permafrost, ocean temperatures changes, and atmospheric processes have a significant impact on mercury cycling in the Arctic. It found that global mercury sources dominated the annual background mercury deposition in the Oil Sands region of Alberta, whereas oil sands mercury emissions made up a significant part of mercury deposition in the immediate vicinity of oil sands operations. A number of ECCC scientists served as lead and contributing authors for the 2021 scientific assessment produced by the Arctic Monitoring and Assessment Programme (AMAP), which summarized current understanding of mercury in the Arctic, including drivers of mercury levels and the effects of mercury exposure on Arctic biota and human health. The assessment included an evaluation of numerous datasets to describe trends in mercury in the Arctic over the past 20-plus years, and a study of the sources, transport and deposition of mercury to and within the Arctic. Atmospheric levels in the Arctic are generally decreasing, possibly because of generally declining emissions from major sources closest to the Arctic, while both increasing and decreasing trends of mercury in Arctic biota have been observed over the last two decades. Contemporary human-created emissions and re-emission of historical mercury contamination (e.g. by wildfires) are major sources that are transported to the Arctic by the atmosphere, ocean currents, and rivers. The assessment provided updated information on long-range transport and deposition processes and advanced understanding of how mercury is stored and cycled within the Arctic environment.
Publications	Dastoor, A., Angot, H., Bieser, J., Christensen, J.H., Douglas, T.A., Heimbürger-Boavida, L.-E., Jiskra, M., Mason, R.P., McLagan, D.S., Obrist, D., Outridge, P.M., Petrova, M.V., Ryjkov, A., St. Pierre, K.A., Schartup, A.T., Soerensen, A.L., Toyota, K., Travnikov, O., Wilson, S.J., Zdanowicz, C. *Arctic mercury cycling.* Nat Rev Earth Environ 3, 270–286 (2022), DOI: 10.1038/s43017-022-00269-w Steffen, A., Angot, H., Dastoor, A., Dommergue, A., Heimbürger-Boavida, L.-E., Obrist, D., and Poulain, A.: Mercury in the Cryosphere, Chapter 9. *Advances in Atmospheric Chemistry*. Volume 3: Chemistry in the Cryosphere, Part 2, 459–502 (2022), DOI: 10.1142/9789811230134_0009 Dastoor, A., Ryjkov, A., Kos, G., Zhang, J., Kirk, J., Parsons, M., and Steffen, A.: *Impact of Athabasca oil sands operations on mercury levels in air and deposition*, Atmos. Chem. Phys., 21, 12783–12807 (2021), DOI: 10.5194/acp-21-12783-2021 Morris, A.D., Rigét, F., Wilson, S., Steffen, A., Stupple, G. + 71 additional coauthors, AMAP Assessment 2021: *Mercury in the Arctic, Chapter 2: Temporal Trends of Mercury in Arctic Media*, Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway, 2021. Dastoor, A., Zhang, L. + 41 additional coauthors, AMAP Assessment 2021: Mercury in the Arctic, Chapter 3: *Changes in Arctic Mercury Levels: Emissions Sources, Pathways and Accumulation*, Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway, 2021.

	Polycyclic aromatic hydrocarbons (PAHs) and polycyclic aromatic compounds (PACs)
Focus of Research	Characterizing PAHs in urban and semi-urban ambient air, and evaluating health risks by assessing the effects of PAC particle size on human exposure.
Results	A study investigated the contribution of 22 individual alkylated PAHs to the overall concentration and toxicity of PAHs in air in Toronto, Ontario, and found that these alkylated and gaseous PAHs - which are not routinely included in many air quality monitoring programs - have a significant toxic impact. In a study assessing the particle size distribution of PACs in samples and its effects on human health, it was determined that skin contact exposure to PACs is comparable to inhalation, in terms of lifetime cancer risks, despite lower daily dermal exposure doses, implying that health impacts can be underestimated if only inhalation is considered.
Publications	Moradi, M., Hung, H., Li, J., Park, R., Shin, C., Alexandrou, N., Iqbal, M.A., Takhar, M., Chan, A., Brook, J.R.: *Assessment of Alkylated and Unsubstituted Polycyclic Aromatic Hydrocarbons in Air in Urban and Semi-Urban Areas in Toronto, Canada*, Environ. Sci. Technol. 2022, 56, 5, 2959–2967, DOI:10.1021/acs.est.1c04299 Tian, M., Liang, B., Zhang, L., Hu, H., Yang, F., Peng, C., Chen, Y., Jiang, C., Wang, J. *Measurement of size-segregated airborne particulate bound polycyclic aromatic compounds and assessment of their human health impacts - A case study in a megacity of southwest China* (2021) Chemosphere, 284, art. no. 131339, DOI: 10.1016/j.chemosphere.2021.131339

	Persistent organic pollutants (POPs) and chemicals of emerging Arctic concern (CEACs)
Focus of Research	Reviewing the literature concerning unintentionally produced polychlorinated biphenyls (UP-PCBs), investigating the transport and circulation of various contaminants in the Arctic, and examining concentrations of hexachlorocyclohexane (a pesticide) in Lake Superior water.
Results	A review on the formation pathways and transport of UP-PCBs determined that dye and pigment manufacturing and industrial thermal processes produce UP-PCB emissions globally. UP-PCBs make up a significant proportion of total PCBs, from a few percent to 85%, and continues to increase. Climate change is increasing the movement of contaminants such as POPs and CEACs within Arctic ecosystems; for example, melting glaciers and permafrost are releasing these contaminants into marine and freshwater ecosystems. From 1986 to 2016, concentrations of two isomers of hexachlorocyclohexane were monitored in Lake Superior water. By 2016, only 2.7% and 7.9% of 1986 quantities remained of the two isomers. The primary removal process was volatilization, followed by degradation and outflow through rivers, while sedimentation was minor. The study emphasizes the success of regulatory controls on pesticides as well as the importance of long-term monitoring of chemicals in water to interpret removal processes and trends in biota.
Publications	Mastin, J., Harner, T., Schuster, J.K., South, L.: *A review of PCB-11 and other unintentionally produced PCB congeners in outdoor air*, Atmospheric Pollution Research, 13 (4), art. no. 101364, DOI:10.1016/j.apr.2022.101364 Hung, H., Halsall, C., Ball, H., Bidleman, T., Dachs, J., De Silva, A., Hermanson, M., Kallenborn, R., Muir, D., Sühring, R., Wang, X., Wilson, S.: *Climate change influence on the levels and trends of persistent organic pollutants (POPs) and chemicals of emerging Arctic concern (CEACs) in the Arctic physical environment - a review*, Environ. Sci.: Processes Impacts, 2022, DOI: 10.1039/D1EM00485A Bidleman, T.F., Backus, S., Dove, A., Lohmann, R., Muir, D., Teixeira, C., Jantunen, L.: *Lake Superior Has Lost over 90% of Its Pesticide HCH Load since 1986*, Environ. Sci. Technol. 2021, 55, 14, 9518–9526, DOI: 10.1021/acs.est.0c07549

7.1.1.2 Chemicals and effects in wildlife, fish and associated food webs and ecosystems

Reviews of mercury and biological effects in exposed of Arctic biota	
Focus of Research	The Arctic Monitoring and Assessment Programme (AMAP) produced a scientific assessment of mercury in the Arctic in 2021. This AMAP report and related journal papers were made possible by data contributions and the involvement of international experts on mercury (in the Arctic) including numerous ECCC scientists. The chapters of this new mercury assessment have been revised and published as separate review articles in a peer-reviewed Special Issue of the journal *Science of the Total Environment*.
Results	Concerns about the risks posed by mercury to human health and the global environment led to the 2013 Minamata Convention on Mercury, which came into force in 2017. The Convention creates a global regulatory framework, introducing controls on mercury mining, emissions to air, land and water, and the phase-out of mercury use in a number of products and processes. The Arctic Monitoring and Assessment Programme (AMAP) has produced scientific assessments of mercury in the Arctic since 1998. The latest assessment AMAP Assessment 2021: Mercury in the Arctic, from which this summary is derived, updates the 2011 AMAP assessment that focused solely on mercury, as well as information presented in recent AMAP assessments of contaminant effects on Arctic wildlife (2018), and also introduces the latest information on mercury and human health in the Arctic. Information produced by AMAP, and the involvement of Indigenous Peoples and Arctic countries, were crucial in the negotiations leading up to the Minamata Convention, the preamble of which references “the particular vulnerabilities of Arctic ecosystems and Indigenous communities”. The Convention mandates ongoing assessment of its effectiveness, which requires monitoring of mercury pollution. This latest assessment from AMAP provides current scientific information and context that the international community will need to understand the impact of the Convention on the Arctic environment and people, and identifies additional research needed to minimize these impacts of mercury.

<table>
<tr><th colspan="2">Reviews of mercury and biological effects in exposed of Arctic biota</th></tr>
<tr><td>Publications</td><td>
AMAP Assessment 2021: Mercury in the Arctic, ISBN – 978-82-7971-111-7, Report Chapters:
2021 AMAP Mercury Assessment, Summary for Policy-makers | AMAP
Dietz, R., Letcher, R.J. + 54 additional coauthors. 2022. AMAP Assessment 2022 Report, Chapter 6: What are the toxicological effects of mercury in Arctic marine and terrestrial mammals?, Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway
Houde, M., Krümmel, E.M., Letcher, R.J. + 37 additional coauthors. 2022. AMAP Assessment 2022 Report, Chapter 9: Contributions and perspectives of Indigenous Peoples to the study of mercury in the Arctic, Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway
McKinney, M.A., Chételat, J., Burke, S.M., Elliott, K.H., Fernie, K.J., Houde, M., Kahilainen, K.K., Letcher, R.J., Morris, A.D., Muir, D.C.G, Routti, H., Yurkowski, D.J. 2022. AMAP Assessment 2022 Report, Chapter 5: Climate change and mercury in the Arctic: Biotic interactions, Arctic Monitoring and Assessment Programme (AMAP),
Morris, A.D., Rigét, F.F., Wilson, S., Letcher, R.J. + 31 additional coauthors. 2022. AMAP Assessment 2022 Report, Chapter 4: Temporal trends of mercury in Arctic biota: 10 more years of progress in Arctic monitoring, Chapter 2, Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway
Corresponding Journal Publications of Specific AMAP Report Chapters:
Chételat, J., McKinney, M.A., Amyot, M., Dastoor, A., Douglas, T.A., Heimbürger-Boavida, L.-E., Kirk, J., Kahilainen, K.K., Outridge, P.M., Pelletier, N., Skov, H., St. Pierre, K., Vuorenmaa, J., Wang, F.: Climate change and mercury in the Arctic: Abiotic interactions, Science of the Total Environment, 824, art. no. 153715, DOI: /10.1016/j.scitotenv.2022.153715
Dietz, R., Letcher, R.J. + 54 additional coauthors. 2022. What are the toxicological effects of mercury in Arctic marine and terrestrial mammals? Special Issue-Science of the Total Environment, Vol. 829, Article #154445, DOI:10.1016/j.scitotenv.2022.154445
Houde, M., Krümmel, E.M., Letcher, R.J. + 37 additional coauthors. 2022. Contributions and perspectives of Indigenous Peoples to the study of mercury in the Arctic. Special Issue-Science of the Total Environment, in press.
McKinney, M.A., Chételat, J., Burke, S.M., Elliott, K.H., Fernie, K.J., Houde, M., Kahilainen, K.K., Letcher, R.J., Morris, A.D., Muir, D.C.G, Routti, H., Yurkowski, D.J. 2022. Climate change and mercury in the Arctic: Biotic interactions, Special Issue-Science of the Total Environment, Vol. 829, Article #155221, DOI: /10.1016/j.scitotenv.2022.155221
Morris, A.D., Rigét, F.F., Wilson, S., Letcher, R.J. + 31 additional coauthors. 2022. Temporal trends of mercury in Arctic biota: 10 more years of progress in Arctic monitoring. Special Issue-Science of the Total Environment, Vol., 829, Article #155803, DOI: /10.1016/j.scitotenv.2022.155803
Other Arctic-mercury related reviews:
Sonne, C., Letcher, R.J., Jenssen, B.M. and Dietz, R. 2022. Chapter 6 - Arctic Ecosystems, Wildlife and Man: Threats from Persistent Organic Pollutants and Mercury. In: Arctic One Health: Challenges for Northern Animals and People (ed. M. Tryland). ISBN: 978-3-030-87852-8
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Changes over time and the influence of climate and weather factors on mercury in Hudson Bay polar bears, caribou, and seabird eggs	
Focus of Research	The focus of this research was on changes over time in total mercury (THg) levels in caribou (*Rangifer tarandus groenlandicus*) from the Qamanirjuaq herd, polar bears (Ursus maritimus), and thick-billed murre eggs (*Uria lomvia*), all from the Hudson Bay region. Climate/weather variables were modelled with THg levels over time to identify the factors of influence and to potentially improve temporal trends by modelling year. This research was the result of collaborations between ECCC (and other) Arctic researchers of the Northern Contaminants Program (CIRNAC), the Nunavut Department of Environment, and many Indigenous Peoples from the participating Nunavut communities.
Results	The changes over time of mercury in Arctic wildlife is presently inconsistent within and between species and are often insignificant, which limits data interpretation. The present study compared time series of THg concentrations in liver of polar bear (2007/08–2015/16), eggs of thick-billed murres (1993–2015) and kidney of caribou (2006–2015) from the Hudson Bay region of Canada and examined THg levels over time with available climate and weather data. Significant time trends of THg concentrations were not detected in any species. However, in multivariate models that included time-lagged sea ice freeze up dates, THg concentrations increased in Qamanirjuaq caribou. Sea ice conditions were also related to THg levels in polar bear liver but not those in eggs of murres, though year was not a significant factor. Greater precipitation levels one to two years prior to sampling were associated with greater THg concentrations in polar bears and caribou, likely due to greater deposition, flooding and discharge from nearby wetlands and rivers. Time-lagged Arctic and/or North Atlantic Oscillation (AO/NAO) indices also generated significant, inverse models for all three species, agreeing with relationships in other time series of similar length. The magnitude and direction of many relationships were affected by season, duration of time-lags, and the length of the time series. The findings support recent observations suggesting that temporal studies monitoring Hg in Arctic wildlife should consider including key climatic or weather factors to help identify consistent variables of influence and to improve temporal analyses of THg time series. This study helps to assess the effectiveness of regulations in connection to the Minamata Convention on Mercury, which depends on optimal interpretation of Hg time trends in high trophic level species.
Publication	Morris, A.D., Braune, B.M., Gamberg, M., Stow, J., O'Brien, J. and Letcher, R.J. 2022. *Temporal change and the influence of climate and weather factors on mercury concentrations in Hudson Bay polar bears, caribou, and seabirds.* Environmental Research, Vol., 207, Article #: 112169, DOI: /10.1016/j.envres.2021.112169

Climate change, mercury, perfluoroalkyl substances, linked to hormone, behavioural, and reproductive responses in Arctic seabirds	
Focus of Research	Arctic wildlife concurrently experience multiple stressors, including climate change and environmental contaminants. Some contaminants may disrupt hormones that govern wildlife behaviour and responses to climatic variations. Interactions of mercury, perfluoroalkyl acids, and other chemical pollutants, on hormones, foraging behaviours, and hatching success, were identified in a long-lived Arctic seabird, thick-billed murres (*Uria lomvia*), breeding in northern Hudson Bay (2016-2018). Murres are a species heavily reliant on sea-ice, and like other birds, their thyroid hormones (e.g., triiodothyronine) have important roles in metabolism, incubation, and thermoregulation. This study was a collaboration of ECCC research scientists (Kim Fernie, Robert Letcher, Birgit Braune) and colleagues and students of McGill University.
Results	Thick-billed murres were sampled in 2016 through 2018 while breeding in northern Hudson Bay. The murres had more mercury than legacy or replacement organic chemicals or pesticides. Mercury, thyroid hormones, and foraging behaviours of the birds, varied annually, and sea-ice breakup was 1-2 weeks earlier (2016, 2017) or similar (2018) to the 50-year average. When murres were likely already stressed due to early sea-ice breakup (2016, 2017), their blood mercury levels influenced circulating triiodothyronine, that in turn, reduced the birds' foraging time underwater. It was concluded that when sea-ice breaks up early in the breeding season, mercury may interfere with the ability of murres to adjust their foraging behaviour, via thyroid hormones, to varying sea-ice conditions. Perfluoroalkyl acid pollutants also occurred in the blood of the same murres, and were higher in females than males likely reflecting feeding differences. Several of these chemicals altered circulating triiodothyronine in males, and were negatively associated with the birds' body weight. Some perfluoroalkyl acids were also related negatively to when their eggs hatched, possibly from disrupting the birds' incubation behaviour that led to earlier hatch dates. This study concluded that as an Arctic seabird experiencing several indirect effects of climate change, the interaction of perfluoroalkyl acid pollutants on the thyroid activity of the birds, may cause additional stress to murres.
Publications	Esparza, I., Elliott, K.H., Choy, E.S., Braune, B.M., Letcher, R.J., Patterson, A., Fernie, K.J. *Mercury, legacy and emerging POPs, and endocrine-behavioural linkages: implications of Arctic change in a diving seabird.* Environmental Research. volume 212A, 2022, 113190, DOI:10.1016/j.envres.2022.113190 Choy, E.S., Elliott, K.H., Esparza, I., Patterson, A., Letcher, R.J. Fernie, K.J. *Potential disruption of thyroid hormones by perfluoroalkyl acids in an Arctic seabird during reproduction.* Environmental Pollution volume 305, 2022, 119181, DOI:10.1016/j.envpol.2022.119181

Review of climate change and the flow of persistent organic chemical pollutants through Arctic food webs	
Focus of Research	The Arctic Monitoring and Assessment Programme (AMAP) produced a scientific assessment of the influence of global climate change on persistent organic pollutants (POPs) and chemicals of emerging Arctic concern (CEACs) in 2021, including a chapter on the accumulation and toxicity of these chemicals in Arctic food webs. This AMAP report and related journal review papers, was made possible by the involvement of international experts on persistent organic pollutants (in the Arctic) including numerous ECCC scientists and as well as many Indigenous Peoples from the participating communities across many national and international jurisdictions. The chapters of this new climate change-persistent organic pollutants assessment are published as separate review articles in a peer-reviewed Special Issue of the journal Environmental Science: Processes and Impacts.
Results	Concerns regarding the exposure, accumulation and toxicity of POPs and CEACs to wildlife, human health and the global environment, led to the U.N. Stockholm Convention on Persistent Organic Pollutants (1972). The Convention creates a global regulatory framework, introducing controls on the production and use of POPs and CEACs, their emissions to the environment, and the phasing-out of multiple chemical pollutants used in various products and processes. The Arctic Monitoring and Assessment Programme (AMAP) has contributed to the Stockholm Convention via its scientific assessments of POPs and CEACs in the Arctic since 1998. This new report summarizes the current understanding of how climate change influences natural processes that in turn affect POPs and CEACs, including in Arctic wildlife and food webs. Climate change interacts with other environmental stressors to impact contaminants and their toxicity to multiple Arctic wildlife species, populations and ecosystems; these stressors include physical climate parameters (e.g., climate oscillation indices, precipitation, water salinity, sea-ice age and quality), thawing of permafrost, species moving northward leading to changes in food webs. Although collectively understudied, these and other multiple stressors may cumulatively affect some Arctic wildlife populations. Global regulations and climate change can influence POPs and CEACs, but more information on a broad range of habitats, species, and processes, is required to better understand the consequences of climate change to the distribution, accumulation, and effects of POPs and CEACs in the Arctic.
Publication	Borgå, K., McKinney, M., Routti, H., Fernie, K.J., Giebichenstein, J., Muir, D., Hallanger, I. *The influence of global climate change on accumulation and toxicity of POPs and CEACs in Arctic food webs: A review.* Environmental Science: Processes and Impacts (Special Issue). 2022, DOI: 10.1039/D1EM00469G

A review of metabolic transformation of brominated flame retardants in wildlife	
Focus of Research	The focus of this review initiative was to carry out a comprehensive and systematic review of all of the available literature information since 2015 regarding the non-human animal-mediated biotransformation and metabolism of brominated flame retardant (BFR) contaminants in global wildlife, and critically evaluate the current and key knowledge gaps and research needs. This review was a collaboration of an ECCC research scientist (Robert Letcher), his PhD student (Tristan Smythe), and colleagues at the University of Stockholm, Sweden (Ake Bergman) and Nanjing University of Science and Technology, P.R. China (Guanyong Su).
Results	Over the past few decades, production trends of the flame retardant (FR) industry, and specifically for brominated FRs (BFRs), is for the replacement of banned and regulated compounds with more highly brominated, higher molecular weight compounds including polymeric compounds. Chemical, biological, and environmental stability of BFRs has received some attention over the years but knowledge is currently lacking in the transformation potential and metabolism of replacement emerging or novel BFRs (E/NBFRs). For articles published since 2015, a systematic search strategy reviewed the existing literature on the direct (e.g., in vitro or in vivo) non-human BFR metabolism in fauna (animals). Of the 51 papers reviewed, and of the 75 known environmental BFRs, PBDEs were by far the most widely studied, followed by HBCDDs and TBBPA. Experimental protocols between studies showed large disparities in exposure or incubation times, age, sex, depuration periods, and of the absence of active controls used in in vitro experiments. Species selection emphasized non-standard test animals and/or field-collected animals making comparisons difficult. For in vitro studies, confounding variables were generally not taken into consideration (e.g., season and time of day of collection, pollution point-sources or human settlements). As of 2021 there remains essentially no information on the fate and metabolic pathways or kinetics for 30 of the 75 environmentally relevant E/BFRs. Regardless, there are clear species-specific and BFR-specific differences in metabolism and metabolite formation (e.g. BDE congeners and HBCDD isomers). Future in vitro and in vivo metabolism/biotransformation research on E/NBFRs is required to better understand their bioaccumulation and fate in exposed organisms. Also, studies should be conducted on well characterized lab (e. g., laboratory rodents, zebrafish) and commonly collected wildlife species used as captive models (crucian carp, Japanese quail, zebra finches and polar bears).
Publication	Smythe, T.A., Su, G., Bergman, Å., Letcher, R.J. 2022. *Metabolic transformation of environmentally relevant brominated flame retardants in fauna: A review.* Environment International. Vol. 161, Article #: 107097, DOI: /10.1016/j.envint.2022.107097

Organophosphate diesters and a review of sources, chemical properties, environmental occurrence and adverse effects	
Focus of Research	The present review examined all organophosphate diesters (OPs) that have been reported in the scientific literature up to the end of 2020. The primary objectives were 1) to summarize all OP diesters that have been reported and to analyze their potential characteristics in environments; 2) to characterize their potential sources; 3) to summarize the occurrence and distribution of OP diesters in different environmental matrices; and 4) to discuss the current knowledge regarding the adverse effects from OP diesters in exposed animals or humans. This review was a collaboration of an ECCC research scientist (Robert Letcher) and colleagues and students at Nanjing University of Science and Technology, P.R. China (Guanyong Su).
Results	In recent years, environmental scientists have proven that OP diesters widely exist in a variety of environmental matrices and biotic samples around the world, implying the potential risks from OP diester exposure to biota and humans in the environment. The present paper reports on the review of the scientific literature for studies involving OP diesters and up to the end of 2020. The aim was to assess the present understanding of the physicochemical properties, sources (industrial production and degradation), environmental occurrence of OP diesters, and adverse effects to exposed organisms. In screening the literature at least 23 OP diesters have been reported as contaminants in various environments or as degradation products of OP triesters. The physicochemical properties of OP diesters vary depending on their specific chemical structures. There were multiple sources of OP diesters, including industrial production and biotic or abiotic degradation from OPE triesters. Ten OP diesters are produced somewhere in the world, and the total annual output was estimated to be 17,050 metric tons. The wide application of OP triesters worldwide makes the degradation of OP triesters another critical source of OP diesters to the environment and to organisms. Current monitoring studies have demonstrated that some OP diesters were detectable in the human body (via both blood and urine samples), indoor dust, natural/wastewater, sewage sludge, or organisms worldwide. The adverse effects following direct or indirect exposure to 11 OP diesters in organisms (including animals, humans, bacteria, and algae) have been reported, and the recorded adverse outcomes following exposure to OP diesters included developmental toxicity, alteration of gene expression, and disturbance of nuclear receptor activity. Biomonitoring studies regarding human samples have frequently reported statistically significant associations between the concentrations of OP diesters and markers of human health (mainly related to reproductive toxicity).
Publication	Liu, Y., Gong, S., Ye, L., Li, J., Liu, C., Chen, D., Fang, M., Letcher, R.J., Su, G. 2021. *Organophosphate (OP) Diesters and a review of sources, chemical properties, environmental occurrence, adverse effects, and future directions.* Environment International. Vol.155, Article #: 106691, DOI: 10.1016/j.envint.2021.106691

Evaluating using insect-eating birds to monitor microplastics in the terrestrial environment	
Focus of Research	Microplastics are some of the most ubiquitous environmental pollutants globally. To date, most microplastics research has focused on marine and freshwater ecosystems with only limited research investigating microplastics in terrestrial ecosystems and biota. This study investigated the presence of microplastics (over 125 µm) in tree swallow (Tachicyneta bicolor) chicks, an aerial insectivore bird whose diet involves insects from terrestrial and/or freshwater sources. Comparisons were made between tree swallow chicks that were raised immediately downstream (300 m) of the discharge pipe of a large, urban wastewater treatment plant (WWTP) or 40 km away at a rural conservation area. The study was a collaboration between ECCC research scientists (Kim Fernie, Jennifer Provencher) and the University of Toronto.
Results	Anthropogenic microparticles, including microplastics, were identified in nearly 90% of chicks raised downstream of the wastewater treatment plant and 83% of the reference chicks. All microparticles were fibers in the gastro-intestinal tracts of chicks raised near the wastewater treatment plant, whereas unexpectedly, microparticles were more diverse in the gastro-intestinal tracts of reference chicks, with ~15% characterized as pre-production plastic pellets. The feces of 90% of all chicks contained microparticles that were all fibers, suggesting their excretion by the chicks. Comparatively, the reference chicks had more microparticles in their feces and larger particles in their gastro-intestinal tracts, likely reflecting their more aquatic-based diet compared to the more terrestrial-based diet of the chicks raised downstream of the wastewater treatment plant. The numbers of microparticles were not associated between the chicks' gastro-intestinal tracts and feces, nor with the chicks' body condition or size (weight, organs, feathers). Recommendations included sampling macroinvertebrate prey to permit stronger conclusions regarding wastewater treatment plants as possible sources of microplastics for swallows, and to determine if such macroinvertebrates may be a non-lethal method to characterize microparticle diversity ingested by birds as presently identified in the chicks' gastro-intestinal tracts. It was concluded that sampling feces only, while not indicative of the diversity of microplastics ingested by terrestrial passerines (e.g., tree swallows), is useful for determining their exposure to microparticles.
Publication	Sherlock, C., Fernie, K.J., Munno, K., Provencher, J., Rochman, C. *The potential of aerial insectivores for monitoring microplastics in terrestrial environments.* Science of the Total Environment volume 807, 2022, 150453, DOI:10.1016/j.scitotenv.2021.150453

Effects of neonicotinoid insecticides on non-target aquatic organisms	
Focus of Research	The study assessed the effects of neonicotinoid insecticides on tadpole stress metrics to understand the sublethal effects of chronic exposure to these compounds on sensitive non-target vertebrates. Specifically, blood cell profiles, measures of oxidative stress , susceptibility to parasites and concentrations of a stress hormone, corticosterone were assessed.
Results	Northern leopard frogs (*Rana (Lithobates) pipiens*) were found to show signs of mild stress based on blood cell profiles and some indication for oxidative damage when exposed to clothianidin (a neonicotinoid). Furthermore, thiamethoxam (also a neonicotinoid) altered some blood cell profiles, but neither clothianidin nor thiamethoxam affected corticosterone concentrations or parasite infection status. These studies indicate that northern leopard frog tadpoles exposed to some neonicotinoids for prolonged periods have increased stress responses, but the implications on overall health are unclear. This work contributes to understanding the global concern for neonicotinoid insecticides on non-target aquatic vertebrates and will inform regulations for this pesticide product.
Publications	Gavel, M.J., Young, S.D., Dalton, R.L., Soos, C., McPhee, L., Forbes, M.R., Robinson, S.A. 2021. *Effects of two pesticides on northern leopard frog* (*Lithobates pipiens*) *stress metrics: Blood cell profiles and corticosterone concentrations.* Aquatic Toxicology 235:105820 DOI:10.1016/j.aquatox.2021.105820 **This work was conducted in collaboration with Carleton University* Gavel, M.J., Young, S.D., Blais, N., Forbes, M.R., Robinson, S.A. *Trematodes coupled with neonicotinoids: effects on blood cell profiles of a model amphibian. Parasitology* Research 120 (6): 2135-2148. DOI:10.1007/s00436-021-07176-x **This work was conducted in collaboration with Carleton University* Robinson, S.A., Chlebak, R.J., Young, S.D., Dalton, R.L., Gavel, M.J., Prosser, R.S., Bartlett, A.J., de Solla, S.R. *Clothianidin alters leukocyte profiles and elevates measures of oxidative stress in tadpoles of the amphibian, Rana pipiens.* Environmental Pollution 284:117149 DOI: 10.1016/j.envpol.2021.117149 *This work was conducted in collaboration with Carleton University

Evaluation of thyroid disrupting activities of a synthetic phenolic antioxidant	
Focus of Research	The study assessed the effects of the synthetic phenolic antioxidant 4,4'-thiobis(6-t-butyl-m-cresol) (acronym TBBC) used in a variety of common plastic and rubber products to extend product life from oxidation (e.g., reduce discolouration, rust formation, rubber degradation). The western-clawed frog (*Silurana tropicalis*) was used to determine if embryo survival and development were affected after 96 hours of exposure or if the compound affected metamorphic development of tadpoles after 48 to 52 days of exposure.
Results	Acute 96-hour exposures determined the lethal concentration for 50% mortality (LC_{50}) was 70.5 µg/L and the effective concentration for 50% with malformations (EC_{50}) was 76.5 µg/L. Exposure concentrations from 25 to 100 µg/L affected embryo growth with complete mortality at 200 and 400 µg/L. Chronic exposure to 5 µg/L reduced body size by 8% snf sy 0.002 µg/L reduced body mass by 17% compared to clean water control treatments. This study provides the first amphibian toxicity assessment of TBBC, where it was found to be toxic, induce malformations and inhibit tadpole growth after acute and chronic exposures. The results will contribute to the risk assessment for this compound and inform future toxicity studies on synthetic phenolic antioxidants.
Publication	Reyes, Y.M., Robinson, S.A., De Silva, A., Brinovcar, C., Trudeau, V.L. *Exposure to the synthetic phenolic antioxidant 4,4'-thiobis(6-t-butyl-m-cresol) disrupts early development in the frog Silurana tropicalis.* Chemosphere, DOI: 10.1016/j.chemosphere.2021.132814 **This study was conducted in collaboration with the University of Ottawa.*

Toxicity of rare earth elements in rainbow trout and hydra	
Focus of Research	To determine the toxicity and the mechanism of action of rare earth elements.
Results	The toxicity and mode of action for over 10 rare earth elements were examined in rainbow trout and hydra. The lethal toxicity could be predicted by the electronegativity and ionic radius in fish and hydra. The mode of action studies revealed that rare earth elements could damage (denature) proteins, alter bone formation and damage DNA at concentrations 200 times below the acute toxicity values.
Publications	Hanana, H., Taranu, Z.E., Turcotte, P., Gagnon, C., Kowalczyk, J., Gagné, F. 2020. *Evaluation of general stress, detoxification pathways, and genotoxicity in rainbow trout exposed to rare earth elements dysprosium and lutetium.* Ecotoxicology and Environmental Safety, 2021, 208, 111588 Hanana, H., Taranu, Z.E., Turcotte, P., Kowalczyk, J., Gagné, F. 2021. *Sublethal effects of terbium and praseodymium in juvenile rainbow trout.* Science of the Total Environment, 2021, 777, 146042

7.1.1.3 Nanomaterials

Occurrence and size distribution of silver nanoparticles in wastewater effluents from various treatment processes in Canada	
Focus of Research	The objective of this investigation was to examine the occurrence and the size distribution of Silver (Ag) released from municipal effluents. From an environmental risk management perspective, it is important to better understand the size distribution of Ag released in nanoparticle (NP) form since NPs could possess different toxicities than their bulk ionic counterpart (i.e., Ag (I) because of the high surface area and reactivity). This is the first study on the characterization of NP Ag releases from different WWTPs using single particle-mode Inductively Coupled Plasma-Mass Spectrometry (ICP-MS), a technique adapted for the specific detection of NPs. Municipal effluents from ten municipalities using different treatment processes (from aerated lagoons to advanced biological treatments), were sampled across Canada. Moreover, untreated wastewaters were also collected to determine the overall Ag removal at WWTPs.
Results	ECCC's results showed the presence of silver nanoparticles (Ag NP) in all effluent samples with concentrations reaching 0.5 ng/L on a mass basis. However, on a particle number basis, Ag NP concentrations (expressed in particles/mL) in the 20-34 nm fraction (up to 3400 particles/mL) were much more abundant (>700%) than in the >35 nm larger fraction. The proportion of Ag at the nanoscale (1-100 nm) represents less than 8% of the total suspended Ag for all effluent samples. Because Ag nanotoxicity is size dependent, the determination of size distribution and exposure concentration on a particle number basis (i.e., number instead of mass) could be a useful focus when conducting risk assessments of this class of nanomaterial.
Publication	Gagnon C, Turcotte P, Gagné F, Smyth SA. 2021. *Occurrence and size distribution of silver nanoparticles in wastewater effluents from various treatment processes in Canada.* Environ Sci Pollut Res. 28 : 65952–65959. DOI: 10.1007/s11356-021-15486-x

7.1.2 Health Canada Research

HC funded 24 CMP Research and Monitoring and Surveillance projects in 2021-2022. These projects addressed departmental and international priorities and covered a number of subjects such as:

- the development of new methods for detection of chemicals and assessment of toxicity
- the characterization of chemical exposures in Canadians and their homes
- the characterization and toxicological response to nanomaterials, microplastics and products of biotechnology
- new approach methodologies,
- carcinogenic and genetic toxicity assessment
- the effects of chemicals on human health,
- hazard characterization

7.1.2.1 Chemical substances in Canadians

	National Biomonitoring Program under the Canadian Health Measures Survey (CHMS)
Focus of Research	Canadian Health Measures Survey (CHMS) is a national survey led by Statistics Canada, in partnership with Health Canada and the Public Health Agency of Canada. The physical measures component of the survey includes biomonitoring, the measurement of environmental chemicals or their metabolites in blood, urine and/or hair samples, funded and led by Health Canada's National Biomonitoring Program. Since 2007, the National Biomonitoring Program has established baseline concentrations for over 250 environmental chemicals in Canadians supporting the identification of risk assessment priorities, characterization of exposures in risk assessments, performance measurement of recent risk management actions, while also serving as the basis of numerous scientific research studies.
Results	Significant monitoring and research activities of the National Biomonitoring Program for 2021-2022 included: • the publication of the Sixth Report of Human Biomonitoring of Environmental Chemicals in Canada that includes data for 79 environmental chemicals ((e.g., alternate plasticizers and pesticides) collected from CHMS cycle 6 (2018-2019) • the publication of biomonitoring fact sheets for arsenic, cadmium, lead, mercury, PFAS, DEHP, bisphenol A (BPA) and parabens that highlight changes in Canadians' exposures to these chemicals over time, and comparison among populations in Canada and the United States • the publication of a key paper discussing time trends for 39 environmental chemicals measured in at least three time points between 2007 and 2017 in CHMS • the continued development of the Exposure Load approach for quantifying multi-chemical exposure burden • the refinement of the online biomonitoring guidance value database and comparison tool • the refinement of analytical methods for certain chemicals prioritized for biomonitoring in CHMS cycle 7 • the completion of analysis of the CHMS biobank samples for selected chemicals originally slated for measurement in CHMS cycle 7 minimizing the regulatory impact of the delay in the start of the CHMS cycle 7
Publications	Pollock, T., Karthikeyan, S., Walker, M., Werry, K., St-Amand, A. 2021. *Trends in environmental chemical concentrations in the Canadian population: Biomonitoring data from the Canadian Health Measures Survey 2007-2017.* Environment International. Vol.155, 106678, DOI: 10.1016/j.envint.2021.106678 Health Canada. 2021. Sixth report on human biomonitoring of environmental chemicals in Canada. Minister of Health, Ottawa, ON. ISBN : 2562-9360 Health Canada. 2021. *Arsenic in Canadians.* Ottawa, ON. ISBN: 978-0-660-40587-2 Health Canada. 2021. *Cadmium in Canadians*. Ottawa, ON. ISBN: 978-0-660-40591-9 Health Canada. 2021. *Lead in Canadians*. Ottawa, ON. ISBN: 978-0-660-40595-7 Health Canada. 2021. *Mercury in Canadians*. Ottawa, ON. ISBN: 978-0-660-40597-1 Health Canada. 2021. *Per- and polyfluoroalkyl substances (PFAS) in Canadians*. Ottawa, ON. ISBN: 978-0-660-40601-5 Health Canada. 2021. *Di(2-ethylhexyl) phthalate (DEHP) in Canadians*. Ottawa, ON. ISBN: 978-0-660-40593-3 Health Canada. 2021. *Bisphenol A (BPA) in Canadians.* Ottawa, ON. ISBN: 978-0-660-40589-6 Health Canada. 2021. *Parabens in Canadians.* Ottawa, ON. ISBN: 978-0-660-40599-5

The Maternal Infant Research on Environmental Chemicals (MIREC) Research Platform	
In Collaboration With	Clinical and academic researchers, and Centre Hospitalier Universitaire Sainte-Justine
Focus of Research	The MIREC Research Platform is designed to obtain pan-Canadian data on maternal, fetal, and childhood exposure to priority environmental chemicals and potential adverse health effects on pregnancy, as well as newborn, infant, and childhood growth and development. It encompasses the original MIREC Study of Canadian pregnant women and the follow-up studies of some of their infants (MIREC-Infant Development: MIREC-ID), young children (MIREC-Child Development at age 3: MIREC-CD3, and MIREC-Early Childhood Biomonitoring and Neurodevelopment: MIREC-CD Plus) and adolescents (MIREC - Pubertal Timing, Endocrine and Metabolic Function: MIREC-ENDO). The Platform also includes a repository of MIREC data and biospecimens, the MIREC Biobank, for additional research on the health of mothers and their children.
Results	In 2021-2022, 10 MIREC Research Platform papers were published, six of which were co-authored by Health Canada. These studies investigated prenatal and lactational exposure to multiple chemicals and nutrients including metals, PFAS, bisphenol A, air pollution, and vitamin D. MIREC researchers published the first pan-Canadian dataset of PFAS in human milk concentrations. Another study addressed a scientific controversy regarding the appropriate analytical method for measuring total urinary BPA. The MIREC Research Platform continues to generate new knowledge on early life cumulative exposure to environmental chemicals and potential health risks in vulnerable populations of pregnant women, fetuses, infants, and children that contributes to risk assessment and management of chemicals both in Canada and internationally.
Publications	Ashley-Martin, J., Gaudreau, É., Dumas, P., Liang, C. L., Logvin, A., Bélanger, P., Provencher, G., Gagne, S., Foster, W., Lanphear, B., Arbuckle, T.E. 2021. *Direct LC-MS/MS and indirect GC–MS/MS methods for measuring urinary bisphenol A concentrations are comparable.* Environment International, Vol. 157, article number 106874, DOI: 10.1016/j.envint.2021.106874 Fisher, M., Potter, B., Little, J., Oulhote, Y., Weiler, H. A., Fraser, W., Morisset, A.S., Braun, J., Ashley-Martin, J., Borghese, M.M., Shutt, R., Kumarathasan, P., Lanphear, B., Walker, M., Arbuckle, T. E. 2022. *Blood metals and vitamin D status in a pregnancy cohort: A bidirectional biomarker analysis.* Environmental Research, Vol. 211, article number 113034, DOI: 10.1016/j.envres.2022.113034 Gogna, P., King, W. D., Villeneuve, P. J., Kumarathasan, P., Johnson, M., Lanphear, B., Shutt, R., Arbuckle, T.E., Borghese, M. M. 2021. *Ambient air pollution and inflammatory effects in a Canadian pregnancy cohort.* Environmental Epidemiology, Vol. 5, Issue 5, p e168, DOI: 10.1097/EE9.0000000000000168 Johnson, M., Shin, H. H., Roberts, E., Sun, L., Fisher, M., Hystad, P., Van Donkelaar, A., Martin, R.V., Fraser, W.D., Lavigne, E., Clark, N., Beaulac, V., Arbuckle, T.E. 2022. *Critical Time Windows for Air Pollution Exposure and Birth Weight in a Multicity Canadian Pregnancy Cohort.* Epidemiology (Cambridge, Mass.), Vol. 33, Issue 1, pp 7-16, DOI: 10.1097/EDE.0000000000001428 Rawn, D. F., Dufresne, G., Clément, G., Fraser, W. D., & Arbuckle, T. E. 2022. *Perfluorinated alkyl substances in Canadian human milk as part of the Maternal-Infant Research on Environmental Chemicals (MIREC) study.* Science of The Total Environment, Vol. 831, article number 154888, DOI: 10.1016/j.scitotenv.2022.154888 Weiler, H. A., Brooks, S. P., Sarafin, K., Fisher, M., Massarelli, I., Luong, T. M., Johnson, M., Morisset, A.S., Dodds, L., Taback, S., Helewa, M., von Dadelszen, P., Smith, G., Lanphear, B.P., Fraser, W.D., Arbuckle, T.E. 2021. *Early prenatal use of a multivitamin diminishes the risk for inadequate vitamin D status in pregnant women: results from the Maternal-Infant Research on Environmental Chemicals (MIREC) cohort study.* The American journal of clinical nutrition, Vol. 114, Issue 3, pp 1238-1250, DOI: 10.1093/ajcn/nqab172

Return to 2.1.2 Chemicals in humans

7.1.2.2 Methods

Development of non-targeted methods for use of human biomonitoring data in chemical risk assessment	
In Collaboration With	• U.S. National Institute of Standards and Technology. • U.S. Environmental Protection Agency, Office of Research and Development, Center for Computational Toxicology and Exposure. • Toxicology Centre, University of Saskatchewan. • Southern California Coastal Water Research Project Authority. • Southwest Research Institute. • U.S. Food and Drug Administration, Center for Food Safety and Applied Nutrition. • Institute of Environment & Department of Chemistry and Biochemistry, Florida International University. • U.S. Food and Drug Administration, Center for Devices and Radiological Health. • Agilent Technologies, Inc. • Connecticut Agricultural Experiment Station. • Pacific Northwest National Laboratory. • U.S. Environmental Protection Agency, Office of Research and Development, Center for Public Health and Environmental Assessment. • Department of Food Chemistry and Toxicology, Faculty of Chemistry, University of Vienna.
Focus of Research	Non-targeted analysis (NTA) encompasses a rapidly evolving set of mass spectrometry techniques aimed at characterizing the chemical composition of complex samples, identifying unknown compounds, and/or classifying samples, without prior knowledge regarding their chemical content. Recent advances in NTA are the result of improved and more accessible instrumentation for data generation and analysis tools for data evaluation and interpretation. As researchers continue to develop NTA approaches in various scientific fields, there is a growing need to identify, disseminate, and adopt community-wide method reporting guidelines. In 2018, NTA researchers formed the Benchmarking and Publications for Non-Targeted Analysis Working Group (BP4NTA) to address this need. Consisting of participants from around the world and representing fields ranging from environmental science and food chemistry to 'omics and toxicology, BP4NTA provides resources addressing a variety of challenges associated with NTA. This research supports the risk assessment and risk management of chemicals under the Chemicals Management Plan and responds to Health Canada's responsibilities legislated in the Canadian Environmental Protection Act. The goal of this research is to establish a consensus on NTA-related terms and concepts and to create consistency in reporting practices.
Results	This publication describes the mandate, priorities, and progress of the BP4NTA Working Group. BP4NTA members aim to establish a consensus on NTA-related terms and concepts and to create consistency in reporting practices by providing publicly available web resources, including consensus definitions, reference content, and lists of available tools. Moving forward, BP4NTA will provide a setting for NTA researchers to continue discussing emerging challenges and contribute to additional harmonization efforts. The efforts will allow NTA approaches to be more applicable to screening emerging and unknown chemicals for human exposure assessment. Tools, reporting, and webpages will remain flexible, permitting ongoing updates as NTA techniques evolve and advance.
Publication	Place, B.J., Ulrich, E.M., Challis, J.K., Chao, A., Du, B., Favela, K., Feng, Y.L., Fisher, C.M., Gardinali, P., Hood, A. and Knolhoff, A.M., 2021. *An Introduction to the Benchmarking and Publications for Non-Targeted Analysis Working Group.* Analytical Chemistry, Vol. 93, issue 49, pp.16289-16296, DOI: 10.1021/acs.analchem.1c02660

Development of novel methods to assess endocrine toxicity of chemical replacements	
In Collaboration With	• Department of Pharmacology & Therapeutics, McGill University • Department of Obstetrics & Gynecology, McGill University
Focus of Research	There continues to be a growing concern related to the impact of chemical exposures on the endocrine system. Over the past decades, Canada (under CEPA), and other international governments, have regulated the production and use of chemicals shown to act as endocrine disruptors. Consequently, this has led to an increased use of alternative chemicals to address market needs. However, toxicity data is limited or not available for many of these replacement chemicals. With a focus on select flame retardants and plasticizers as example chemical classes, the main goals of this multidisciplinary team grant research project project titled "Endocrine Disrupting Chemicals: Towards Responsible Replacements" are to (1) determine potential for exposure to replacement chemicals, (2) examine the toxicity and potential adverse health effects, and (3) engage with project partners from government, industry, and non-government agencies to discuss safer replacements.
Results	Non-animal methods are used to assess the toxicity of exposure to concentrations of the emerging chemicals found in food and drinking water as detected in human biomonitoring studies. A range of cell lines representing key endocrine functions show that exposure to various replacements result in cell-line and chemical-specific effects on cell viability and phenotypic endpoints. This project contributes to a global effort to reduce animal testing and provides an improved understanding of the potential for toxicity of chemicals that currently lack health effects data. These methods can provide evidence in a screening strategy to identify chemicals with the potential for reproductive and endocrine effects to set priorities for further assessment.
Publications	Rajkumar, A., Luu, T., Beal, M.A., Barton-Maclaren, T.S., Robaire, B., Hales, B.F. 2021. *Elucidation of the Effects of Bisphenol A and Structural Analogs on Germ and Steroidogenic Cells Using Single Cell High-Content Imaging.* Toxicological Sciences, Vol. 180, Issue 2, pp 224-238, DOI: 10.1093/toxsci/kfab012 Wang, X., Luu, T., Beal, M.A., Barton-Maclaren, T.S., Robaire, B., Hales, B.F. 2022. *The Effects of Organophosphate Esters Used as Flame Retardants and Plasticizers on Granulosa, Leydig, and Spermatogonial Cells Analyzed Using High-Content Imaging.* Toxicological Sciences, Vol. 186, Issue 2, pp 269-287, DOI: 10.1093/toxsci/kfac012 Rajkumar, A., Luu, T., Beal, M.A., Barton-Maclaren, T.S., Hales, B.F., Robaire, B. 2022. *Phthalates and alternative plasticizers differentially affect phenotypic parameters in gonadal somatic and germ cell lines.* Biology of Reproduction, Vol. 106, Issue 3, pp 613-627, DOI: 10.1093/biolre/ioab216

Development and application of computational screening methods to predict chemical potency	
In Collaboration With	Center for Computational Toxicology and Exposure, Office of Research and Development, U.S. Environmental Protection Agency, Research Triangle Park, NC, USA
Focus of Research	Globally, there are thousands of existing and newly introduced chemicals in commerce with increasing complexity and often with limited toxicity and exposure information. There is a critical need for robust high throughput methods for identifying priorities for chemical risk assessment and risk management. Health Canada continues to increase efforts to advance risk science through the exploration, development and application of computational tools and new approach methodologies (NAMs) to effectively leverage and integrate existing and emerging data. This work explored the use of a novel workflow that applied *in silico* predictions and read-across methodology to fill key data gaps supporting prioritization of chemicals on the Canadian Domestic Substances List (DSL).
Results	In this project the use of in silico models were explored to address data needs for high throughput toxicokinetics (HTTK) and to predict biological activity of data-poor chemicals on the DSL. Applying the computational approach expanded the number of chemicals that could be screened from an initial 357 chemicals that met the original data requirements for application of the approach to thousands of chemicals. This work demonstrates the power of using NAMs combined with read-across methods allowing for more concentrated focus on testing and assessment efforts of chemicals demonstrating the highest potential for hazard and risk.
Publication	Beal, M.A., Gagne, M., Kulkarni, S.A., Patlewicz, G., Thomas, R.S., Barton-Maclaren, T.S. 2022. Implementing in vitro bioactivity data to modernize priority setting of chemical inventories. ALTEX, Vol. 39, Issue 1, pp 123-139, DOI: 10.14573/altex.2106171

7.1.2.3 Exposure characterization

Characterization of residential exposures Canadian House Dust Study	
Focus of Research	The Canadian House Dust Study, a national study involving the collection of dust samples from urban households, provides insight into the presence of chemicals of concern in Canadian households, and the levels to which Canadians are typically exposed. This research supports risk assessment and risk management actions under the Chemicals Management Plan and the *Canadian Environmental Protection Act*. The goal of this research is to develop and apply methods for the quantification of specific organic compounds (targeted aryl and alkyl-aryl phosphates, which are common in flame retardants and plasticizers) as well as mercury and total carbon content, in Canadian house dust samples.
Results	Study results indicate that some of the target organic compounds were detected in 100% of the samples and detection frequency aligned with concentrations in flame retardant blends used in large quantities in Canada. Strong correlations were found among the three investigated flame retardants, suggesting that consumer and building products containing mixtures of these substances may be present in Canadian homes. Average mercury (Hg) concentrations were found to be higher than average background concentrations reported for outdoor samples, such as soils and sediments. Additionally, investigation of total carbon (TC) identified a correlation between total Hg and TC, reflecting associations previously seen in the outdoor environment. All together, these studies will not only provide household exposure data for Canadians and assist in the development and prioritization of mitigation strategies, but also establish baseline concentrations from the time of sample collection (2007-2010) to support future monitoring of changes and trends. Monitoring could include assessing the impact of industrial or environmental changes and the effectiveness of mitigation. For example, future monitoring of Canadian house dust may provide additional data to identify changing patterns of flame retardant and Hg exposure in Canadian homes.

Characterization of residential exposures Canadian House Dust Study	
Publications	Kubwabo C., Fan X., Katuri G.P., Habibagahi A., Rasmussen P.E., 2021. *Occurrence of aryl and alkyl-aryl phosphates in Canadian house dust.* Emerging Contaminants, Vol. 7, pp. 149-159, DOI: 10.1016/j.emcon.2021.07.002 Levesque, C., Rasmussen, P.E., 2022. *Determination of Total Mercury and Carbon in a National Baseline Study of Urban House Dust.* Geosciences, Vol. 12, issue 2, art. no. 52, DOI: 10.3390/geosciences12020052

Monitoring of data-poor environmental contaminants in Canadian surface water and sediment	
Focus of Research	The study focuses on methods of detection and measurement of pesticides and pharmaceuticals in aquatic environments. The information from these measurements is critical to understanding the environmental fate, transport, and occurrence of these substances and assessment of their importance to the health and safety of Canadians and the Canadian environment. Traditional monitoring of environmental contaminants in surface water has consisted of analysis for a set of targeted compounds in discrete samples. The study examined new methods of detection of contaminants in rural, urban, and agricultural areas, using two types of passive chemical samplers, combined with non-targeted analysis. This study was conducted in collaboration with Agriculture and Agri-Food Canada.
Results	Traditional targeted sampling has the limitation of providing only information on compounds within a target list at the time and location of sampling. To try to improve on these methods, which potentially miss episodic events and provide only a 'snapshot', two passive samplers were compared, combined with non-targeted analysis (NTA) which detects all ionisable compounds, with the added benefit of data archiving for retrospective mining. Of the two passive samplers compared, polar organic chemicals integrative samplers were found to capture the largest number of analytes with better reproducibility. NTA combined with passive sampling was found to give a more representative picture of the contaminants in mixed-use watersheds representing rural, mixed urban/agricultural, and forested/peri-urban areas. This represents an increase in the amount of chemicals that can be measured, a way to look over a longer term at increases and decreases of a chemical, and the ability to go back and look backwards over previous years at a chemical that is emerging as a new concern.
Publication	Renaud J.B., Sabourin L., Hoogstra S., Helm P., Lapen D.R., Sumarah M.W. 2021 *Monitoring of environmental contaminants in mixed-use watersheds combining targeted and nontargeted analysis with passive sampling.* Environmental Toxicology and Chemistry. 2022 May;41(5):1131-43 (Published online 18 August 2021 in Wiley Online Library (wileyonlinelibrary.com), DOI: https://doi.org/10.1002/etc.5192

Influence of conjugation on fate of hormones and pharmaceuticals in Canadian wastewater treatment plants	
Focus of Research	Pharmaceuticals and hormones may be excreted by humans in conjugated forms, as a result of metabolism. Conjugation is the binding of a small molecule to the larger pharmaceutical or hormone, usually to increase water solubility and make the molecule easier to excrete. Deconjugation (removal of the small molecule) by naturally occurring enzymes in the environment and in wastewater treatment plants (WWTPs) returns the substances to their original form and potency. Detection methods look for only the original free hormone or pharmaceutical and may underestimate the amount, because conjugated forms are not detected. Therefore the level of pharmaceuticals and hormones in municipal WWTPs may be underestimated. The study examined the utility of deconjugating enzymes during screening, to more accurately quantify the occurrence and removal of hormones and pharmaceuticals. This study was conducted in collaboration with Environment and Climate Change Canada.
Results	The study showed that conjugation and deconjugation impact the concentrations and fate of some pharmaceuticals and hormones and their impact varies between analytes and WWTP treatment type. Some pharmaceuticals did not undergo deconjugation in simpler wastewater treatment facilities such as lagoons, and were therefore not removed prior to release, compared to WWTPs which use biological processes in secondary and advanced treatment. Other pharmaceuticals were shown not to undergo deconjugation and removal in any WWTP, indicating the potential for slow deconjugation and increasing prevalence in the natural environment. The study demonstrated that it is useful to include a deconjugating step during screening of water from WWTPs, because it allows identification of the total (conjugated + deconjugated) form of a pharmaceutical or hormone. The technique was discussed for application to other chemicals excreted by humans in conjugated forms, such as BPA.
Publication	Gewurtz S.B., Teslic S., Hamilton M.C., Smyth S.A., 2022. *Influence of Conjugation on the Fate of Pharmaceuticals and Hormones in Canadian Wastewater Treatment Plants*. ACS Environmental Science & Toxicology Water. DOI: 10.1021/acsestwater.1c00376

7.1.2.4 Toxicity characterization

Potency ranking of per-and polyfluoroalkyl substances using high-throughput transcriptomic analysis of human liver spheroids	
In Collaboration With	University of Ottawa and the US National Institutes of Health.
Focus of Research	Per- and poly-fluoroalkylated substances (PFAS) are a large class of chemicals found in the environment due to their industrial and commercial uses, their persistence, and their high mobility. Exposure to PFAS has been linked to health effects including liver and kidney toxicity. Health Canada compiled a list of 23 PFAS that best represent variability in chemical composition across PFAS and importantly, have been found in Canadian drinking water or could be detected in drinking water. In this study, human liver cells in culture grown as spheroids were exposed to a group of 23 PFAS for shorter (1-day) and longer (10-day) durations and then ranked by potency and hazardous potential using toxicogenomic data. Toxicogenomics is a field of study that investigates how genes respond to chemical exposures, providing information on biological changes related to disease. The aim of the investigation was to use high throughput toxicogenomic methods to identify patterns of potency for various groups of PFAS.
Results	Health Canada found that longer carbon chain length PFAS (7 to 10 carbons) were more potent than shorter-chain length PFAS (fewer than 6 carbons). Specific PFAS had a greater likelihood of inducing biological changes at lower exposure levels, and the 23 PFAS studied could be ranked by their potency. This study improves understanding of the health effects of PFAS and demonstrates the potential for toxicogenomic techniques as an alternative to more traditional toxicological methodologies using animals. These techniques are examples of New Approach Methodologies (NAMs), which are essential in moving beyond traditional animal testing methods. Acquiring information on data poor substances for risk assessment has been challenging for regulatory agencies worldwide, including Health Canada, and these NAMs may be an important tool for generating data for future risk assessment activities with respect to PFAS, and other chemical classes.
Publication	Reardon, A. J., Rowan-Carroll, A., Ferguson, S. S., Leingartner, K., Gagne, R., Kuo, B., Williams, A., Lorusso, L., Bourdon-Lacombe, J.A., Carrier, R., Moffat, I., Yauk, C.L., Atlas, E. 2021. *Potency ranking of per-and polyfluoroalkyl substances using high-throughput transcriptomic analysis of human liver spheroids.* Toxicological Sciences, Vol. 184, issue 1, pp 154-169, DOI: 10.1093/toxsci/kfab102

7.1.2.5 Nanomaterials and Microplastics

Low dose antibiotic ingestion potentiates systemic and microbiome changes induced by silver nanoparticles	
In Collaboration With	Environment and Climate Change Canada, and McMaster University
Focus of Research	Health Canada is responsible for regulating applications and products containing nanoparticles (NPs) to protect the health of Canadians. In order to provide scientific evidence towards human health risk assessments of NPs, research at Health Canada is aimed at understanding the behaviour and effects of NPs on human health in various exposure scenarios. Health Canada studied NPs composed of silver, which are added as antibiotics in several different consumer products such as bandages, food packaging, and sports clothing. Existing scientific evidence for the health hazard associated with silver NPs is conflicting, but evidence from exposure to other antibiotics provides a strong rationale to assess silver NP effects on organ function, immunity, metabolism, and gut-associated microbiota. The aim of this study was to investigate systemic toxicity of silver NPs, including toxic effects on the microbiome.
Results	Mice were exposed to silver NPs for 5 weeks by ingestion, with and without low doses of conventional antibiotics. Animals were weighed daily, assessed for glucose tolerance, organ function, tissue and blood immunological markers, and changes in the gut microbiome. The data demonstrated animal weight loss and systemic immunological effects which corresponded with alterations in the gut microflora. Gut microbiota changes were more sensitive indicators of toxicity compared to metabolic or immunological markers. Furthermore, the study identified alterations in the presence of specific types of microbes associated with immunological balance. This study supports the notion that key microbial species in the gut may serve as sensitive indicators of chemical-induced stress, even at doses that may not elicit a systemic response. The results will support development of novel toxicological endpoints that can be used for risk assessment of nanomaterials
Publication	Meier M.J., Nguyen K.C., Crosthwait J, Kawata A., Rigden M. ,Leingartner K., Wong A., Holloway A., Shwed P.S., Beaudette L., Navarro M., Wade M., Tayabali A.F. 2021. *Low dose antibiotic ingestion potentiates systemic and microbiome changes induced by silver nanoparticles. NanoImpact,* Vol. 23, article number 100343, DOI: 10.1016/j.impact.2021.100343

Adverse Outcome Pathways to identify, prioritize and develop mechanisms-informed experimental test systems and targeted toxicity assays for nanomaterials and microplastics safety assessment	
Focus of Research	Nanomaterials (NM) are man-made substances in the size range of 1-100 nanometers with unique properties widely used in various commercial applications. According to animal-based research results, the size-associated properties of some NMs contribute to their toxicity. Microplastics (MP) are small fragments, fibres or particles generated from weathering of plastics in the environment. MPs share many properties with NMs and could also pose a health hazard. Animal testing is not a feasible option for NMs or MPs because of the time and resource intensiveness of toxicity testing methods, the considerable number of particles and the diversity of particle properties to be assessed. Adverse Outcome Pathway (AOP), and AOP-informed mechanism-based approaches are under development as alternatives to animal testing for NM and MP safety assessment. AOPs enable the systematic organization of complex information about mechanisms that eventually lead to toxic effects through simple linear sequences of key biological events at the cellular, tissue and individual or population levels. AOPs allow the design and development of targeted strategies as alternatives to animal testing.
Results	Through a systematic literature review a NM database and a method for identification of Key Events (KEs) from the NM literature were developed. KEs are biological events induced by NMs, related to mechanisms of NM-induced toxicity. Several KEs that can be targeted by readily available, specific, and non-animal, assays were identified. Furthermore, five AOPs related to lung toxicity due to NM inhalation are under development. Moreover, NM literature was used to propose an AOP and to prioritize and develop mechanism-informed experimental test systems and targeted toxicity assays for the safety assessment of MPs. Lastly, the opportunities, challenges, and considerations for assessing NM and MP toxicity were highlighted.
Publications	Halappanavar, S., Mallach, G. 2021. *Adverse outcome pathways and in vitro toxicology strategies for microplastics hazard testing.* Current Opinion in Toxicology, Vol. 28, pp 52-61, DOI: 10.1016/j.cotox.2021.09.002 Rahman, L., Mallach, G., Kulka, R., Halappanavar, S. 2022. *Microplastics and nanoplastics science: collecting and characterizing airborne microplastics in fine particulate matter*. Nanotoxicology, Vol. 15, Issue 9, pp 1253-1278, DOI: 10.1080/17435390.2021.2018065

7.2 Air pollutants and greenhouse gases

Air quality research:

- helps quantify priority air pollutants and determine trends
- improves and validates air quality predictions both in the near term and into the future within the national and global context
- enhances understanding of the impacts of air pollution on Canadians and the environment
- tackles emerging issues
- develops and refines tools to communicate the health impacts of air pollution
- underpins and informs evidence-based policy and regulatory development including the setting of Canadian Ambient Air Quality Standards and Residential Indoor Air Quality Guidelines.

7.2.1 Environment and Climate Change Canada Research

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. A sample of the research papers on the topics of air pollutants and GHGs published in peer-reviewed scientific journals in 2021-2022 is referenced below.

Long term trends and characteristics of airborne particulate matter in Canadian urban areas	
Focus of Research	Trends in the amounts and types of carbon contained in atmospheric fine particulate matter ($PM_{2.5}$) were analyzed using National Air Pollution Surveillance (NAPS) network data from seven Canadian cities over the period 2003-2017. The characteristics and sources of trace elements in $PM_{2.5}$, and $PM_{10\text{-}2.5}$ (coarse particulate matter), were investigated in dense traffic areas in Toronto and Vancouver, from 2015–2017.
Results	Analysis showed only a modest decline in concentrations of organic carbon, but a significant decrease in the concentration of elemental carbon, which is associated with combustion processes such as biomass burning and fossil fuel combustion, especially from diesel engines. Declining use of firewood for fuel and more stringent emissions standards and regulations in the transportation sector were identified as causes of this decline. Overall, the results of the study of PM near urban roadways show that non-exhaust traffic-related processes (crustal/road dust, brake/tire wear) were major contributors to the various metal species in PM that are prone to form reactive oxidation products that may negatively affect human health.
Publications	Wang, H., Zhang, L., Yao, X., Cheng, I., Dabek-Zlotorzynska, E. *Identification of decadal trends and associated causes for organic and elemental carbon in PM2.5 at Canadian urban sites*, Environment International, 159, art. no. 107031, DOI:10.1016/j.envint.2021.107031, 2021 Celo, V., Yassine, M.M., Dabek-Zlotorzynska, E.: *Insights into Elemental Composition and Sources of Fine and Coarse Particulate Matter in Dense Traffic Areas in Toronto and Vancouver, Canada*, Toxics, 9 (10), Art. No. 264, DOI:10.3390/toxics9100264, 2021

Effects of Tier 3 fuel on motorcycle emissions	
Focus of Research	Tests were conducted on three motorcycles produced for the North American market to compare the impacts on emissions of using Tier 3 fuel containing 10% ethanol (E10) versus Tier 2 fuel without ethanol (E0).
Results	Generally, the tests showed that using E10 fuels compared with E0 fuels resulted in reduced emissions of carbon monoxide, carbon dioxide, hydrocarbons and some air toxics such as toluene and benzene; the potential to form ozone was also reduced. There was no trend found regarding emissions of particulate matter, and some pollutant emissions increased (NOx, acetaldehyde). The study provides insights on the emission inventory impacts from the introduction of ethanol-containing fuels.
Publication	Rosenblatt, D., Stokes, J., Caffrey, C., Brown, K.: *Effect of North American Certification Test Fuels on Emissions from On-Road Motorcycles*, SAE Technical Papers, DOI:10.4271/2021-01-1225

Effects on air quality of the COVID-19 pandemic and lockdowns	
Focus of Research	Studying the effects of reduced emissions on key air pollutants in Canada and globally due to the COVID-19 pandemic and lockdowns.
Results	Countries with strict lockdown conditions had average NO_2 concentrations 29% lower than countries without. Global and Canadian studies showed large reductions in NO_2 linked to the decline of vehicle traffic, whereas pollutants such as CO_2 and fine particulate matter showed lesser reductions or did not have a clear change.
Publications	Sokhi, R.S., Singh, V., Querol, X., Finardi, S., Targino, A.C., Andrade, M.D.F., Pavlovic, R., Garland, R.M., Massagué, J., Kong, S., Baklanov, A., Ren, L., Tarasova, O., Carmichael, G., Peuch, V.-H., Anand, V., Arbilla, G., Badali, K., Beig, G., Belalcazar, L.C., Bolignano, A., Brimblecombe, P., Camacho, P., Casallas, A., Charland, J.-P., Choi, J., Chourdakis, E., Coll, I., Collins, M., Cyrys, J., da Silva, C.M., Di Giosa, A.D., Di Leo, A., Ferro, C., Gavidia-Calderon, M., Gayen, A., Ginzburg, A., Godefroy, F., Gonzalez, Y.A., Guevara-Luna, M., Haque, S.M., Havenga, H., Herod, D., Hõrrak, U., Hussein, T., Ibarra, S., Jaimes, M., Kaasik, M., Khaiwal, R., Kim, J., Kousa, A., Kukkonen, J., Kulmala, M., Kuula, J., La Violette, N., Lanzani, G., Liu, X., MacDougall, S., Manseau, P.M., Marchegiani, G., McDonald, B., Mishra, S.V., Molina, L.T., Mooibroek, D., Mor, S., Moussiopoulos, N., Murena, F., Niemi, J.V., Noe, S., Nogueira, T., Norman, M., Pérez-Camaño, J.L., Petäjä, T., Piketh, S., Rathod, A., Reid, K., Retama, A., Rivera, O., Rojas, N.Y., Rojas-Quincho, J.P., San José, R., Sánchez, O., Seguel, R.J., Sillanpää, S., Su, Y., Tapper, N., Terrazas, A., Timonen, H., Toscano, D., Tsegas, G., Velders, G.J.M., Vlachokostas, C., von Schneidemesser, E., VPM, R., Yadav, R., Zalakeviciute, R., Zavala, M.: *A global observational analysis to understand changes in air quality during exceptionally low anthropogenic emission conditions*, Environment International, 157, 106818 (2021), DOI: 10.1016/j.envint.2021.106818 Mashayekhi, R., Pavlovic, R., Racine, J., Moran, M.D., Manseau, P.M., Duhamel, A., Katal, A., Miville, J., Niemi, D., Peng, S.J., Sassi, M., Griffin, D., McLinden, C.A. *Isolating the impact of COVID-19 lockdown measures on urban air quality in Canada (2021) Air Quality*, Atmosphere and Health, DOI: 10.1007/s11869-021-01039-1 You Y, Byrne B, Colebatch O, Mittermeier RL, Vogel F, Strong K. *Quantifying the Impact of the COVID-19 Pandemic Restrictions on CO, CO2, and CH4 in Downtown Toronto Using Open-Path Fourier Transform Spectroscopy*, Atmosphere, 12(7), 848 (2021), DOI: 10.3390/atmos12070848 Zhao, X., Fioletov, V., Alwarda, R., Su, Y., Griffin, D., Weaver, D., Strong, K., Cede, A., Hanisco, T., Tiefengraber, M., McLinden, C., Eskes, H., Davies, J., Ogyu, A., Sit, R., Abboud, I., Lee, S.C.: *Tropospheric and Surface Nitrogen Dioxide Changes in the Greater Toronto Area during the First Two Years of the COVID-19 Pandemic*, Remote Sens. 2022, 14(7), 1625, DOI: 10.3390/rs14071625

Atmospheric emissions from wildfires and other biomass burning	
Focus of Research	Evaluating the influence of forest-fire emissions on the accuracy of weather and air quality forecasts, and measuring gaseous mercury emissions in plumes of forest wildfires.
Results	It was determined that emissions plumes create feedback loops which affect local weather and the behaviour of the plumes themselves. Incorporating these effects can significantly improve forecast accuracy. Aircraft-based measurements of gaseous mercury in the smoke plume downwind of a forest fire in northern Saskatchewan were used to estimate the concentrations of mercury at the source. Comparison with existing estimation methods indicates that the assumptions used in those methods create extremely high uncertainty of the results, making it difficult to extrapolate these results to all forest fires.
Publications	Makar, P. A., Akingunola, A., Chen, J., Pabla, B., Gong, W., Stroud, C., Sioris, C., Anderson, K., Cheung, P., Zhang, J., and Milbrandt, J. *Forest-fire aerosol–weather feedbacks over western North America using a high-resolution, online coupled air-quality model*, Atmos. Chem. Phys., 21, 10557–10587 (2021), DOI: 10.5194/acp-21-10557-2021 McLagan, D. S., Stupple, G. W., Darlington, A., Hayden, K., and Steffen, A. *Where there is smoke there is mercury: Assessing boreal forest fire mercury emissions using aircraft and highlighting uncertainties associated with upscaling emissions estimates*, Atmos. Chem. Phys., 21, 5635–5653 (2021), DOI: 10.5194/acp-21-5635-2021, 2021

Sources and deposition of air emissions from the Alberta oil sands	
Focus of Research	Atmospheric emissions, including sources, atmospheric lifetimes, and deposition in and downwind of the oil sands region (OSR), and the estimation of fugitive emissions of pollutants, including volatile organic compounds (VOCs), from tailings ponds.
Results	Oil sands-related sources are regional contributors to nearly all air pollutants. Most pollutants exhibit enhanced air concentrations within approximately 20 km of surface-mining activities, with some enhanced concentrations greater than 100 km downwind. Oil sands industries were a key source. The transport distances and lifetimes of SOx and NOx emitted from oil sands operations were substantially shorter than air quality models predicted, suggesting greater deposition of these pollutants close to their sources and less deposition further away than previously thought. Field measurements indicated that, in 2017, one tailings pond emitted between 2600 and 4000 tons of VOCs, approximately double the quantity reported using currently accepted estimation methods. Further analysis indicated that these emissions contributed up to 57% of the total VOCs measured at the nearby community of Fort McKay, reinforcing the importance of accurate VOC emission estimation methods for tailings ponds.

Sources and deposition of air emissions from the Alberta oil sands	
Publications	Horb, E.C., Wentworth, G.R., Makar, P.A., Liggio, J., Hayden, K., Boutzis, E.I., Beausoleil, D.L., Hazewinkel, R.O., Mahaffey, A.C., Sayanda, D., Wyatt, F., Dubé, M.G. *A decadal synthesis of atmospheric emissions, ambient air quality, and deposition in the oil sands region*, Integrated Environmental Assessment and Management, DOI: 10.1002/ieam.4539, 2021 Mamun, A.A., Celo, V., Dabek-Zlotorzynska, E., Charland, J.-P., Cheng, I., Zhang, L. *Characterization and source apportionment of airborne particulate elements in the Athabasca oil sands region* (2021) Science of the Total Environment, 788, art. no. 147748, DOI: 10.1016/j.scitotenv.2021.147748 Hayden, K., Li, S.-M., Makar, P., Liggio, J., Moussa, S. G., Akingunola, A., McLaren, R., Staebler, R. M., Darlington, A., O'Brien, J., Zhang, J., Wolde, M., and Zhang, L.: *New methodology shows short atmospheric lifetimes of oxidized sulfur and nitrogen due to dry deposition*, Atmos. Chem. Phys., 21, 8377–8392, DOI:10.5194/acp-21-8377-2021, 2021 Moussa, S.G., Staebler, R.M., You, Y., Leithead, A., Yousif, M.A., Brickell, P., Beck, J., Jiang, Z., Liggio, J., Li, S.-M., Wren, S.N., Brook, J.R., Darlington, A., Cober, S.G.: *Fugitive Emissions of Volatile Organic Compounds from a Tailings Pond in the Oil Sands Region of Alberta*, Environ. Sci. Technol., 55, 19, 12831–12840, doi.org/10.1021/acs.est.1c02325, 2021

7.2.2 Health Canada research

In 2021-2022, HC continued to research the health impacts of human exposure to indoor and outdoor air pollutants in order to provide guidance to governments, industries, other organizations and individuals on how to address air pollution. HC scientists published 38 articles in peer reviewed scientific journals. These publications addressed issues such as:

- the implications of air pollution exposure on the incidence and severity of COVID-19 in communities
- the effect of air pollutants on birth outcomes and on the development of diseases such as asthma, diabetes, and cancer
- the risks associated with elevated exposure to traffic and industrial pollutants
- the interactions between air pollution and stress pathways

7.2.2.1 Role of stress in health effects of air pollutants

The role of stress and stress reactivity in mediating impacts of air pollutants on the brain and lungs	
Focus of Research	Previous studies have shown that exposure to ambient air pollution in Canada is associated with increased risk of neurological and mental health disorders (e.g. cognitive decline, dementia, depression). While the underlying mechanisms are unclear, stress may be a central unifying mechanism underlying health impacts and susceptibility. This project focuses on how the local and systemic stress responses initiated following pollutant exposure contribute to effects on health, with particular attention on brain and lungs. More specifically, the objective of this research is to investigate the role of stress responses in mediating impacts of pollutant inhalation using *in vivo* and *in vitro* models, examining the biological pathways that underlie the health effects of air pollution.
Results	HC showed that exposure to ozone, a highly reactive air pollutant, increases stress hormone levels in the lungs. These stress hormone levels were shown to control the responses to ozone of immune cells in the lungs. Differences in the inflammation response between high and low stress responsive subgroups suggests that individual differences in stress response may be important in determining effects of exposure to air pollutants. Inhalation of particulate air pollution was shown to impact markers of key central nervous system (CNS) stress pathways, blood pressure, and heart rate variability. These research results suggest stress hormones are a key part of the body's response to air pollutants and highlight how individual differences in health and genes may contribute to vulnerability. Health Canada has also successfully established a system for assessing exposure of lung cells to gases and particulates, an important step in enabling assessment of effects of air pollutants in human cells using more physiologically-relevant exposure models. Future research will expand understanding of the mechanisms of air pollutants and stress in cell models alongside epidemiological studies in the Canadian context.
Publications	Thomas, J., Stalker, A., Breznan, D., Thomson, E.M. 2021. *Ozone-dependent increases in lung glucocorticoids and macrophage response: Effect modification by innate stress axis function.* Environmental Toxicology and Pharmacology. Vol. 86, DOI: 10.1016/j.etap.2021.103662 Thomas, J., Thomson, E.M., 2021 *Modulation by ozone of glucocorticoid-regulating factors in the lungs in relation to stress axis reactivity*. Toxics. Vol 9, Issue 11, article number 290, DOI: 10.3390/toxics9110290 Thomson, E.M., 2021. *Air pollution, stress, and allostatic load: Linking systemic and central nervous system impacts* in Alzheimer's Disease and Air Pollution: The Development and Progression of a Fatal Disease from Childhood and the Opportunities for Early Prevention. pp 387-404, DOI: 10.3233/AIAD210032 Vincent, R., Kumarathasan, P, Goegan, P., Bjarnason, S.G., Guénette, J., Karthikeyan, S., Thomson, E.M., Adamson, I.Y., Watkinson, W.P., Battistini, B., Miller, F.J., 2022. *Acute cardiovascular effects of inhaled ambient particulate matter: Chemical composition-related oxidative stress, endothelin-1, blood pressure, and ST-segment changes in Wistar rats*. Chemosphere, Vol. 296, DOI: 10.1016/j.chemosphere.2022.133933

7.2.2.2 Air pollution and COVID-19

Impacts of exposure to air pollution on COVID-19	
In Collaboration With	Hospitals and Universities in Canada and Chile
Focus of Research	Many studies have shown that ambient air pollution is associated with a wide range of adverse health effects, including increased risk of respiratory infection. Studies from the United States and Europe suggest that both short and long-term exposure to air pollution may increase the incidence of, and mortality from, COVID-19, a primarily respiratory illness. As COVID-19 is currently at the forefront of public health, existing collaborations including a collaboration in Chile, were leveraged to enhance understanding of the impacts of COVID and air pollution on the health of Canadians. This research investigates the links between ambient air pollution and COVID-19 in Alberta and Ontario, Canada, and in Santiago, Chile.
Results	Short-term increases in ambient air pollution in Santiago, Chile were associated with increased mortality, suggesting that acute increases in air pollution may be a risk factor for daily COVID-19 mortality. In Alberta and Ontario, Health Canada found links between short-term exposure to ambient air pollutants and COVID-19 emergency department visits, suggesting that exposure to air pollution may also lead to more severe COVID-19 disease. Health Canada has also investigated the mechanisms that might link air pollution to COVID-19 infection, such as oxidative stress. Interestingly, in 140 Toronto neighbourhoods, the number of cases of COVID-19 infection was linked to the potential for fine particulate matter ($PM_{2.5}$) to cause oxidative stress. Adjusting for other factors, neighbourhoods with higher levels of oxidative stress from $PM_{2.5}$ had a larger number of COVID-19 cases. This suggests that reducing oxidative stress from air pollution could reduce the incidence of COVID-19. Taken together these results suggest that air pollution may play a role in rates of COVID-19 infection and the severity of COVID-19 disease. More research is needed to confirm these findings, and additional studies are ongoing.
Publications	Dales, R., Blanco-Vidal, C., Romero-Meza, R., Schoen, S., Lukina, A., Cakmak, S., 2021. *The association between air pollution and COVID-19 related mortality in Santiago, Chile: A daily time series analysis.* Environmental Research. Vol 198, number 111284, DOI: 10.1016/j.envres.2021.111284 Lavigne, E., Ryti, N., Gasparrini, A., Sera, F., Weichenthal, S., Chen, H., To, T., Evans, G.J., Sun, L., Dheri, A., Lemogo, L., Kotchi, S.O., Stieb, D., 2022. *Short-term exposure to ambient air pollution and individual emergency department visits for COVID-19: a case-crossover study in Canada.* Thorax, number 2021-217602, DOI:10.1136/thoraxjnl-2021-217602 Stieb, D.M., Evans, G.J., To, T.M., Lakey, P.S.J., Shiraiwa, M., Hatzopoulou, M., Minet, L., Brook, J.R., Burnett, R.T., Weichenthal, S.A., 2021. *Within-City Variation in Reactive Oxygen Species from Fine Particle Air Pollution and COVID-19.* American Journal of Respiratory Critical Care Medicine. Vol. 204 Issue 2, pp 168-177, DOI: 10.1164/rccm.202011-4142OC [epub 2 Apr 2021] Stieb, D.M., 2022 *Strengthening the Epidemiological Evidence Linking Air Pollution and COVID-19*. American Journal of Respiratory Critical Care Medicine. Vol 205, Issue 6, pp 605-606, DOI: 10.1164/rccm.202112-2813ED [epub 15 Mar 2022]

7.2.2.3 Associations between air pollution and health outcomes

Chronic disease and air pollution: disease trajectory & intervention	
In Collaboration With	Statistics Canada, Environment and Climate Change Canada, ICES, and Canadian and International Universities.
Focus of Research	Air pollution has major public health and economic consequences. Health Canada is comprehensively investigating the role of chronic exposure to air pollution (months to years) in affecting individuals' trajectories over different health states (e.g. heart and vascular diseases), and how this unfolds along different physiological pathways. Considering the preponderance of evidence of the health effects of air pollution, the first objective of the project is to move beyond the question "does air pollution affect health?", to the question "how does air pollution affect health?". The second objective is to further evaluate the effectiveness of some widely implemented or potential individual- and policy-level interventions in reducing air health effects, as considerable uncertainty exists concerning which actions can be taken to reduce air pollution effects.
Results	This project draws on the Canadian Census Health and Environment Cohort (CanCHEC), and takes advantage of novel scientific approaches, including causal inference methodologies and quasi experimental designs. Key results include consistent association between long-term exposure to ambient air pollution and myocardial infarction and stroke hospitalization in the CanCHEC cohort. Furthermore, members of the CanCHEC cohort who moved from areas of lower particulate air pollution to areas of higher air pollution showed a significant increase in mortality when compared to those who moved between areas that had similar air pollution. Correspondingly, moving from areas of higher particulate air pollution to areas of lower pollution was associated with reduced mortality. This information provides important data to support evidence-based health guidance. Future studies will investigate the impacts of interventions that reduce air pollution, as well as for estimating the burden of exposure on various aspects of the disease trajectory.
Publications	Chen H., Kaufman J.S., Olaniyan T., Pinault L., Tjepkema M., Chen L., van Donkelaar A., Martin R.V., Hystad P., Chen C., Kirby-McGregor M., Bai L., Burnett R.T., Benmarhnia T. *Changes in exposure to ambient fine particulate matter after relocating and long term survival in Canada: quasi-experimental study*. The British Medical Journal. Vol. 375, number 2368, DOI: 10.1136/bmj.n2368 Olaniyan, T., Pinault, L., Li, C., van Donkelaar, A., Meng, J., Martin, R.V., Hystad, P., Robichaud, A., Ménard, R., Tjepkema, M., Bai, L., Kwong, J.C., Lavigne, E., Burnett, R.T., Chen, H., 2021. *Ambient air pollution and the risk of acute myocardial infarction and stroke: A national cohort study.* Environmental Research. Vol. 204, Pt A, number 111975, DOI: 10.1016/j.envres.2021.111975

7.2.2.4 Indoor air pollution and health

Sioux Lookout Zone: Children's Health Study	
In Collaboration With	Children's Hospital of Eastern Ontario; University of Ottawa; Northern Ontario School of Medicine; Nishnawbe Aski Nation; Energy Matters; Carleton University; Sioux Lookout First Nations Health Authority; Sioux Lookout Meno Ya Win Health Centre; Carleton University
Focus of Research	According to the Canadian Paediatric Society, housing directly affects the health of children and youth. First Nations and Inuit are disproportionately affected by crowded and inadequate housing, which has been associated with increased hospital admissions of children for respiratory tract illnesses. It has been shown that Aboriginal children in communities in the Sioux Lookout Zone (Sioux Lookout First Nations Health Authority; SLZ) in northern Ontario have elevated rates of asthma, bronchiolitis and pneumonia, but there is little information on their indoor environmental quality. This study aimed to evaluate Indoor Environmental Quality (IEQ) in houses of 98 children living in four isolated communities in this area in relation to respiratory health and related utilisation of health care services
Results	This study showed that much of the housing in the Sioux Lookout Zone area is in poor condition and that the children have high rates of respiratory infections, medical evacuations and dermatological conditions requiring treatment. Indoor endotoxin load was extremely high, and associated with LRTI, hospitalization for chest illnesses early in life, and wheezing with colds. Upper respiratory infections were associated with increased exposure to mold indoors.
Publication	Kovesi, T., Mallach, G., Schreiber, Y., McKay, M., Lawlor, G., Barrowman, N., Tsampalieros, A., Kulka, R., Root, A., Kelly, L., Kirlew, M., Miller, J. D. (2022). *Housing conditions and respiratory morbidity in Indigenous children in remote communities in Northwestern Ontario, Canada.* 194(3), E80–E88. DOI: 10.1503/cmaj.202465

7.2.2.5 Air pollution from transportation sources

Canadian Atlantic Marine Air Pollution Study	
In Collaboration With	Environment and Climate Change Canada, Ontario Ministry of Environment, Conservation and Parks, University of Rochester and Dalhousie University.
Focus of Research	To address marine shipping air pollution, Canada and the United States jointly implemented a North American Emissions Control Area (NA ECA) within which ships are regulated to use lower-sulphur marine fuel or equivalent sulphur dioxide (SO_2) scrubbers (i.e., 3.5% maximum fuel sulphur reduced to 1% sulphur in 2012 and 0.1% in 2015). To investigate the effects of these regulations on local air quality, air pollutant concentrations (including SO_2, $PM_{2.5}$, NO_2, O_3 and related $PM_{2.5}$ components) were examined between 2010 –2016 at the Canadian port cities of Halifax, Vancouver, Victoria, Montreal and Quebec City.
Results	Study results indicate that the implementation of the NA ECA improved air quality at Canadian port cities immediately following the requirement for lower-sulphur fuel. Specifically, SO_2 concentrations showed large decreases at all sites, with the largest improvements in the coastal cities when the 0.1% fuel sulphur regulation took effect. Residual fuel oil marker species vanadium (V) and Nickel (Ni) in $PM_{2.5}$ dramatically declined following regulation implementation. This is consistent with decreased residual fuel oil use and suggestive of a switch to low-sulphur distillate fuel oil. Smaller reductions in $PM_{2.5}$ were also observed, reflecting the importance of non-marine PM sources.

Canadian Atlantic Marine Air Pollution Study	
Publication	Anastasopolos, A., Sofowote, U., Hopke, P., Rouleau, M., Shin, T., Dheri, A., Peng, H., Kulka, R., Gibson, M., Farah, P-M., Sundar, N. *Air quality in Canadian port cities after regulation of low-sulfur marine fuel in the North American Emissions Control Area.* The Science of the Total Environment, Vol. 791, 147949, pp 1-12, DOI:10.1016/j.scitotenv.2021.147949

7.2.2.6 Toxicity of air pollution

Full list of publications included in Annex.

7.2.2.7 Global health and economic impacts of particulate matter

Full list of publications included in Annex.

Appendix - Tables

Table 5. CESI updates and new releases in 2021-2022

Date	Indicators
April 2021	• Global greenhouse gas emissions • Greenhouse gas emissions from large facilities • National greenhouse gas emissions
May 2021	• Canada's conserved areas • Pulp and paper effluent quality • Temperature change in Canada
June 2021	• Greenhouse gas concentrations
July 2021	• Air pollutant emissions • Water quality in Canadian rivers • Land based greenhouse gas emissions and removals • Global trends in conserved areas
October 2021	• Releases of harmful substances to water • Land use change • Restoring the Great Lakes Areas of Concern • Sustainability of timber harvest • Ecological integrity of national parks • Managing metal and diamond mining effluent quality in Canada • Household use of chemical pesticides and fertilizers
November 2021	• Emissions of harmful substances to air • Reductions in phosphorous loads to Lake Winnipeg
December 2021	• Marine pollution spills • Phosphorous loading to Lake Erie • International comparison: air pollutant emissions in selected countries
January 2022	• Solid waste disposal and diversion • Changes in the status of wildlife species at risk • Species at risk population trends
February 2022	• Management of Canadian aquaculture
March 2022	• Snow Cover in Canada

Return to 2.5 Canadian Environmental Sustainability Indicators

Table 6. Summary of existing substance assessment decisions published from April 2021 to March 2022
Cells shaded green indicate action taken during reporting period.

Name of Substance (number of substances)	Draft screening assessment[1]	Conclusion on s. 64 toxicity[2] criteria? (number of substances)	Final screening assessment[3]	Risk Management Scope Document	Risk Management Approach Document	Action taken (number of substances)
1-Nitropropane (1)	December 7, 2019	not met	February 5, 2022	NA[4]	NA	NFA[5]
Acetonitrile (1)	June 22, 2019	not met	April 3, 2021	NA	NA	NFA
Acids and Bases Group (22)	December 4, 2021	not met		NA	NA	NFA
Alcohols Group (21)	March 12, 2022	toxic (3) – Benzenemethanol (benzyl alcohol) – Methanol – 1-Butanol not met (18)		March 2022		Screening assessment proposes addition (3) to Schedule 1 NFA (18)
Alkyl Halides Group (4)	March 5, 2022	toxic (1) 1-bromopropane not met (3)		March 2022		Screening assessment proposes addition (1) to Schedule 1 NFA (3)
Anthraquinones Group (7)	November 3, 2018	toxic (1) Solvent Violet 13 not met - (6)	July 17, 2021		July 2021	Screening assessment proposes addition (1) to Schedule 1 NFA (6)
Benzoxazole, 2,2'-(1,4-naphthalenediyl) bis-(Fluorescent brightener 367) (1)	February 22, 2020	not met	February 5, 2022	NA	NA	NFA
Caprolactam (1)	August 14, 2021	not met		NA	NA	NFA
Chlorocresol (1)	July 27, 2019	toxic	May 22, 2021		May 2021	Screening assessment proposes addition (1) to Schedule 1

Name of Substance (number of substances)	Draft screening assessment[1]	Conclusion on s. 64 toxicity[2] criteria? (number of substances)	Final screening assessment[3]	Risk Management Scope Document	Risk Management Approach Document	Action taken (number of substances)
Coal tars and their distillates (6)	June 11, 2016	toxic	June 26, 2021		June 2021	Notice adding substances (6) to Schedule 1 June 26, 2021
Corn, steep liquor (1)	December 7, 2019	not met	July 10, 2021	NA	NA	NFA
DTPMP (Phosphonic acid, [[(phosphonomethyl) Imino]bis[2,1-ethanediylni trilobis(methylene)]] tetrakis-) (1)	March 16, 2019	not met	April 3, 2021	NA	NA	NFA
Esters Group (14)	March 19, 2022	toxic (1) substance Acetic acid, methyl ester not met (13)		March 2022		Screening assessment proposes addition (1) to Schedule 1 NFA (13)
Flame Retardants (10)	November 6, 2021	toxic (6) – triethylphosphate (TEP) – Triphenyl phosphate (TPHP) – isodecyl diphenyl phosphate (IDDP) – tert-butylphenyl diphenyl phosphate (BSDP) – bis(tert-butylphenyl) phenyl phosphate (BDMEPPP) – isopropylated triphenyl phosphate (IPPP) not met (4)		November 2021		Screening assessment proposes addition (6) to Schedule 1 NFA (4)
Heptamethylnonane (1)	February 1, 2020	not met	February 5, 2022	NA	NA	NFA
Lotus corniculatus, extract (1)	December 7, 2019	not met	August 14, 2021	NA	NA	NFA
Monocyclic and Bicyclic Sesquiterpenes Group (16)	May 8, 2021	toxic (3) – T&T clove oil – Sandalwood oil – guaiazulene not met (13)		May 2021		Screening assessment proposes addition (3) to Schedule 1 NFA (13)

Name of Substance (number of substances)	Draft screening assessment[1]	Conclusion on s. 64 toxicity[2] criteria? (number of substances)	Final screening assessment[3]	Risk Management Scope Document	Risk Management Approach Document	Action taken (number of substances)
Phenol, methylstyrenated (1)	November 6, 2021	toxic		November 2021		Screening assessment proposes addition (1) to Schedule 1
Select hydrocarbon-based substances (8)	January 8, 2022	not met		NA	NA	NFA
Selenium and its compounds (29)		toxic (29)	December 2017		December 2017	Notice adding to Schedule 1 on May 12, 2021
Substances identified as being of low concern (34)	February 26, 2022	not met		NA	NA	NFA
Talc (1)	December 8, 2018	toxic	April 22, 2021		April 2021	Notice proposing addition (1) to Schedule 1 May 22, 2021*
Triazines and Triazole Group (3)	April 13, 2019	not met	July 3, 2021	NA	NA	NFA

[1]Date that the screening assessment was published in the *Canada Gazette*.
A screening assessment looks to determine the potential harm that a substance or a group of substances can cause to human health and the environment. Screening assessments vary in complexity and may result in either a toxic conclusion (i.e. meets section 64 criteria) or a non-toxic conclusion

[2]Section 64 of CEPA defines a substance as toxic "if it entering or may enter the environment in a quantity or concentration or under conditions that: (a) have or may have an immediate or long-term effect on the environment or its biological diversity;
(b) constitute or may constitute a danger to the environment on which life depends; or (c) constitute or may constitute a danger in Canada to human life or health"

[3]Date that the final screening assessment was published in the *Canada Gazette*

[4]NA – not applicable

[5]NFA - no further action

Return to s.3.1.2.1 Risk assesment of existing substances

Table 7. Canadian Environmental Quality Guidelines published or Perfluorooctane sulfonate (PFOS) under development in 2021-2022

Environmental compartment	Published	Under development
Water		– Nickel – Neonicotinoid Pesticides (4) – Polycyclic aromatic hydrocarbons (PAHs) and alkyl substituted PAHs – Perfluorooctanoic acid (PFOA)
Soils	Perfluorooctane sulfonate (PFOS)	– Perfluorooctanoic acid (PFOA)
Groundwater	Perfluorooctane sulfonate (PFOS)	– Guidelines for n = 99 substances Perfluorooctanoic acid (PFOA)
Soil vapour		– Guidelines for n = 41 substances

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Table 8. Federal Environmental Quality Guidelines published or under development in 2021-2022

Environmental compartment	Published	Under development
Water	Copper	– Aluminum* – BTEX (benzene, toluene, ethylbenzene, xylene) – D4 Siloxane* – Iron* – Rare Earth Elements (REEs) (4) – Triclocarban
Sediment	nil	– D4 Siloxane* – Rare Earth Elements (REEs) (4)
Fish tissue	nil	– D4 Siloxane – Selenium – Triclocarban
Wildlife diet	nil	– D4 Siloxane*
Bird egg	nil	– Selenium*
Soil	nil	– nil
Groundwater	nil	– nil

*Draft guidelines published for comments

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Table 9. Significant New Activity Notices of intent for existing substances from April 2021 to March 2022

Substance	Publication date
1,2-Benzenediamine, dihydrochloride (CAS RN 615-28-1)	February 5, 2022
1,2-Benzenedicarboxylic acid, bis(2-methoxyethyl) ester (CAS RN 117-82-8)	February 5, 2022
1,2-Benzenedicarboxylic acid, dipentyl ester (CAS RN 131-18-0)	February 5, 2022
1,2-Oxathiolane, 2,2-dioxide- (CAS RN 1120-71-4)	February 5, 2022
1,3,5-Trioxane (CAS RN 110-88-3)	February 5, 2022
1,3-Benzenediamine, 2-methyl- (CAS RN 823-40-5)	February 5, 2022
1,3-Benzenediamine, 4-methoxy-, sulfate (1:1) (CAS RN 39156-41-7)	February 5, 2022
1,3-Benzenediamine, ar-methyl- (CAS RN 25376-45-8)	February 5, 2022
1,3-Benzodioxole, 5-propyl- (CAS RN 94-58-6)	February 5, 2022
1,3-Propanediol, 2,2-bis(bromomethyl)- (CAS RN 3296-90-0)	February 5, 2022
1,4-Dithiin, 2,3-dihydro-5,6-dimethyl-, 1,1,4,4-tetraoxide (CAS RN 55290-64-7)	February 5, 2022
1-Propene, 2,3-dichloro- (CAS RN 78-88-6)	February 5, 2022
1-Propene, 3-chloro- (CAS RN 107-05-1)	February 5, 2022
1-Triazene, 1,3-diphenyl- (CAS RN 136-35-6)	February 5, 2022
2-Butenal (CAS RN 4170-30-3)	February 5, 2022
2-Butenal, (E)- (CAS RN 123-73-9)	February 5, 2022
2-Hexanone (CAS RN 591-78-6)	February 5, 2022
2-Propenoic acid, 3-(3,4-dihydroxyphenyl)- (CAS RN 331-39-5)	February 5, 2022
4(1H)-Pyrimidinone, 2,3-dihydro-2-thioxo- (CAS RN 141-90-2)	February 5, 2022
7-Oxabicyclo[4.1.0]heptane, 3-oxiranyl- (CAS RN 106-87-6)	February 5, 2022
Acetamide (CAS RN 60-35-5)	February 5, 2022
Acetamide, 2-chloro- (CAS RN 79-07-2)	February 5, 2022
Acetamide, N-methyl- (CAS RN 79-16-3)	February 5, 2022
Benzenamine, 4,4’-carbonimidoylbis[N,N-dimethyl- (CAS RN 492-80-8)	February 5, 2022
Benzenamine, 4,4’-methylenebis[N,N-dimethyl- (CAS RN 101-61-1)	February 5, 2022
Benzenamine, 4-[(4-aminophenyl)(4-imino-2,5-cyclohexadien-1-ylidene)methyl]-, monohydrochloride (CAS RN 569-61-9)	February 5, 2022
Benzenamine, N-hydroxy-N-nitroso-, ammonium salt (CAS RN 135-20-6)	February 5, 2022
Benzene, 2-methyl-1,3-dinitro- (CAS RN 606-20-2)	February 5, 2022
Benzene, methyldinitro- (CAS RN 25321-14-6)	February 5, 2022

Substance	Publication date
Benzenemethanaminium, N-[4-[[4-(dimethylamino)phenyl][4-[ethyl[(3-sulfophenyl)methyl] amino]phenyl]methylene]-2,5-cyclohexadien-1-ylidene]-N-ethyl-3-sulfo-, hydroxide, inner salt, sodium salt (CAS RN 1694-09-3)	February 5, 2022
Bicyclo[2.2.1]hept-5-ene-2,3-dicarboxylic acid, 1,4,5,6,7,7-hexachloro- (CAS RN 115-28-6)	February 5, 2022
Boric acid (H3BO3), sodium salt (CAS RN 13840-56-7)	February 5, 2022
Carbamic acid, [(2-methylpropoxy)thioxomethyl]-, ethyl ester (CAS RN 103122-66-3)	February 5, 2022
Ethanamine, N-ethyl-N-nitroso- (CAS RN 55-18-5)	February 5, 2022
Ethane, 1,1,2-trichloro- (CAS RN 79-00-5)	February 5, 2022
Ethane, pentachloro- (CAS RN 76-01-7)	February 5, 2022
Ethanethioamide (CAS RN 62-55-5)	February 5, 2022
Ethene, bromo- (CAS RN 593-60-2)	February 5, 2022
Ethene, tetrafluoro- (CAS RN 116-14-3)	February 5, 2022
Formamide, N-methyl- (CAS RN 123-39-7)	February 5, 2022
Hydrazine, phenyl- (CAS RN 100-63-0)	February 5, 2022
Hydrazine, phenyl-, monohydrochloride (CAS RN 59-88-1)	February 5, 2022
Hydrazine, sulfate (1:1) (CAS RN 10034-93-2)	February 5, 2022
Hydroxylamine, sulfate (1:1) (salt) (CAS RN 10046-00-1)	February 5, 2022
Methane, tribromo- (CAS RN 75-25-2)	February 5, 2022
Methanesulfonic acid, ethyl ester (CAS RN 62-50-0)	February 5, 2022
Methanesulfonic acid, methyl ester (CAS RN 66-27-3)	February 5, 2022
Morpholine, 2,6-dimethyl-4-tridecyl- (CAS RN 24602-86-6)	February 5, 2022
Naphtha (petroleum), catalytic dewaxed (CAS RN 64742-66-1)	February 5, 2022
Nickel carbonyl (Ni(CO)4), (T-4)- (CAS RN 13463-39-3)	February 5, 2022
Nickel, bis[1-[4-(dimethylamino)phenyl]-2-phenyl-1,2-ethenedithiolato(2-)-S,S']- (CAS RN 38465-55-3)	February 5, 2022
Oxirane, [(methylphenoxy)methyl]- (CAS RN 26447-14-3)	February 5, 2022
Oxirane, phenyl- (CAS RN 96-09-3)	February 5, 2022
Phenol, pentachloro-, sodium salt (CAS RN 131-52-2)	February 5, 2022
Propane, 1,2,3-trichloro- (CAS RN 96-18-4)	February 5, 2022
Urea, N'-(3-chloro-4-methylphenyl)-N,N-dimethyl- (CAS RN 15545-48-9)	February 5, 2022

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Table 10. Significant New Activity Orders for existing substances from April 2020 to March 2021

Order No.	Substance	Publication date
2021-87-21-01	Benzene, 1-chloro-2-[2,2-dichloro-1-(4-chlorophenyl)ethyl]- (CAS RN 53-19-0)	July 21, 2021

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Table 11. Notices of Ministerial Conditions for new substances from April 2021 to March 2022

Substance	Publication date[1] published in the *Canada Gazette, Part I.*
Phosphonic acid, P,P'-(1-hydroxydodecylidene)bis- (CAS RN 16610-63-2) CAS RN 16610-63-2	July 10, 2021
1,3-Propanediol, 2-ethyl-2-(hydroxymethyl)-, polymer with oxirane, 4- (dimethylamino) benzoate (CAS RN 2067275-86-7)	June 12, 2021
1-Propanaminium, 3-amino-N-(carboxymethyl)-N,N-dimethyl-, N-C8-18 acyl derivs., inner salts (CAS RN 97862-59-4)	July 3, 2021
1,2-Ethanediamine, N-(2-aminoethyl)-, reaction products with glycidyl p-tolyl ether (CAS RN 68411-70-1)	May 29, 2021
Phenol, 4,4'-(1-methylethylidene)bis-, polymer with 2-(chloromethyl)oxirane and 4,4'-methylenebis[cyclohexanamine] (CAS RN 38294-67-6)	April 24, 2021

[1]Date on which the Notice was published in the *Canada Gazette, Part I*

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Table 12. Significant New Activity Notices and Order for new substances issued from April 2021 to March 2022

SNAc Notice No.	Substance	Publication date[1]
11449	Oxirane, 2,2'-[(1-methylethylidene)bis[4,1-phenyleneoxy[1-(butoxymethyl)-2,1-ethanediyl]oxymethylene]]bis- (CAS RN 71033-08-4)	July 10, 2021[2]
2021-87-08-01	Graphene (CAS RN 1034343-98-0)	January 5, 2022[2]

[1]Date on which the Final Notice or Order published in the *Canada Gazette, Part I.*
[2]Variation to a Significant New Activity

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Table 13. Living organisms deleted from the Domestic Substances List

Confidential substance identity number	Inanimate biotechnology product and living organism
18115-7	*Alcaligenes species*
18116-8	*Alteromonas species*
18120-3	*Bacillus species 1*
18118-1	*Bacillus species 2*
18119-2	*Bacillus species 3*
18121-4	*Bacillus species 4*
18122-5	*Bacillus species 5*
18129-3	*Bacillus species 7*
18130-4	*Cellumonas species*
18131-5	*Enterobacter species*
18124-7	*Flavobacterium species*
18125-8	*Micrococcus species*
18132-6	*Nitrobacter species*
18133-7	*Nitrosomonas species*
18117-0	*Pseudomonas species 1*
18123-6	*Pseudomonas species 2*
18126-0	*Pseudomonas species 3*
18127-1	*Pseudomonas species 4*
18134-8	*Pseudomonas species 5*
18135-0	*Pseudomonas species 6*
18136-1	*Rhodopseudomonas species*
18128-2	*Thiobacillus species*

Return to Risk assessment of existing living organisms

Table 14. Significant New Activity Notices for new living organisms from April 2021 to March 2022

Notice No.	Substance	Date published in the *Canada Gazette, Part I*
20598	Bacillus amyloliquefaciens subspecies amyloliquefaciens strain P6T48	May 22, 2021
19238	Bacillus amyloliquefaciens subspecies amyloliquefaciens strain W215	April 17, 2021

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Table 15. Significant New Activity Notices of Intent for living organisms from April 2021 to March 2022

Substance	Date published in the *Canada Gazette, Part I*
KB-1® Anaerobic Dechlorinating Consortium containing *Dehalococcoides spp.**	June 19, 2021
*Pseudomonas aeruginosa ATCC 31480***	June 19, 2021
*Pseudomonas aeruginosa ATCC 700370***	June 19, 2021
*Pseudomonas aeruginosa ATCC 700371***	June 19, 2021
*Pseudomonas fluorescens ATCC 13525**	June 19, 2021
*Saccharomyces cerevisiae expressing pyruvate formate lyase activating enzyme, pyruvate formate lyase, and bifunctional acetaldehyde-CoA/alcohol dehydrogenase from Bifidobacterium adolescentis and a glucoamylase from Saccharomycopsis fibuligera**	June 19, 2021
B/h PIV3/RSV F2**	June 19, 2021
*Fowlpox virus (TBC-FPV; POXVAC-TC strain)***	June 19, 2021
Fowlpox virus (TBC-FPV; POXVAC-TC strain) with modified PSA, B7.1, ICAM-1, LFA-3**	June 19, 2021
Modified Yeast**	June 19, 2021
*Pichia species strain**	June 19, 2021
Shewanella putrefaciens strain AB3-01*	June 19, 2021
*Thiobacillus W5 consortium***	June 19, 2021
Vaccinia virus (TBC-Wy; NYCBH strain) with modified PSA, B7.1, ICAM-1, LFA-3*	June 19, 2021
Yeast**	June 19, 2021
*proposed SNAc variation **proposed SNAc recission	

Return to s.3.2.2 Risk management

Table 16. Significant New Activity Orders for existing living organisms from April 2021 to March 2022

Substance	Date Published in the *Canada Gazette, Part 2*
Trichoderma reesei strain ATCC 74252	August 18, 2021

Return to s.3.2.2 Risk management

Table 17. Guideline documents for Canadian drinking water quality from April 2020 to March 2021

Published final guidelines	In progress
• Metribuzin (June 2021) • Temperature (December 2021) • Providing Safe Drinking Water in Areas of Federal Jurisdiction (December 2021) • Diquat (January 2022) • Dicamba (January 2022) • Withdrawal of Select Guidelines for Canadian Drinking Water Quality (January 2022) • 2,4-Dichlorophenoxyacetic acid (2,4-D) (February 2022) • Cyanobacteria and their Toxins in Recreational Water (February 2022) • Monitoring the Biological Stability of Drinking Water in Distribution Systems (February 2022) • Bromoxynil (February 2022) • 4-Chloro-2-methylphenoxcyacetic Acid (MCPA) March 2022)	• Dimethoate and omethoate (June 2021) • Physical, aesthetic and chemical characteristics of recreational water (June 2021) • Indicators of fecal contamination of recreational water (November 2021) • Understanding and managing risks in recreational water (December 2021)

Return to s.3.4 Drinking water quality

Table 18. Disposal at sea quantities permitted (in tonnes) and permits issued from April 1 2021 to March 31 2022

Material	Quantity by region			Total quantity permitted	Permits by region			Total permits issued
	Atlantic	Quebec	Pacific and Yukon		Atlantic	Quebec	Pacific and Yukon	
Dredge material	1 181 050	143 000	2 653 300	3 977 350	13	8	16	37
Fisheries waste	27 270	1150	0	28 420	25	3	0	28
Geological matter	0	0	1 605 500	1 605 500	0	0	13	13
Vessels	0	0	0	0	0	0	0	0
Organic matter	400	0	0	400	2	0	0	2
Total				**5 611 670**				**80**

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

Return to s.3.5.2 Disposal at sea

Table 19. Percentage reductions of air pollutants from 1990-2019 from major sources

Source	Pollutant	Percentage decrease 1990-2020
Non-ferrous refining and smelting • closures of outdated smelters and effective risk management (including implementation of pollution prevention measures)	Hg	99%
	Cd	98%
	SOx	93%
	Pb	91%
Home firewood burning • reduction in wood consumption and adoption of more efficient wood combustion equipment	$PM_{2.5}$	43%
	VOC	39%
	CO (carbon monoxide)	34%
	PAH (polycyclic aromatic hydrocarbons)	29%

Source	Pollutant	Percentage decrease 1990-2020
Coal-fired electric power generation • phasing out of coal-fired plants that are replaced by lower-emission sources	HCB (hexachlorobenzene)	98%
	Hg	75%
	SOx	69%
Light-duty gasoline trucks and vehicles • effective fuel and engine regulations	NOx	69%
	PAH	69%
Transportation associated with combustion of gasoline • effective fuel and engine regulations	VOC	69%
	CO	82%
Waste incineration • improvements in incineration technologies	Dioxins and Furans	70%
	HCB	68%

Return to s.3.4 Drinking water quality

Table 20. Current administrative and equivalency agreements under CEPA by jurisdiction

Jurisdiction (s)	Agreement	Description	Activities for 2021-2022
British Columbia	Canada-British Columbia Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016	• 102 notifications received • There was a delay in the five-year renewal of the agreement. However, collaboration has continued throughout the renewal process.
	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 came into force on March 25, 2020 when the Order Declaring that the Provisions of the Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector) Do Not Apply in British Columbia was registered. While in force, 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)*	• Annual compliance data for the first year of implementation (2020) was received in December of 2021 and reviewed. Similar information will be submitted each year throughout the duration of the equivalency agreement, allowing ECCC to monitor the implementation of the provincial regulation and ensure an equivalent outcome is achieved.
Alberta	Canada-Alberta Equivalency Agreement 1994	Equivalency agreement in place since 1994 that applies to pulp and paper mills and secondary lead smelters. The following CEPA regulations no longer apply in Alberta: • *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* (all sections) • *Pulp and Paper Mill Defoamer and Wood Chips Regulations* (sections 4(1), 6(2), 6(3)(b), 7 and 9) • *Secondary Lead Smelter Release Regulations* (all sections)	• No information
	Canada-Alberta Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016	• 185 notifications • There was a delay in the five-year renewal of the agreement. However, collaboration has continued throughout the renewal process.

Jurisdiction (s)	Agreement	Description	Activities for 2021-2022
Alberta	Agreement on the Equivalency of Federal and Alberta Regulations Respecting the Release of Methane from the Oil and Gas Sector in Alberta, 2020	Equivalency agreement (s.10) Signed on October 7, 2020, and came into force on October 26, 2020 when the Order Declaring that the Provisions of the Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector) Do Not Apply in Alberta was registered. While in force, the following CEPA regulations no longer apply in Alberta: • *Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)*	• Annual compliance data for the first calendar year of implementation (2020) was received in December of 2021 and reviewed. Similar information will be submitted each year throughout the duration of the equivalency agreement, allowing ECCC to monitor the implementation of the provincial regulation and ensure an equivalent outcome is achieved.
Saskatchewan	Canada-Saskatchewan Administrative Agreement for the *Canadian Environmental Protection Act*	Administrative agreement in place since 1994 that deals with compliance promotion and enforcement of regulations pertaining to pulp and paper mills and ozone-depleting substances, as well as general information sharing. Partially amended by 2016 Environmental Occurrences Notification Agreement.	• No information
	Canada-Saskatchewan Environmental Occurrences Notification Agreement*	Administrative agreement s.9 2016 Amended the 1994 Administrative agreement with respect to the notification of environmental occurrences.	• 45 notifications received • There was a delay in the five-year renewal of the agreement. However, collaboration has continued throughout the renewal process.
	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. While in force, the following CEPA regulations no longer apply in Saskatchewan: • Reduction of Carbon Dioxide Emissions from *Coal-fired Generation of Electricity Regulations*	• Annual compliance data was received for the first year of implementation (2020) and reviewed. Similar information will be submitted each year throughout the duration of the equivalency agreement, allowing ECCC to monitor the implementation of the provincial regulation and ensure an equivalent outcome is achieved.
	Agreement on the Equivalency of Federal and Saskatchewan Regulations Respecting The Release of Methane from the Oil and Gas Sector in Saskatchewan, 2020	Equivalency agreement (s.10) Signed on September 29, 2020, and came into force on October 26, 2020 when the Order Declaring that the Provisions of the Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector) Do Not Apply in Saskatchewan was registered. While in force, the following CEPA regulations no longer apply in Saskatchewan: • Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)	• Annual compliance data for the first calendar year of implementation (2020) was received in December of 2021and reviewed. Similar information will be submitted each year throughout the duration of the equivalency agreement, allowing ECCC to monitor the implementation of the provincial regulation and ensure an equivalent outcome is achieved.

Jurisdiction (s)	Agreement	Description	Activities for 2021-2022
Manitoba	Canada-Manitoba Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016	• 18 notifications received • There was a delay in the five-year renewal of the agreement. However, collaboration has continued throughout the renewal process.
Ontario	Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health	Administrative agreement (s.9) New agreement came into force June 1, 2021. 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 from 2021 to 2026.	See the *Canada Water Act* Annual Report 2021-2022 for an update on progress under this Agreement.
	Canada-Ontario Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016	• 127 notifications received • There was a delay in the five-year renewal of the agreement. However, collaboration has continued throughout the renewal process.
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	Equivalency agreement (s.10) 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*	• Annual compliance data was received for the first calendar year of implementation (2020) and reviewed. Similar information will be submitted each year throughout the duration of the equivalency agreement, allowing ECCC to monitor the implementation of the provincial regulation and ensure an equivalent outcome is achieved.
Northwest Territories	Canada-Northwest Territories Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016	• 3 notifications received • Agreement expired in March 2021 and will not be renewed.
Yukon	Canada-Yukon Environmental Occurrences Notification Agreement*	Administrative agreement (s.9) 2016	• 4 notifications received • There was a delay in the five-year renewal of the agreement. However, collaboration has continued throughout the renewal process.

Jurisdiction (s)	Agreement	Description	Activities for 2021-2022
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	• All parties submitted to ECCC their data from NAPS Sites collected in 2019. After validation and data packaging, data are now publically available on the federal government Open Data Portal. • The NAPS data collected in the first 6 months of 2020 were used to assess the impact of the COVID-19 lockdown on air quality. Observed decreases in some pollutant levels were mostly due to reduction in traffic volumes.

*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.

Return to s.5.2 Federal-provincial/territorial agreements

Table 21. Number of inspections, investigations and enforcement measures taken under CEPA from April 1, 2021 to March 31, 2022

Regulation	Inspections			Investigations[1]			Enforcement measures[2]			
	On-site	Off-site	Total	Started **prior** to fiscal year and ongoing	**Started** during fiscal year	**Ended** in fiscal year	**Written warnings**[3]	Number of **subjects** involved in EPCOs[4]	**EPCOs**[3]	**AMPs**[3]
Total	**350**	**319**	**669**	**29**	**3**	**10**	**77**	**7**	**7**	**108**
2-Butoxyethanol Regulations	22	0	22	1	0	0	1	0	0	0
Benzene in Gasoline Regulations	2	4	6	0	0	0	0	0	0	0
CEPA – various section(s)	31	20	51	6	1	4	15	1	1	55
Chromium Electroplating, Chromium Anodizing and Reverse Etching Regulations	16	7	23	0	0	0	8	0	0	0
Concentration of Phosphorus in Certain Cleaning Products Regulations	3	0	3	0	0	0	1	1	1	0
Cross Border Movement of Hazardous Waste and Hazardous Recyclable Material Regulations	55	18	73	1	0	0	0	0	0	0
Disposal at Sea Regulations	2	29	31	0	0	1	0	0	0	0
Environmental Emergency Regulations	55	56	111	1	0	0	6	1	1	0
Export and Import of Hazardous Waste and Hazardous Recyclable Material Regulations	0	0	0	0	0	0	8	0	0	10
Federal Halocarbon Regulations, 2003	7	49	56	1	0	0	1	0	0	0
Fuels Information Regulations, No. 1	6	5	11	0	0	0	0	0	0	2
Interprovincial Movement of Hazardous Waste Regulations	2	0	2	0	0	0	0	0	0	0
Gasoline Regulations							5	0	0	0
Microbeads in Toiletries Regulations	14	3	17	0	0	0	3	1	1	0
National Pollutant Release Inventory	0	3	3	0	0	0	0	0	0	0
New Substances Notification Regulations (Chemicals and Polymers)	2	3	5	0	0	0	2	0	0	0
Notice s. 56 for a Pollution prevention plan	4	1	5	0	0	0	0	0	0	0

Regulation	Inspections			Investigations[1]			Enforcement measures[2]			
	On-site	Off-site	Total	Started **prior** to fiscal year and ongoing	**Started** during fiscal year	**Ended** in fiscal year	**Written warnings**[3]	Number of **subjects** involved in EPCOs[4]	EPCOs[3]	AMPs[3]
Off-Road Compression-Ignition Engine Emission Regulations	7	1	8	0	0	0	4	0	0	25
Off-Road Compression-Ignition (Mobile and Stationary) and Large Spark-Ignition Engine Emission Regulations	12	0	12	1	0	0	3	0	0	0
Off-Road Small Spark-Ignition Engine Emission Regulations	1	0	1	1	0	0	0	0	0	0
On-Road Vehicle and Engine Emission Regulations	0	0	0	1	0	0	0	0	0	0
Ozone-depleting Substances and Halocarbon Alternatives Regulations	8	5	13	0	0	0	3	0	0	0
PCB Regulations	5	18	23	0	0	0	0	1	1	0
PCB Waste Export Regulations, 1996	0	0	0	0	0	0	0	0	0	0
Products Containing Mercury Regulations	1	0	1	0	0	0	0	0	0	0
Prohibition of Asbestos and Products Containing Asbestos Regulations	14	4	18	0	0	0	2	0	0	0
Prohibition of Certain oxic Substances Regulations, 2012	8	0	8	1	0	0	0	0	0	0
Pulp and Paper Mill Defoamer and Wood Chip Regulations	0	3	3	0	0	0	0	0	0	0
Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations	0	11	11	0	0	0	0	0	0	0
Reduction in the Release of Volatile Organic Compounds Regulations (Petroleum Sector)	1	0	1	0	0	0	0	0	0	0
Renewable Fuels Regulations	10	3	13	1	0	0	4	0	0	2
Solvent Degreasing Regulations	2	0	2	0	0	0	2	0	0	0

Regulation	Inspections			Investigations[1]			Enforcement measures[2]			
	On-site	**Off-site**	**Total**	Started **prior** to fiscal year and ongoing	**Started** during fiscal year	**Ended** in fiscal year	**Written warnings**[3]	Number of **subjects** involved in EPCOs[4]	**EPCOs**[3]	**AMPs**[3]
Storage Tank Systems or Petroleum Products and Allied Petroleum Products Regulations	14	22	36	5	2	0	4	0	0	12
Sulphur in Diesel Fuel Regulations	8	4	12	0	0	0	1	0	0	2
Sulphur in Gasoline Regulations	2	4	6	0	0	0	0	0	0	0
Tetrachloroethylene Use in Dry Cleaning and Reporting Requirements) Regulations	3	43	46	1	0	0	4	0	0	0
Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations	3	0	3	2	0	0	0	1	1	0
Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations	15	0	15	2	0	1	0	1	1	0

[1]Investigations are tabulated by the number of investigation files at the regulation level, based on the start or end date of the investigation. An investigation may be counted under 1 or more regulations.

[2]Enforcement measures issued between April 1, 2021 and March 31, 2022. Note that the initial inspection may have been conducted in a different fiscal year than when the measure was issued.

[3]Written warnings, Environmental Protection Compliance Orders (EPCOs) and Administrative Monetary Penalties (AMPs) are tabulated by number of measures issued at the regulation level. For example, if 1 warning is issued for 2 different regulations, the number of warnings is 2.

[4]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 1 regulatee was issued an EPCO for 3 sections of the PCB Regulations, the number of subjects involved is 1.

Return to 6.2.2 Enforcement activities

Table 22. Number of prosecutions, tickets and penalties issued between April 1, 2021 to March 31, 2022

Instrument	Prosecutions		Tickets	Penalties		
	Convicted subjects[1]	Guilty counts[2]		Environmental Damages Fund (EDF)	Administrative Monetary Penalty (AMPs)	Total Penalty Amount
Total	**0**	**1**	**1**	**$0.00**	**$161,000.00**	**$161,000.00**
CEPA – various section(s)	0	1	0	**$0.00**	$26,000.00	$26,000.00
Cross Border Movement of Hazardous Waste and Hazardous Recyclable Material Regulations	0	0	0	**$0.00**	$22,000.00	$22,000.00
Fuels Information Regulations, No. 1	0	0	0	**$0.00**	$2,000.00	$2,000.00
Off-Road Compression-Ignition Engine Emission Regulations	0	0	0	**$0.00**	$28,000.00	$28,000.00
On-Road Vehicle and Engine Emission Regulations	0	0	0	**$0.00**	$45,000.00	$45,000.00
Renewable Fuels Regulations	0	0	0	**$0.00**	$2,000.00	$2,000.00
Solvent Degreasing Regulations	0	0	1	**$0.00**	$0.00	$0.00
Sulfur in Diesel Fuel Regulations	0	0	0	**$0.00**	$2,000.00	$2,000.00
Storage Tank Systems for Petroleum Products and Allied Petroleum Products Regulations	0	0	0	**$0.00**	$34,000.00	$34,000.00

[1] The number of subjects convicted during the reporting period, based on date sentenced.

[2] The number of sections of legislation or regulations, for which there was a charge or conviction during the reporting period. For example, if 1 person is charged with 2 counts under CEPA, this is considered 1 charge laid against the subject and 2 counts.

Return to 6.2.2 Enforcement activities

Annex - Research Publications

A comprehensive list of all of the research published in the 2021-2022 reporting year by ECCC and HC, including the work already highlighted in section 7 of this report, appears below. Publications in the bibliography contain either the Digital Object Identifier (DOI) or International Standard Book Number (ISBN). Copy and paste the DOI or ISBN into your search browser to be directed to an online publication of the research.

Chemical Substances

Environment and Climate Change Canada

Chemical Substances in the Environment

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Ankley, G.T., Cureton, P., Hoke, R.A., Houde, M., Kumar, A., Kurias, J., Lanno, R., McCarthy, C., Newsted, J., Salice, C.J., Sample, B.E., Sepulveda, M.A., Steevens, J., Valsecchi, S. 2020. *Assessing the ecological risks of per- and polyfluoroalkyl substances: Current state-of-the science and a proposed path forward.* Environmental Toxicology and Chemistry. 40: 564-605. Critical review. Open Access. https://doi.org/10.1002/etc.4869

Barrett. H., Dua, X., Houde, M., Lair, S., Verreault, J., Peng, H. 2021. *Suspect and nontarget screening revealed class-specific temporal trends (2000-2017) of poly- and perfluoroalkyl substances in beluga whales (Delphinapterus leucas).* Environmental Science and Technology 55: 1659-1671. https://doi.org/10.1021/acs.est.0c05957

Bidleman, T.F., Backus, S., Dove, A., Lohmann, R., Muir, D., Teixeira, C., Jantunen, L. 2021. *Lake Superior Has Lost over 90% of Its Pesticid*e HCH Load since 1986. Environmental Science and Technology, DOI: 10.1021/acs.est.0c07549

Chételat, J., McKinney, M.A., Amyot, M., Dastoor, A., Douglas, T.A., Heimbürger-Boavida, L.-E., Kirk, J., Kahilainen, K.K., Outridge, P.M., Pelletier, N., Skov, H., St. Pierre, K., Vuorenmaa, J., Wang, F. 2022. *Climate change and mercury in the Arctic*: Abiotic interactions. Science of the Total Environment, 824, art. no. 153715, DOI: 10.1016/j.scitotenv.2022.153715

Dastoor, A., Angot, H., Bieser, J., Christensen, J.H., Douglas, T.A., Heimbürger-Boavida, L.-E., Jiskra, M., Mason, R.P., McLagan, D.S., Obrist, D., Outridge, P.M., Petrova, M.V., Ryjkov, A., St. Pierre, K.A., Schartup, A.T., Soerensen, A.L., Toyota, K., Travnikov, O., Wilson, S.J., Zdanowicz, C. 2022. *Arctic mercury cycling*. Nat. Rev. Earth Environ., 3, 270–286, DOI: 10.1038/s43017-022-00269-w

Dastoor, A. + 42 additional coauthors, *AMAP Assessment 2021: Mercury in the Arctic, Chapter 3: Changes in Arctic Mercury Levels: Emissions Sources, Pathways and Accumulation*, Arctic Monitoring and Assessment Programme (AMAP), Tromsø, Norway, 2021.

Dastoor, A., Ryjkov, A., Kos, G., Zhang, J., Kirk, J., Parsons, M., Steffen, A. 2021. I*mpact of Athabasca oil sands operations on mercury levels in air and deposition.* Atmos. Chem. Phys., 21, 12783–12807, DOI: 10.5194/acp-21-12783-2021

Fremlin, K.M., Elliott, J.E., Martin, P.A., Harner, T., Saini, A., Gobas, F.A.P.C. 2021. *Fugacity-Based Trophic Magnification Factors Characterize Bioaccumulation of Cyclic Methyl Siloxanes within an Urban Terrestrial Avian Food Web: Importance of Organism Body Temperature and Composition.* Environ. Sci. Technol., 55, 20, 13932–13941, DOI: 10.1021/acs.est.1c04269

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

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Lalonde, B., Garron, C. *Perfluoroalkyl Substances (PFASs) in the Canadian Freshwater Environment.* Arch Environ Contam Toxicol 82, 581–591 (2022), DOI: 10.1007/s00244-022-00922-x

Li, W.-L., Zhang, Z.-F., Li, Y.-F., Hung, H., Yuan, Y.-X. 2021. *Assessing the distributions and fate of household and personal care chemicals (HPCCs) in the Songhua Catchment, Northeast China*. Science of the Total Environment, 786, art. no. 147484, DOI: 10.1016/j.scitotenv.2021.147484

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Liu, Z., Cui, S., Zhang, L., Zhang, Z., Hough, R., Fu, Q., Li, Y.-F., An, L., Huang, M., Li, K., Ke, Y., Zhang, F. 2021. *Occurrence, variations, and risk assessment of neonicotinoid insecticides in Harbin section of the Songhua River, northeast China.* Environmental Science and Ecotechnology, 8, art. no. 100128, DOI: 10.1016/j.ese.2021.100128

Mastin, J., Harner, T., Schuster, J.K., South, L. 2022. *A review of PCB-11 and other unintentionally produced PCB congeners in outdoor air.* Atmospheric Pollution Research, 13 (4), art. no. 101364, DOI: 10.1016/j.apr.2022.101364

Melymuk, L., Nizzetto, P.B., Harner, T., White, K.B., Wang, X., Tominaga, M.Y., He, J., Li, J., Ma, J., Ma, W.-L., Aristizábal, B.H., Dryer, A., Jiménez, B., Muñoz-Arnanz, J., Odabasi, M., Dumanoglu, Y., Yaman, B., Graf, C., Sweetman, A., Klánová, J. 2021. *Global intercomparison of polyurethane foam passive air samplers evaluating sources of variability in SVOC measurements.* Environmental Science and Policy, 125, 1-9, DOI: 10.1016/j.envsci.2021.08.003

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Naccarato, A., Tassone, A., Martino, M., Moretti, S., Macagnano, A., Zampetti, E., Papa, P., Avossa, J., Pirrone, N., Nerentorp, M., Munthe, J., Wängberg, I., Stupple, G. W., Mitchell, C. P. J., Martin, A. R., Steffen, A., Babi, D., Prestbo, E. M., Sprovieri, F., Wania, F. 2021. *A field intercomparison of three passive air samplers for gaseous mercury in ambient air.* Atmos. Meas. Tech., 14, 3657–3672, DOI: 10.5194/amt-14-3657-2021

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Chemicals and Effects in Wildlife, Fish and Associated Food Webs and Ecosystems

Borgå, K., McKinney, M., Routti, H., Fernie, K.J., Giebichenstein, J., Muir, D., Hallanger, I. *The influence of global climate change on accumulation and toxicity of POPs and CEACs in Arctic food webs: A review.* Environmental Science: Processes and Impacts (Special Issue). 2022. DOI: 10.1039/D1EM00469G

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Health Canada

Chemical Substances in Canadians

**Research published in addition to the articles previously reported in s.7.1.2. This research was conducted in collaboration with MercuNorth, Institut National de santé publique du Québec, University of Sherbrooke, and other national and international institutions.*

*Adlard, B., Lemire, M., Bonefeld-Jørgensen, E. C., Long, M., Ólafsdóttir, K., Odland, J. O., Rautio, A., Myllynen, P., Sandanger, T.M., Dudarev, A.A., Bergdahl, I.A., Wennberg, M., Berner, J., Ayotte, P. 2021. *MercuNorth–monitoring mercury in pregnant women from the Arctic as a baseline to assess the effectiveness of the Minamata Convention.* International journal of circumpolar health, Vol. 80, Issue 1, article number 1881345, DOI: 10.1080/22423982.2021.1881345

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Associations between air pollution and Health Outcomes

** Research published in addition to the articles previously reported in s.7.2.2.3. Key collaborations include Statistics Canada and Canadian and International Universities and Organisations.*

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