Environment and Climate Change Canada
Environnement et Changement climatique Canada

PHOSPHORUS LOADING TO LAKE ERIE

CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

Canada

Suggested citation for this document: Environment and Climate Change Canada (2025) Canadian Environmental Sustainability Indicators: Phosphorus loading to Lake Erie. Consulted on *Month day, year*. Available at: https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/phosphorus-loading-lake-erie.html

Cat. No.: En4-144/92-2025E-PDF
ISBN: 978-0-660-79717-5
Project code: EC25115

Environment and Climate Change Canada
Public Inquiries Centre
Place Vincent Massey Building
351 Saint-Joseph Boulevard
Gatineau QC K1A 0H3
Toll Free: 1-800-668-6767
Email: enviroinfo@ec.gc.ca

Aussi disponible en français

CANADIAN ENVIRONMENTAL SUSTAINABILITY INDICATORS

PHOSPHORUS LOADING TO LAKE ERIE

November 2025

Table of contents

List of Figures

List of Tables

Phosphorus loading to Lake Erie

Lake Erie is the fourth largest lake by surface area and the shallowest of the North American Great Lakes. Located on both sides of the Canada and United-States border, Lake Erie covers an area of 103,700 square kilometers (km^2). It is of great economic and environmental importance to the 11 million people who live in its watershed, in terms of transportation, recreation and tourism, biodiversity, and ecological services. Lake Erie is also subject to pressure from human activities such as agriculture and urbanization. These activities cause daily discharges and runoff of pollutants such as phosphorus.

High phosphorus levels lead to degraded water quality, algae blooms and zones of low oxygen that negatively impact aquatic life. In the absence of human activities, natural background levels of phosphorus are relatively low.

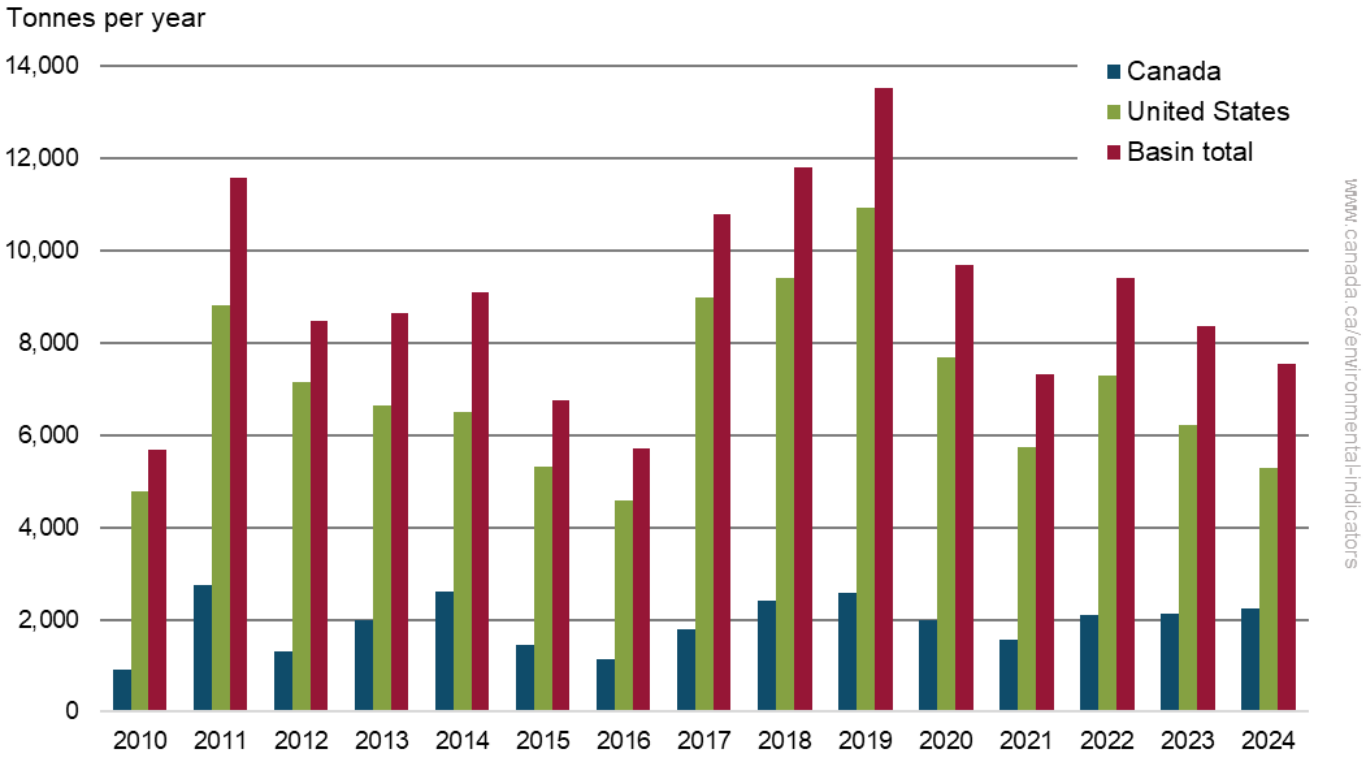
Through the Canada–US Great Lakes Water Quality Agreement, Canada and the United States have agreed to reduce phosphorus loads entering the western and central basin of Lake Erie by 40% from 2008 levels to protect water quality and ecosystem health.

This indicator provides information about the amount of phosphorus reaching Lake Erie, known as phosphorus loading, mainly caused by human activity.

Key results

- In 2024, the estimated total phosphorus loading to Lake Erie was 7,536 tonnes, with 30% (2,237 tonnes) from Canada
- The highest estimated total phosphorus loading to Lake Erie was 13,536 tonnes in 2019 with 19% (2,592 tonnes) from Canada
- A decrease in the estimated total load was recorded in 2023 and 2024 compared to 2022 (11% and 20%, respectively)
- The observed reductions in total phosphorus load in 2023 and 2024 were likely attributable to the low flow conditions experienced across the basin during this time compared to previous years

Figure 1. Estimated total phosphorus loading to Lake Erie, 2010 to 2024



Data for Figure 1

Note: Basin total values include loadings from runoff and tributaries in Canada and the United States, loadings from Lake Huron and atmospheric sources of phosphorus. Half of the total phosphorus loadings from atmospheric sources and half of those from Lake Huron were allocated to each country. Values are rounded to the nearest whole number. Totals may not add up due to rounding. For more information, see the Data sources and methods section.
Source: Environment and Climate Change Canada (2025) Freshwater Quality Monitoring and Surveillance Division.

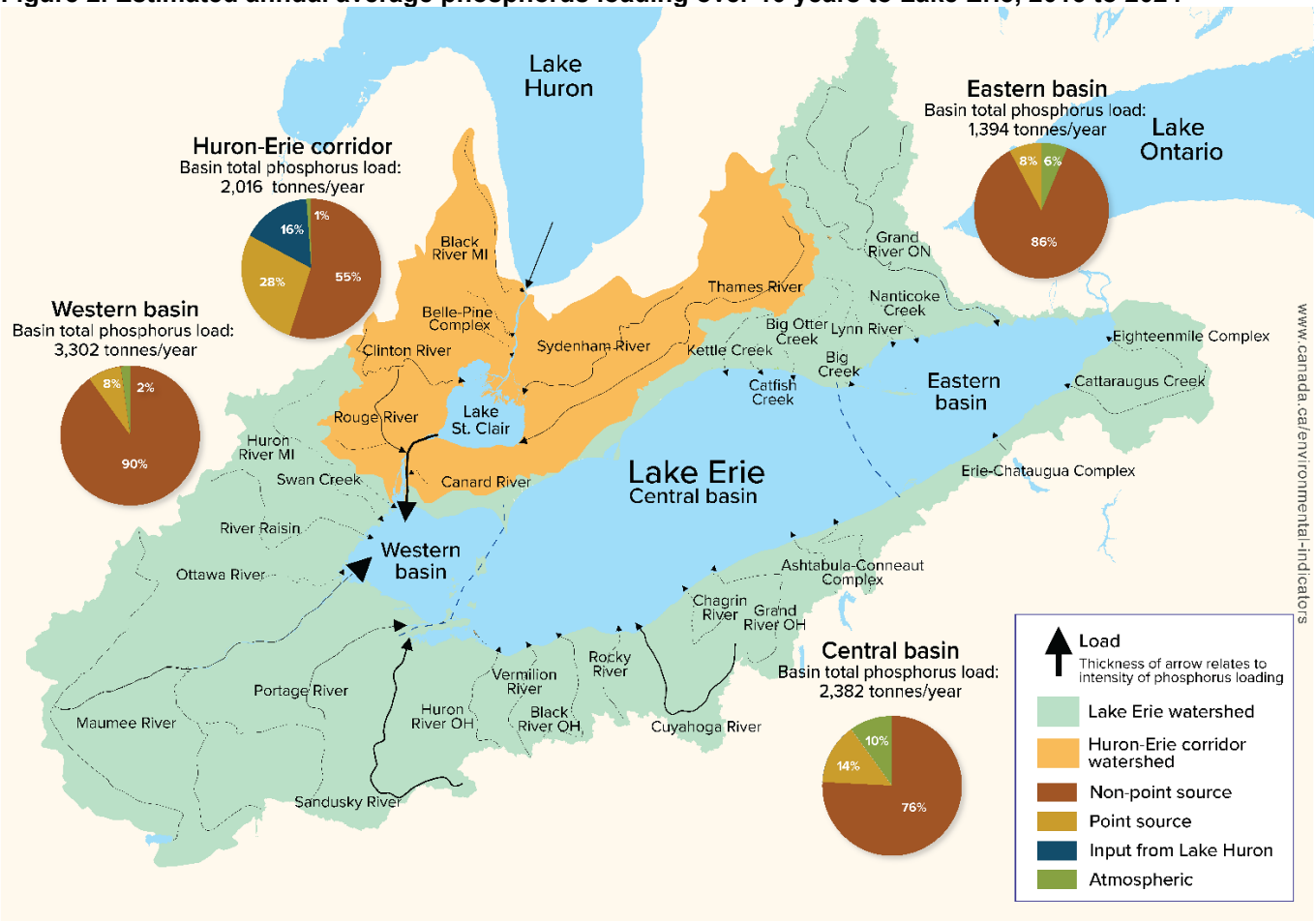
Phosphorus loading varies from year to year due mainly to climatic factors. Dry years in the region will lead to low levels of runoff from surrounding lands with less phosphorus being discharged into the lake from its tributaries.

In 2024, the estimated total phosphorous loading to Lake Erie from Canada and the United States (7,536 tonnes) was among the top 5 lowest estimated loads in the past 15 years. Total phosphorus load was 44% lower than the 2019 peak of 13,536 tonnes, which occurred during the wettest year since 2008, and 20% lower than the 2022 level.

However, Canada's contribution never exceeded one-third of this estimated total load, varying between 16% and 30% during this period. Also, Canada's contribution fluctuated much less than the estimated total and the proportion of US estimated contribution to the lake.

Lake Erie is the shallowest, warmest and most productive of the 5 Great Lakes. The lake is divided into 3 sub-basins: western (the shallowest), central (the largest) and eastern (the deepest). More than 50% of phosphorus enters the lake from the Detroit River or tributaries in the western basin. Figure 2 shows that non-point sources, such as agriculture and, to a much lesser extent, urban storm water runoff, are the largest contributor of total phosphorus loads to Lake Erie. For example, in the western basin of the lake, these sources accounted for up to 90% of the total estimated load where impacts from algal growth are greatest. In addition to point, non-point, and atmospheric sources, the Huron-Erie corridor contributes approximately 16% of Lake Erie's total phosphorus load, originating from both Lake Huron outflow and other tributary inputs along the corridor.

Figure 2. Estimated annual average phosphorus loading over 10 years to Lake Erie, 2015 to 2024



Data for Figure 2

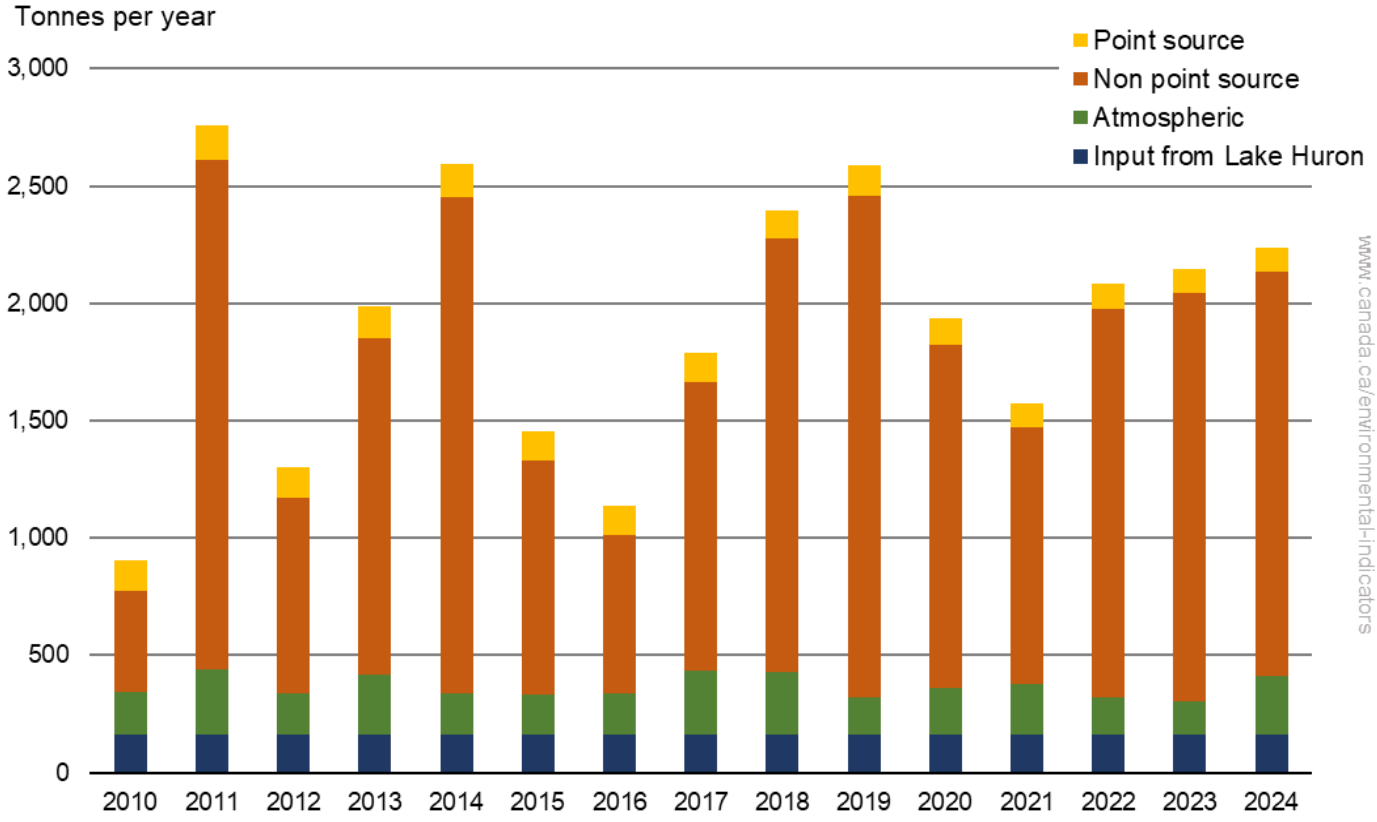
Note: Point source includes municipal sewage treatment plant effluent and industrial effluent. Non-point source includes agriculture and urban storm water runoff. Atmospheric deposition refers to phosphorus being deposited directly to the lake. The Huron-Erie corridor watershed includes input from Lake Huron, point and non-point sources and atmospheric deposition within the watershed. For more information, see the Data sources and methods section.
Source: Environment and Climate Change Canada (2025) Freshwater Quality Monitoring and Surveillance Division.

Phosphorus loading to Lake Erie from Canadian sources

Key results

- Total phosphorus loading to Lake Erie from Canada comes mainly from non-point sources such as agriculture and urban stormwater runoff
- From 2010 to 2024, non-point sources accounted for an average of 72% of the total load from Canada with an estimated minimum of 47% in 2010 and a maximum of 83% in 2019
- In 2024, this percentage slightly exceeded the average for this period, at 77%

Figure 3. Estimated total phosphorus loading to Lake Erie by source, Canada, 2010 to 2024



Data for Figure 3

Note: The total phosphorous loadings from atmospheric sources and from Lake Huron were halved to roughly estimate the Canadian contributions. Loadings from Lake Huron are estimates from models. Values are rounded to the nearest whole number. Totals may not add up due to rounding. For more information, see the Data sources and methods section.
Source: Environment and Climate Change Canada (2025) Freshwater Quality Monitoring and Surveillance Division.

Point sources include municipal sewage treatment plant effluents and industrial effluents. These are sources of phosphorus that can be identified as a single source, for example, an effluent discharge pipe going into a water body.

Non-point sources are diffuse sources of pollution and include agriculture and urban stormwater runoff. Non-point sources of phosphorus come from excess fertilizer and manure applied to the soil. Runoff from rainfall or snowmelt accumulates and transports these pollutants, then deposits them in lakes and rivers.

Phosphorus loading from non-point sources was lowest in 2010, 2012 and 2016, and accounted for the lowest shares of the total estimated load (47%, 64% and 59%), which coincides with low precipitation years in the Lake Erie basin.[1]

In 2024, the phosphorus load from non-point sources was 1,721 tonnes, accounting for 77% of the total estimated load. Although this was slightly lower that in 2023, it was still one of the highest loads during this period.

[1] Coordinating Committee (2025) Coordinating Committee Products and Datasets. Retrieved on September 19, 2025.

About the indicator

What the indicator measures

The Phosphorus loading to Lake Erie indicator reports on the total phosphorus loads flowing directly into Lake Erie or from its tributaries and includes loads from:

- atmospheric deposition
- point sources (for example, wastewater treatment plants)
- non-point sources (primarily agriculture runoff)
- Lake Huron

In the absence of human activities, natural background levels of phosphorus loading are relatively low. The indicator provides information about the amount of phosphorus flowing into Lake Erie mainly due to human activities.

Why this indicator is important

Healthy freshwater is an essential resource. It protects the biodiversity of aquatic flora and fauna. It is used for manufacturing, energy production, irrigation, swimming, boating, fishing and for domestic purposes. Poor water quality damages the health of freshwater ecosystems. It can also disrupt fishing, tourism and agriculture, and increase treatment cost to meet drinking water standards. When there is too much phosphorous in water, the growth of algae and certain types of bacteria associated with it, called cyanobacteria, can become excessive and harmful. Cyanobacteria can release substances that are harmful to fauna and flora. As they decay, excess algae and bacteria can also reduce the amount of oxygen available to fish and other aquatic animals. They can also affect human health, if humans are exposed to them.

Under the Canada–US Great Lakes Water Quality Agreement, Canada and the United States have agreed to reduce phosphorus loads entering the western and central basin of Lake Erie by 40% from 2008 levels. This objective is to reduce the extent of harmful and toxic algal blooms and the number of zones of depleted oxygen (hypoxia), to protect water quality and ecosystem health. For Canada, this means a reduction in phosphorus loads of 212 tonnes per year. Studies are underway to support the development of a target for the eastern basin of Lake Erie. Several more years of data are necessary to detect a clear overall trend in phosphorus loading that accounts for year-to-year variations in climate.

To calculate phosphorus loads, it is important to know the volume of water (discharge) and phosphorus concentration. The phosphorus load is the total quantity of phosphorus that is being released into a water body over a certain period of time, such as per day, month, or year and/or from certain sources (for example agriculture, runoff, etc.). Increased loadings from various sources can lead to increased concentrations in a water body.

Related initiatives

The indicator contributes to the sustainable development goals of The 2030 Agenda for Sustainable Development. It is linked to the 2030 Agenda's Goal 6: Clean water and sanitation and Target 6.3: "By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally."

Related indicators

The Phosphorus levels in the offshore waters of the Canadian Great Lakes, the Nutrients in Lake Winnipeg and the Nutrients in the St. Lawrence River indicators report the status of total phosphorus and total nitrogen levels.

The Water quality in Canadian rivers indicator provides a measure of the ability of river water across Canada to support plants and animals.

Data sources and methods

Data sources

The data used in this indicator comes from Canadian and American sources; the province of Ontario, Michigan and Ohio states, and the federal governments.

More information

Data on phosphorus loading are derived from a number of Canadian and American sources:

- Canadian sources
  - Environment and Climate Change Canada
  - Ontario Ministry of Environment, Conservation and Parks
- American sources
  - United States Geological Survey
  - Heidelberg University
  - Michigan Department of Environmental Quality
  - Ohio Environmental Protection Agency
  - United States Environmental Protection Agency

Data are of various types, including point source discharges (for example, municipal sewage treatment plant effluents or industrial effluents), hydrologic flow, tributary water quality and atmospheric deposition. Tributary water quality includes data from sampling sites at 13 Canadian tributaries (the Thames River, Sydenham River, Grand River, Turkey Creek, Big Creek, Big Otter Creek, Lynn Creek, Kettle Creek, Leamington tributaries [4 tributaries; included in 2018-2024 loading estimates], Canard River,[2] and Nanticoke Creek). Data are associated with the 3 Lake Erie's basins: western, central and eastern. They provide a means to specify the general geographic origin of point and non-point sources. The geographic origin is not specified for atmospheric deposition and Lake Huron inputs, and for these sources, an equal allocation between the United States and Canada has been used as an approximation.

Point source data have been updated for 2022 and 2023. Phosphorous loads have been updated from 2018 to 2023. The loads of the year 2024 were estimated to use 2023-point source data as a placeholder.

Detailed data files are available through the Government of Canada's Open Data Portal.

Methods

Data on point source releases, atmospheric deposition and non-point sources (calculated using water flows and water quality data) are used to estimate phosphorus loading to Lake Erie.

More information

Phosphorus loading is calculated on a hydrologic year basis. A hydrologic year differs from a calendar year in that it runs from October 1 of a given year to September 30 of the following year. Hydrologic years are commonly used for calculations, to account for precipitation falling as snow in late autumn and winter and draining in the following spring or summer's snowmelt.

Point source releases data, in the form of monthly average total phosphorous effluent concentration and associated flows, were retrieved from effluent compliance data maintained by the Ontario Ministry of the Environment, Conservation and Parks and the United States Environmental Protection Agency. Tributary phosphorous concentrations are based on water quality monitoring data from the Ontario Ministry of the Environment, Conservation and Parks, Environment and Climate Change Canada, United States Geological Survey, US state agencies and Heidelberg University. Atmospheric deposition data were retrieved as monthly values of precipitation quantities and total phosphorous concentrations from Environment and Climate Change Canada. Flow data were obtained as average daily release data

[2] Prior to 2017, Canard River was used as a placeholder in the Western basin to account for the missing Leamington tributary data. The Leamington tributary only started being monitored in 2017 and data for the years 2008 to 2016 is not available.

retrieved from the United States' Geological Survey National Water Inventory System and from the Water Survey Canada hydrometric data, maintained by Environment and Climate Change Canada.

For all sources, phosphorus loading is estimated by multiplying the concentration (for example, kilograms of phosphorus per litre of water) by the flow rate (for example, cubic metres of water per day). The total loading to the lake is the sum of atmospheric deposition, loads from Lake Huron, as well as point sources and non-point sources that flow directly into the lake or from tributaries.

Phosphorus loadings from 2008 to 2019 and from 2022 to 2024 were estimated by using the Lake Erie Loading Tool version 1.4.0, which is based on the process and methods used by Maccoux et al. 2016. For the 2020 year, loadings were calculated using a regression analysis, rather than the Beale method described in Maccoux et al. 2016, due to low sample numbers at all sites. For the 2021 year, loadings were calculated using regression analysis for sites with low sample numbers and the Beale approach for sites with sufficient sample counts. These approaches were determined to be the most appropriate because a significant portion of data were missing for most of the tributaries due to COVID-19 pandemic restrictions.[3] Unmonitored watershed areas were estimated using the Unit Area Load (UAL) approach, where the loading per square kilometre is calculated using data from an adjacent monitored watershed. Unmonitored areas are usually located downstream of the monitored tributary that flows directly into the lake.

Flow data for the Canard River in 2024 were estimated using a rating curve created from level and flow data from previous years. The Leamington tributaries were included in the 2024 load estimate based on data collected from the Essex Region Conservation Authority.

Phosphorus loadings from Lake Huron are estimates from models based on the assumption that the phosphorus loads from Lake Huron are relatively stable from year to year.

For more details on the methods and calculations used, see Maccoux et al. 2016.

Caveats and limitations

The indicator is based on total phosphorus concentrations only. Concentrations of total phosphorus may include different proportions of reactive, soluble, and bioavailable phosphorus which has the most impactful in terms of algae blooms and eutrophication. The indicator and data included in this report are not suitable for assessing soluble reactive phosphorus loading.

Phosphorus loadings from Lake Huron are estimates from models and then applied annually. This method for estimating the Lake Huron load is based on the assumption that the phosphorus loads from Lake Huron are relatively stable from year to year. Recently, studies on the Huron-Erie corridor have suggested that loadings from Lake Huron are more variable than previously assumed. The methods are under review.

Climatic factors, such as precipitation or drought, greatly influence the amount of phosphorus entering a water body. Given the year-to-year variability, a longer time period is required to determine a statistically significant trend of phosphorus loading. As such, great caution should be exercised when making comparisons across years and estimating trends.

For the 2020 and the 2021 data, where there were sites with low number of samples, a regression analysis approach was applied because the sampling frequency in most tributaries was reduced or not completed due to restrictions related to the COVID-19 pandemic.

Resources

References

Environment and Climate Change Canada and the U.S. Environmental Protection Agency (2022) State of the Great Lakes 2022 - Technical Report (PDF; 20.4 MB). Cat No. En161-3/1E-PDF. EPA 905-R-22-004. Retrieved on September 19, 2025.

[3] Greenberg T (2021) Environment and Climate Change Canada, personal communication.

Environment and Climate Change Canada and the U.S. National Oceanic and Atmospheric Administration (2025) Annual Climate Trends and Impacts Summary for the Great Lakes Basin. Retrieved on September 19, 2025.

Maccoux MJ, Dove A, Backus SM and Dolan DM (2016) Total and soluble reactive phosphorus loadings to Lake Erie: A detailed accounting by year, basin, country, and tributary. Journal of Great Lakes Research 42(6):1151 to 1165. Retrieved on September 19, 2025.

Related information

Canada–Ontario Agreement on Great Lakes Water Quality and Ecosystem Health

Canada–US Great Lakes Water Quality Agreement

Great Lakes Freshwater Ecosystem Initiative

Annex

Annex A. Data tables for the figures presented in this document

Table A.1 Data for Figure 1. Estimated total phosphorus loading to Lake Erie, 2010 to 202

Year	Total phosphorus loading United States portion (tonnes per year)	Total phosphorus loading Canada portion (tonnes per year)	Total phosphorus loading Basin total (tonnes per year)
2010	4,769	903	5,672
2011	8,817	2,758	11,575
2012	7,161	1,304	8,465
2013	6,648	1,989	8,637
2014	6,491	2,596	9,087
2015	5,313	1,457	6,770
2016	4,578	1,135	5,713
2017	8,993	1,791	10,784
2018	9,395	2,412	11,807
2019	10,944	2,592	13,536
2020	7,702	1,992	9,693
2021	5,747	1,572	7,318
2022	7,292	2,108	9,400
2023	6,233	2,135	8,368
2024	5,300	2,237	7,537

Note: Basin total values include loadings from runoff and tributaries in Canada and the United States, loadings from Lake Huron and atmospheric sources of phosphorus. Half of the total phosphorus loadings from atmospheric sources and half of those from Lake Huron were allocated to each country. Values are rounded to the nearest whole number. Totals may not add up due to rounding. For more information, see the Data sources and methods section.
Source: Environment and Climate Change Canada (2025) Freshwater Quality Monitoring and Surveillance Division.

Table A.2 Data for Figure 2. Estimated annual average phosphorus loading over 10 years to Lake Erie, 2015 to

Watershed	Source	Annual 10-year average from 2015 to 2024 of phosphorus loading (tonnes per year)
Huron-Erie corridor	Lake Huron	321
Huron-Erie corridor	Atmospheric	25
Huron-Erie corridor	Point source	572
Huron-Erie corridor	Non-point source	1,098
Huron-Erie corridor	Total	2,016
Western basin	Atmospheric	55
Western basin	Point source	273
Western basin	Non-point source	2,974
Western basin	Total	3,302
Central basin	Atmospheric	228
Central basin	Point source	331

Watershed	Source	Annual 10-year average from 2015 to 2024 of phosphorus loading (tonnes per year)
Central basin	Non-point source	1,823
Central basin	Total	2,382
Eastern basin	Atmospheric	91
Eastern basin	Point source	107
Eastern basin	Non-point source	1,196
Eastern basin	Total	1,394

Note: Point source includes municipal sewage treatment plant effluent and industrial effluent. Non-point source includes agriculture and urban storm water runoff. Atmospheric deposition refers to phosphorus being deposited directly to the lake. The Huron-Erie corridor watershed includes input from Lake Huron, point and non-point sources and atmospheric deposition within the watershed. For more information, see the Data sources and methods section.
Source: Environment and Climate Change Canada (2025) Freshwater Quality Monitoring and Surveillance Division.

Table A.3 Data for Figure 3. Estimated total phosphorus loading to Lake Erie by source, Canada, 2010 to 2024

Year	Total phosphorus loading from point sources (tonnes per year)	Total phosphorus loading from non-point sources (tonnes per year)	Total phosphorus loading atmospheric (tonnes per year)	Total phosphorus loading from Lake Huron (tonnes per year)	Total phosphorus loading from all sources (tonnes per year)
2010	132	427	184	161	903
2011	147	2,173	277	161	2,758
2012	131	837	175	161	1,304
2013	141	1,429	258	161	1,989
2014	143	2,115	177	161	2,596
2015	129	998	169	161	1,457
2016	125	671	179	161	1,135
2017	127	1,230	273	161	1,791
2018	120	1,864	267	161	2,412
2019	126	2,144	162	161	2,592
2020	126	1,506	199	161	1,992
2021	104	1,090	216	161	1,572
2022	108	1,682	158	161	2,108
2023	102	1,730	142	161	2,135
2024	104	1,721	251	161	2,237

Note: The total phosphorous loadings from atmospheric sources and from Lake Huron were halved to roughly estimate the Canadian contributions. Loadings from Lake Huron are estimates from models. Values are rounded to the nearest whole number. Totals may not add up due to rounding. For more information, see the Data sources and methods section.
Source: Environment and Climate Change Canada (2025) Freshwater Quality Monitoring and Surveillance Division.

Additional information can be obtained at:

Environment and Climate Change Canada
Public Inquiries Centre
Place Vincent Massey Building
351 Saint-Joseph Boulevard
Gatineau QC K1A 0H3
Toll Free: 1-800-668-6767
Email: enviroinfo@ec.gc.ca