AIR QUALITY 101

Science 30 Teacher Overview and Activity Guide

This learning package was designed by the West Central Airshed Society (WCAS), a not-for-profit multi-stakeholder organization that collects and shares information about ambient air quality in West Central Alberta.

As Alberta's inaugural Airshed organization, WCAS is responsible for operating air quality monitoring stations that measure the level of pollutants in the outdoor air; providing credible science-based data and educational outreach to all stakeholders, including the public; and working collaboratively to better air quality in West Central Alberta.

We invite you to explore this teacher guide and the other learning package materials (including the classroom presentation and accompanying teaching script) that are available on our website, and hope that you and your students enjoy the content and activities that follow.

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We hope you and your students enjoy these resources! To offer feedback, or if you require further information, please contact us at info@wcas.ca

OVERVIEW

This Teacher Guide is part of the larger Science 30 learning package—*Air Quality 101*— which introduces students to the various ways human activities and natural events can impact the quality of our air. Through an inquiry-based presentation and hands-on activities, students will learn how air pollution harms the environment, ecosystems, and our health. This material also focuses on current efforts to monitor and predict air quality in Alberta and teaches students how to locate, interpret, and make use of publicly available air quality data.

LEARNING PACKAGE QUICK FACTS

- Can be used for both in-class or online instruction
- Meets the needs of a variety of different learning styles
- Is flexible—use the whole lesson or pick and choose activities according to your goals
- Access to the internet and equipment to display PowerPoint is required
- All materials are available on our website, including:
    - An inquiry-based PowerPoint lesson containing four activities and two videos
    - A Teaching Script (included in the lesson slideshow and available as a separate document)

CURRICULUM CONNECTIONS

This learning package aligns with Alberta's Science 30 curriculum, Unit B: Chemistry & the Environment:

- 30–B1.8k outline the chemical reactions (e.g., combustion reactions) that produce air pollutants (i.e., sulfur dioxide and nitrous oxides) that, when combined with water, ultimately result in acid deposition.
- 30–B1.9k describe impacts on the biotic and abiotic components of the environment caused by acid deposition.
- 30–B1.2sts explain how science and technology have both intended and unintended consequences for humans and the environment.
- 30–B1.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results.
- 30–B2.5k identify and explain how human activities and natural events contribute to the production of photochemical smog, the depletion of the ozone layer and increased concentrations of organic compounds in the environment; e.g., driving a car, use of CFCs, agricultural practice.
- 30–B3.1k describe the risks and benefits of using chemical processes that may produce products and/or by-products that have the potential to harm the environment.

LEARNING OUTCOMES

At the end of this unit, students will be able to:

- List common outdoor air pollutants and their sources
- Illustrate how weather conditions and topography influence the distribution of pollutants in our atmosphere
- Describe some of the chemical transformations primary pollutants can undergo once emitted into the atmosphere
- Explain how air pollutants can have profound effects on living things and the environment, even when present in very small concentrations
- Interpret air quality data and forecasts
- Reflect on how their daily activities contribute to local air quality and identify behavioral changes they can adopt to help improve conditions
- Appreciate that scientific questions require insight from a variety of different disciplines in order to be solved

LESSON OUTLINE & INSTRUCTIONS

The *Air Quality 101* lesson is a PowerPoint presentation consisting of 43 slides. Appropriate software and computer equipment is required to teach this material. A secure internet connection is also necessary, as the lesson contains links to online videos.

When starting the PowerPoint, be sure to use “presenter view;” this will allow you to read the teaching script located in the “notes” section of the slideshow. Notes written in italics are the suggested teaching script while CAPITAL LETTERS signify an action that is required (e.g., CLICK SLIDE) and any additional information is written in normal lettering.

The entire presentation will take roughly 60 to 90 minutes to cover (not including time spent on activities). You may wish to split the material up, so your lesson unfolds over several days. The content is divided into two modules:

MODULE 1 (SLIDES 2 - 23)

Introduces students to air pollution issues ranging from local (e.g., photochemical smog) to global (e.g., ozone depletion) in their scale and impact. Students will learn about common air pollutants, the environmental factors that influence the dispersal of pollutants in our atmosphere, and air pollution’s effect on the health of humans and ecosystems. In an associated case study (i.e., Activity 2: Case Study — The Great Smog of 1952), students apply this knowledge to determine the causes of a historic air pollution episode.

- 2 activities – additional 90 minutes

MODULE 2 (SLIDES 24-43)

Addresses current efforts to monitor, measure, and manage air quality in Alberta. Students will learn about Airsheds, how they function, who is involved (i.e. stakeholders), and the role these organizations play in keeping our communities safe. In the associated activities, students will develop the skills necessary to interpret air quality data and to use this information to make informed decisions about their outdoor activities.

- 2 activities – additional 100 minutes
- 2 videos

While we encourage you to cover all activities in the lesson, if time is at a premium, you may pick and choose activities as needed. The Teaching Script is written such that if any activities are left out, the lesson still functions, however, please note that Activity 4 builds on knowledge from Activity 3.

This Teacher Guide provides an in-depth overview of the activities embedded in the *Air Quality 101* lesson. Teachers should review this information carefully. Where applicable, the activity outlines contain:

- Time required
- Summary
- Essential questions
- Preparation required
- Materials list
- Background information
- Activity instructions
- Teacher tips
- Modifications
- Student worksheets (+ answer keys)

ACTIVITY 1: WHERE DO YOU STAND?

Time required: 15-20 minutes

SUMMARY

This introductory value-line activity allows teachers to assess students' understanding of and interest in air quality issues before beginning the lesson. The value line is designed to activate student's prior knowledge of air pollution and to provide them with an opportunity to share their perceptions of the subject with their peers.

ESSENTIAL QUESTIONS

- Why is breathing clean air important?
- How and why does air quality vary around the world?
- Are personal actions necessary and/or sufficient to help solve air pollution problems?
- What role can legislation play in curbing air pollution?

MATERIALS

- 5 pieces of paper, numbered 1-5
- Tape

PREPARATION

- Ensure you have enough space in your classroom (or other location) for students to move freely and safely along the value line.
- Establish the value line by evenly spacing out and taping numbers 1-5 to your walls and/or floors.

TEACHER BACKGROUND INFORMATION

*Use the following points to guide your class discussion (these are included in the teaching script):

- Clean air is one of the basic requirements of human health and wellbeing. We breathe approximately 20,000 times a day, so clean air is essential to a good quality of life.
- Emissions of many air pollutants have decreased substantially throughout the world in recent decades. However, air pollutant concentrations are still too high, and air quality remains an issue.
- The World Health Organization estimates that ambient (outdoor) air pollution is responsible for 4.2 million premature deaths every year, with an additional 3.8 million premature deaths linked to household air pollution. These statistics make air pollution the world's largest environmental health risk and among the largest global health risks.
- Alberta and its urban centres (such as Edmonton) benefit from relatively good air quality, but weather conditions, natural disasters, and industrial accidents sometimes create dangerous air quality episodes.
- Cities are often thought of as having worse air quality than rural areas, however, this is not always the case. Agricultural activities can produce a significant amount of air pollution by way of livestock operations and crop management (e.g., the use of fertilizers).
- Air pollution is a problem throughout the world but is often worse in developing and densely populated countries, such as China and India. These countries tend to have a higher reliance on fossil fuels and emit more pollutants because of their large populations.
- Laws, regulations, and policies have been successful in the past at curbing emissions; however, legislation tends to be focused on big emitters (i.e., industry) as opposed to public behaviour.

- Many everyday human activities result in air pollution; therefore, by changing our habits and behaviours, we can help improve local air quality. Laws and regulations are not the only way to help solve air pollution problems. If we want to be successful, a combination of approaches must be taken.
- Humanity has the necessary knowledge and tools to improve air quality, but we need to be invested in this topic and willing to make changes to our daily routines for progress to occur.

INSTRUCTIONS

- Display Slide #3, which contains the value line scale:
  - 1 – Strongly disagree
  - 2 – Somewhat disagree
  - 3 – Unsure or neutral
  - 4 – Somewhat agree
  - 5 – Strongly agree
- Explain that you will be reading aloud a series of statements. Note that you must click the slideshow to reveal the following statements one at time:
  - Clean air is a basic human right
  - Air pollution is a global problem that lawmakers should prioritize
  - Air pollution affects our local community
  - Environmental laws should target big polluters (like businesses and industries) rather than individuals
  - My everyday actions impact local air quality
  - My generation can do something about air pollution
- For each statement, have students determine which spot on the value line most closely represents their opinion. Then ask students to line up according to their stance.
- Encourage students to verbalize what they notice about the feelings of the group, e.g., "over half the class agrees with this statement."
- If possible, invite students to partner with someone who disagrees with their stance and discuss their differing positions.
- Debrief the value line judgement with your entire class.
- You may also wish to build in the opportunity for students to change their stance on a statement, after hearing the insights of their peers.
- Proceed in the same fashion for each statement.

*** During your discussion, be sure to distinguish air quality from climate change. While the two topics are related, and poor air quality can contribute to climate change and vice versa, they are two distinct topics. Climate change scientists look at the long-term cumulative effects of human activity on the Earth while air quality experts are more concerned with shorter time periods, and some will focus on local air pollution issues.

MODIFICATIONS

This activity is flexible; it can be done in a variety of locations. If space is an issue, you may wish to conduct the activity outdoors, using numbered pilons. If students are learning online, have them write down and display the number that corresponds to their answer. In addition, feel free to modify the value-line scale and add or remove statements as you see fit.

TEACHER TIPS

Where students place themselves on the value line is not as important as the conversation it creates. Let this activity be an opportunity for students to recall and share what they already know about air quality, the causes and effects of air pollution, and their level of engagement with the topic.

Learning about pollution and air quality issues can be overwhelming for students; be sure to keep the tone of your conversation open, considerate, and hopeful. Remind students that the actions we take in our local communities can make a difference.

*This activity was inspired by a resource on climate change by Ingenium, Canada's Museum of Science & Innovation: https://energy.techno-science.ca/docresources/TWD_English.pdf

ACTIVITY 2: CASE STUDY – THE GREAT SMOG OF 1952

Time required: 60-75 minutes

SUMMARY

In this case study, students investigate London's Great Smog of 1952—an air pollution episode that claimed the lives of approximately 12,000 people. Students are broken up into five teams: Geographers; Meteorologists; Energy Specialists; Chemists; and Medical Doctors, each examining the tragedy from a different scientific perspective. Groups are given a set of facts about the event and asked to present the most pertinent information to the class. The teacher facilitates a class discussion to uncover the combination of factors that led to the Great Smog. With this knowledge, students then propose a series of solutions that could be implemented to prevent a similar disaster from occurring in the future. These proposals will be compared with the actual steps taken by London lawmakers.

ESSENTIAL QUESTIONS

- How do environmental factors as well as societal and economic circumstances work together to determine the quality of our air?
- How have urban problems, such as severe air pollution, have raised society's awareness of the environment and our need to protect it?
- What role can governments, industries, and the public play in helping to curb air pollution?

REQUIRED MATERIALS

- Expert testimony sheets – one copy per group
- Clearing the Air worksheet – one copy per group, or one per student

BACKGROUND INFORMATION

Recent and detailed summaries of the Great Smog of 1952 can be found online. You may wish to read a few accounts to obtain a good understanding of the event before facilitating the class discussion:

- https://www.history.com/news/the-killer-fog-that-blanketed-london-60-years-ago
- https://www.metoffice.gov.uk/weather/learn-about/weather/case-studies/great-smog
- https://www.britannica.com/event/Great-Smog-of-London
- https://www.bbc.com/future/article/20151221-the-lethal-effects-of-london-fog

INSTRUCTIONS

- Before beginning this activity, have students recall the four main factors that influence air quality (as stated in Slide #7 of the PowerPoint lesson):

1. Sources
2. Emissions
3. Chemical Transformations
4. Dispersion

- Read the "Synopsis of the Great Smog" and the "Activity Premise" aloud to the class (see pages 9 and 10).
- Divide students into five teams: Geographers, Meteorologists, Energy Specialists, Chemists, and Medical Doctors and distribute the "expert testimony" sheets to the appropriate groups.
- Allow teams enough time to digest the information on their sheets and encourage them to write a series of questions they'd like to pose to the other experts.
- Let students know that they will be presenting their insights to the rest of the class. The goal will be for the class to work collaboratively to determine how various factors contributed to the Great Smog of 1952.
- Have each group of experts make a small presentation to the class and encourage discussion amongst groups to uncover why the smog episode had such a devastating impact on London's residents.
- During the presentations and class discussion, be sure students address the following questions:
    - **Emissions:** What types of primary pollutants were emitted during the Great Smog of 1952?
    - **Sources:** Where did these pollutants come from?
    - **Circumstances:** What environmental, economic, and societal circumstances influenced the amount of pollutants emitted into London's atmosphere?
    - **Chemical Transformations:** Did the primary pollutants react and change in the atmosphere? Did any secondary pollutants form?
    - **Dispersion:** How did topography and weather conditions impact this air pollution episode?
    - **Outcomes:** How did the Great smog impact Londoners health?
- To conclude this activity, your students will be tasked with proposing solutions that would prevent a similar disaster from happening in the future. You may choose to keep students in the same groups they were originally assigned to, or create new (perhaps smaller) groups, for this portion of the activity.
- Distribute the "Clearing the Air" worksheets to each group and give them enough time to complete the first question (see page 20).
- Facilitate a class discussion about possible solutions, and then let students know how London's lawmakers chose to address the situation. Background information on London's various Clean Air Acts is found after the "Activity Premise" on the pages that follow.
- With this knowledge, students should then proceed to completing the second question on their worksheet.

SYNOPSIS OF THE GREAT SMOG OF 1952

The Great Smog of 1952 was an air pollution episode of unprecedented duration and severity. It lasted from Friday, December 5th to Tuesday, December 9th. Initial estimates reported that 4,000 people had died of the smog; but recent evidence suggests that number was much higher.

The smog became so thick, people couldn't see their own feet. This, of course, had widespread effects: public transit shutdown, as did ambulance services. "The tube," an underground railway system, was Londoners only option for public transportation. The London airport was also greatly affected, with hardly any flights making it into or out of the city. The smog eventually began to creep into buildings and homes; operas, concerts, and sporting events were cancelled. Crime was also a problem, with thieves stealing from shops and people on the street.

The British government initially preferred to see the Great Smog of 1952 as a "natural disaster" that was beyond their control. Thanks to public pressure, however, they eventually established the Beaver Committee, whose goal it was to: (1) determine the causes of this event, (2) better understand the poor air quality that had been plaguing the city for centuries, and (3) recommend preventative actions.

ACTIVITY PREMISE

You are part of a committee of experts tasked with investigating the Great Smog of 1952. Your goal is to determine what factors contributed to this catastrophic event. Together, your class will examine: (1) the combination of chemicals and particulate matter released into the atmosphere at the time, (2) how environmental conditions, including weather and topography, contributed to the build up of these pollutants, and (3) the smog's effects on Londoners' health—both in the short and long term.

Once you have uncovered the reasons why the Great Smog of 1952 was so lethal, your class will then make recommendations as to what regulations and/or restrictions should be imposed to curb emissions and reduce the impact on environmental and human health. These solutions will then be compared to those proposed by the Beaver Committee as well as the actions taken by London's lawmakers.

BACKGROUND INFORMATION: THE AFTERMATH OF THE GREAT SMOG

The Beaver Committee's report included recommendations that eventually wound up in the **Clean Air Act of 1956.** This new legislation:

- Required that adequate levels of smokeless fuels be available for public consumption and that the public be urged to use these fuels during periods of heavy fog.
- Required that warnings be issued when weather patterns that could result in heavy smog were expected.
- Aimed to control domestic sources of smoke pollution by establishing smokeless zones throughout the city. In these areas, smokeless fuels had to be used.
- Provided incentives (such as conversion grants) to enable residents to make the transition to cleaner home heating sources, such as oil and natural gas.
- Relocated power stations to more rural areas away from the city.

The Clean Air Act of 1956 was later amended and added to by the **Clean Air Act of 1968** (which followed another bout of bad smog in the 1960s). This Act:

- Required power stations and industries burning coal, liquid, or gaseous fuels to have taller chimney stacks – based on the principle that the higher the chimney the better the dispersal of the air pollution. See the source below for more details: http://www.soe.uoguelph.ca/webfiles/gej/AQ2017/Walton/index.html

BACKGROUND INFORMATION: OUTCOMES OF THE CLEAN AIR ACTS

The Clean Air Act of 1956 was revolutionary and represented a major global milestone in environmental protection. In the years that followed, a host of other industrial nations were inspired to follow suit.

The Clean Air Acts of 1956 and 1968 were later repealed and consolidated into the Clean Air Act of 1993. Together, these laws helped improve London's air quality and public health, and so too did the introduction of new fuels and technologies. The switch from coal to oil and gas as the main fuels for heating, cooking, transport, and industrial activities reduced certain emissions dramatically. Gas and oil produce only a fraction of the soot, smoke, and sulphur emissions associated with coal. These emissions, however, have now been replaced by less visible pollutants, such as nitrogen oxides.

*This activity was inspired by a resource from the Ventura County Air Pollution Control District: http://www.vcapcd.org/AirTheFilm/pubs/AirPollutionTragedyLessonPlan.pdf

GEOGRAPHERS
EXPERT TESTIMONY

Review the information below to determine how London's physical geography and population played a role in the Great Smog of 1952. Consider the fact that London is (and was) a major urban centre.

London is located in the southeastern portion of England (see map to the right). It is the capital city and largest urban area of the United Kingdom. In 1952, its population was approximately 8 million. London is a port on the Thames, a river large enough for boats and ships.

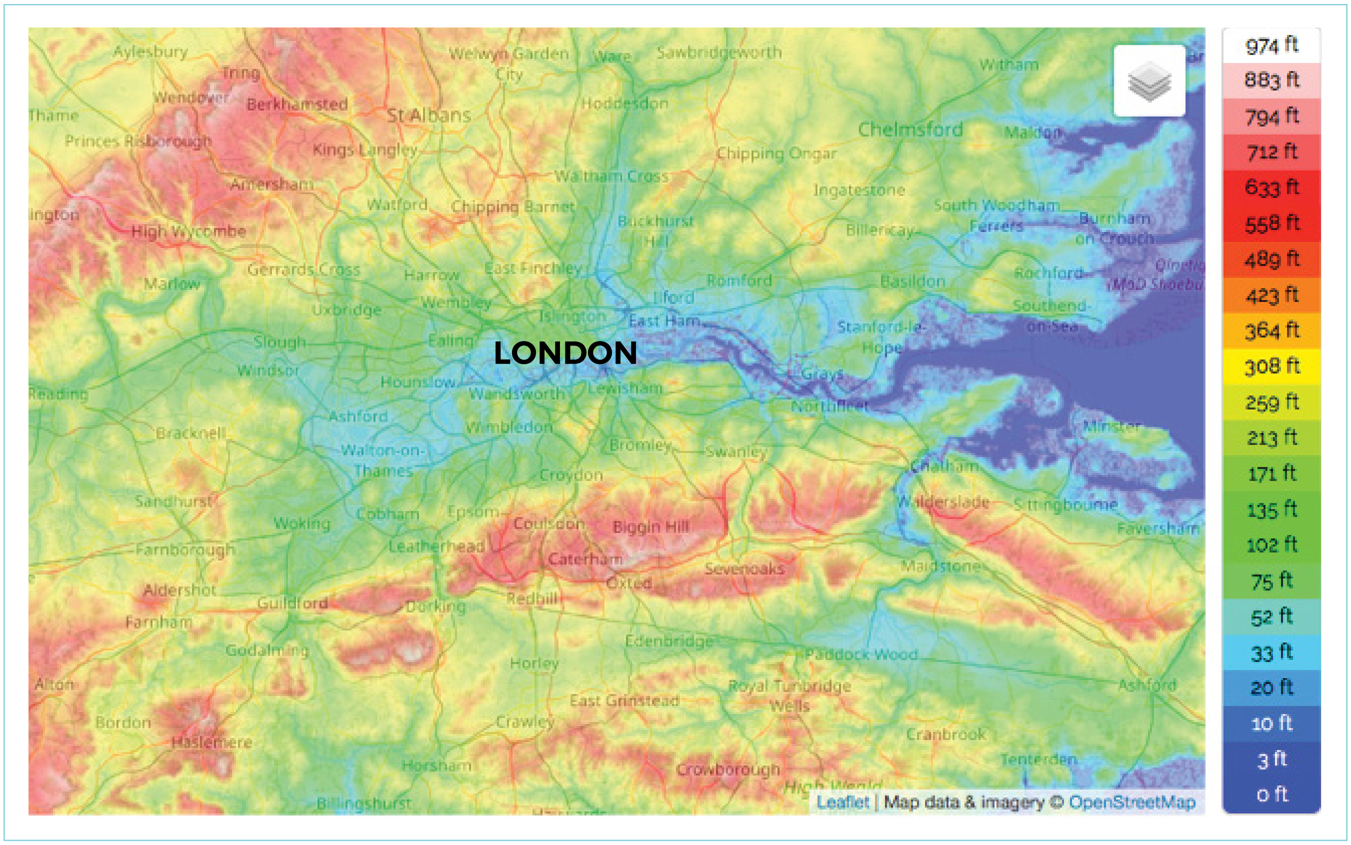
The climate of London is similar to the rest of the country, with warm summers, cool winters, no wet or dry season, and often moderate-to-strong winds. London is classified as having a temperate maritime climate.

TOPOGRAPHIC MAP OF THE UNITED KINGDOM

Source: Wikipedia Commons https://commons.wikimedia.org/wiki/File:Uk_topo_en.jpg

**Significant areas of hills and mountains are depicted in varying shades of brown, depending on their altitude above sea level. The darker the shade, the higher the elevation.*

TOPOGRAPHIC MAP OF GREATER LONDON & SURROUNDING AREA



Source: topographic-map.com https://en-gb.topographic-map.com/maps/lpj5/London/

At a smaller scale, London lies within the bowl of the London Basin. The centre of the basin is dominated by the valley of the Thames, which runs from east to west (see map above).

The city is surrounded by low hills—none more than a few hundred feet high—with marshland on its outskirts and a large river (the Thames) running through it. This topography makes the city particularly susceptible to winter fogs, and it encourages temperature inversions (a weather phenomenon wherein a layer of warm air traps cooler air beneath it).

*A basin is a dip or depression in the Earth's surface.

METEOROLOGISTS
EXPERT TESTIMONY

Review the information below to determine how weather conditions contributed to the buildup of pollutants in London's air during the Great Smog of 1952.

There had been a cold snap in London in November and early December of 1952, with heavy snowfalls covering the area. Temperatures remained at or slightly below freezing in the city throughout the Great Smog episode.

From December 5th through December 8th, an anticyclone (or area of high pressure) was centred over southern England. This system produced a long period of stable weather, clear skies, and very light winds—conditions that are ideal for both radiation fog and temperature inversions.

Fog is essentially a cloud at ground level; it consists of tiny water droplets or ice crystals floating in the air. Fog is influenced by nearby bodies of water, topography, and weather conditions.

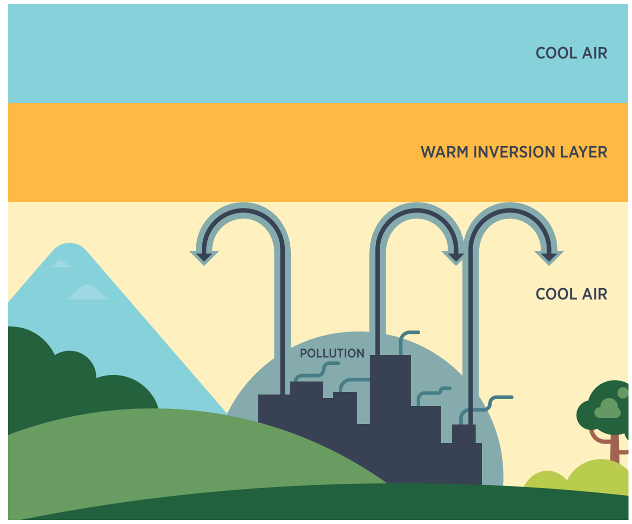
For both fog and clouds to form, the air temperature needs to cool to its dew-point temperature (the temperature at which condensation occurs). Once this happens, the water vapour in our air condenses into droplets and forms fog.

Radiation fog often occurs in London during the winter, but these episodes usually do not last long. The fog of 1952 was noteworthy for both its thickness and duration.

Radiation fog forms overnight as the ground loses (or radiates) the heat it had absorbed during the day. When moist air comes into contact with the ground, it cools to its dew-point temperature, forming fog. Morning sun usually "burns off" this type of fog by heating the ground and causing fog to evaporate.

The same radiation that causes fog can also result in a temperature inversion.

TEMPERATURE INVERSION & EFFECTS ON AIR POLLUTION



Under normal atmospheric conditions, we find warm air at ground level and cooler air above, which allows air to rise easily and carry away pollutants. In a temperature inversion, the temperatures are upside down: the cooler air is at ground level, and the warmer air is higher up. The cooler air cannot rise, and the warmer air above acts like a lid, trapping pollutants near the ground and creating poor air quality.

In December of 1952, the air beneath London's inversion layer not only contained water droplets from the fog, but also smoke and other pollutants emitted from the city's many chimneys and power stations. The resulting smog had nowhere to go and eventually grew to cover an area over 50 km wide.

The build up of smoke in London's air became so thick that the morning sun had a hard time breaking through to heat the ground; the air at ground level remained cool and the fog stayed in place in central London for four straight days.

On December 9th, a low-pressure system brought in rain and a strong southwesterly wind that pushed London's smog away from the city and out to the North Sea.

ENERGY SPECIALISTS
EXPERT TESTIMONY

Review the information below to determine how energy production and use may have played a role in the Great Smog of 1952. Consider how economic and societal circumstances may have influenced Londoners' choice of fuel.

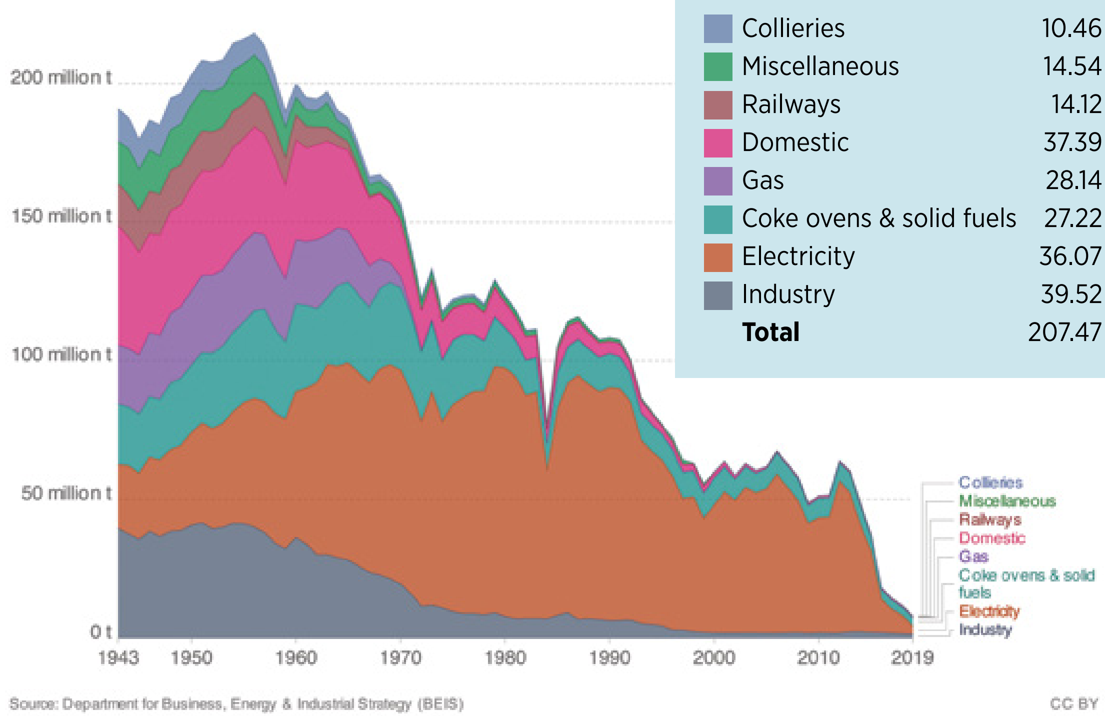
Coal replaced wood as the main fuel source in Britain by the 1700s.

At the time of the Great Smog, coal was used for industrial purposes and to generate electricity—in fact, in 1952, numerous coal-fired power stations operated within the Greater London area.

In addition, burning coal was the primary way to heat homes and businesses in London and was also used heavily by the railway system.

COAL BY END USER IN THE UNITED KINGDOM

Coal use differentiated by its end use category.
This is measured in tonnes per year.



1952	
Collieries	10.46 million t
Miscellaneous	14.54 million t
Railways	14.12 million t
Domestic	37.39 million t
Gas	28.14 million t
Coke ovens & solid fuels	27.22 million t
Electricity	36.07 million t
Industry	39.52 million t
Total	207.47 million t

Source: Our World in Data https://ourworldindata.org/death-uk-coal
*Note: A colliery is a coal mine.

ENERGY SPECIALISTS
EXPERT TESTIMONY (CONT.)

Coal is a solid fossil fuel made up primarily of carbon as well as varying amounts of impurities (like sulphur). There are four main types of coal, which are ranked based on the amount of carbon they contain as well as the amount of energy they can produce:

Rank / Name	Dry Carbon Content (%)	Value	Characteristics
Highest / Anthracite ("hard coal")	86% - 92%	$$$$$	• Rarest and cleanest type of coal • Burns efficiently and produces a higher heat than other coals • Contains the least amount of impurities • Produces little smoke
Middle / Bituminous ("soft coal")	76% - 86%	$$$	• Most abundant type of coal • Cheaper and easier to extract than anthracite coal • Releases a significant amount of energy when burned • Produces more smoke than anthracite coal
Low / Subbituminous	70% - 76%	$$	• Does not burn as efficiently as higher ranked coals • Can lead to harmful emissions, particularly soot, sulphur oxides, nitrogen oxides, and mercury
Lowest / Lignite ("brown coal")	65% - 70%	$	• Dirtiest coal • Burns inefficiently • Contains the most impurities of all coals, which leads to higher levels of harmful emissions • Produces the most soot and smoke

In 1950s London, most of the coal used to heat homes and businesses was on the lower end of the spectrum. A bad economy at the end of World War II led the British government to export their best coal to other countries; power stations and railways got the next-best coal, while dirty, low-quality coal was made available to citizens to heat their homes.

*Soot is a type of particulate matter (PM) that is formed by the incomplete combustion (burning) of coal. It is a major component of coal smoke.

CHEMISTS
EXPERT TESTIMONY

Review the information below to determine the types of pollutants that were released into London's atmosphere during the Great Smog of 1952 (and how these emissions reacted with the environment to form toxic air).

The following amounts of pollutants were emitted each day during the Great Smog:

- 2,000 tonnes of carbon dioxide (CO_2)
- 1,000 tonnes of particulate matter (PM)
- 370 tonnes of sulphur oxides (SO_x) → which transformed to 800 tonnes of sulphuric acid (H_2SO_4)

These pollutants came from a variety of sources in the city that were burning coal. Coal is a solid fossil fuel, rich in carbon (C). When it burns, the chemical bonds holding its carbon atoms in place are broken, releasing energy and producing carbon dioxide (CO_2):

Combustion equation: $C + O_2 \rightarrow CO_2$ + energy (heat)

Combustion is a chemical process in which a substance reacts rapidly with oxygen to produce energy in the form of light and heat.

Complete combustion transforms all of the carbon in coal into carbon dioxide (CO_2) and releases the maximum amount of energy from this fuel. However, combustion is rarely complete.

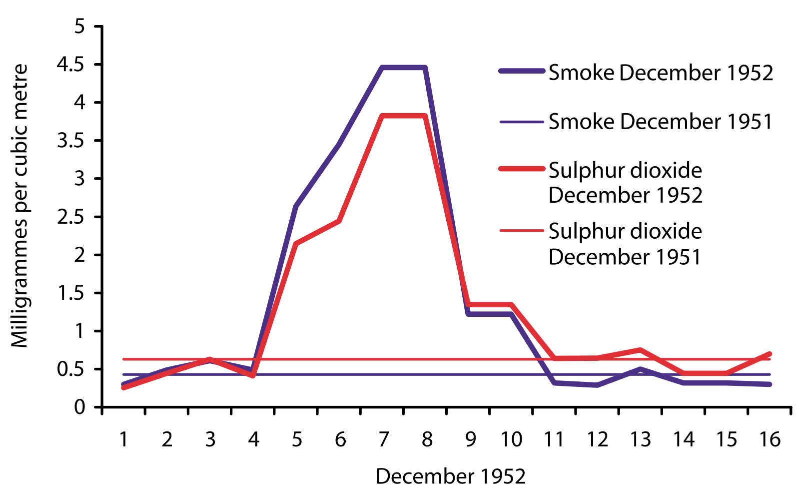
Incomplete combustion occurs when there is not enough heat and oxygen for the coal to burn fully. This situation leaves behind unburned or half-burned particles of carbon (also known as soot). These particles are released into the atmosphere as a dark cloud of smoke.

Coal contains not only carbon but also varying amounts of impurities, like sulphur and nitrogen; for this reason, other chemicals are emitted into the air when we burn coal, such as sulphur oxides (SO_x) and nitrogen oxides (NO_x).

From December 4th through 10th of 1952, London recorded unusually high amounts of both smoke and sulphur dioxide in the air.

Figure 1
Smoke and sulphur dioxide concentrations at County Hall during the Longon smog of December 1952 compared to the average concentrations in December 1951

Source: London County Council 1953



Source: Greater London Authority https://cleanair.london/app/uploads/CAL-217-Great-Smog-by-GLA-20021.pdf

CHEMISTS
EXPERT TESTIMONY (CONT.)

Sulphur dioxide (SO_2) emissions can react with oxygen and water molecules in the atmosphere to form sulphuric acid (H_2SO_4), one of the main ingredients in acid rain. See below for the chemical formula:

$2SO_2$	+	O_2	→	$2SO_3$
Sulphur dioxide		Oxygen		Sulphur trioxide
SO_3	+	H_2O	→	H_2SO_4
Sulphur trioxide		Water		Sulphuric acid

Measurements show that the smog of 1952 was highly acidic.

During the Great Smog, tiny droplets of sulphuric acid built up in London's naturally foggy environment. When the sun rose each morning, it "burned off" some of the fog, but left behind a haze of smaller acidic particles. Each day the smog persisted, London's air became more and more toxic.

MEDICAL DOCTORS
EXPERT TESTIMONY

Review the information below to determine which pollutants were to blame for the high number of deaths that occurred during the Great Smog of 1952. How did these emissions affect both the short- and long-term health of Londoners?

Londoners were used to breathing dirty air on occasion, so during the early stages of the Great Smog of 1952, most residents did not panic, nor did they take many precautions.

It was not until several weeks after the incident, when officials reported the number of individuals who'd died during the event, that people began to realize just how dangerous this bout of smog had been.

DEATHS IN LONDON: WINTER OF 1952 VS. THE AVERAGE NUMBER OF DEATHS FROM 1947-1951

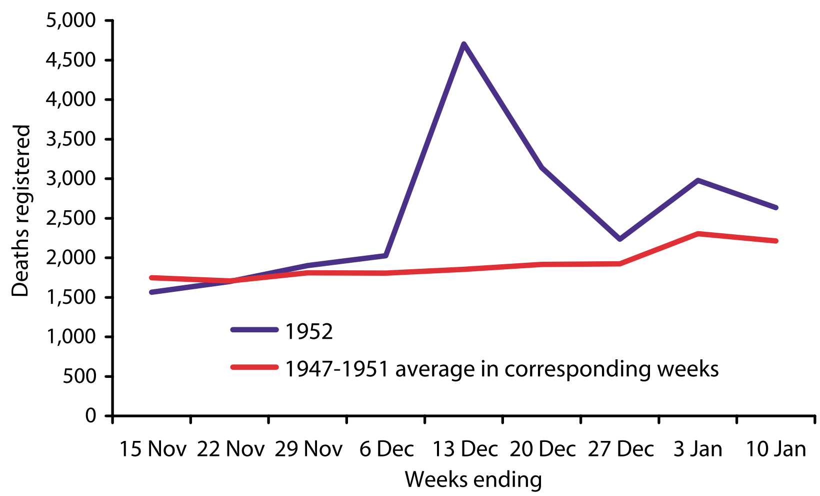


Figure 2
Deaths registered during the London smog of December 1952

Source: Ministry of Health 1954

Source: Greater London Authority https://cleanair.london/app/uploads/CAL-217-Great-Smog-by-GLA-20021.pdf

At the time, it was estimated that approximately 4,000 Londoners died prematurely either during or in the aftermath of the smog event. Today, it is believed that the death toll was closer to 12,000 people and that another 100,000 people became sick because of the toxic air.

The official causes of death were mainly respiratory (lung) diseases, such as bronchitis and emphysema, and to a lesser extent, cardiovascular (heart) diseases.

People over the age of 65 and those already suffering from ill health were the groups most likely to have died during the Great Smog of 1952.

MEDICAL DOCTORS
EXPERT TESTIMONY (CONT.)

Hospital patients who experienced mild symptoms complained of burning eyes and throats.

A recent study found that the Great Smog was responsible for thousands of cases of asthma. Londoners who were babies or young children during the Great Smog event are 20% more likely to suffer from this respiratory disease than people who lived outside of the city in 1952.

Children are more likely to suffer from air pollution because their lungs are less-developed, and they breathe faster than adults.

The following pollutants were emitted each day during the Great Smog event:

- 2,000 tonnes of carbon dioxide (CO_2).
- 1,000 tonnes of particulate matter (PM)
- 370 tonnes of sulphur oxides (SO_X) → which transformed to 800 tonnes of sulphuric acid (H_2SO_4)

COMMON HEALTH PROBLEMS ASSOCIATED WITH AIR POLLUTANTS

Pollutant	Mild Symptoms	Severe Symptoms
Carbon Dioxide (CO_2)	Headaches, dizziness, restlessness, pins-and-needles feeling	Elevated blood pressure, coma, convulsions
Sulphur Dioxide (SO_2)	Eye and throat irritation, increased vulnerability to respiratory infections and chronic bronchitis	Can contribute to cardiovascular and respiratory diseases
Sulphuric Acid (H_2SO_4)	Eye, nose, and throat irritation, choking, difficulty breathing, and tightness in chest	Can cause serious damage to lungs and result in death
Particulate Matter (PM)	Coughing, scratchy throat, increased vulnerability to respiratory infections	Can contribute to cardiovascular and respiratory diseases (like bronchitis)

STUDENT WORKSHEET: CLEARING THE AIR

Statement: *Londoners could not do much to change the fact that their city is prone to fog, but they could do something to prevent the addition of toxic smoke from mixing with this fog to create smog.*

1. **Considering the statement above, come up with recommendations on how to solve the poor air quality problems experienced by London in the mid-twentieth century.** Hint: "burn less coal" is not a detailed enough answer. How would you go about burning less coal? What other types of fuel might you encourage the use of?

2. **Compare your recommendations with the regulations/legislation put in place by the Clean Air Acts of 1956 and 1968 (your teacher will elaborate). Were they similar? Do you think your ideas would have been more successful? Why or why not?**

ACTIVITY 3: ONE IN A BILLION

Time required: 40 minutes

SUMMARY

In this experiment, students follow a set of instructions to dilute a solution of food colouring and water. Students will convert food colouring/water ratios to the measurements used in air quality science: parts per million (ppm) and parts per billion (ppb). They will compare the ratios they've created to the ratios of various gases present in the atmosphere as well as the established limits for certain pollutants in Alberta. In doing so, students will recognize that pollutants need only to be present in small concentrations to cause damage to living things.

ESSENTIAL QUESTIONS

- What does part per million (ppm) and part per billion (ppb) mean?
- How different is 1 part per million from 1 part per billion?
- Why are air pollutant concentrations measured using ppm and ppb?

MATERIALS (PER GROUP)

- Food colouring (preferably dark colours)
- White ice cube trays with 10 or more slots
- Permanent marker and masking tape to label ice cube slots 1-10
- 2 eye droppers or pipettes
- Several cups of water
- Rubber gloves (to avoid staining hands)

PREPARATION

- Using tape and a permanent marker, label the ice cube trays with the numbers 1 through 10 (each number should represent a separate slot on the tray). This step can be done by the students if you prefer.
- Set up workstations for each group, ensuring they have all the necessary supplies to conduct the experiment.

INSTRUCTIONS

- Display Slide #32.
- Follow the teaching script to introduce this activity.
- Divide students in small groups depending on the amount of supplies you have.
- Discuss the concept of a solution with your students. In this activity, solution refers to the mixture of food colouring and water.
- Explain that students will create a series of solutions containing different amounts of water and food colouring.
- Hand out supplies and review the steps of the procedure with students before they begin.

MODIFICATIONS

If required, students can use an online ppm/percentage calculator to help them convert measurements.

*This activity was adapted from a resource created by North Carolina's Department of Environmental Quality: https://deq.nc.gov/about/divisions/air-quality/air-quality-outreach/air-quality-public-involvement/air-awareness/its-our-air/1-3-parts-million

Name:________________________________

STUDENT WORKSHEET: ONE IN A BILLION

INSTRUCTIONS

You should be using two different eyedroppers or pipettes for this activity. Be sure to use one solely for when you add clean water to your ice cube tray.

1. Use the eyedropper or pipette to put 10 drops of food colouring into slot #1 of your ice cube tray.
2. Using the same eyedropper or pipette, remove one drop of food colouring from slot #1 and place it into slot #2.
3. Use the clean eyedropper or pipette to add nine drops of clean water to slot #2. Stir the solution.
4. Complete the second row of the table below.
5. Remove one drop from slot #2 and place in slot #3.
6. Use the clean eyedropper or pipette to add nine drops of clean water to slot #3. Stir the solution.
7. Complete the third row of the table below.
8. Remove one drop from slot #3 and place it in slot #4.
9. Use the clean eyedropper or pipette to add nine drops of clean water to slot #4. Stir the solution.
10. Fill out the fourth row of the table.
11. Repeat these steps until you've filled in all 10 slots of the ice cube tray.

Ratio of food colouring to solution expressed as...

Slot Number	Fraction	Percentage (parts per hundred)	Parts per million (ppm)	Parts per Billion (ppb)
1	10/10	100%	1,000,000 ppm	1,000,000,000 ppb
2	1/10	10%	100,000 ppm	
3	1/100			
4				
5				
6				
7				
8				
9				
10				

*1 ppm is equal to 1000 ppb

STUDENT WORKSHEET: ONE IN A BILLION

FOLLOW-UP QUESTIONS

1. Observe and compare the solution from slot #1 to that of slot #10.

   a. How does the appearance of the solution in slot #1 differ from that of slot #10?

   ____

   ____

   ____

   ____

   b. Why do these solutions differ in appearance?

   ____

   ____

   ____

   ____

2. Earth's atmosphere contains 78% nitrogen.

   a. How would you display this percentage in **parts per million?** (Hint: solve for x in the following equation: 78/100 = x/1,000,000)

   ____

   b. Which slot of the ice cube tray most closely represents the concentration (ppm) of nitrogen in our atmosphere?

   ____

3. Argon is a "trace gas" found in Earth's atmosphere (meaning it is present in a very small concentration).

   a. Argon makes up 0.9% of the atmosphere. How many **parts per million** is that? (Hint: solve for x in the following equation: 0.9/100 = x/1,000,000)

   ____

   b. Which slot of the ice cube tray most closely represents the concentration (ppm) of Argon in our atmosphere?

   ____

STUDENT WORKSHEET: ONE IN A BILLION

4. Nitrogen dioxide (NO_2) is a harmful pollutant that is measured in **parts per billion.**

   a. In Alberta, hourly nitrogen dioxide levels exceeding **159 ppb** are considered dangerous for our health. Which slot of the ice cube tray is closest to representing this level of pollution?

   ___

   b. Nitrogen dioxide (NO_2) concentrations that are equal to or lower than **20 ppb** are considered to have minimal effects on our health. Which slot of the ice cube tray is closest to representing this level of pollution?

   ___

5. Sulphuric acid (H_2SO_4), one of the main ingredients in acid rain, is measured in **parts per billion.** Although acid rain is not a problem in Alberta, the government has established guidelines for sulphuric acid, in case this pollutant appears in the province.

   a. In Alberta, if hourly sulphuric acid levels were ever to exceed **2.5 ppb**, this would be considered dangerous for our health. Which slot of the ice cube tray is closest to representing this level of pollution?

   ___

6. Think about how this experiment relates to air quality....

   a. Why is the concentration of pollutants in our air measured in parts per million and parts per billion?

   ___

   ___

   ___

   ___

   ___

   b. When studying air quality, why is it important to understand that parts per million and parts per billion are used to measure very small concentrations?

   ___

   ___

   ___

   ___

   ___

ONE IN A BILLION
ANSWER KEY

Ratio of Food Colouring to Solution Expressed as...

Slot Number	Fraction	Percentage (parts per hundred)	Parts per million (ppm)	Parts per Billion (ppb)
1	10/10	100%	1,000,000 ppm	1,000,000,000 ppb
2	1/10	10%	100,000 ppm	100,000,000 ppb
3	1/100	1%	10,000 ppm	10,000,000 ppb
4	1/1,000	0.1%	1,000 ppm	1,000,000 ppb
5	1/10,000	0.01%	100 ppm	100,000 ppb
6	1/100,000	0.001%	10 ppm	10,000 ppb
7	1/1,000,000	0.0001%	1 ppm	1,000 ppb
8	1/10,000,000	0.00001%	0.1 ppm	100 ppb
9	1/100,000,000	0.000001%	0.01 ppm	10 ppb
10	1/1,000,000,000	0.0000001%	0.001 ppm	1 ppb

FOLLOW-UP QUESTIONS

1.a. The solution in slot #1 is much darker in colour than that found in slot #10

1.b. The solution in slot #1 consists solely of food colouring, while the solution in slot #10 contains a very small concentration of food colouring

2.a. 780,000 ppm

2.b. Slot #1

3.a. 9,000 ppm

3.b. Slot #3

4.a. Slot #8

4.b. Slot #9

5.a. Slot #10

6.a. Pollutants are found in small concentrations in our atmosphere—ppm and ppb are ideal for indicating the presence of a substance in such small amounts

6.b. Air pollutants need only to be found in small concentrations in order to cause harm to living things

ACTIVITY 4: BIRTHDAY-TA ANALYSIS

Time required: 1 hour

SUMMARY

Using historical data accessible online (from Alberta EPA and federal government) students will investigate the quality of the air on their most recent birthday. They will look at AQHI readings, pollutant concentrations, and weather conditions and make observations about the relationship between these datasets. In doing so, students will develop the skills necessary to interpret air quality data and to be able to use this information to make informed decisions about their outdoor activities.

There are two parts to this activity:
Part #1: Individual Data Collection and Analysis – 45 mins
Part #2: Class Data Comparison and Hypotheses – 15 mins

REQUIRED MATERIALS

- Access to computers for research purposes
- Copies of the data analysis student worksheets

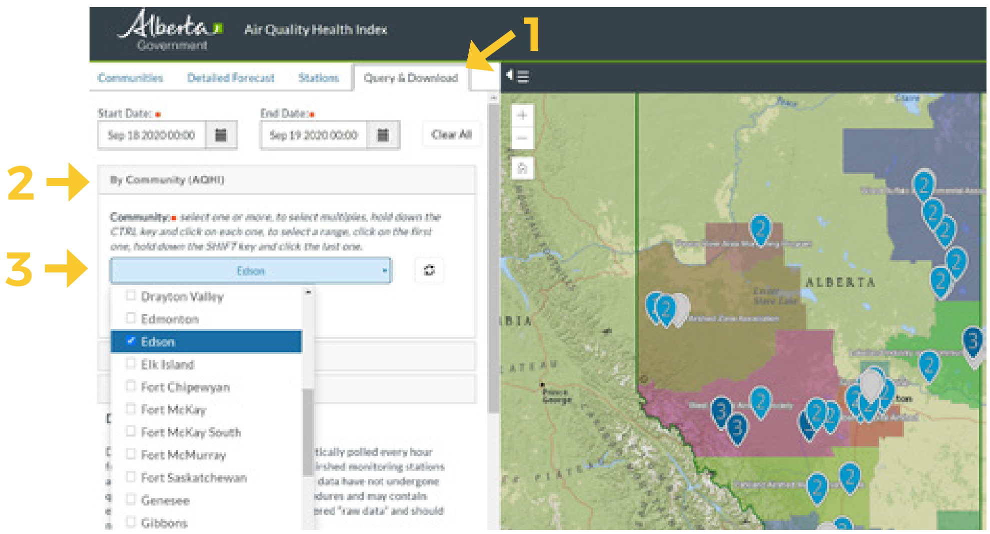
ESSENTIAL QUESTIONS

- How do emissions and weather conditions work together to determine the quality of our air?
- How is Canada's Air Quality Health Index (AQHI) calculated?
- What is air quality typically like in our local community?
- Is there a noticeable pattern when looking at air quality in our community over the span of a year?

PREPARATION

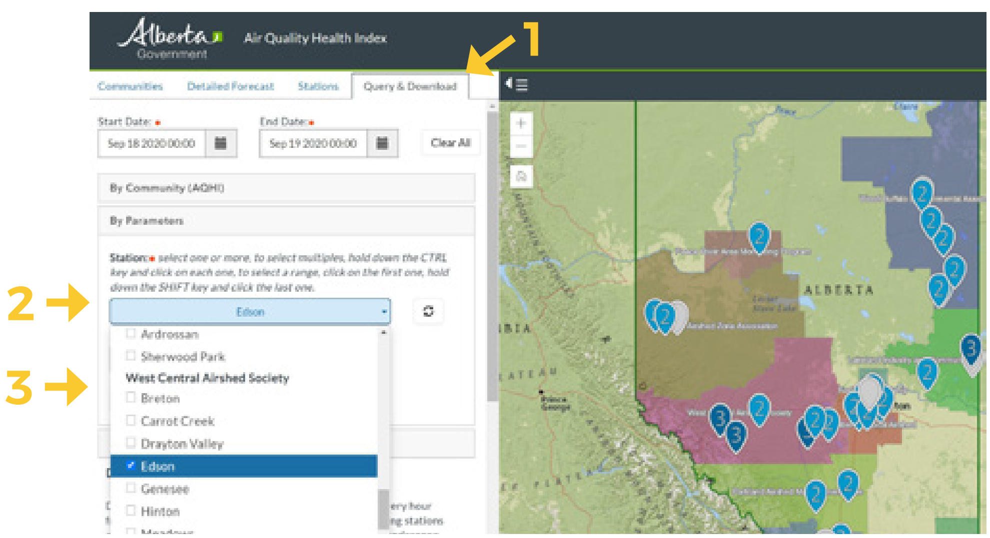
To be consistent, your students will observe data from the community where your school is located (or the nearest municipality that has accessible data). To ensure they retrieve the proper information, it is necessary that you visit the data websites first to identify:

- Name of Community (for AQHI data)
- Name of Monitoring Station (for pollutant concentrations)
- Name of Weather Station (for weather conditions)
- Follow the instructions below to do so.



AQHI data—to identify the community where your school is located or the nearest municipality that has data, visit: http://airquality.alberta.ca/map

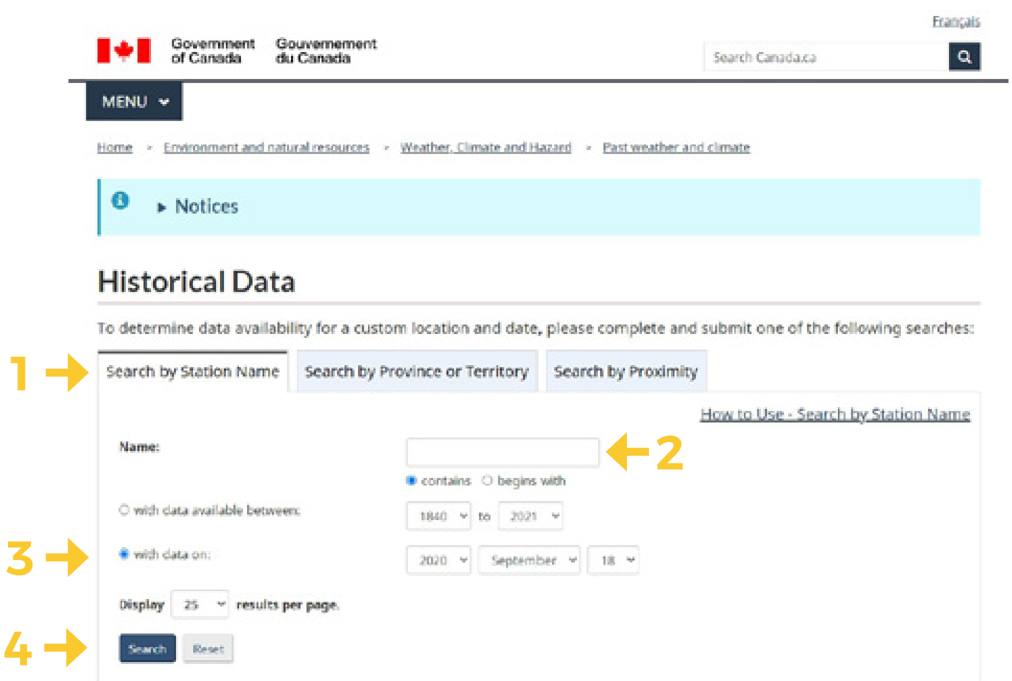
1. Click the "Query & Download" tab from the top menu on the left-hand side.
2. Click the "By Community (AQHI)" tab.
3. Search for and identify the municipality that is closest to your school.



**Smaller communities tend to have one station listed, while bigger cities may have multiple stations.*

Pollutant Concentration Data—to identify the monitoring station that is closest to your school, visit: http://airquality.alberta.ca/map

1. Click the "Query & Download" tab from the top menu on the left-hand side.
2. Click the "By Parameters" tab.
3. Search for and identify the station that is closest to your school.



The "Search by Proximity" tab can also be used, but the process is more complicated; for this reason, we've suggested using "Search by Station Name."

Weather Data—to identify the weather station that is closest to your school, visit: https://climate.weather.gc.ca/historical_data/search_historic_data_e.html

1. Use the "Search by Station Name" tab.
2. Enter the name of the municipality nearest to your school, where it says "Name:".
3. Select "with data on." There is no need to input a date as the site should already list today's date.
4. Then click the "Search" button in the bottom left-hand corner. This will take you to a list of weather stations in the area—select the one nearest to your school. If you're in a small community, there may only be one weather station listed.

INSTRUCTIONS – PART #1 (INDIVIDUAL DATA COLLECTION AND ANALYSIS)

- Provide students with the Student Worksheet Packet
- Ask them to fill out the necessary information on the first page, including:
    - the date of their most recent birthday (*be sure they include the day of the week – this will be important for Part #2 of the activity)
    - the names of the community, monitoring station, and weather station that are closest to your school – you should have already identified these following the instructions above.
- Provide a demonstration of how to search for the required data on both the provincial and federal websites.
- Have students complete Part #1 of the activity, which asks them to locate, record, and interpret AQHI, pollutant, and weather data.

INSTRUCTIONS – PART #2 (CLASS COMPARISON AND HYPOTHESES)

- Ensure students have the "Class Comparison" worksheets (found in the Student Worksheet Packet, pages 41 and 42) and have students create hypotheses for each of the questions posed.
- Part #2 requires some math to be done on behalf of the teacher. You can choose either to collect the worksheets from you students ahead of time and do your calculations before proceeding to the in-class discussion or do the math on the spot by taking polls in class.
- You will need to determine:
  - What peak AQHI health-risk category was most common on your student's birthdays? *Review student responses for AQHI data question 4.d.; possible answers include:
    - low [1-3]
    - moderate [4-6]
    - high [7-10]
    - very high [10+]
  - Whether the day of week or month of year, when birthdays fell, had an impact on the AQHI readings. *Review student answers for AQHI data question 4.a. to see the highest (or peak) AQHI readings for each birthday. On the first page of their worksheet package, students should have indicated their birth month as well as the day of the week that their most recent birthday fell.
- Once you have compiled this information, lead a class discussion around the questions posed in Part #2.
- It is likely that the peak AQHI health risk levels recorded by your students will tend to be on the lower end of the spectrum. Use this as an opportunity to discuss the fact that Alberta enjoys relatively good air quality.
- It is likely that the birthdates which fell on weekdays will have higher AQHI readings. Use this as an opportunity to discuss how our behaviours are different on weekdays then on weekends. For instance, with less people commuting to work on weekends and traffic being lighter, we would expect some decrease in the amount of vehicle emissions.
- In terms of how the month of one's birthday could impact the peak AQHI levels, this will depend greatly on the year. If it was a particularly bad year for wildfires in Alberta, then we might expect to see those student's whose birthday fell during the summertime to (on average) have the worst AQHI readings. On the other hand, if it was a particularly cold winter, we might expect to see this time of year as having the worst AQHI readings since these conditions increase the frequency of temperature inversions and winter smog.

MODIFICATIONS

The Part #1 of this activity can be assigned as homework, or can be done in class, if you have access to enough computers. If assigning this activity as homework, you may wish to provide a demonstration on how to access the data ahead of time. The worksheets provide detailed instructions, but if students do not follow these carefully, they may receive error messages and be unable to view the data.

If you'd prefer not to do any data analysis yourself, you can skip Part #2.

TEACHER TIPS

It is possible that large portions of data may not be available for a student's birthday. If this is the case, they may wish to choose the day before or after their actual birthday, so they can continue to participate in the activity. This scenario provides a good opportunity to discuss how data integrity and validity may be affected by instrument malfunctions, connection problems, or power failures.

Name:__________________________________

PART #1
STUDENT WORKSHEET PACKET: BIRTHDAY-TA ANALYSIS

In this activity, you will investigate what the outdoor air was like in your community on your most recent birthday. To do so, you'll be analyzing historical data that is available online. You will look at AQHI readings, pollutant concentrations, and weather conditions, then make observations about the relationship between these datasets.

List your most recent birthday in the space provided below, and be sure to indicate the day of the week along with the date (for example: Friday, September 18th, 2020)

____

To be consistent, you and your classmates will be observing data from the community where your school is located (or the nearest place that has available data). Your teacher will indicate the community and monitoring stations you will be looking at for each part of the activity. Record this information before proceeding.

Community (for AQHI data):

____

Monitoring Station (for pollutant concentrations):

____

Weather Station (for weather conditions):

____

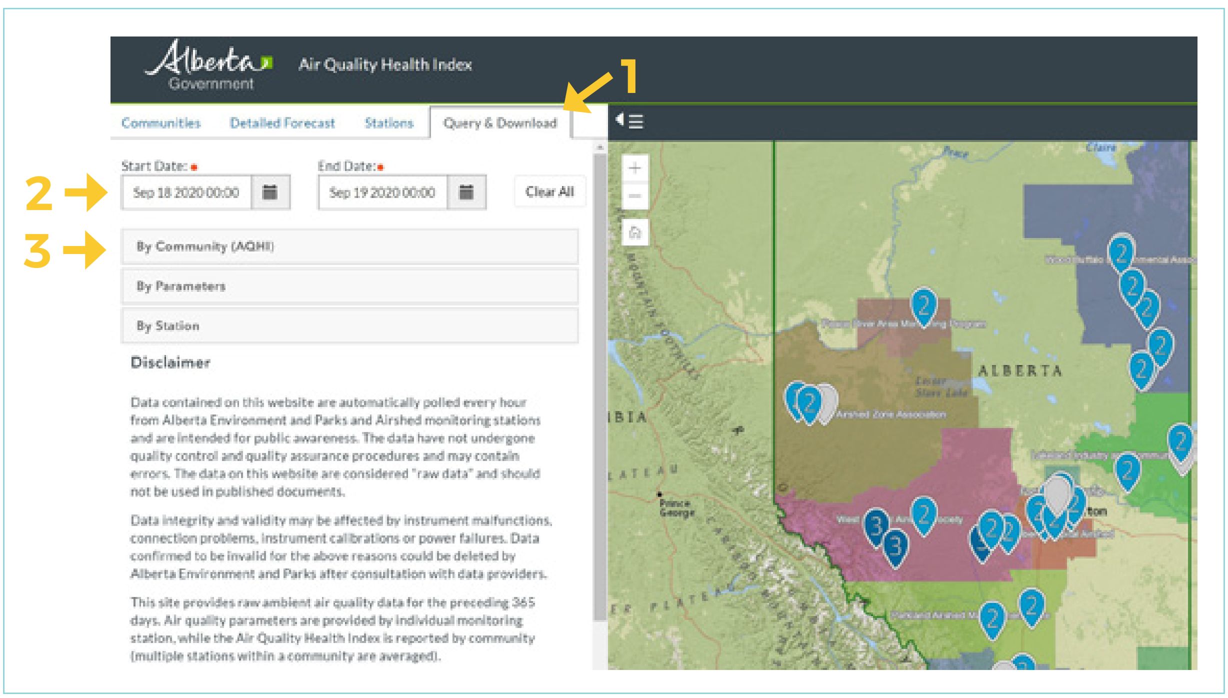
***It is possible that there will be gaps in the data from your birthday. Make note of any gaps you see. You will be asked about this later on in the activity.

AIR QUALITY HEALTH INDEX (AQHI) DATA COLLECTION

You will start by looking at AQHI data from the provincial Air Data Warehouse. To do so, go to: http://airquality.alberta.ca/map

- This will take you to a page showing a map of Alberta and the maximum AQHI forecasts for today, tonight, and tomorrow.
- To look up historical data:
  1. Click the "Query & Download" tab from the top menu on the left-hand side of the screen. This section provides data from one year ago up until today's date.
  2. Enter your most recent birthday in the space provided (note the site uses a 24-hour clock: use **00:00 for the start and end times of your birthday**). For example, if your most recent birthday was Friday, September 18th 2020, you'd enter the following:

     Start Date: September 18th 2020 00:00
     End Date: September 19th 2020 00:00
  3. Next, click the "By Community (AQHI)" tab—this will prompt you to select a city or other municipality. Select the one that is nearest to your school (see the first page of your worksheet packet—your teacher should have provided this information).
- You can view the AQHI data in graph and/or table form to help you answer the questions below. Click either the "Graph Data" or "Tabular Data" buttons to display results. Use this data to answer questions 1 to 6 below. The following AQHI Chart will also be helpful.



AQHI HEALTH MESSAGES CHART

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population	General Population
Low Risk	1 – 3	**Enjoy** your usual outdoor activities.	**Ideal** air quality for outdoor activities.
Moderate Risk	4 – 6	**Consider** reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms.	**No need to modify** your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High Risk	7 – 10	**Reduce or reschedule** strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.	**Consider** reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High Risk	Above 10	**Avoid** strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	**Reduce or reschedule** strenuous activities outdoors. Children and the elderly should also take it easy.

AQHI DATA QUESTIONS

1. Time of Day

What was the AQHI on your birthday at the following intervals:

a. Morning 06:00 (6am): __________

b. Afternoon 12:00 (12pm): __________

c. Evening 18:00 (6pm): __________

2. Change vs. Stability

a. Did the AQHI change a lot over the course of the day or remain relatively stable?

____

____

____

3. Patterns

a. When looking at the AQHI readings for the whole day, do you notice a pattern? What parts of the day does the air quality seem to be better and worse?

____

____

____

____

____

b. Why might this be? (Hint: think about the types of human activities that produce emissions and the types of weather conditions that can contribute to poor air quality).

____

____

____

____

____

4. High AQHI

*Refer to the AQHI Health Chart to help you answer these questions:

a. What was the highest AQHI reading (1-10) recorded on your birthday? __________

b. What time of day did this high AQHI reading occur? (You can provide a range if the AQHI remained high for several hours in a row, for example: "from 06:00 – 10:00").

____

c. What AQHI colour code corresponds to this reading (blue, yellow, red, or dark red)?

____

d. What health risk category corresponds to this AQHI reading (low, moderate, high, or very high)?

____

5. Change of plans?

a. At anytime during your birthday, did the AQHI reach a level that would have persuaded you to change your outdoor plans? *Refer to the health messages section of the AQHI Chart and consider whether you are part of the general population or the at-risk group – if you have asthma or other breathing problems, you belong to the at-risk category.

____

6. Data Gaps

a. Did you notice any gaps in the data? Circle your answer and provide details below. YES or NO

____

____

____

____

POLLUTANT DATA COLLECTION

Now that you know about the health risks of the air quality on your birthday, you will look closer at the concentration of pollutants in the air on that day. You'll be using the same website you looked at for the AQHI (http://airquality.alberta.ca/map).

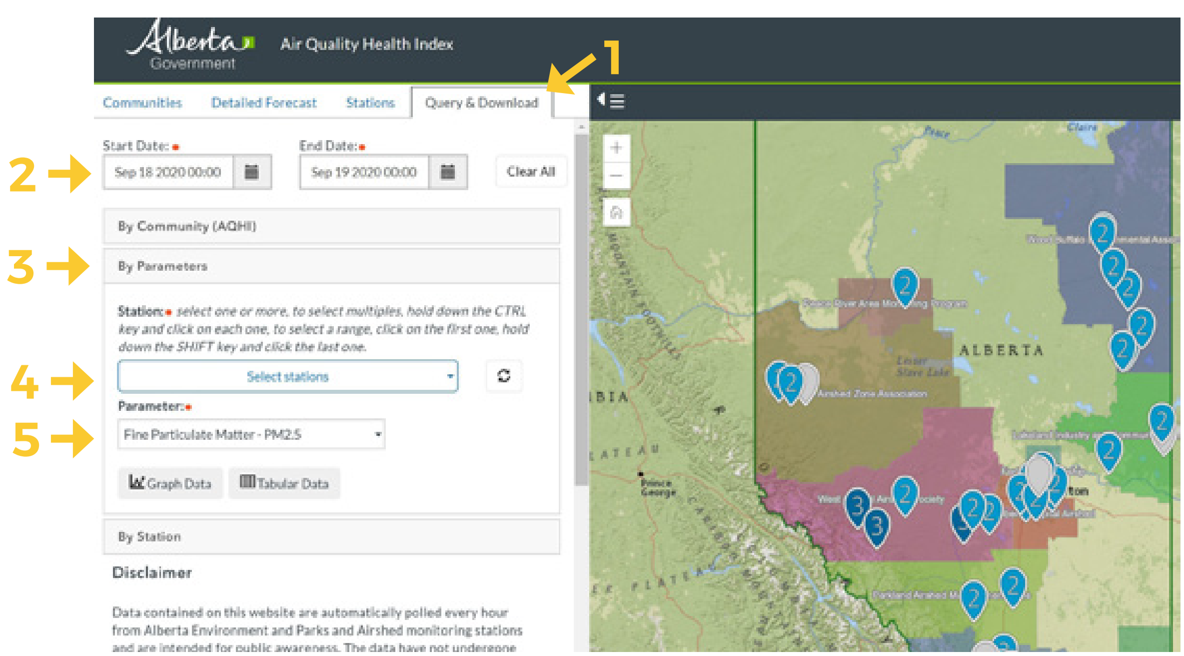
- To look up historical data:

  1. Click the "Query & Download" tab from the menu in the top left-hand corner of the screen.
  2. Enter your most recent birthday in the space provided (*please note that the site uses a 24-hour clock). For example, if your most recent birthday was Friday, September 18th, 2020 you'd enter the following:

     Start Date: September 18th 2020 00:00
     End Date: September 19th 2020 00:00

  3. To search for pollutant concentrations, use the "By Parameters" tab. This section allows you to look at data from a specific monitoring station.
  4. Select the station that is closest to your school (see page 1 – your teacher should have provided this information).
  5. Once you've entered the proper monitoring station, click the "Parameter" drop-down menu to search for data on specific pollutants.

- You can view the data in graph and/or table form to help you answer the questions below. Click either the "Graph Data" or "Tabular Data" buttons to display results. Use this data to answer questions 1-5 below. The information on the next page will also be helpful...



MEASURING AIR POLLUTION IN ALBERTA

Three main pollutants are considered indicators of the overall outdoor air quality and are used to calculate the AQHI:

1. Fine particulate matter ($PM_{2.5}$)
2. Nitrogen dioxide (NO_2)
3. Ground level ozone (O_3)

The concentrations of these pollutants are measured hourly and this information is used to determine the Air Quality Health Index. Hourly pollutant concentrations are compared against Alberta's Ambient Air Quality Objectives (AAQOs). When pollutant levels are above these numbers, the AQHI value will be High Risk (7 to 10) or Very High Risk (10+).

ALBERTA'S AMBIENT AIR QUALITY OBJECTIVES (AAAQO)

Pollutant	Ambient Air Quality Objective (hourly)	Unit of measurement
Fine Particulate Matter ($PM_{2.5}$)	80	$\mu g/m^3$
Nitrogen Dioxide (NO_2)	159	ppb
Ground-Level Ozone (O_3)	76	ppb

**$\mu g/m^3$ = micrograms per cubic meter of air* **ppb = parts per billion*

POLLUTANT CONCENTRATION QUESTIONS

***Please note that this website provides data for nitrogen dioxide and ground-level ozone in parts per million (ppm). You will have to convert this amount to parts per billion (ppb) in order to determine whether these pollutant concentrations ever exceeded Alberta's Ambient Air Quality Objectives. To do so, multiply the ppm measurement by 1000.

1. Fine Particulate Matter ($PM_{2.5}$)

a. What was the highest recorded concentration of this pollutant on your birthday?

___________ µg/m³

b. What time(s) of day did this occur?

____

c. Did this pollutant ever exceed the Ambient Air Quality Objective on your birthday?
*Refer to the AAQO Chart to help you answer.
Circle your answer: YES or NO

2. Nitrogen Dioxide (NO_2)

a. What was the highest recorded concentration of this pollutant on your birthday?

___________ ppm x 1000 = ___________ ppb

b. What time(s) of day did this occur?

____

c. Did this pollutant ever exceed the Ambient Air Quality Objective on your birthday? *Refer to the AAQO Chart to help you answer.
Circle your answer: YES or NO

3. Ground-Level Ozone (O_3)

a. What was the highest recorded concentration of this pollutant on your birthday?

___________ ppm x 1000 = ___________ ppb

b. What time(s) of day did this occur?

____

c. Did this pollutant ever exceed the Ambient Air Quality Objective on your birthday?
*Refer to the AAQO Chart to help you answer.
Circle your answer: YES or NO

4. Connection to AQHI

a. Did any of these pollutant concentrations peak when the AQHI was also at its highest level?
If so, which pollutant(s)? *To answer this question, you'll have to refer back to the data you collected for the **AQHI,** specifically question **4.b.**

____

____

____

5. Data Gaps

a. Did you notice any gaps in the pollutant data?
Circle your answer and provide details below:
YES or NO

____

____

____

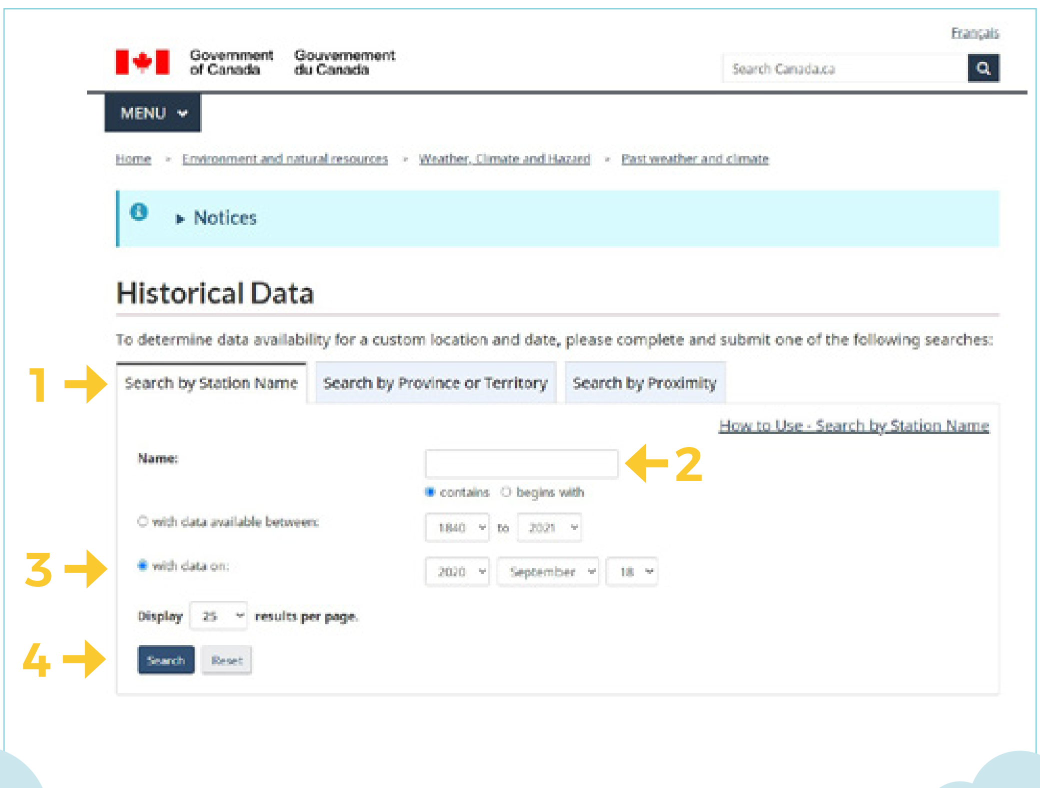
____

WEATHER DATA

Now let's see how weather impacted the quality of the air on your birthday. To find out about the weather conditions on your most recent birthday, go to: https://climate.weather.gc.ca/historical_data/search_historic_data_e.html

1. Use the "Search by Station Name" tab.
2. Enter the name of city or municipality nearest to your school, where it says "Name:".
3. Select "with data on" and input the date of your most recent birthday.
4. Click the "Search" button in the bottom left-hand corner.

- This will take you to a list of weather stations in the area; identify the one nearest to your school (see the first page of your worksheet packet—your teacher should have provided this information).
- Before clicking "Go," be sure the "Data Interval" column reads "hourly" and that the date of your birthday appears in the Year, Month, and Date columns.
- Now you should see a table listing hourly weather conditions on your birthday. If you prefer to view this information as a graph, click the icon of a crooked arrow at the bottom of each weather condition. Use this information to help you answer questions 1 to 8.



WEATHER DATA QUESTIONS

1. Weather throughout the day

a. Complete the table below using the data you've found.

Weather Condition	06:00	12:00	18:00
Temperature (°C)			
Relative Humidity (%)			
Wind Speed			
Visibility (km)			
"Weather" Notes (if applicable - see last column on the right)			

**Relative humidity refers to the amount of water vapour in the air versus the amount of water vapour the air can hold.*

**Visibility in kilometres (km) is the distance at which objects of suitable size can be seen and identified. Visibility can be reduced by precipitation, fog, haze, or other obstructions such as blowing smoke or dust.*

2. Atmospheric Conditions

a. Did weather conditions stay relatively stable throughout the day? Or did the weather change drastically from hour to hour? Be descriptive in your answer.

____

____

____

____

____

3. Temperature

a. What was the maximum temperature recorded on your birthday? __________ °C

b. What was the minimum temperature recorded on your birthday? __________ °C

4. Precipitation

a. Was there any precipitation (rain, snow, hail, etc.) recorded on your birthday? You will find this information in the "weather" column of the table. Circle your answer: YES or NO

b. If you answered yes, what type(s) of precipitation was/were recorded?

____

____

WEATHER DATA QUESTIONS CONTINUED

5. Wind Speed

a. What were the average wind speeds recorded on your birthday? Give a range of wind speeds, and use descriptive words in your answer (for example, "winds were between three and eight kilometers per hour, which is not very windy").

6. Cloud Coverage

a. Was there any indication of cloud coverage on your birthday? You will find this information in the "weather" column of the table.
Circle your answer: YES or NO

b. If you answered yes, which time(s) of day were clouds recorded?

7. Connection to AQHI

a. Describe, in general terms, the weather conditions at the time when the AQHI reading peaked on your birthday.

*To answer this question, you'll have to refer back to the data you collected for the AQHI, specifically question 4.b.

8. Data Gaps

a. Did you notice any gaps in the weather data? Circle your answer and provide details below:
YES or NO

DATA ANALYSIS

1. Based on the AQHI, pollutant, and weather data you've collected, write a detailed description of the local air quality on your most recent birthday. If relevant, include information about the time of year (season) your birthday occurred and how this may have impacted air quality.

2. Were there gaps in the data; was any information missing? YES or NO

    a. If yes, explain how the missing data could impact the accuracy of your description above.

    b. Are there any other areas/parameters you could investigate that would give you a better understanding of the air quality on your last birthday?

Name:________________________________

PART #2
STUDENT WORKSHEET PACKET: CLASS COMPARISON

The next portion of the activity involves creating hypotheses (educated guesses) about how the data from your birthday will compare to that of your classmates as well as what the combined data says about the general pattern of air quality in your community. Use both what you've learned in the Air Quality 101 lesson and your own personal birthday data to answer the following questions.

1. When you take into consideration everyone's birthday, which peak AQHI health-risk level do you think will be most common? (low, moderate, high, or very high)

Explain your answer:

Now test your hypothesis by analyzing the available data. Was your hypothesis correct? (Circle the answer).
YES or NO

2. Will those birthdates that fell on weekends or weekdays have the highest AQHI readings?

Explain your answer:

Now test your hypothesis by analyzing the available data. Was your hypothesis correct? (Circle the answer).
YES or NO

3. Will those birthdates that took place during warm (summer) or cold (winter) months have the worst AQHI readings?

Explain your answer:

Now test your hypothesis by analyzing the available data. Was your hypothesis correct? (Circle the answer).
YES or NO

EXTENSION ACTIVITIES & SUGGESTED RESOURCES

OPTIONAL EXTENSION ACTIVITY – POLLUTION SOLUTION DEBATE

There are a lot of innovative, wacky, and oftentimes controversial ideas out there for solving our air pollution problems. For example, in the UK, the government proposed eliminating speed bumps to reduce vehicle emissions. Others have suggested putting a ban Christmas lights or restricting their use to certain hours to reduce the consumption of electricity. These solutions have some obvious pros and cons. If you're looking for a way to expand on the material in this learning package, we suggest holding a debate with your students about the pros and cons of various pollution solutions. Some examples can be found: https://innovate-eco.com/17-innovative-ways-to-reduce-air-pollution-in-our-cities/

If you'd like to focus your discussion around motor vehicle emissions, these two solutions could lead to an interesting discussion:

- Motorways to be covered with canopies to trap pollution:

https://www.independent.co.uk/environment/pollution-motorway-tunnels-cover-roads-air-quality-highways-england-a7874221.html

- Taking away speedbumps and other traffic-calming measures:

https://www.independent.co.uk/news/uk/home-news/speed-bumps-remove-uk-roads-scrapped-air-pollution-fight-plan-government-a7676096.html

This activity is an opportunity to weigh values and make personal decisions about one's own daily behavior. Students should consider the intended and unintended consequences of the proposed solutions. The debate should lead to a balanced understanding of the costs of human activity for air quality, as well as our health and that of the environment. Moderation and lack of waste should characterize your class's conclusions. The definition of what is acceptable in terms of our values and whether we should compromise to get our needs met should form part of the discussion.

SUGGESTED RESOURCES

If you've enjoyed this learning package and want to investigate the topic of air quality further, see our website, for additional resources.

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