

AN INTRODUCTION TO FINE PARTICULATE AIR POLLUTION

FOR TEACHERS (2023)

AN INTRODUCTION TO PM2.5

Fine particulate matter (PM2.5) is a class of air pollution consisting of solid and liquid particles suspended in the air. The "2.5" refers to the size of its particles in micrometers (also μm or microns), and includes everything $2.5\mu\text{m}$ and smaller. The particles consist of things like carbon dioxide, ammonia, nitrogen and sulfur oxides, black carbon, viruses like COVID-19, and several others. PM2.5 forms the bulk of both indoor and outdoor air pollution worldwide.

Wildfire smoke is one source of particulate matter in ambient air. Due to climate change it is expected that the frequency and duration of wildfires, and the resulting exposure of the population to PM 2.5 will increase. Traffic exhaust fumes, backyard burning, and industrial stack emissions also contribute to ambient PM2.5 concentrations year-round, while residential burning remains the single largest contributor in winter. In New Brunswick, 65% of wintertime PM2.5 pollution comes from residential woodstoves.

The effects of increased exposure from any of these sources amplifies the health risks already experienced by sensitive populations.



HEALTH EFFECTS

To understand how minuscule 2.5 microns is, consider a single human hair. On average, the diameter of a hair is between 70–90 μm . If we go even smaller, a single lone red blood cell would tower over PM2.5 with its diameter of 7–8 μm !)

At 2.5 μm , a particle is so small that our nose hairs and upper airway mucous have absolutely no effect in containing these toxins and allowing them to be coughed or sneezed out – they simply pass right through! PM2.5 reaches the deepest parts of our lungs with every breath, penetrates the lung walls, and enters our bloodstream. From there it circulates to – literally – every part of the body, including the brain.

Exposure to particulate matter in the air can cause asthma attacks, restrict breathing for people with chronic lung disease like COPD, and cause heart attacks and stroke. Chronic exposure suppresses the immune systems of young children, making it more difficult for them to fight off respiratory tract infections. A 2021 study by McGill University found that worldwide, PM2.5 is responsible for an estimated 4.2 million premature deaths every year, and the World Health Organization considers its health risks so great that their official stance is

"There is no safe level of exposure."

Certain demographics have higher risk factors:

- children
- pregnant people
- the elderly
- people with compromised immune systems or suffering chronic respiratory and cardiac disease



The risks also extend to our wildlife. Migratory songbird populations, for example, are declining rapidly across all of North America. PM2.5 has been strongly linked with abnormal egg production & hatching rates, as well as adult metabolism disorders and lung health issues which make the birds less fit for migration - ultimately leading to the early demise of those individuals.



GOALS

Our focus with this project is in engaging children with clean air habits so that they grow up to become healthier, environmentally aware adults.



> We believe that increasing science literacy and promoting climate action can begin at any age! <

With climate change, the intensity and frequency of wildfire events is increasing, and there is an urgent need to transition to less polluting heating sources. The materials we've developed:

- introduce basic air quality concepts
- encourage interaction with the real-time mapping data from a network over over 200 small PM2.5 sensors Canada-wide (<https://cyclone.unbc.ca/aqmap/v3>)
- prompt students to think about how to use this data to plan outdoor activities (similar to how one checks the weather)
- encourage discussion about simple actions to protect our health and reduce toxic emissions

ACCESS

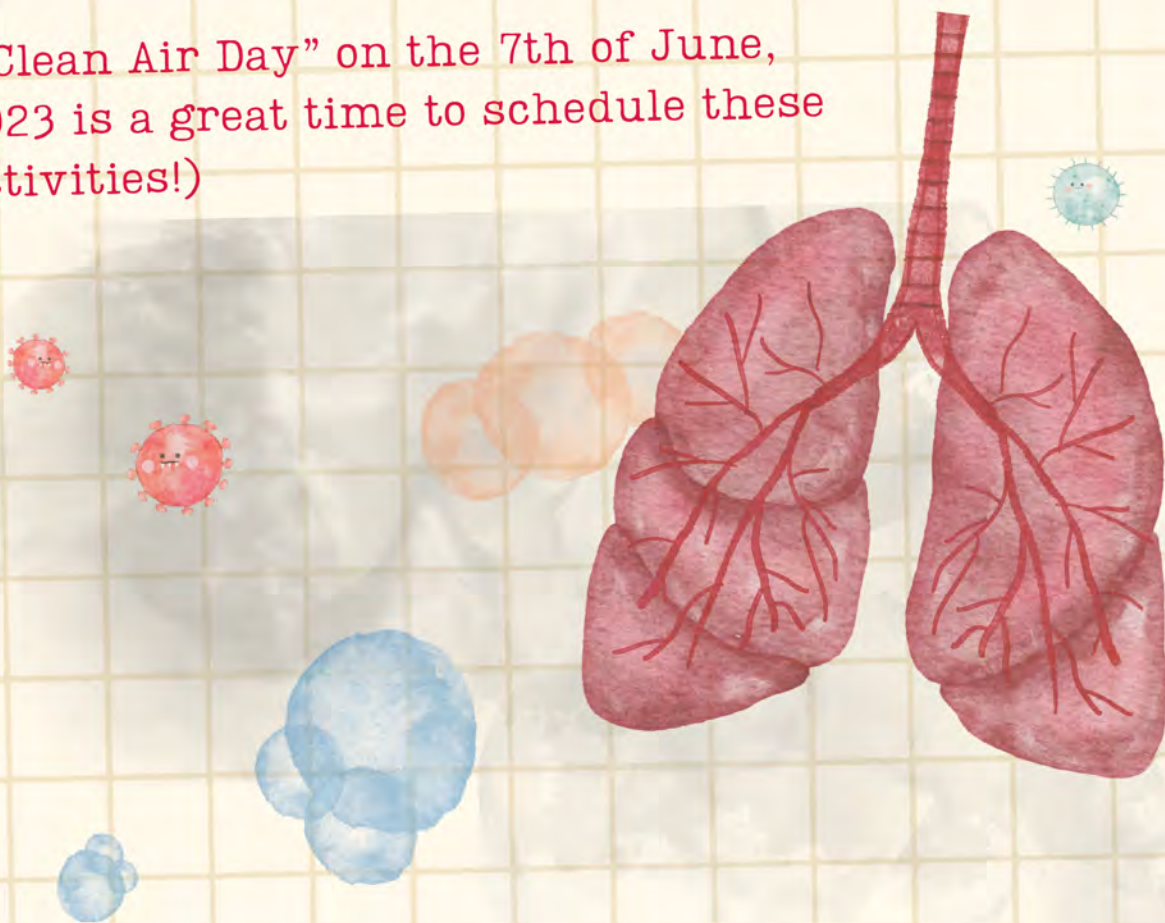
Thanks to funding from the Environmental Trust Fund, we've been able to provide the Science East Museum in Fredericton with their own small sensor and an interactive display kiosk. Visiting students can use tablets to manipulate a live map which shows real-time PM2.5 measurements from 200+ devices across Canada, including the one mounted directly to the Science East building. We hope that having a PM2.5-sensor showing the quality of air students are breathing during their visit will prove interesting and thought-provoking.



If you're unable to visit Science East in person, you can still make use of our free packet of printable posters, bookmarks, and classroom worksheets.* The worksheets (attached) vary in complexity to allow for different ages and abilities, and are designed to encourage creative and collaborative discussion about air quality.

*all materials can be found on our website

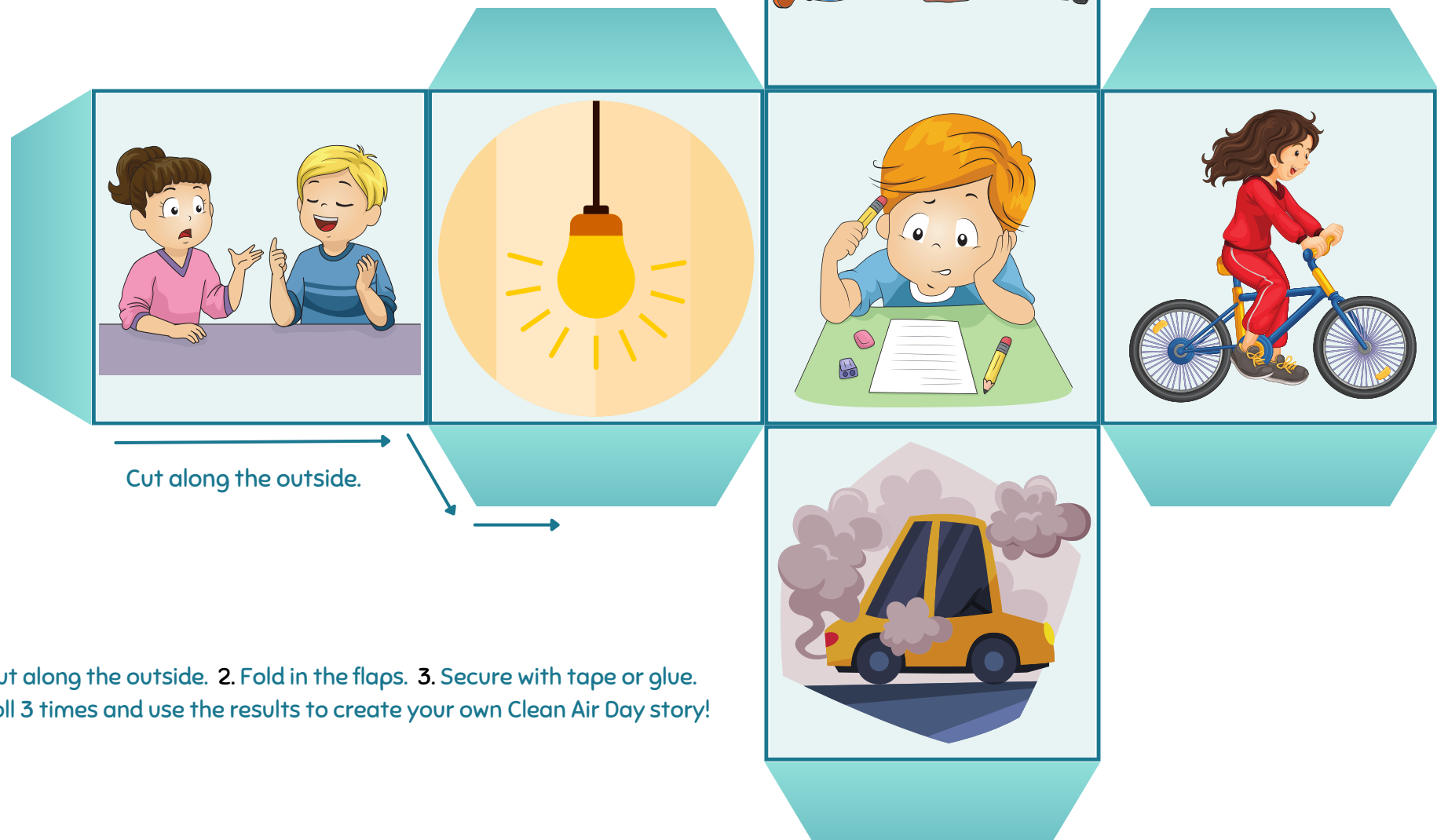
("Clean Air Day" on the 7th of June, 2023 is a great time to schedule these activities!)



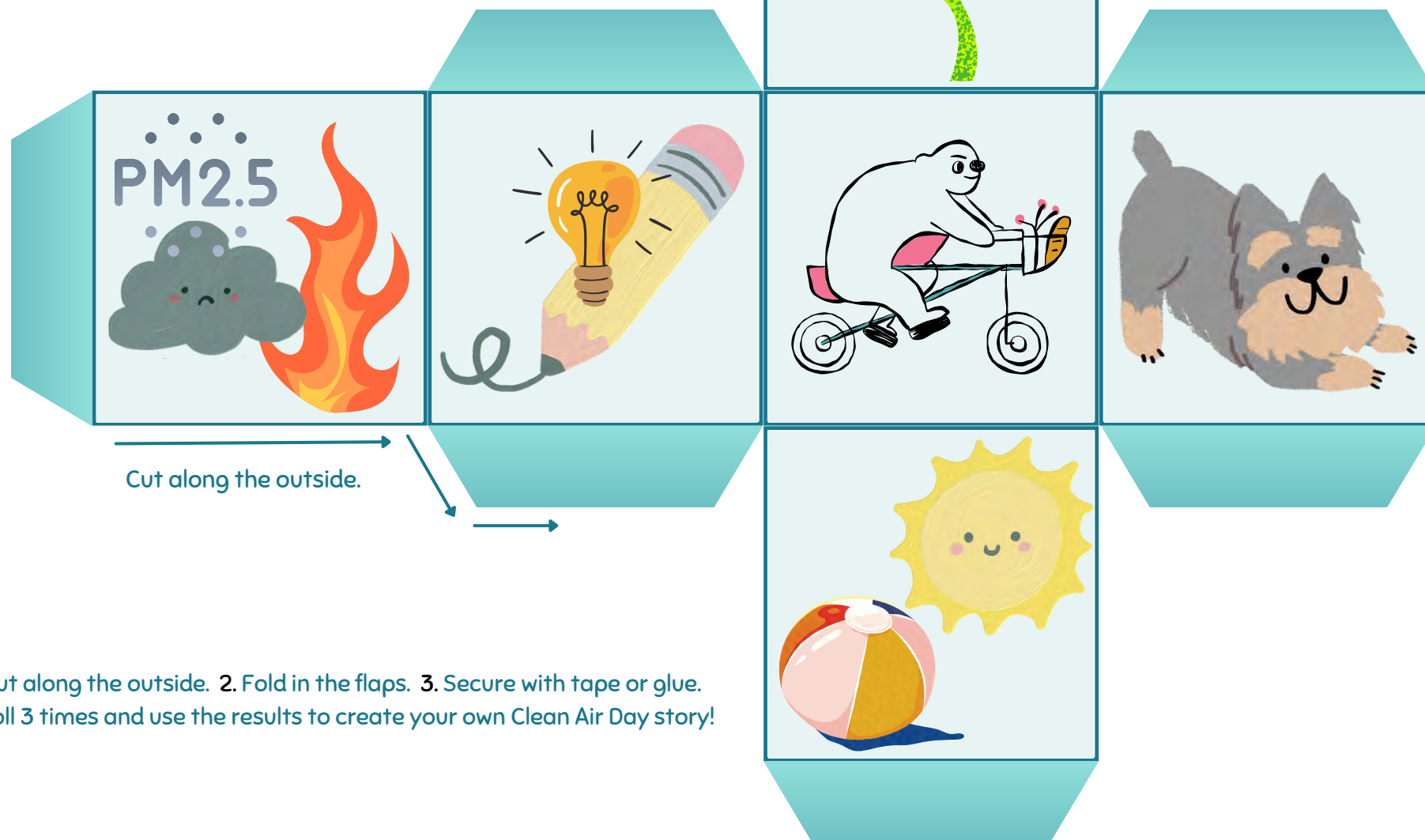


SIMPLE WORKSHEETS

CLEAN AIR DAY STORY DICE



CLEAN AIR DAY STORY DICE



1. Cut along the outside.
2. Fold in the flaps.
3. Secure with tape or glue.
4. Roll 3 times and use the results to create your own Clean Air Day story!

Name _____

Clean Air Day Creative Writing

Roll 1 was:

Roll 2 was:

Roll 3 was:

Using your 3 results (in order!) to write a short story about Clean Air. Be as silly and creative as you can; and have fun!

[illegible]

Name _____

[illegible]

Nom : _____

[illegible]

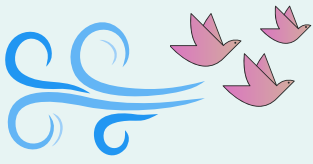


AIR QUALITY WORDSEARCH

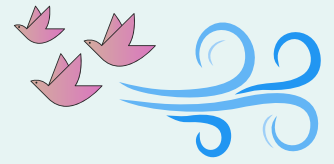
Find and circle the words
Note: some are spelled
backwards... or diagonally!

M	T	R	D	B	E	K	O	M	S	S	K	I	T	Y	E
I	E	L	E	P	C	L	A	S	E	R	O	N	M	W	R
C	A	T	I	K	A	F	N	D	H	O	L	V	Q	T	U
R	G	N	W	P	R	R	I	E	W	X	R	E	D	I	F
O	H	A	Z	U	B	X	T	T	E	R	G	R	M	M	L
N	E	T	D	U	O	M	R	I	B	U	Q	S	B	E	U
I	R	U	G	Q	N	L	O	R	C	E	N	I	S	T	S
V	X	L	O	Y	H	L	G	Z	O	U	M	O	H	A	C
O	Y	L	I	G	J	V	E	M	P	E	L	N	P	B	H
R	G	O	F	O	Z	O	N	E	A	B	E	A	U	L	A
R	T	P	L	M	B	A	C	K	B	A	C	K	T	I	O
V	G	F	R	S	G	R	E	C	E	S	S	A	T	E	L
W	D	A	M	M	O	N	I	A	W	R	Y	J	Y	C	G

- ozone
- nitrogen
- smoke
- particulate
- smog
- inversion
- sulfur
- micron
- pollutant
- oxides
- carbon
- ammonia



Clean Air is...



Think about what having clean air means to you, and create your own poster below using the theme of Clean Air. Use your imagination!

A large, empty rectangular box with a black border, intended for a student to draw and create a poster about clean air. The box occupies the majority of the page below the introductory text.



INTERMEDIATE WORKSHEETS

FOR CLEAN AIR DAY

~~~~~ I WILL: ~~~~~

#1

Talk to someone about the health harms of air pollution



#2

Walk, skateboard, or ride my bike instead of using cars!



#3

Recycle, reuse, & compost at home, instead of burning waste



#4

Plant and care for native flowers, plants and trees (and help bees!)



#5

Use less energy (turn off lights I'm not using, wear layers, etc.)



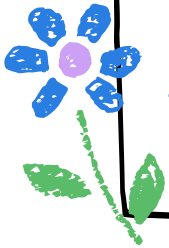
# FOR CLEAN AIR DAY

~~~~~ I WILL: ~~~~~

#1



#2



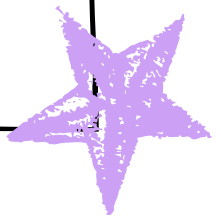
#3



#4



#5



NAME: _____

DATE: _____

MY AIR QUALITY S.M.A.R.T. GOALS

Setting realistic and achievable outcomes.

My goal is:

S
SPECIFIC

What do I want to
happen?

M
MEASUREABLE

How will I know when I
have achieved my goal?

A
ATTAINABLE

Is the goal realistic and
how will I accomplish it?

R
RELEVANT

Why is my goal
important to me?

T
TIMELY

What is my deadline
for this goal?

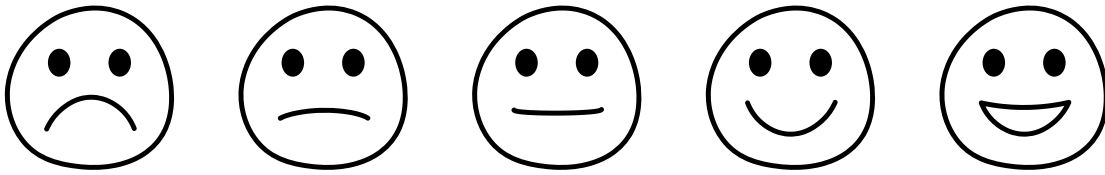
Name: _____

Date: _____

Daily REFLECTION

Today is:

How I feel about the air today:



What does the nearest air quality monitor show?

Reason for my rating

Should I do anything differently today?

THINKING OUTSIDE THE BOX

Team up into small groups and ask each other the following questions. Work together to come up with as many ideas as you can! Then, present your ideas to your classmates.

How do the different seasons affect air quality in your community?

What are some ideas to decrease/avoid exposure to air pollutants during warmer seasons?

What are some ideas to decrease/avoid exposure to air pollutants during cooler seasons?

What actions can you take to improve air quality in your community?

Why is it important to monitor air quality?

What are some ways to protect yourself on days with poor air quality?





HOW CLEAN IS THE AIR WE BREATHE?

Let's look at Air Quality!

Name

Date

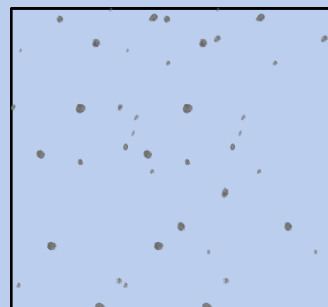
Look at the map of PM2.5 sensor stations at <https://cyclone.unbc.ca/aqmap/v3> and use it to answer the following questions:

1. Count the number of stations in New Brunswick (both ○ and ◇). Use the roller on your mouse to zoom in if there seem to be more stations in a small area, then zoom back out to continue counting. How many stations?

2. Look at the colour of the station markers. The colour indicates the level of PM2.5 measured at that station. Match the colour to the legend on the right of the map. What colour range (or ranges) do the stations fall into?

3. The units for measuring the volume of PM2.5 in air are $\mu\text{g}/\text{m}^3$ (say: “micrograms per metre cubed”). This is a very small amount! Recall when you learned about mass in math class, and how much one gram is. A gram is pretty small... But there are ONE MILLION micrograms in a gram! A measurement of $1 \mu\text{g}/\text{m}^3$ means one microgram of PM2.5 inside one cubic metre of air. To understand how much space a cubic metre of air is, imagine a metre stick being one side of a big cube. That's one cubic metre. So a measurement of $1 \mu\text{g}/\text{m}^3$ means one millionth of a gram inside one cubic metre of air.

A PM2.5 measurement of $1 \mu\text{g}/\text{m}^3$ is pretty clean air, but constantly breathing in air that has, say, $30 \mu\text{g}/\text{m}^3$ of PM2.5 in it adds up to a lot of particulate going in to your lungs and can cause or worsen health issues such as asthma. That's why the government sets a threshold level of PM2.5. If an area's PM2.5 is consistently higher than this safe threshold, we look at ways to make the air quality better. What are some things that can be done to make air quality better in an area?



4. a) Tally up the number of stations reporting each level of PM2.5 on the map, and fill in the table below. Hint: Start at the top of New Brunswick and carefully work your way down, left to right. Zoom in where you see several stations overlapping, tally their value, and then zoom back out to continue counting.

| PMP.5 level
($\mu\text{g}/\text{m}^3$) | Number of stations
with this number |
|---|--|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 9+ | |

4. b) What is the most common PM2.5 level in the province right now?

5. Click on any station on the map. Click "Plot Time Series". After a moment, a graph will appear. Along the bottom of the graph (the "x-axis") are dates, moving forward in time as you go to the right. On the left side of the graph (the "y-axis"), are shown the values of PM2.5.

5. a) What is the graph showing us?

5. b) Approximately what is the the highest value of PM2.5 plotted on your graph? On what date was the highest value recorded?

5. c) Approximately what is the lowest value of PM2.5 plotted on your graph? On what date was the lowest value recorded?

Use the following data to answer questions 6 and 7:

| Time | PMP.5 level
($\mu\text{g}/\text{m}^3$) |
|----------|---|
| 6:00 am | |
| 7:00 am | |
| 8:00 am | |
| 9:00 am | |
| 10:00 am | |
| 11:00 am | |
| 12:00 am | |
| 1:00 pm | |
| 2:00 pm | |
| 3:00 pm | |
| 4:00 pm | |
| 5:00 pm | |
| 6:00 pm | |
| 7:00 pm | |
| 8:00 pm | |

6. a) What is the highest observation (the “maximum”) in $\mu\text{g}/\text{m}^3$?

6. b) What is the lowest observation (the “minimum”) in $\mu\text{g}/\text{m}^3$?

6. c) What is the most common observation in $\mu\text{g}/\text{m}^3$?

The average (or “mean”) PM_{2.5} level is calculated as the sum of all the PM_{2.5} values, divided by the number of observations.

7. a) What is the sum of all the PM_{2.5} values? (Show your work.)

7. b) How many observations are reported in the table? (Show your work.)

7. c) What is the average PM_{2.5} level? (Show your work.)

Take a look around the map by zooming out to a larger area. Are there any dark blue areas? Are there any yellow or orange? What do you think it means if a station or an area is yellow or orange? Discuss with your classmates.

8. What do you think is happening in areas that are not light blue? Can you think of any reasons why the PM might be higher there?

Ruby lives in Fredericton, a small city in Canada. The average PM_{2.5} concentration in Fredericton today was 4 µg/m³. Max lives in Toronto, the largest city in Canada. The average PM_{2.5} concentration in Toronto today was 16 µg/m³.

9. a) How much higher was the PM_{2.5} in Toronto than in Fredericton today in µg/m³?

9. b) Can you think of some reasons why the PM_{2.5} level may be higher in Toronto than in Fredericton?

Survey your classmates on how they got to school today. Use the totals to make a bar graph on the graph paper below.



Walk: _____

Bike: _____

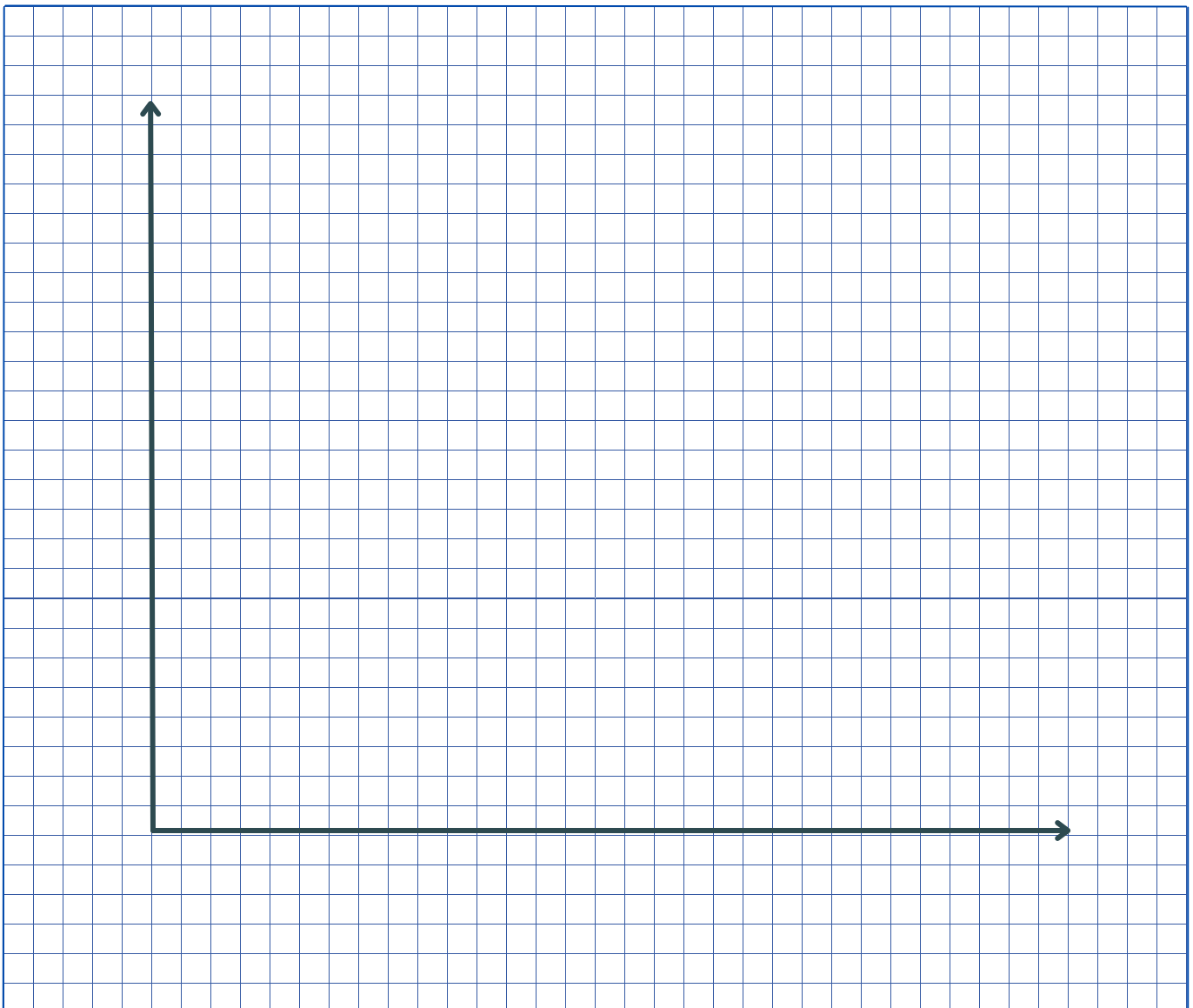
Car: _____

Carpool: _____

Bus: _____

Other: _____

How students get to school:



Go on a walk in your home neighbourhood and identify different sources of PM_{2.5}. Count them, then plot the numbers on the bar graph below.

How many:

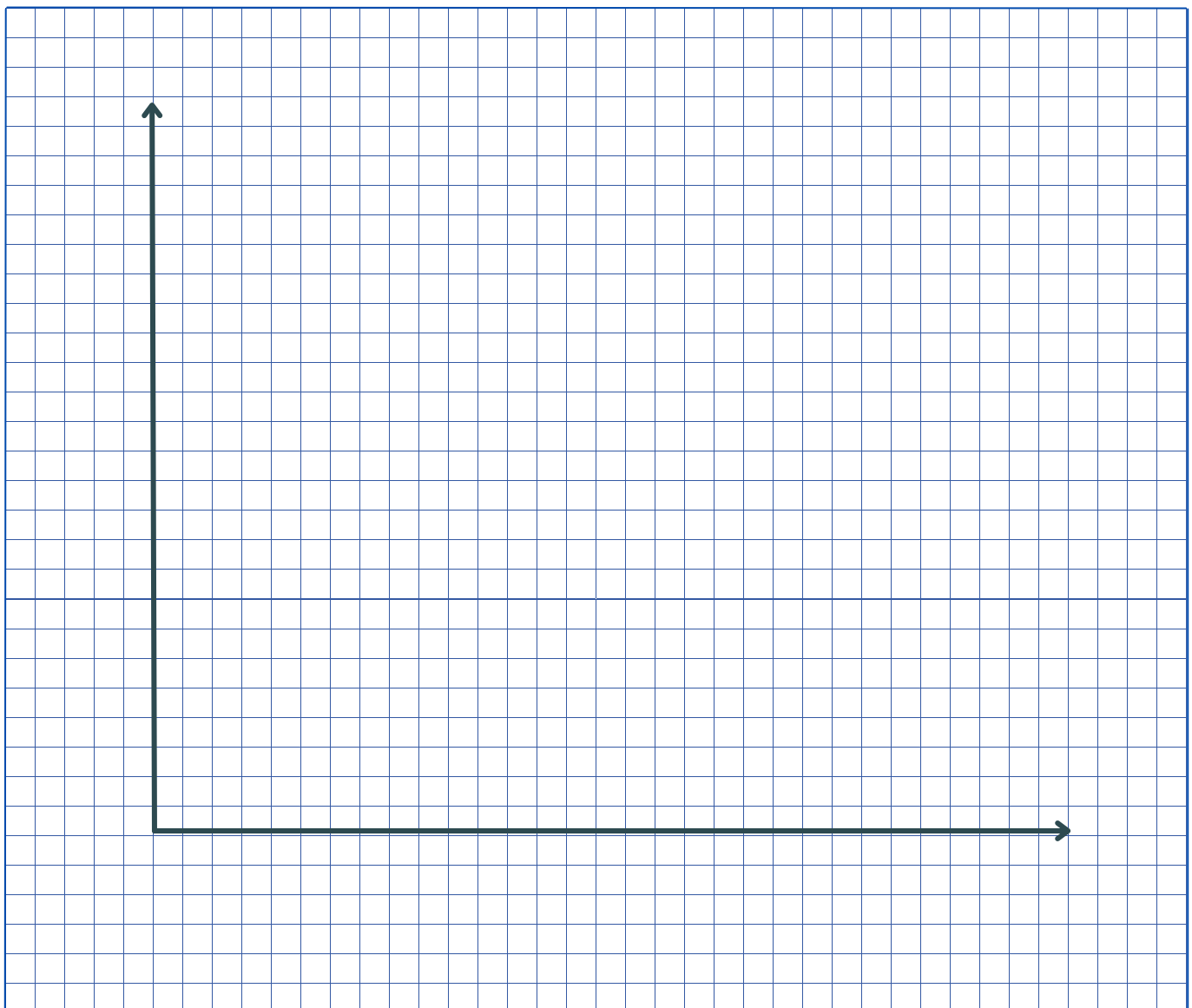
... chimneys or campfires? _____

... construction sites? _____

... people smoking or vaping? _____

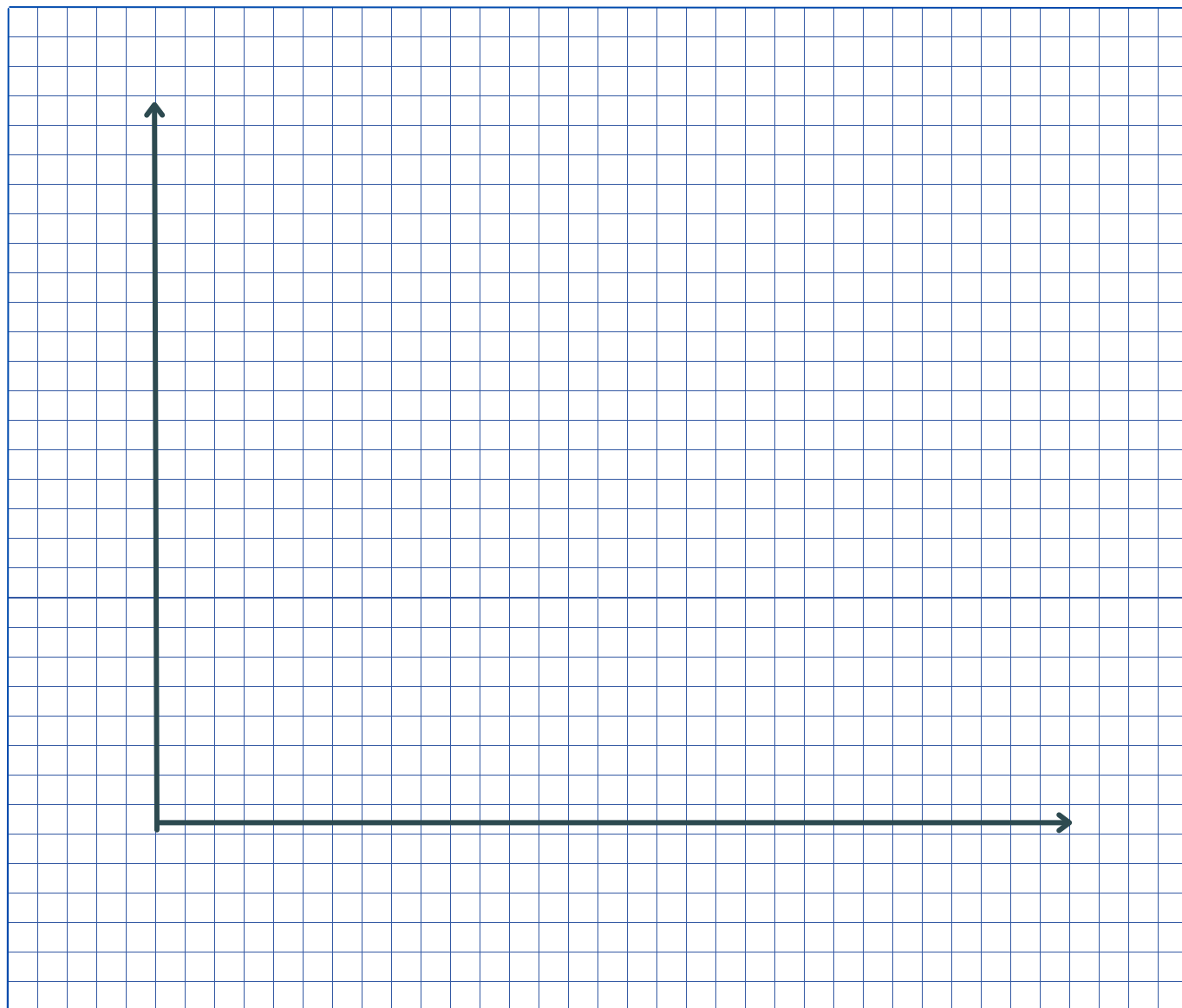
... factories or smoke stacks? _____

My sources of PM_{2.5}



You and your classmates have collected data on sources of particulate matter seen around your neighbourhoods. Team up with someone from a different neighbourhood, and compare your results. Create another bar graph to show the comparison. (Hint, your graph will have two colours- one for each area!)

Total sources of PM2.5



After students have collected data on sources of particulate matter from a walk around their neighbourhood, have everyone combine their data together. With the new totals, they can create another bar graph to show the data.



ADVANCED WORKSHEETS

AIR QUALITY IN CANADA

IT IS IMPORTANT FOR OUR HEALTH AND FOR THE ENVIRONMENT TO PROTECT THE AIR QUALITY (AQ) AROUND US. WHY IS AQ OFTEN WORSE IN CITIES? USE THE CANADIAN MAP OF AIR QUALITY (PM_{2.5}) MEASUREMENT STATIONS AT: [HTTPS://CYCLONE.UNBC.CA/AQMAP/V3](https://cyclone.unbc.ca/aqmap/v3) TO FORM YOUR HYPOTHESIS.

AUTHORS

Name: _____ Name: _____

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WITH THANKS TO:



Your Environmental Trust Fund at Work
Votre Fonds en fiducie pour l'Environnement au travail

INTRODUCTION

PM_{2.5} is a class of air pollutants made up of minuscule toxic solids and gasses. It's a serious concern for people's health - especially children, pregnant people, the elderly, and anyone with health conditions like asthma or heart disease.

Wood smoke is largely composed of PM_{2.5}. In the summer of 2021, smoke was transported to NB from wildfires all the way over in western Canada. (!) Environment and Climate Change Canada (ECCC) was able to track the ground-level smoke plumes during this event using a network of over 200 small PM_{2.5} sensors. As a result, they issued air quality warnings to at-risk communities.

PM_{2.5} also comes from vehicle exhaust fumes, wood burning for heat, construction projects... lots of things generate PM_{2.5}! The amount of PM_{2.5} in the air we breathe can vary by season, by geographic location, and with daily weather changes. Our hypothesis is:

OBJECTIVE

To compare PM_{2.5} levels in different Canadian cities and determine which factors might lead to an increase or decrease in the concentration of airborne fine particulate matter.

METHODOLOGY

Take a look around the map by zooming out to a larger area

- Are there any areas that are dark blue?
- Are there any that are yellow, orange?
- What do you think it means if a station or an area is yellow or orange? ... Red?
- What do you think is happening in areas that are not light blue?
- Can you think of any reasons why the PM might be higher there?
- Discuss with your group.

(Hint: You can also show studies of existing literature to use as references.)

RESULTS/FINDINGS

Show your findings and answer the question or hypothesis stated in your introduction/objective.

- List your findings briefly in bullet points

Important: Avoid using too much technical detail or using excessive jargon when presenting them. Be succinct!

Image: Young masked woman experiencing difficulty breathing in humid, smoggy air.

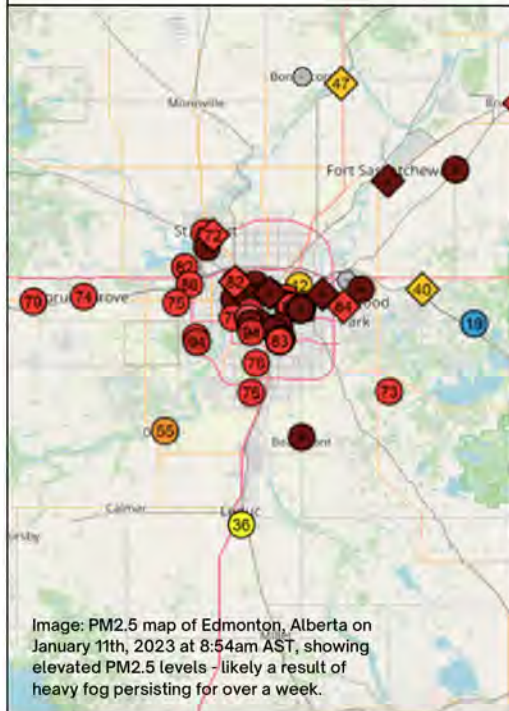


Image: PM_{2.5} map of Edmonton, Alberta on January 11th, 2023 at 8:54am AST, showing elevated PM_{2.5} levels - likely a result of heavy fog persisting for over a week.

| City/Town | Time | PM _{2.5} (µg/m ³) |
|-----------|-------|--|
| | 0700h | |
| | 0800h | |
| | 0900h | |
| | 1000h | |
| | 1100h | |
| | 1200h | |
| | 1300h | |
| | 1400h | |
| | 1500h | |
| | 1600h | |
| | 1700h | |
| | 1800h | |
| | 1900h | |
| | 2000h | |
| | 2100h | |

(THIS TABLE IS AN EXAMPLE OF HOW YOU MIGHT LIKE TO ORGANISE THE INFORMATION YOU FIND FROM LOOKING AT THE SENSOR MAP. BAR GRAPHS AND PIE CHARTS ARE SOME OTHER OPTIONS!)

TABLES AND GRAPHS CAN MAKE INFORMATION EASIER TO UNDERSTAND. PLACE YOURS HERE!

ANALYSIS

Expand on your findings by discussing what methods were used to analyse your data. (Keep it simple and direct to the point!) Use bullets for emphasis. Include key graphs, tables, illustrations, and other images that support the study and show a visual analysis of the data.

CONCLUSION

Summarize your study and let the viewers know two to three key findings. You can also add a description of each that can give them an idea of what comes next. This section can also include any implications of the study, and if there are any actions or recommendations for future study.

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RESULTS/FINDINGS

Image 1:

TABLES AND GRAPHS CAN MAKE INFORMATION EASIER TO UNDERSTAND. PLACE YOURS HERE!

ANALYSIS

CONCLUSION

Image 2:



PEER REVIEW

Name: _____

You will read four different examples from the PM2.5 Air Quality comparisons. Your job is to read them and rank where you think they fall on the scale for each criteria. Make sure to indicate which example you're reading!

COMPLIMENTS

Was the writing interesting to read? Is it easy to understand? What did you like?

SUGGESTIONS

Were the steps logical? Would you change anything?

CORRECTIONS

Were there any mistakes, or areas of confusion? Give some feedback!

EXAMPLE #

COMPLIMENTS

Snoozefest.

Really interesting!

SUGGESTIONS

Your hypothesis didn't make sense

Flowed well and very informative!

CORRECTIONS

Errors made it hard to understand.

Pretty much perfect!

CONSTRUCTIVE FEEDBACK:

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WHAT IS ONE THING YOU THINK YOU CAN IMPROVE ON FOR YOUR NEXT SCIENTIFIC STUDY?



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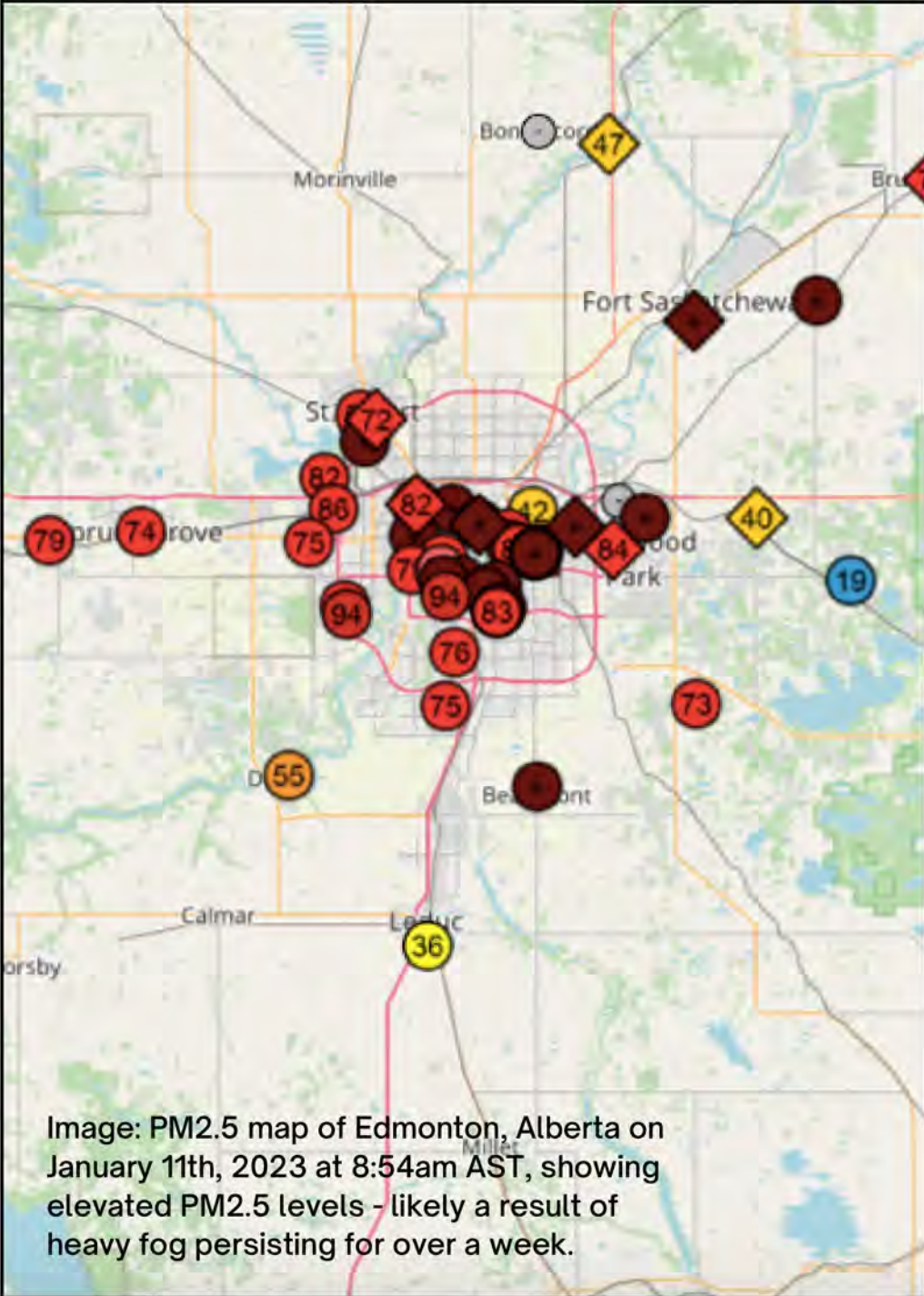


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| | 0900h | |
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| | 1400h | |
| | 1500h | |
| | 1600h | |
| | 1700h | |
| | 1800h | |
| | 1900h | |
| | 2000h | |
| | 2100h | |

(THIS TABLE IS AN EXAMPLE OF HOW YOU MIGHT LIKE TO ORGANISE THE INFORMATION YOU FIND FROM LOOKING AT THE SENSOR MAP. BAR GRAPHS AND PIE CHARTS ARE SOME OTHER OPTIONS!)

TABLES AND GRAPHS CAN MAKE INFORMATION EASIER TO UNDERSTAND. PLACE YOURS HERE!

ANALYSIS

Expand on your findings by discussing what methods were used to analyse your data. (Keep it simple and direct to the point!) Use bullets for emphasis. Include key graphs, tables, illustrations, and other images that support the study and show a visual analysis of the data.

CONCLUSION

Summarize your study and let the viewers know two to three key findings. You can also add a description of each that can give them an idea of what comes next. This section can also include any implications of the study, and if there are any actions or recommendations for future study.

AIR QUALITY IN CANADA

IT IS IMPORTANT FOR OUR HEALTH AND FOR THE ENVIRONMENT TO PROTECT THE AIR QUALITY (AQ) AROUND US. WHY IS AQ OFTEN WORSE IN CITIES? USE THE CANADIAN MAP OF AIR QUALITY (PM2.5) MEASUREMENT STATIONS AT: [HTTPS://CYCLONE.UNBC.CA/AQMAP/V3](https://cyclone.unbc.ca/aqmap/v3) TO FORM YOUR HYPOTHESIS.

AUTHORS

Name: _____ Name: _____

Name: _____ Name: _____

WITH THANKS TO:



INTRODUCTION

PM2.5 is a class of air pollutants made up of minuscule toxic solids and gasses. It's a serious concern for people's health - especially children, pregnant people, the elderly, and anyone with health conditions like asthma or heart disease.

Wood smoke is largely composed of PM2.5. In the summer of 2021, smoke was transported to NB from wildfires all the way over in western Canada. (!) Environment and Climate Change Canada (ECCC) was able to track the ground-level smoke plumes during this event using a network of over 200 small PM2.5 sensors. As a result, they issued air quality warnings to at-risk communities.

PM2.5 also comes from vehicle exhaust fumes, wood burning for heat, construction projects... lots of things generate PM2.5! The amount of PM2.5 in the air we breathe can vary by season, by geographic location, and with daily weather changes. Our hypothesis is:

METHODOLOGY

Take a look around the map by zooming out to a larger area

- Are there any areas that are dark blue?
- Are there any that are yellow, orange?
- What do you think it means if a station or an area is yellow or orange? ... Red?
- What do you think is happening in areas that are not light blue?
- Can you think of any reasons why the PM might be higher there?
- Discuss with your group.

(Hint: You can also show studies of existing literature to use as references.)

RESULTS/FINDINGS

Image 1:

OBJECTIVE

To compare PM2.5 levels in different Canadian cities and determine which factors might lead to an increase or decrease in the concentration of airborne fine particulate matter.

TABLES AND GRAPHS CAN MAKE INFORMATION EASIER TO UNDERSTAND. PLACE YOURS HERE!

ANALYSIS

CONCLUSION

Image 2:

AQ PROJECT PLANNER

MY PROJECT GOAL

DUMP ZONE: OTHER IDEAS
(TO DEAL WITH LATER)

TODAY'S MUST-DO TASKS

1. _____

2. _____

3. _____

NOTES:

TODAY'S COULD-DO TASKS

1. _____

2. _____

3. _____

NOTES:

*FOCUS ON TODAY'S TASKS AND DUMP THE REST FOR LATER!

AQ PROJECT PLANNER

This image shows a vertical sheet of white paper with horizontal dashed lines, typical of primary-ruled notebook paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.[illegible]

***TRACK YOUR PROGRESS BY KEEPING NOTES AND JOTTING DOWN IDEAS!**

AQ PROJECT PLANNER

[illegible][illegible]

***TRACK YOUR PROGRESS BY KEEPING NOTES AND JOTTING DOWN IDEAS!**

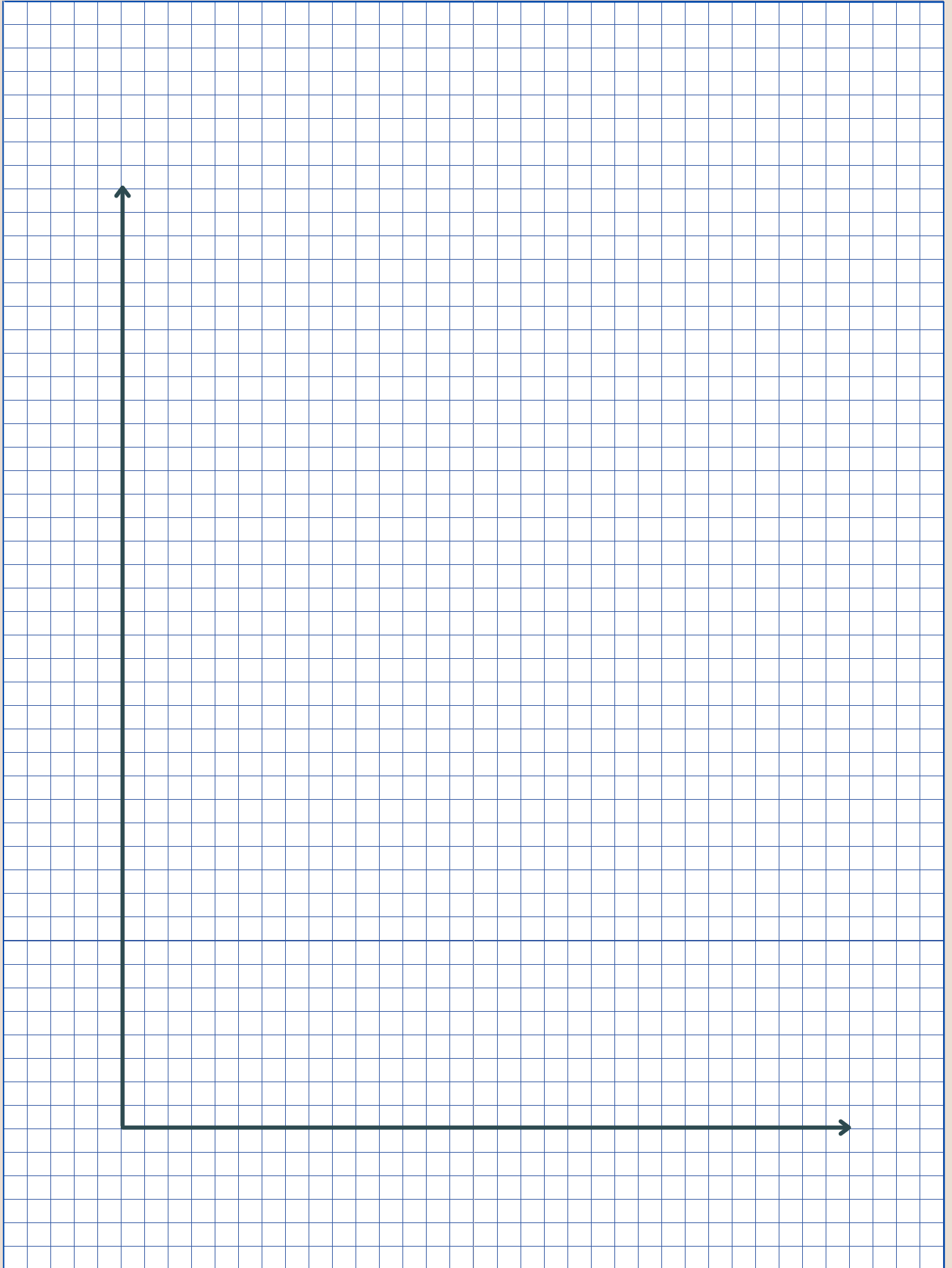
[illegible]

AQ PROJECT PLANNER

| | |
|--|--|
| | |
| | |

***TRACK YOUR PROGRESS BY KEEPING NOTES AND JOTTING DOWN IDEAS!**

GRAPH PAPER



You've learned that seasonal weather and events like wildfires can impact air quality, but did you know that GEOGRAPHY plays a part too?

Warm polluted air normally rises and disperses into the atmosphere,... but sometimes weather does weird things and flips right on it's head!

It's called a **temperature inversion**, and it means that polluted air gets stuck under a blanket of warm air and can't rise. This usually happens on cool, clear nights when the temperature drops quickly...and especially around low-lying ground!

A city has more cars, more factories, and more people so it makes sense for a city to have more pollution, right? ... BUT...

IMAGINE that you live in a small country town in a valley. Most homes burn wood for heat, and when you woke up today it was very cold and foggy. It seems like the fog just won't go away! You have a headache, and your friend's asthma is acting up.

... What do you think is happening?

What can you do to help the air get back to normal?



HINT: Fog is visual cue that an inversion has happened.



Your feedback is valuable to us. if you found these resources useful, or have any comments suggestions, please reach out to us at info@nblung.ca

Thank you for your support!

