ACTIVITY 7

# Reducing Scientific Uncertainty

INVESTIGATION

ACTIVITY 7

# Reducing Scientific Uncertainty

## ACTIVITY SUMMARY

**Students map air quality sensor data for a fictional town before and after work begins at a construction site. They consider the sources of uncertainty in the data and brainstorm ways to reduce that uncertainty. They calculate how the mean varies from the range and its implications for air quality. Limitations of the data include small sample size and systematic error. Students discuss how addressing limitations of the data can lead to new conclusions.**

ACTIVITY TYPE
INVESTIGATION

NUMBER OF
40–50 MINUTE
CLASS PERIODS
1-2

## KEY CONCEPTS & PROCESS SKILLS

1. When there is scientific uncertainty in data, probabilistic reasoning is a method for determining the likelihood of different outcomes on which to base a decision.
2. Probabilistic reasoning can be used to identify meaningful patterns in data (*signal*) about a phenomenon being investigated. Variations in the data (*noise*) can increase scientific uncertainty by distorting or hiding the signal.
3. Uncertainty in data is often a result of errors. Scientific errors can be random or systematic and can lead to conclusions that are less likely to be correct.
4. Scientific methods can reduce sources of uncertainty. Techniques to reduce random error include taking repeated measurements and averaging across many samples. Techniques to reduce systematic errors include calibrating equipment more carefully and designing investigations to control for other factors that could influence the results (*confounds*).
5. Confidence intervals, confidence levels, and error bars describe the uncertainty of data and the probability that data are accurate.

CONCEPTUAL TOOLS


**NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTION:**
Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (*Science and Engineering Practice: Analyzing and Interpreting Data*)

Evaluate the impact of new data on a working explanation and/or model of a proposed process or system. (*Science and Engineering Practice: Analyzing and Interpreting Data*)

## MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- VISUAL AID 7.1 "Scoring Guide: Analyzing and Interpreting Data (AID)"
- ITEM-SPECIFIC SCORING GUIDE: Activity 7, Connections to Everyday Life Item 5
- VISUAL AID 3.1 "Air Quality Index (AQI)" (OPTIONAL)

FOR EACH PAIR OF STUDENTS

- SET OF 6 COLORED PENCILS: green, yellow, orange, red, purple, and maroon
- RULER

FOR EACH STUDENT

- 2 STUDENT SHEETS 7.1 "Map of Kairoba"
- STUDENT SHEET 7.2 "Writing Frame: Evidence and Trade-Offs (E&T)" (OPTIONAL)
- SCORING GUIDE: Analyzing and Interpreting Data (AID) (OPTIONAL)

# TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in mint.

## GETTING STARTED (5 MIN)

**1 Present the fictional scenario in Procedure Step 1.**

- The scenario presented in Step 1 can be shared with the class in multiple ways. Read the scenario aloud to the class or have individual students read it aloud while others follow along with the text (either as a whole class or in small groups).
- Reading the scenario aloud can better support comprehension for many students, including neurodiverse students and emerging multilingual learners who often have more highly developed listening and oral skills than reading comprehension skills. Alternatively, students can read the scenario independently.

## PROCEDURE SUPPORT (30 MIN)

**2 Guide students in completing Procedure Part A.**

- Divide students into groups of four who will work in pairs. Each pair will map the data for one date (Procedure Steps 3–7) and then compare their air quality data with the data from the other pair (Procedure Step 8) to see if there is any change between Oct. 25 and Nov. 1, one week after work at the construction site began.
- In Procedure Step 2, students discuss how a construction project might affect the air quality (both short-term and long-term) at three proposed sites for a housing development. Site A is closest to the construction site, while Site C is the furthest away. Students may hypothesize that initial work on a site, particularly when previous buildings are demolished or the foundation is being dug, could result in increased particulate matter, particularly at Site A. When construction is complete, the particulate matter levels would be expected to return to previous levels. Air quality data that would support these ideas would be higher AQI levels after the start of construction, and AQI levels similar to preconstruction levels after construction is completed. Emphasize the role of data in reducing scientific uncertainty in scientific claims.

- In Procedure Step 4, distribute 1 copy of Student Sheet 7.1, "Map of Kairoba," to each student and a set of 6 colored pencils to each pair. If you don't have maroon pencils, let students know that they should use another color, such as brown, to represent the "Hazardous (maroon)" entry in Figure 7.1: "Air Quality Index (AQI)." While students are mapping and assessing the AQI of the data, you may wish to project optional Visual Aid 3.1, "Air Quality Index (AQI)"; this makes it easier for students to identify where on the AQI index each value falls.

- A sample student response to Student Sheet 7.1 (from Parts A and B) can be found at the end of this Teacher Edition, while additional sample responses are shown here:

| DATE | AQI RANGE | AIR QUALITY | AQI AVERAGE |
|---|---|---|---|
| **Oct 25** | *Sensors 1–10: 22–101* | *Good — Unhealthy for Sensitive Groups* | *Sensors 1–10: 64* |
| **Nov 01** | *Sensors 1–10: 35–141* | *Good — Unhealthy for Sensitive Groups* | *Sensors 1–10: 64* |
| **Nov 08** | *Sensors 1–13: 14–301* | *Good — Hazardous* | *Sensors 1–13: 86* |

- Have both pairs in each group share their responses to the questions in Procedure Step 8. Sample responses are shown here:

### Sample Student Responses, Procedure Step 8

- **How did the air quality compare on October 25 vs. November 1?**

  *For both dates, the range of air quality data fell into the same AQI categories (good, moderate, and unhealthy for sensitive groups), and the average AQI was the same for October 25 and November 1. But on October 25 there were only 3 sensors showing good AQI, while on November 1 there were 6.*

- **Does the mapped data support the claim from the article that the air quality is not affected by construction? Why or why not?**

  *Yes, because it shows that the average AQI did not change after construction began. Also, there were more sensors with good AQI readings on November 1 (one week after construction began) than on October 25 (no construction).*

- **Explain what additional data would increase your certainty in this conclusion.**

  *Additional evidence that would make me more certain includes having additional sensors placed near the construction site, having more sensors throughout the town, and having more information about the quality of the sensors.*

**3 Guide students in completing Procedure Part B.**

- In Part B, students are provided with data for three additional sensors as well as an additional date (November 8). In Procedure Step 9, students map the three additional data points near the construction site for either Oct. 25 or Nov. 1 on their original copies of Student Sheet 7.1. This data indicates that the construction site did worsen the air quality, but only in the neighborhood closest to the site.
- In Procedure Step 10, distribute a second copy of Student Sheet 7.1 to each student so they can record the additional data for November 8. Students should observe that the air quality on November 8 (while construction was ongoing) was good in all areas except those closest to the construction site.
- Sample student responses for the additional data follow.

**Sample Student Responses, Procedure Step 12**

- What systematic error from the initial data set was corrected for when you found the three additional sensors?

  *Missing data.*

- Does this larger data set support the article's claim that the construction has no impact on AQI? Use the data to explain your answer.

  *No, it doesn't support the claim because the additional sensor data shows poorer air quality near the site. For example, on November 8 (when construction was still happening), data from the 3 sensors closest to the construction site ranged from 212–301 (very unhealthy and hazardous).*

- What additional evidence would you want to collect to reduce uncertainty in your conclusion?

  *I would want to have additional sensors placed near the construction site, more sensors placed throughout the town, more information about the quality of the sensors, and more long-term data.*

**4 Highlight the cause of the systematic error in the data.**

The answers to Procedure Step 12 are a key insight, so make sure students make the connection: There was a systematic error in the initial data set caused by the lack of any sensors near the construction site, which caused the data set to miss the effect of the site on AQI. Without sensors in this crucial area, the data supported the claim that the factory had no effect on AQI. With sensors in this area, it begins to look as if the factory may be affecting air quality after all.

## SYNTHESIS OF IDEAS (20 MIN)

**5 Use Build Understanding and Connections to Everyday Life items to synthesize ideas.**

- You may wish to supply additional scaffolding for Build Understanding item 3 by inviting students to consider what factors might impact air quality at the neighborhood level and asking them to think about how population density and/or average income might (a) affect air quality or (b) serve as proxies for other factors that could affect air quality. For example, a higher population density might mean more cars, which could worsen air quality. Or it might mean less green space within private property, as apartment buildings tend to take up more of a property's footprint than single-family houses, which could also worsen air quality. Average income in cities tends to correlate inversely with population density—wealthier families tend to live in houses or larger apartments, and poorer families tend to live in smaller apartments.

- For students who need support organizing and writing their responses, you may wish to provide optional Student Sheet 7.2, "Writing Frame: Evidence and Trade-Offs," to compose their responses. Students could also use Student Sheet 7.2 only as a reference or as a checklist as they write their responses. A sample student response for this student sheet is shown at the end of this activity. For more information on a Writing Frame, see Appendix 1: Literacy Strategies.

**6 Assess student growth using the Analyzing and Interpreting Data (AID) Scoring Guide for Connections to Everyday Life item 5.**

- The graph in Figure 7.4 represents days when the number of ER visits due to asthma is excessive. If a dot is present for an age group on a certain day, it means that there were excessive asthma visits for that age group on that day. It could be the case that various age groups had slightly elevated asthma visits, which did not constitute being marked as excessive for that age group, but when all age groups were combined, it was enough to be marked excessive for all ages. It can also be the case that there are some age groups that were marked excessive on a day, but when all age groups were combined, there were not enough cases to be marked as excessive for the "all ages" category (perhaps some groups had few cases, reducing the overall average).

- Remind students of the Analyzing and Interpreting Data Scoring Guide. You may wish to project Visual Aid 7.1, "Scoring Guide: Analyzing and Interpreting Data (AID)," for your students to review each level and clarify your expectations.

- Do not share the item-specific version of the Scoring Guide (Item-Specific Scoring Guide: Activity 7, Connections to Everyday Life Item 5) with students as it provides specific information on how to respond to the item prompt. Review the Item-Specific Scoring Guide to support scoring this specific item.

- Remind students that you expect to see them demonstrate growth in their analysis and interpretation of data, and they may want to review their responses to the assessment in Activity 3 (Build Understanding item 2). You may also want to let students know that they will have one more opportunity in the unit to be assessed (Activity 10, Build Understanding item 2).

- Depending on your students, you may want to have them provide feedback on one another's work for revision prior to turning in their work to you for scoring. Alternatively, consider having students turn in a rough draft to you for feedback and revision.
- Sample responses for Levels 1–4 are provided for Connections to Everyday Life item 5. Review these responses to get an idea of what is expected for each level alongside the Item-Specific Scoring Guide. See Appendix 2: Assessment Resource at the end of the Teacher's Guide for more guidance and information on using the Scoring Guides and assessment system with your students.

7 To conclude the activity, evaluate if your students are able to identify the essential ideas of the activity by revisiting the Guiding Question, *What are ways to collect and analyze data to reduce scientific uncertainty?* Students should recognize that addressing systematic error when designing an experiment is an important part of reducing scientific uncertainty.

# SAMPLE STUDENT RESPONSES

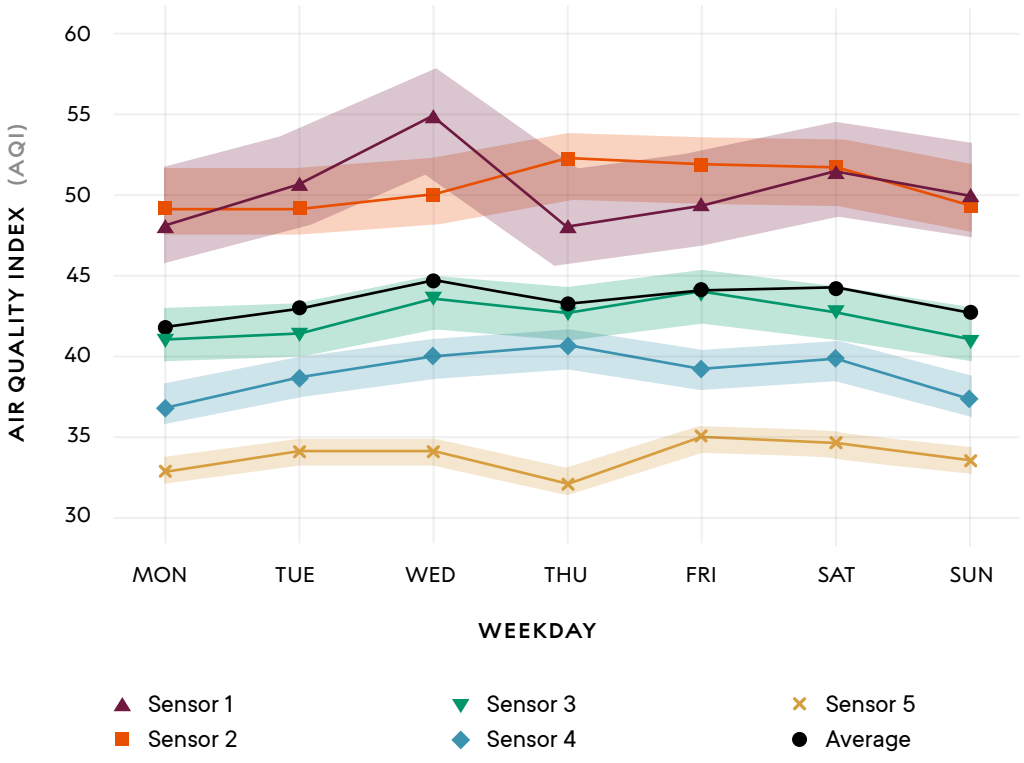
## BUILD UNDERSTANDING

① **Describe at least two possible sources of systematic error when collecting and analyzing air quality data. Then explain how you could address each of these errors to reduce your uncertainty in the data.**

*The placement of air quality sensors and any miscalibration of a sensor can result in systematic error. Carefully planning the placement of sensors and checking that they are taking accurate measurements can reduce systematic error.*

② **The graph in Figure 7.2 shows daily average AQI at 5 sites in 1 city over the course of a week. The shaded areas indicate the 95% confidence interval of the daily averages at each site. The black line represents the average of the 5 sites for each day.**

**FIGURE 7.2**
AQI Readings for 5 Sites in 1 City



**a** **Based on the confidence intervals of each sensor, identify which sensor has the least uncertainty and which has the most uncertainty. Describe how this affects your conclusions about the data.**

*Sensor 5 has the least uncertainty because it has the smallest confidence interval, and Sensor 1 has the most uncertainty because it has the largest confidence interval. I am not confident that the AQI at the Sensor 1 location is regularly good because it has a large confidence interval and the data fluctuates a lot in the good-moderate AQI range.*

**b** **A city official proudly claims that the city's AQI is always good (0–50). Do you agree? Support your answer with evidence.**

Students may have different responses and should support their answers with evidence.

- *I agree because four of the five sensors provided an average of good air quality readings over a period of seven days.*
- *I disagree because Sensors 1 and 2 have air quality readings that are in the moderate AQI range. If you live near those sensors and are part of a population is sensitive to poor air quality, you are not always experiencing good air quality.*

**c** **Would you be more concerned about your local air quality if you lived near Sensor 1 or Sensor 5? Explain.**

*I would be more concerned about air quality if I lived near Sensor 1. Sensor 1 has higher average PM2.5 readings than Sensor 5, and some of the individual readings go higher than "good" on the AQI. So I would be more concerned that my air quality could sometimes be bad for my health.*

③ **It is time for the city of Kairoba to make a decision about which site to build. As part of their decision-making, they have created a table of additional considerations. Based on your work in the activity and the information in Table 7.3, where would you recommend the city build? Support your answer with evidence and identify the trade-offs of your decision.**

**TABLE 7.3**
Additional Housing Considerations

| | SITE A | SITE B | SITE C |
|---|---|---|---|
| NUMBER OF PROPOSED APARTMENTS | 100 | 100 | 75 |
| RELATIVE COST TO BUILD | $$ | $ | $$$ |

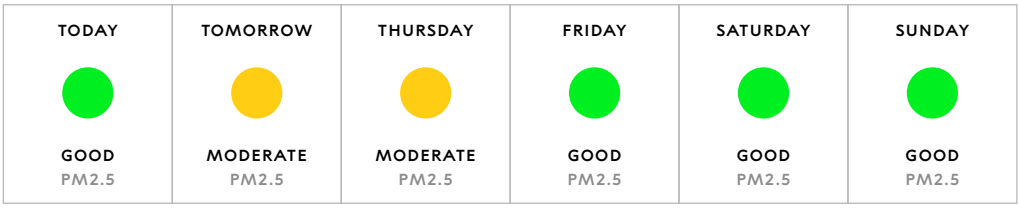
*I recommend that they build on Site C because it will have the best air quality for future residents. The sensor data showed that the poorest air quality was closest to the construction site. Site C is the farthest from the current construction site. Also, it has three parks in that area, likely improving*

*the air quality. The trade-offs are that the air quality in the cleanest part of the city will decrease for a period of time, and it will cost the most money for the fewest units (75). But I think it will be worth it in the long run.*

## CONNECTIONS TO EVERYDAY LIFE

④ **The U.S. Environmental Protection Agency (EPA) provides air quality forecasts for cities and counties around the United States. Look at the air quality forecast in Figure 7.3, which shows PM2.5 levels over a period of six days.**

**FIGURE 7.3**
Air Quality Forecast




**a What do you predict the PM2.5 levels are likely to be on Monday? Explain your answer, using probabilistic reasoning.**

*I predict the PM2.5 levels to be good because it will have been good for the previous three days as well as four out of the previous six days.*

**b What additional information could reduce uncertainty in your prediction?**

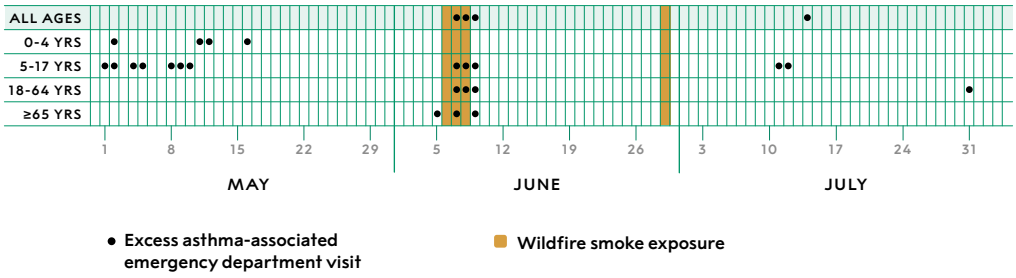
*Having more information about local weather conditions and local sources of PM2.5.*

⑤ **Examine Figure 7.4, which shows dots when emergency room (ER) visits due to asthma are higher than average.**

**Suppose you want to know if wildfire smoke was a cause for this increase. Explain what conclusions you could make from the data in this graph. Be sure to include the following in your explanation:**

- **Describe the patterns you observe between wildfires and ER visits due to asthma.**
- **Describe the part of the graph that looks like a signal.**
- **Considering the relationship between wildfires and ER visits due to asthma, describe which day(s) appear to be noise.**
- **Explain what could have created this noise in the data.**
- **Explain what conclusions you can make about the relationship between wildfires and ER visits due to asthma.**

**FIGURE 7.4**
Emergency Room Visits for City Region 1




### Level 4 response

*The data shows that there is an increase in ER visits due to asthma on June 7, 8, and 9, and there is wildfire smoke exposure on June 6, 7, and 8. There is wildfire smoke on June 29 but no increase in ER visits due to asthma. There are also increased visits in early May and a few days in July but no wildfire smoke during those times. The signal we are investigating is an increase in ER visits due to asthma when there are wildfires. The noise appears to be the increased visits in early May and various dates in July when there was no wildfire smoke. There are lots of triggers of asthma besides wildfire smoke that could have caused increased visits. The increase in visits in early May might be because of increased pollen during spring, which could trigger more asthma attacks. The days in July might be from air pollution that isn't from wildfire smoke. There appears to be a relationship between wildfire smoke and ER asthma visits because every age except 0–4 had increased ER visits due to asthma for several days during smoke events in early July.*

### Level 3 response

*There is wildfire smoke exposure on June 6, 7, and 8, and there are increased ER visits due to asthma on June 7, 8, and 9. There's one other day of wildfire smoke, and days in May and July where there are increased ER visits due to asthma but no wildfire smoke. The signal is increased ER visits due to asthma when there is wildfire smoke. The noise is when there is no wildfire smoke, but there are increased visits. This might happen because other things can trigger asthma. This data shows there is probably a relationship between wildfire smoke exposure and increased ER visits due to asthma.*

### Level 2 response

*When there is wildfire smoke exposure on June 6, 7, and 8, there are increased ER visits due to asthma a day later (June 7, 8, and 9). The signal is more ER visits, and the noise is maybe because of other things on other days. I think wildfire smoke triggers asthma.*

### Level 1 response

*When there is wildfire smoke exposure there are usually more ER visits due to asthma. Wildfire smoke can trigger asthma. It's a signal, but other things can also trigger asthma.*

## REFERENCES

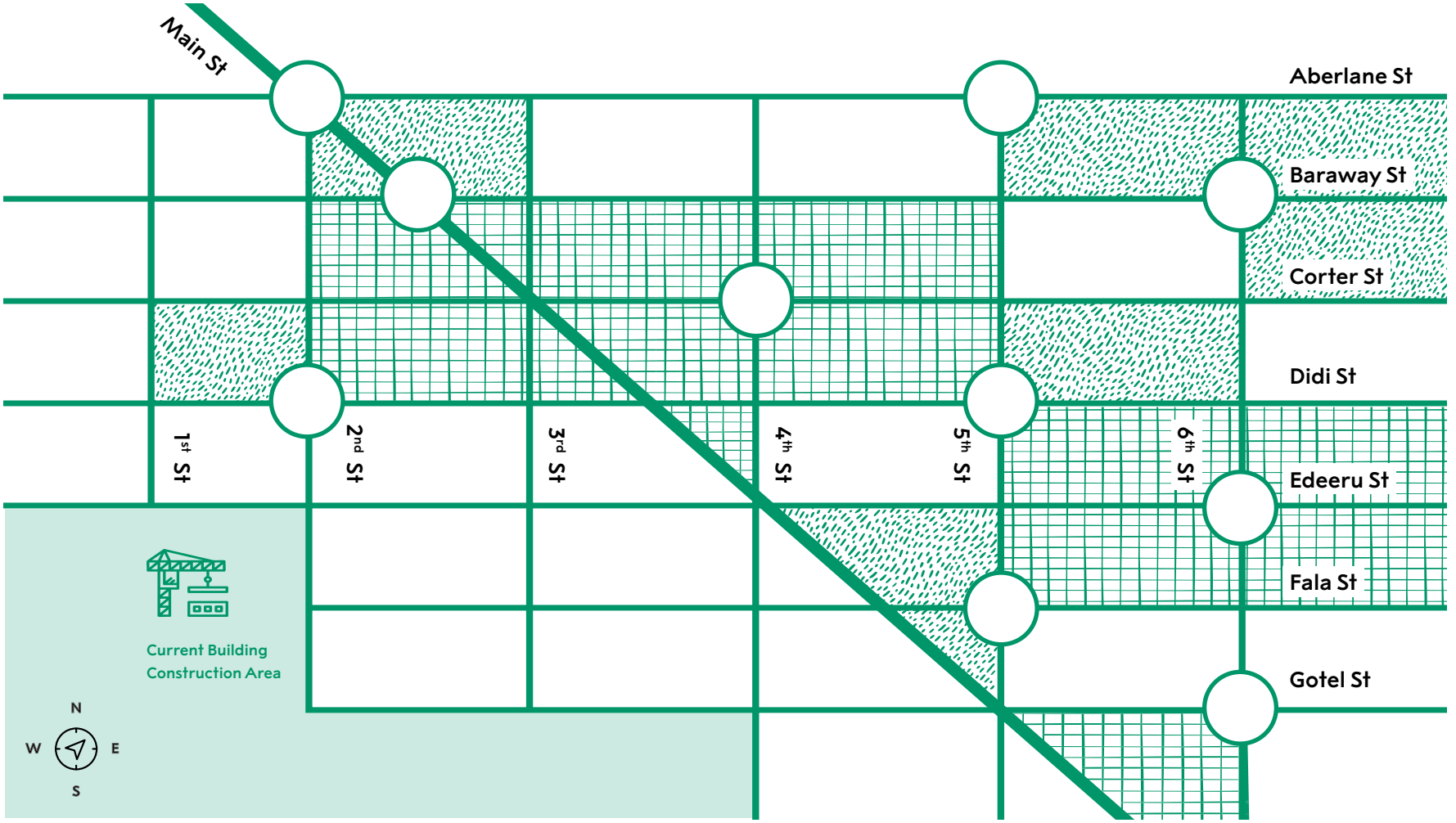

McArdle, C. E., Dowling, T. C., Carey, K., et al. (2023). Asthma-associated emergency department visits during the Canadian wildfire smoke episodes—United States, April—August 2023. *Morbidity and Mortality Weekly Report, 72*:926–932. http://dx.doi.org/10.15585/mmwr.mm7234a5

U.S. Environmental Protection Agency. (2023). *Particulate matter (PM2.5) trends: National trends PM2.5 AIr Quality 2000–2022*. https://www.epa.gov/air-trends/particulate-matter-pm25-trends#:~:text=Nationally%2C%20average%20PM2.5%20concentrations,our%20Particulate%20Matter%20Pollution%20page.

Yan, H., Li, Q., Feng, K., & Zhang, L. (2023). The characteristics of PM emissions from construction sites during the earthwork and foundation stages: An empirical study evidence. *Environmental Science and Pollution Research International, 30*(22), 62716-62732. https://pmc.ncbi.nlm.nih.gov/articles/PMC10167100/

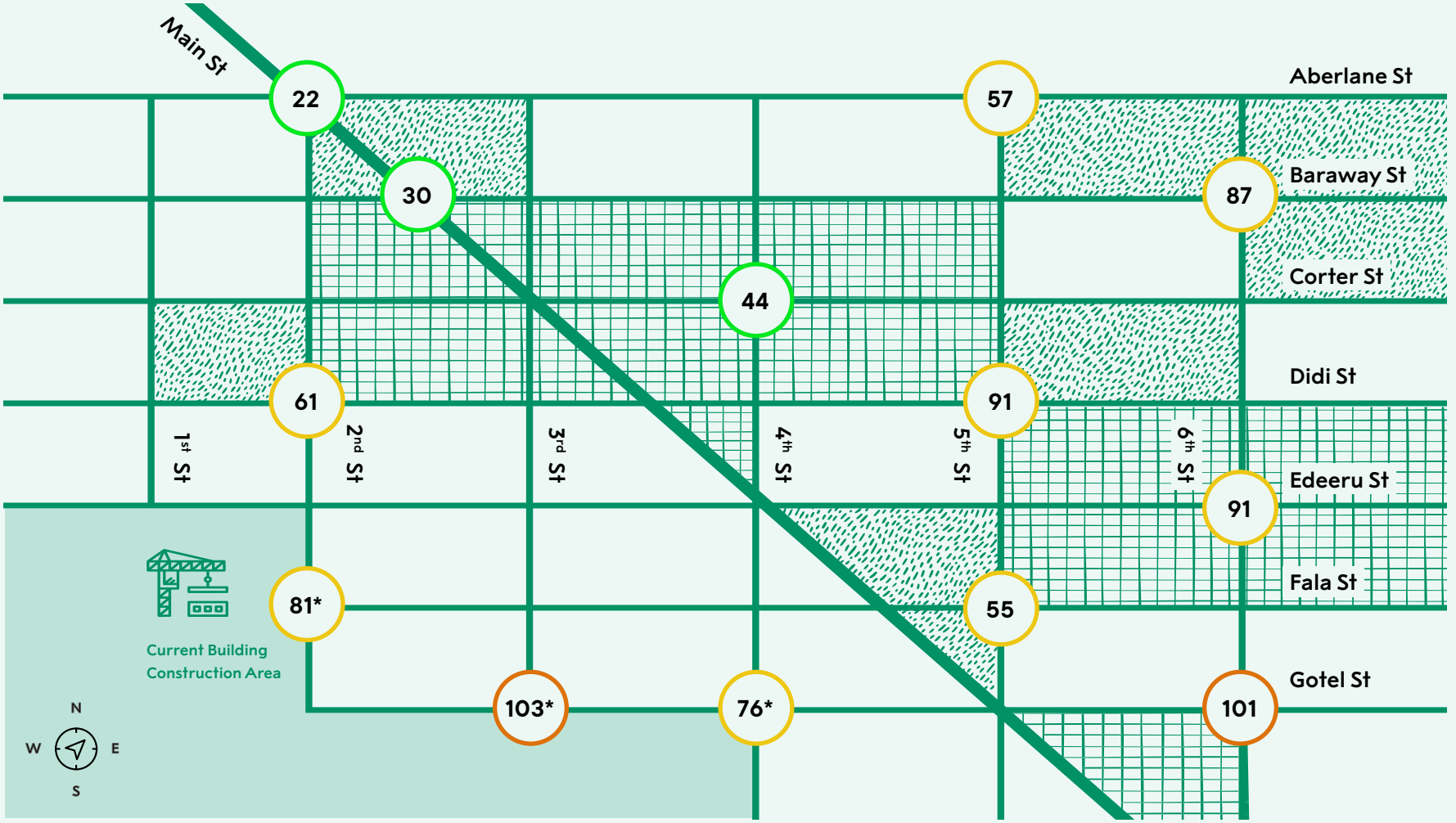
STUDENT SHEET 7.1 | MAP OF KAIROBA | NAME

DATE OF DATA COLLECTION AVERAGE AQI



STUDENT SHEET 7.1 | MAP OF KAIROBA | NAME SAMPLE STUDENT RESPONSE FOR OCT 25

DATE OF DATA COLLECTION Oct 25 AVERAGE AQI 64

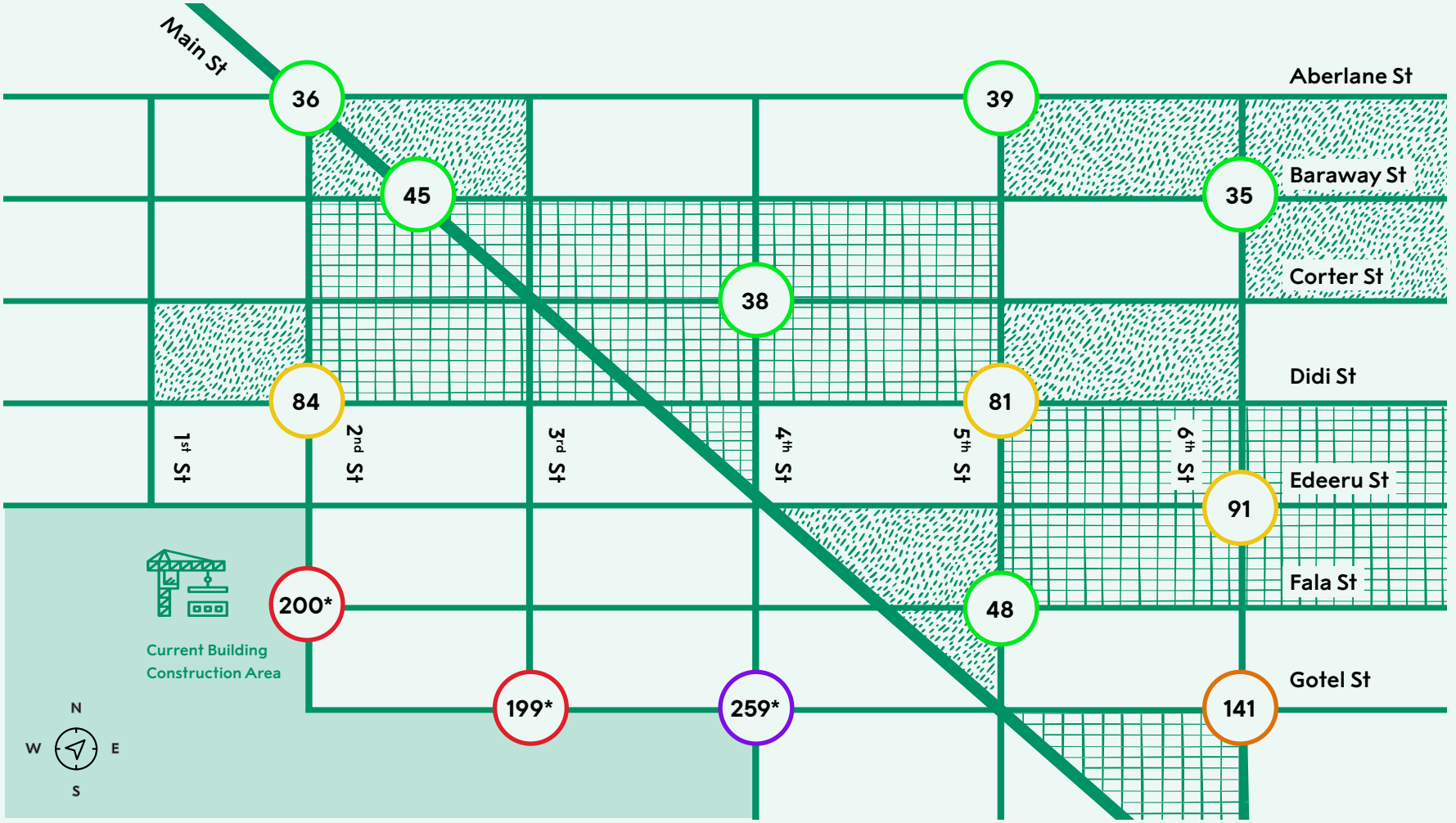



RESIDENTIAL COMMERCIAL GREEN SPACE

* 3 additional sensor data sites added during Procedure Part B

STUDENT SHEET 7.1 | MAP OF KAIROBA | NAME SAMPLE STUDENT RESPONSE FOR NOV 1

DATE OF DATA COLLECTION Nov 01 AVERAGE AQI 64

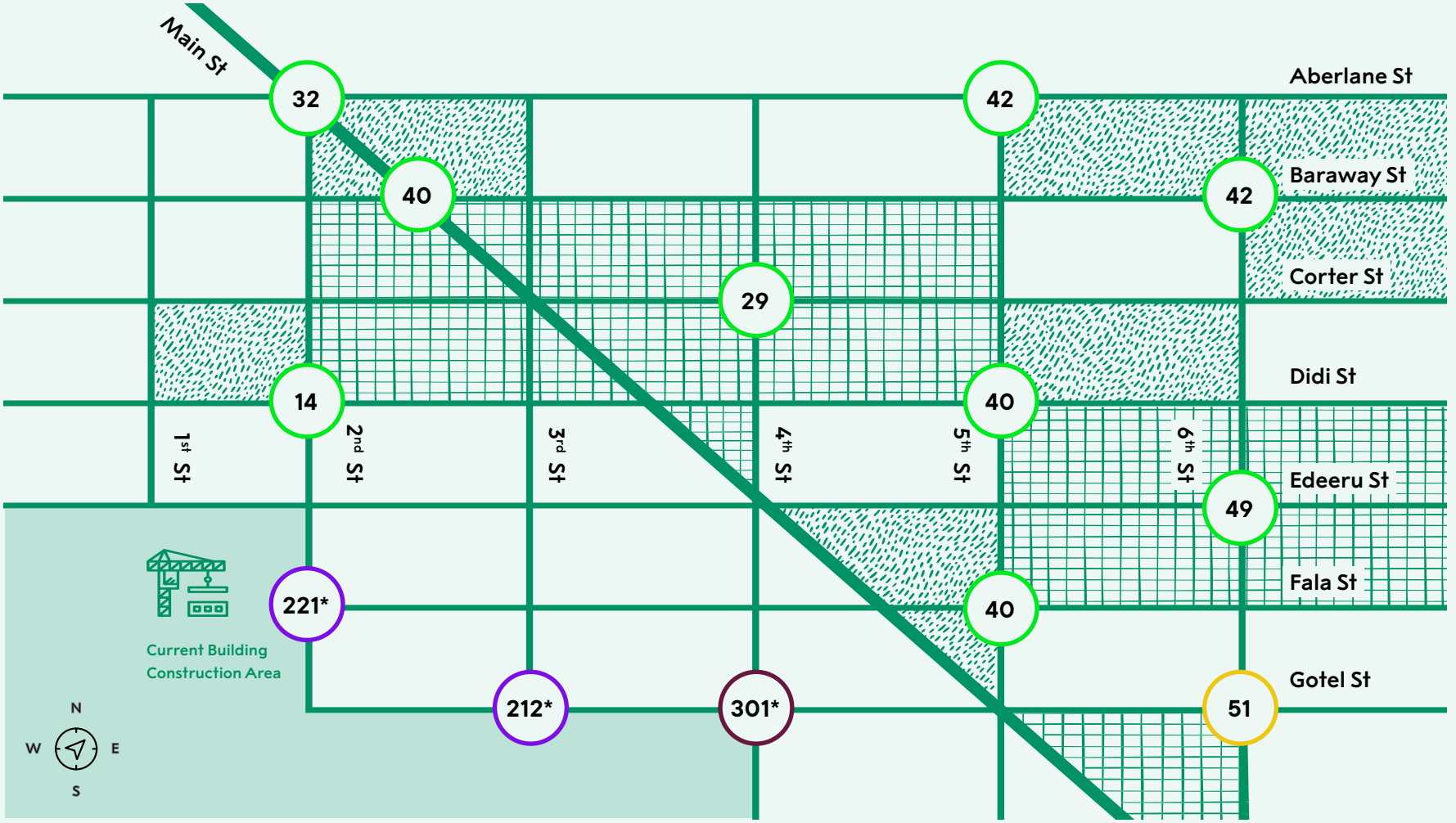



RESIDENTIAL COMMERCIAL GREEN SPACE

* 3 additional sensor data sites added during Procedure Part B

STUDENT SHEET 7.1 | MAP OF KAIROBA | NAME SAMPLE STUDENT RESPONSE FOR NOV 8

DATE OF DATA COLLECTION Nov 08 AVERAGE AQI 86




RESIDENTIAL COMMERCIAL GREEN SPACE

* 3 additional sensor data sites added during Procedure Part B

**There is a lot of discussion about the issue of**

**My decision is that**

**My decision is based on the following evidence:**

**First,**

**Second,**

**Third,**

**The trade-off(s)**

**People who disagree with my decision might say that**

**There is a lot of discussion about the issue of**

*where to build new housing.*

**My decision is that**

*Site B is the best location.*

**My decision is based on the following evidence:**

**First,**

*the poorer air quality due to the construction site will likely improve once construction stops.*

**Second,**

*the building of new housing is also a construction project and will decrease air quality for nearby residents while it is being built. Site B is farther from the current site than Site A.*

**Third,**

*Site B is the cheapest location on which to build a large number of units (100).*

**The trade-off(s)**

*is that nearby residents will continue to have poor air quality for a period of time.*

**People who disagree with my decision might say that**

*if everyone keeps building near the same neighborhoods, those residents will never have good long-term air quality.*

## VISUAL AID 7.1 | SCORING GUIDE: ANALYZING AND INTERPRETING DATA (AID)

### WHEN TO USE THIS SCORING GUIDE:

This Scoring Guide is used when students analyze and interpret data that they have collected or that has been provided to them.

### WHAT TO LOOK FOR:

- Response describes patterns and trends in data.
- Response interprets patterns and trends to describe possible causal relationships.

| LEVEL | GENERAL DESCRIPTION |
|---|---|
| **Level 4**<br>**Complete and correct** | The student analyzes the data with appropriate tools, techniques, and reasoning.<br>The student identifies and describes patterns in the data and interprets them completely and correctly to identify and describe relationships.<br>When appropriate, the student:<br>• makes distinctions between causation and correlation.<br>• states how biases and errors may affect interpretation of the data.<br>• states how study design impacts data interpretation. |
| **Level 3**<br>**Almost there** | The student analyzes the data with appropriate tools, techniques, and reasoning.<br>The student identifies and describes patterns in the data BUT incorrectly and/or incompletely interprets them to identify and describe relationships. |

| LEVEL | GENERAL DESCRIPTION |
|---|---|
| **Level 2**<br>**On the way** | The student analyzes the data with appropriate tools, techniques, and reasoning.<br>The student identifies and describes, BUT does not interpret, patterns and relationships. |
| **Level 1**<br>**Getting started** | The student attempts to analyze the data BUT does not use appropriate tools, techniques and/or reasoning to identify and describe patterns and relationships. |
| **Level 0**<br>**Missing or off task** | The student's analysis is missing, illegible, or irrelevant to the goal of the investigation. |
| **X** | The student had no opportunity to respond. |

**WHEN TO USE THIS SCORING GUIDE:**

This Scoring Guide is used when students analyze and interpret data that they have collected or that has been provided to them.

**WHAT TO LOOK FOR:**

- Response describes patterns and trends in data.
- Response interprets patterns and trends to describe possible causal relationships.

| LEVEL | GENERAL DESCRIPTION | ITEM-SPECIFIC DESCRIPTION |
|---|---|---|
| **Level 4**<br>**Complete and correct** | The student analyzes the data with appropriate tools, techniques, and reasoning.<br>The student identifies and describes patterns in the data and interprets them completely and correctly to identify and describe relationships.<br>When appropriate, the student:<br>• makes distinctions between causation and correlation.<br>• states how biases and errors may affect interpretation of the data.<br>• states how study design impacts data interpretation. | The student response:<br>• gives detailed descriptions of patterns in the data, including within and across days.<br>• thoroughly describes sound reasoning and evidence for conclusions about air quality.<br>• provides a potential source of noise in the data with a thorough explanation of reasoning, including the limitations of the available data. |

| LEVEL | GENERAL DESCRIPTION | ITEM-SPECIFIC DESCRIPTION |
|---|---|---|
| **Level 3**<br>**Almost there** | The student analyzes the data with appropriate tools, techniques, and reasoning.<br>The student identifies and describes patterns in the data BUT incorrectly and/or incompletely interprets them to identify and describe relationships. | The student response:<br>• describes patterns in the data, including within and across days.<br>The student response may have minor errors or limited responses related to:<br>• describing reasoning and evidence for conclusions about air quality.<br>• providing a potential source of noise in the data with an explanation of reasoning and limitations of the available data. |
| **Level 2**<br>**On the way** | The student analyzes the data with appropriate tools, techniques, and reasoning.<br>The student identifies and describes, BUT does not interpret, patterns and relationships. | The student response:<br>• describes patterns in the data, including within and/or across days.<br>The student response may have errors or limited responses/reasoning related to:<br>• describing reasoning and evidence for conclusions about air quality.<br>• providing a potential source of noise in the data with an explanation of reasoning and limitations of the available data. |

| LEVEL | GENERAL DESCRIPTION | ITEM-SPECIFIC DESCRIPTION |
|---|---|---|
| **Level 1**<br>**Getting started** | The student attempts to analyze the data BUT does not use appropriate tools, techniques, and/or reasoning to identify and describe patterns and relationships. | The student response:<br>• describes patterns in the data that may be general or contain errors.<br><br>The student response may have errors or limited responses/reasoning related to:<br>• describing conclusions about air quality.<br>• providing a potential source of noise in the data, with reasoning. |
| **Level 0**<br>**Missing or off task** | The student's analysis is missing, illegible, or irrelevant to the goal of the investigation. | |
| **X** | The student had no opportunity to respond. | |

| AQI CATEGORY (COLOR) | INDEX VALUE | DESCRIPTION OF AIR QUALITY |
|---|---|---|
| **Good** (green) | 0–50 | Air quality is satisfactory, and air pollution poses little or no risk. |
| **Moderate** (yellow) | 51–100 | Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive* to air pollution. |
| **Unhealthy for Sensitive* Groups** (orange) | 101–150 | Members of sensitive* groups may experience health effects. The general public is less likely to be affected. |
| **Unhealthy** (red) | 151–200 | Some members of the general public may experience health effects. Members of sensitive* groups may experience more serious health effects. |
| **Very Unhealthy** (purple) | 201–300 | Health alert:<br>The risk of health effects is increased for everyone. |
| **Hazardous** (maroon) | 301 AND HIGHER | Health warning of emergency conditions: Everyone is more likely to be affected. |

* According to the American Lung Association, sensitive groups include children under 18, adults over 65, people with chronic heart or lung disease, people who are pregnant, and people with diabetes. Adults who are active outdoors, including outdoor workers and frequent outdoor exercisers, can be considered sensitive because of prolonged exposure to outside air.