Earth and Space Science

A Study of Atmosphere, Climate, and Air Chemistry

PM2.5/Air Pollution

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Many educators and researchers in the Salt Lake Valley are passionate in teaching our communities about the air quality issues we face. There are existing resources for teachers to use in their classrooms that explore and describe the fundamentals of air chemistry and pollution, the role geography plays in forming inversions, the types and relative sizes of particulate matter pollution, and hands-on ways of collecting visual particulate matter pollution samples. The purpose of this curriculum is to list these resources and complement them by providing learning activities focused on skills related to analyzing inversion event data.

As technological capabilities continue to grow at astounding rates, so do the number and size of data sets. Consequently, there is growing need for scientists to organize, analyze and help society learn from this information. The need exists for preparing students for the field of data science and training all students how to use data to ask and answer scientific questions. In high school, especially, teachers should be helping students practice the skills of making predictions, analyzing graphs and using data to support ideas, and apply their learning to real world issues.

This teaching module contains detailed background information, teacher preparation materials, lesson plans, and MesoWest website directions for an engaging lecture on air quality. The module can be used to create an interactive learning experience for your students to increase their air pollution knowledge base and interest level in their local environment. We encourage you to print out information from any website you visit as websites are not permanent.

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Standards Alignment

This curriculum can be used to meet new Utah Science with Engineering Education (SEED) Standards implemented for the 2020/2021 academic year. Each of the included lessons are designed to give students practice making informed predictions, analyzing real-world data, and critically evaluating scientific hypotheses. It includes *exercises* that align with:

Strand ESS.3: System Interactions: Atmosphere, Hydrosphere, and Geosphere

Standard ESS.3.4
Analyze and interpret patterns in data about the factors influencing weather of a given location. Emphasize the amount of solar energy received due to latitude, elevation, the proximity to mountains and/ or large bodies of water, air mass formation and movement, and air pressure gradients. (ESS2.D)

Strand ESS.4: Stability and Change in Natural Resources

Standard ESS.4.4
Evaluate **design solutions** for a major global or local environmental problem based on one of Earth's systems. *Define the problem, identify criteria and constraints, analyze available data on proposed solutions, and determine an optimal solution.* Examples of major global or local problems could include water pollution or availability, air pollution, deforestation, or energy production. (ESS3.C, ETS1.A, ETS1.B, ETS1.C)

This material can be used as class experiments for:
Standard ESS.4.1
Construct an explanation for how the availability of natural resources, the occurrence of natural hazards, and changes in climate affect human activity. Examples of natural resources could include access to fresh water, clean air, or regions of fertile soils. Examples of factors that affect human activity could include that rising sea levels cause humans to move farther from the coast

or that humans build railroads to transport mineral resources from one location to another. (ESS3.A, ESS3.B)

Curricular Goal

The goal of this curriculum is to develop in students data science skills using existing data related to air quality in the Salt Lake Valley, and can be extended to include other areas. The MesoWest website provides real time as well as historical air quality data from a variety of sensors across the state of Utah. These data sets can be used by teachers to achieve the goal(s) of asking and answering scientific questions using data.

Target Grade Level

These lessons are designed for use in high school Earth Science courses. However, parts of the lessons could be easily adapted for use with middle school age students. The lesson plans are designed in a modular format, so that they may be used independently to supplement existing curriculum in the classroom or integrated together as an entire unit.

How To Use The Lessons

Teacher Preparation

Depending on a teacher's existing knowledge of air quality issues, individual teachers will need to familiarize themselves with a) the basics of air quality dynamics in the Salt Lake Valley and b) the process for using and retrieving data from the MesoWest website before working with students on the lessons. The resources in "Additional Resources" provide relevant background information, slides to use, and MesoWest navigation information.

Academic Information for Lesson Plans

To provide flexibility for using the lessons and incorporating them into pre-existing curricula, this curriculum includes a variety of "Academic Information". The purpose of the Academic Information is to provide links to already established material prepared by other authors that provide background information and skills to students new to Atmospheric Science and data analysis. Depending on student knowledge and individual teacher needs, these activities can be incorporated, modified, or ignored. We advise saving this information as pdf files because websites change or sometimes are deleted. Please site the information you choose to use.

Activities

Each of the included lessons are designed to give students practice making informed predictions, analyzing real-world data, and critically evaluating scientific hypotheses.

We present each of activity with three "Options", depending on an individual teacher's needs:

1. **Option A:** The lesson is offered with a complete set of graphs (from the MesoWest website) and all other material needed to complete the lesson. This option does not require any time spent retrieving data or generating graphs and allows teachers to focus their time on the analysis of graphs.

2. **Option B:** The lesson is identical to "Option A" but replaces pre-constructed graphs with a link to a Google Sheet data set. This option allows teachers to incorporate student practice with generating graphs either by hand or using spreadsheet applications.

3. **Option C:** This option is geared toward teachers that want to have their students interface with the MesoWest website. This website contains real-time and historical air quality data that are used in these lessons. Teachers choosing to use Option C can walk their students through retrieving the data directly from the MesoWest website for analysis. This option is a great choice for teachers that want their students to do one of the extension activities suggested in Lesson #4 or for teachers that want to design a project of their own that incorporates data from the MesoWest website.

Each of the included lessons include directions for Options A, B and C and teachers may choose the option that is best for their curriculum and students.

Teacher Materials

Each lesson includes a “Teacher’s Lesson Plan” section that gives special instructions to help the teacher prepare the lesson. There is a “purpose” statement for each lesson that gives teachers the goal of the particular lesson and they should make sure students achieve this goal. Each of the lessons are broken down into specific instructions for Options A, B and C.

Student Materials

Each lesson includes a series of worksheets that students use to complete the lesson. Student worksheets come in two forms. One form is for use by students with access to laptops or other technology that allows them to write directly onto a Google Docs document. The other form is a printable PDF that is ready for students to fill in by hand. Teachers may choose the form that works best for their students.

MesoWest website: http://meso2.chpc.utah.edu/aq/

Academic Information for Lesson Plans - Curriculum materials from other authors

Academic Information, Lesson #1: Components of the Atmosphere

In order to understand issues of air quality it is essential to be familiar with the basic structure and composition of the atmosphere.

- http://www.cpalms.org/Public/PreviewResourceLesson/Preview/129989
    - Atmospheric Composition lesson plan from the state of Florida's "CPALMS" program. Using guided and independent practices, students are led through the basics of the physical components of the atmosphere.
- https://climate.ncsu.edu/edu/Atmosphere
    - This website from the North Carolina Climate Office includes some great basic information on atmospheric composition, weather phenomena and other climatic issues.
- http://forces.si.edu/atmosphere/pdf/Atmo-Activity-1.pdf.
    - This activity from the Smithsonian National Museum of Natural History includes a hands-on project that engages students in diagraming atmospheric structure.

Academic Information, Lesson #2: Climate

Patterns in local climate (long term averages of weather) needs to be understood before interpreting data sets.

- https://cleanet.org/clean/literacy/climate/index.html
    - The Climate Literacy and Energy Awareness Network (CLEAN) has an excellent climate curriculum that leads students through the essentials of climate science.

Academic Information, Lesson #3: Anthropogenic Inputs to the Atmosphere

Man-made pollutants are a significant component of smog and photochemical smog.

- https://energyeducation.ca/encyclopedia/Smog
    - A good summary from the University of Calgary on the basic components, formation and health consequences of smog.
- https://www.teachengineering.org/activities/view/cub_air_lesson02_activity1
    - Hands-on activity from "Teach Engineering" for a student-built smog collection device.
- https://www.kued.org/whatson/the-air-we-breathe/background/pollution-sources
    - A discussion of man-made pollution sources from a Salt Lake City - local news organization, KUED.org.

Academic Information, Lesson #4: Graphing Time-Series Data

The exercises we present include the need to graph temperatures and particle density through time. If students lack these skills (or just need practice) the links below are some good practice activities for them.

- https://nzmaths.co.nz/resource/time-series
    - New Zealand Maths have an excellent set of practice data sets (having nothing to do with air quality) that allow students to practice time series graphs. Graphs can be constructed by hand or easily cut and pasted into graphing software or Excel.
- https://maths.nayland.school.nz/3-8-time-series/
    - Nayland College has an excellent series of exercises (with video tutorials) that lead students through more complex time series analysis. Links to Excel data sets are included.

Academic Information, Lesson #5: Inversion Events

Inversion events are not unique to Salt Lake Valley, but they are a characteristic of the winter climate of the region. Understanding how inversions form and trap particulates is critical to the exercises below.

- https://www.ag.ndsu.edu/publications/crops/air-temperature-inversions-causes-characteristics-and-potential-effects-on-pesticide-spray-drift
    - Scroll to the discussion on inversions.
- https://www.stevespanglerscience.com/lab/experiments/colorful-convection-currents/
    - Hands-on demonstration From Steve Spangler Science on the effect of temperature on the movement of fluids. This demo uses water, but it demonstrates how cold air can also be trapped.

Academic Information, Lesson #6: PM 2.5

Particles smaller than 2.5 micrometers have some important health concerns. They are usually elevated during inversion events - this is the theme of the Teacher Lesson Plans we present. A good introduction along with links to the MesoWest data this document uses can be found at:

- http://home.chpc.utah.edu/~whiteman/PM 2.5/PM 2.5.html#big
    - This site developed by the University of Utah's Atmospheric Sciences Department includes excellent discussions of the importance of tracking PM 2.5 and links to current weather and short-term forecasts. This is a nice introduction to the lessons below which use the idea of prediction in a scientific context using real-world data.
- http://www.health.utah.gov/utahair/pollutants/PM/
    - This site developed by the State of Utah, Department of Health gives information on current air quality conditions, pollutants, and health effects of air pollution. This is an official state site that is important for referencing and comparing to surrounding air quality instruments.

Additional Resources

Appendix A includes PowerPoint slides from a lecture created by Erik Crosman at the University of Utah that can be used as teaching materials in class.

Appendix B is a description of how to navigate the MesoWest website.

Additional classroom and background resources on air quality can be found in the URLs below. In addition to the Academic Information section included above, these websites can be used to complement this curriculum.

AIRU College of Engineering Teaching Modules
https://airu.coe.utah.edu/teaching-modules/

Breathe Utah Air Aware Programs
https://www.breatheutah.org/education/air-aware-school-programs

Utah Genetics Size and Scale Interactive
http://learn.genetics.utah.edu/content/cells/scale/

Air Pollution: What's the Solution Lessons
http://ciese.org/curriculum/airproj/

Winter PM 2.5 Pollution in Salt Lake Valley
http://home.chpc.utah.edu/~whiteman/PM 2.5/PM 2.5.html#big

Recess Guidance Tool
https://schools.graniteschools.org/frost/files/2017/01/recessguidancetool.pdf

Lesson Plans

Lesson #1 – Components of the Atmosphere-
Phenomenon: In the winter time there are days where the air in Utah appears cloudy or foggy all day.

Purpose – To use changes in PM2.5 during an inversion event to understand air chemistry, to identify local atmospheric chemical patterns, to analyze real-time events to understand cause and effect of trends, and to understand stability and change in local atmospheric chemical reactions.

Overview - Students first predict and sketch a graph of PM 2.5 during an inversion event. They then create and/or analyze a graph of an inversion event (Systems and models), while thinking about how all the different components of the system affect the results (temperature, time of day, pollution source, etc.). A series of questions walks them through comparing their prediction to the actual graph, analyzing change over time and considering why the graph has this shape. Finally, students create a set of data and a graph for a fictional inversion event.

Background Concepts - For students lacking graphing skills, we recommend Academic Information, Lesson #2 (which covers graph-reading skills) and Academic Information, Lesson #4 (which discusses graph creation). You can choose to spend more or less time developing these concepts based on your curriculum and available time.

Prediction - Using their student handout, ask your students to draw a graph that predicts what happens to PM 2.5 concentrations during an inversion event (keeping in mind the system as a whole, including temperature of day, time of event, pollution source, etc.). If needed, use some of the questions below to prompt them in making their predictions (what type of graph should they make, what will be on the X axis, what will be on the Y axis, what is your scale on the Y axis, etc).

Procedure - Based on your goals, you can choose Option A, B or C for your students (See: How To Use These Lessons above). Pass out the appropriate student worksheet (A, B or C) and encourage students to follow the procedure on their handout. You can choose to walk students through each step as a class or allow students to work at their own pace.

Option A - All instructions needed for this option are on the student handout.

Option B - Here is a link to the data set you can use for this lesson. Click on the link to open the data set in Google Sheets. Depending on the access your students have to spreadsheet applications, you can choose to have them create their graphs in Google Sheets or in another spreadsheet application such as Numbers or Excel. Given the diversity of graphing applications that exist, we have not provided specific instructions for creating the graph for this lesson. Rather, as teachers you can customize this section of the lesson to meet your needs. To see a sample of the graph your students will make, refer to the student handout for Option A. Once students have graphed their data, the procedure is identical to Option A.

Option C - Here is a link to the MesoWest Air Quality website. This website houses the air quality data for the sensors in the Salt Lake Valley. Use the map to display the different sites in the Salt Lake valley. You can compare how the data compares to the Utah Department of Env. Quality here. You can also use this website for a direct link to a few sensors. It is highly recommended to go through this procedure

before completing the activity with your students. Specific instructions are provided on the student handout for how to use the MesoWest website to generate a graph of a specific inversion event. To see a sample of the graph your students will make, refer to the student handout for Option A. Once students have generated their graph on the MesoWest website, the procedure is identical to Option A.

Student worksheets are provided separately - see below in curriculum documents.

Lesson #2 – Climate -
Phenomenon: 'Bad air days' and other changes in our sky have a pattern, every winter they reoccur.

Purpose – To use multiple variables to understand the structure and function of various components of our local atmosphere, to better understand air chemistry, to identify local atmospheric chemical patterns, to analyze real-time events to understand cause and effect of trends, and to understand stability and change in local atmospheric chemical reactions.

Overview - Students predict and sketch a graph of how PM 2.5 concentrations (quantity) and temperature change before, during and after an inversion event to understand how the system works, thinking about how all the different components of the system affect the results (temperature, time of day, pollution source, etc.). They then create and/or analyze graphs of these two variables before, during and after an inversion event. A series of questions walks them through comparing their prediction to the actual graph, analyzing how the two variables change over time and considering whether or not these two variables have a relationship. Finally, students make predictions about the relationship between PM 2.5 and other variables (temperature, air pressure).

Background Concepts - This lesson requires students to be able to create and interpret graphical data. For students lacking graphing skills, we recommend Academic Information, Lesson #2 (which covers graph-reading skills) and Academic Information, Lesson #4 (which discusses graph creation). In addition, information concerning inversion events is covered in Academic Information, Lesson #5.

Prediction - Using their student handout, ask your students to draw graphs that predict what happens to PM 2.5 concentrations and temperature before, during and after an inversion event. If needed, use some of the questions below to prompt them in making their predictions (what type of graphs should they make, what will be on the X axis, what will be on the Y axis, what is your scale on the Y axis, etc).

Procedure - Based on your goals, you can choose Option A, B or C for your students (See: How To Use These Lessons above). Pass out the appropriate student worksheet (A, B or C) and encourage students to follow the procedure on their handout. You can choose to walk students through each step as a class or allow students to work at their own pace.

Option A - All instructions needed for this option are on the student handout.

Option B - Here is a link to the data set you can use for this lesson. Click on the link to open the data set in Google Sheets. Depending on the access your students have to spreadsheet applications, you can choose to have them create their graphs in Google Sheets or in another spreadsheet application such as Numbers or Excel. Given the diversity of graphing applications that exist, we have not provided specific instructions for creating the graph for this lesson. Rather, as teachers you can customize this section of the lesson to meet your needs. To see a sample of the graphs your students will make, refer to the student handout for Option A. Once students have graphed their data, the procedure is identical to Option A.

Option C - Here is a link to the MesoWest Air Quality website. This website houses the air quality data for the sensors in the Salt Lake Valley. Use the map to display the different sites in the Salt Lake valley. You can compare how the data compares to the Utah Department of Env. Quality here. You can also use this website for a direct link to a few sensors. It is a good idea to go through this procedure once

before completing the activity with your students. Specific instructions are provided on the student handout for how to use the MesoWest website to generate a graphs of a specific inversion event. To see a sample of the graphs your students will make, refer to the student handout for Option A. Once students have generated their graphs on the MesoWest website, the procedure is identical to Option A.

Student worksheets are provided separately - see below in curriculum documents.

Lesson #3 – Anthropogenic Inputs to the Atmosphere -Spatial Variation of a Variable
Phenomenon: On bad air days, the pollution starts from the north part of town and moves to the south, so is the air cleaner in the south?

Purpose – To examine the spatial variability of a variable, PM 2.5, during an inversion event, to identify patterns across a valley, to identify local atmospheric chemical patterns, and to predict various causes of movement. This will allow the students to further understand stability and change in local atmospheric patterns, both with and without pollutants.

Overview - Students predict how PM 2.5 varies across the Salt Lake Valley. They then create and/or analyze graphs to compare PM 2.5 concentrations at different sensor locations in the valley. Finally, students overlay the PM 2.5 data on a map to examine how this parameter varies spatially. A series of questions walks them through comparing their prediction to the actual spatial variability, analyzing how PM 2.5 varies spatially and considering why this relationship exists.

Background Concepts - This lesson requires students to be able to create and interpret graphical data. For students lacking graphing skills, we recommend Academic Information, Lesson #2 (which covers graph-reading skills) and Academic Information, Lesson #4 (which specifically discusses graphing time series type data).

Prediction - Using their student handout, ask your students to make a color coded map that predicts how PM 2.5 concentrations will vary throughout the valley during an inversion event. Ask your students to construct an explanation (4-6 sentence justification for their prediction below their map), while thinking about how all the different components of the system affect the results (temperature, time of day, pollution source, etc.). If needed, use some of the questions below to prompt them in making their predictions (what direction is North, how does elevation vary across the map, how do other weather variables vary across the valley, what colors will you use to represent different ranges of PM 2.5, etc).

Procedure - Based on your goals, you can choose Option A, B or C for your students (See: How To Use These Lessons above). Pass out the appropriate student worksheet (A, B or C) and encourage students to follow the procedure on their handout. You can choose to walk students through each step as a class or allow students to work at their own pace.

Option A - All instructions needed for this option are on the student handout.

Option B - Here is a link to the data set you can use for this lesson. Click on the link to open the data set in Google Sheets. Depending on the access your students have to spreadsheet applications, you can choose to have them create their graphs in Google Sheets or in another spreadsheet application such as Numbers or Excel. Given the diversity of graphing applications that exist, we have not provided specific instructions for creating the graph for this lesson. Rather, as teachers you can customize this section of the lesson to meet your needs. To see a sample of the graphs your students will make, refer to the student handout for Option A. Once students have graphed their data, the procedure is identical to Option A.

Option C - Here is a link to the MesoWest Air Quality website. This website houses the air quality data for the sensors in the Salt Lake Valley. Use the map to display the different sites in the Salt Lake valley. You can compare how the data compares to the Utah Department of Env. Quality here. You can also

use this website for a direct link to a few sensors. It is a good idea to go through this procedure once before completing the activity with your students. Specific instructions are provided on the student handout for how to use the MesoWest website to view a map of current PM 2.5 concentrations at various sensor locations. The map can then be used to select sensors across the valley and compare data from a specific PM 2.5 event. To see a sample of the graph your students will make, refer to the student handout for Option A. You can have your students manually select the data, input it into a spreadsheet application and generate their graph. Alternatively, you can click here for a link to the data set you can use for this lesson. Click on the link to open the data set in Google Sheets. Depending on the access your students have to spreadsheet applications, you can choose to have them create their graphs in Google Sheets or in another spreadsheet application such as Numbers or Excel. Given the diversity of graphing applications that exist, we have not provided specific instructions for creating the graph for this lesson. Rather, as teachers you can customize this section of the lesson to meet your needs. To see a sample of the graphs your students will make, refer to the student handout for Option A. Once students have graphed their data, the procedure is identical to Option A.

Student worksheets are provided separately - see below in curriculum documents.

Lesson #4 - Extension Project
Phenomenon: HOW DO WE MAKE SENSE OF ALL THIS DATA?

Purpose – To allow students the opportunity to: practice asking and/or define problems and analyze and interpret data while using mathematics and computational thinking, construct explanations and design solutions, engage in an argument from evidence, and obtain evaluate and communicate information using data science.

Overview - Teachers can build upon Lessons #1-3 by creating a data science project opportunity for their students. These can be single topic data analysis projects or long-term time series analyses. Below we have provided a few possible questions that might be of interest to explore using the data provided on the MesoWest website. Feel free to use one of these, alter one of these, or have your students come up with their own ideas! Make sure students think about all the different components of the system and how they can affect the results (temperature, time of day, pollution source, etc.).

Possible Research Questions

- What is the pattern between PM 2.5 concentration and elevation?
- How do student-constructed particulate collectors (e.g. like those from the Academic Information-Lesson #3 activity) correspond to PM 2.5 concentration data, what could be the cause of the difference? How does that effect the results?
- Has the duration of inversion events changed over time, does the spatial scale change over time?
- Has the number of inversion events per winter changed over time?
- What is the relationship between PM 2.5 concentration and air pressure, temperature, humidity, or another variable, what patterns do you see?
- What are the different types of PM 2.5 sensors on the MesoWest website and how closely do their data correspond, are these sensors stable, how are they changing between sensors?
- Is there a relationship between PM 2.5 concentration and socioeconomic indicators in the Salt Lake Valley?
- Has the maximum PM 2.5 concentration been increasing as population has increased in the Salt Lake Valley?
- How does smoke from forest fires influence PM 2.5 concentrations in the Salt Lake Valley in the summer?

Student Worksheets - Google Doc Version

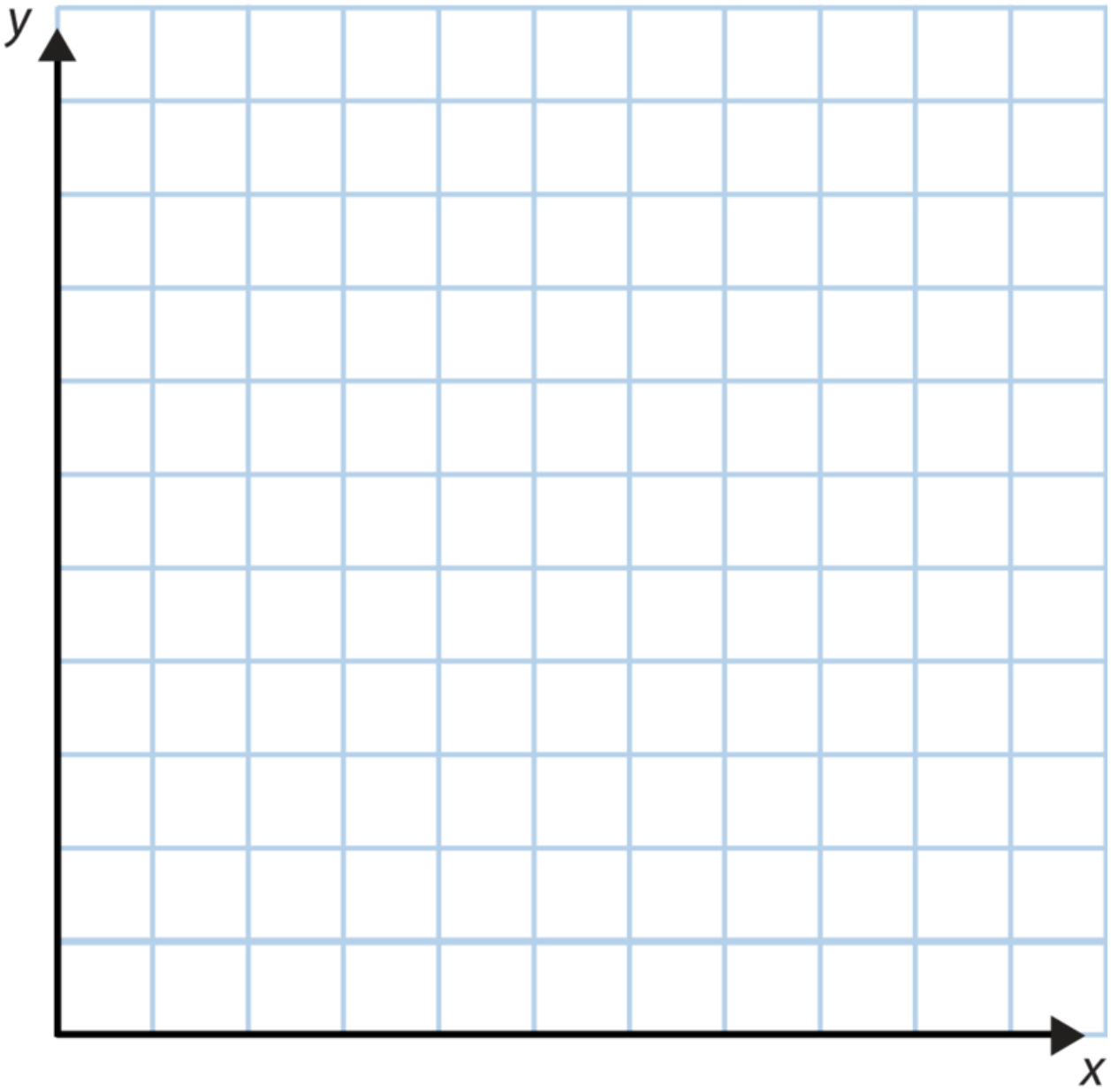
Student Worksheets

Lesson #1 - Predicting and Drawing Graphs

Name _____ **Date** _____

Lesson #1 - Predicting and Drawing Graphs **Prediction Worksheet**

Phenomenon: In the winter time there are days where the air in Utah appears cloudy or foggy all day.



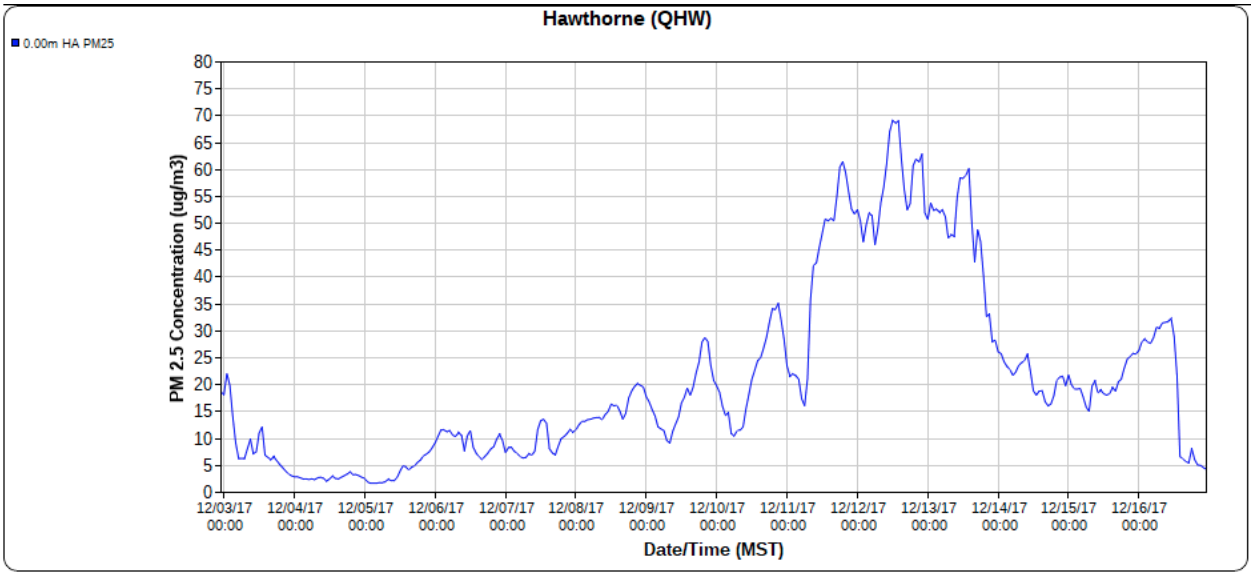
<u>Prediction</u> - draw a graph that predicts what happens to PM 2.5 concentrations during an inversion event. Be sure to label both axes with the appropriate variables and units.

Name _____ **Date** _____

Lesson #1 - Predicting and Drawing Graphs **Procedure and Analysis Worksheet**

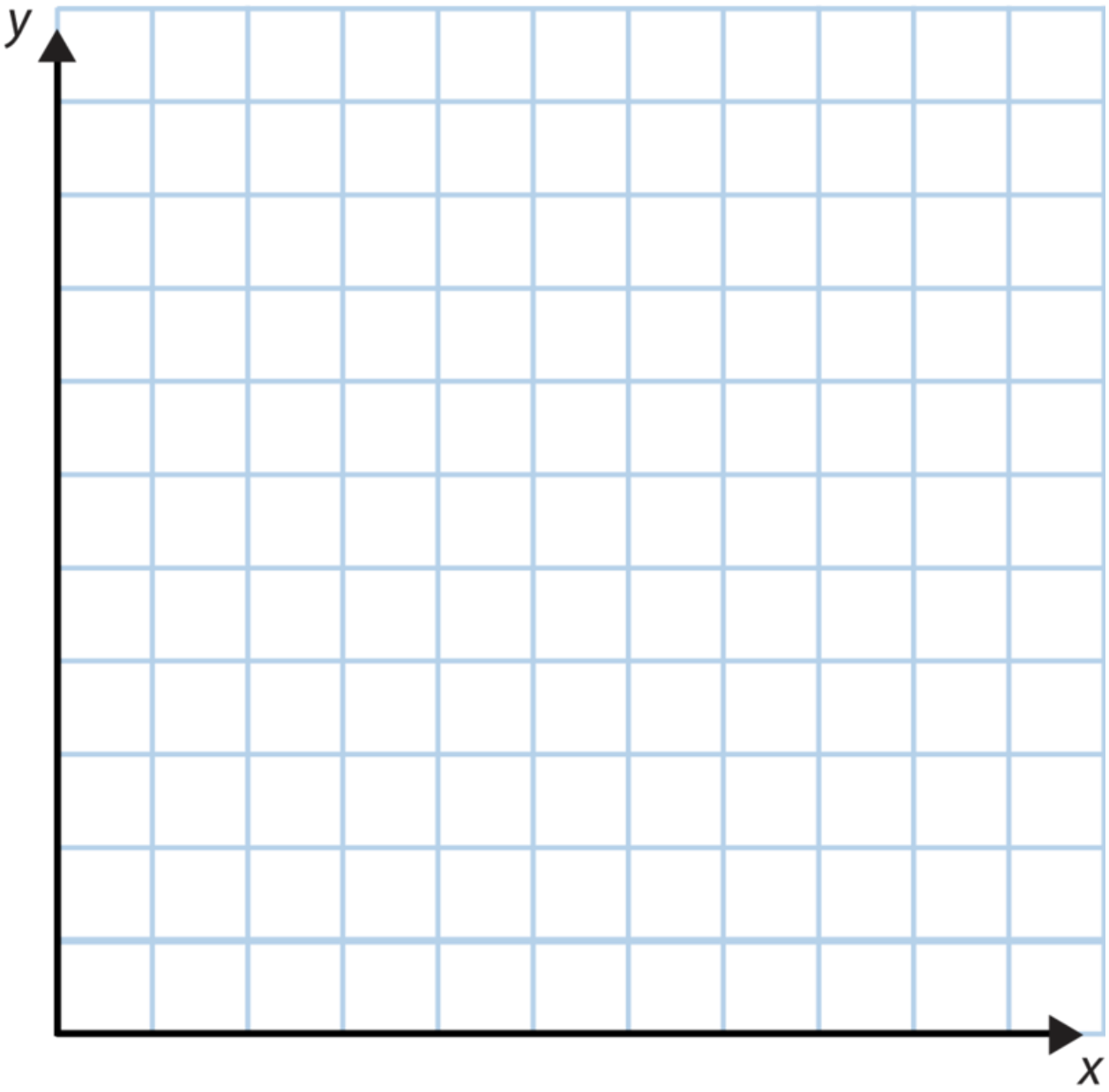
Phenomenon: In the winter time there are days where the air in Utah appears cloudy or foggy all day.

OPTION A



1. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General patterns in the data
    f. High and Low data points
    g. Is there anything else you notice?
2. Develop questions from the patterns you see in the data.
3. Construct an explanation for what you think could be occurring (minimum 4 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #1.
4. How did your prediction compare to the actual graph?
5. What was the maximum PM 2.5 concentration during this inversion event?
6. Look at the recess guidance tool linked here. What would schools in the valley have chosen for recess that day?
7. Over what period of time did the PM 2.5 concentrations exceed the acceptable level for all students?
8. Create an argument for evidence This graph represents a typical inversion event in the valley. Answer the following questions to describe this event.
    a. How long did the event last?
    b. Over what period of time were PM 2.5 concentrations increasing?
    c. Over what period of time were PM 2.5 concentrations decreasing?
    d. How many times bigger is the max event as compared to the minimum event?
    e. Did PM 2.5 concentrations increase and decrease at the same rate or different rates?

9. On the graph paper below, create a graph/model that represents an inversion event during which students with respiratory symptoms would have been advised to stay indoors. Be sure to scale and label both axes. *Optional* to help with planning your graph, complete the prompts below.
    a. Over what period of time will your inversion event occur (what dates/times)?
    b. What will be the max PM 2.5 concentration?
    c. What will be the min PM 2.5 concentration?
    d. How long will it take for PM 2.5 to reach the max concentration?
10. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.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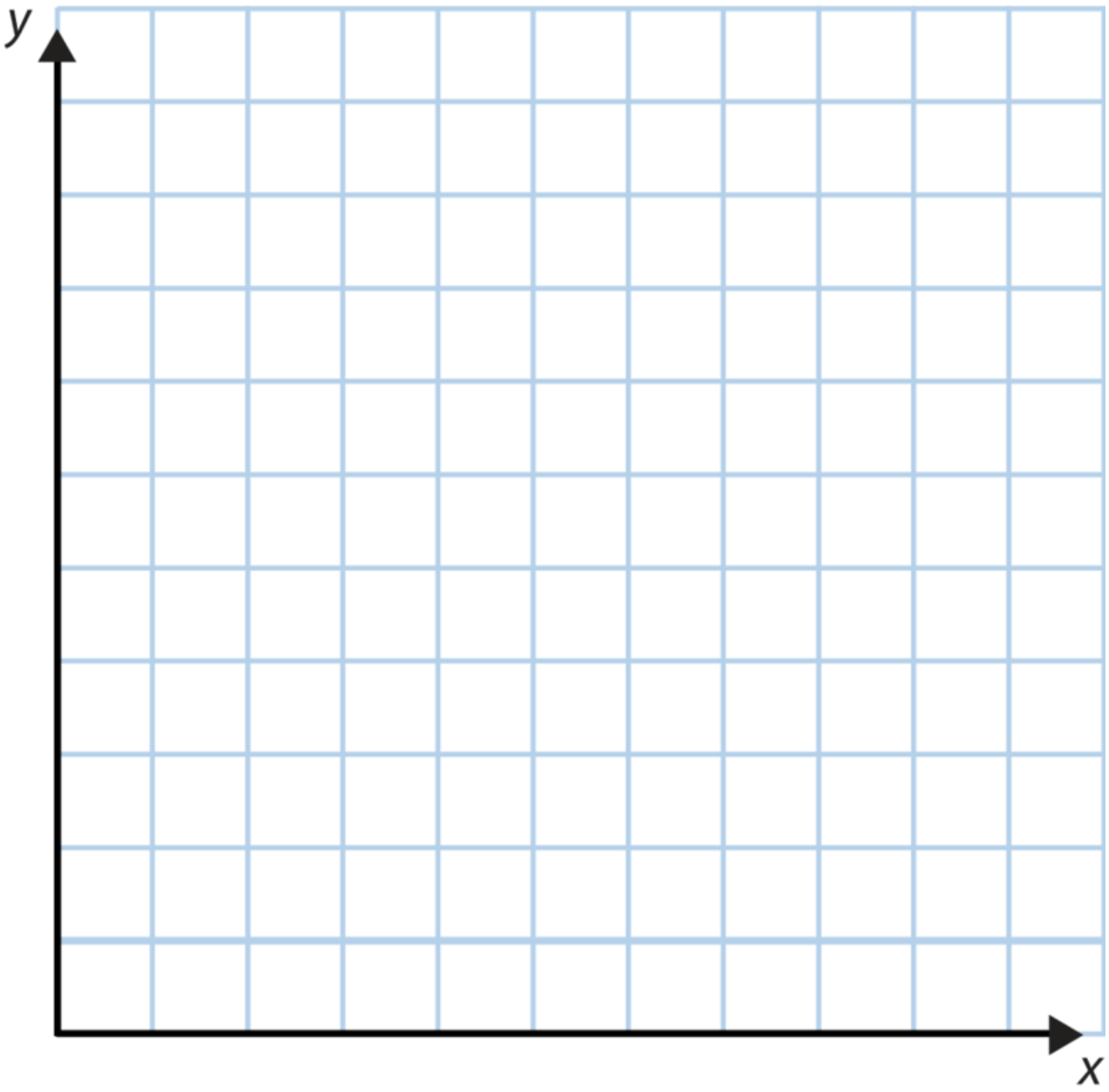
Name _____ **Date** _____

Lesson #1 - Predicting and Drawing Graphs **Procedure and Analysis Worksheet**

Phenomenon: In the winter time there are days where the air in Utah appears cloudy or foggy all day.

OPTION B

1. Use the data set provided by your teacher to create a graph of PM 2.5 concentration over time for this inversion event. Follow your teacher's instructions to graph this data.
2. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General patterns in the data
    f. High and Low data points
    g. Is there anything else you notice?
3. Develop questions from the patterns you see in the data.
4. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #2.
5. What was the maximum PM 2.5 concentration during this inversion event?
6. Look at the recess guidance tool linked here. What would schools in the valley have chosen for recess that day?
7. Over what period of time did the PM 2.5 concentrations exceed the acceptable level for all students?
8. Create an argument for evidence from your prediction verses other data.
9. This graph represents a typical inversion event in the valley. Answer the following questions to describe this event.
    a. How long did the event last?
    b. Over what period of time were PM 2.5 concentrations increasing?
    c. Over what period of time were PM 2.5 concentrations decreasing?
    d. How many times bigger is the max event as compared to the minimum event?
    e. Did PM 2.5 concentrations increase and decrease at the same rate or different rates?
10. On the graph paper below, create a graph/model that represents an inversion event during which students with respiratory symptoms would have been advised to stay indoors. Be sure to scale and label both axes. *Optional* to help with planning your graph, complete the prompts below.
    a. Over what period of time will your inversion event occur (what dates/times)?
    b. What will be the max PM 2.5 concentration?
    c. What will be the min PM 2.5 concentration?
    d. How long will it take for PM 2.5 to reach the max concentration?
11. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.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Name _____ **Date** _____

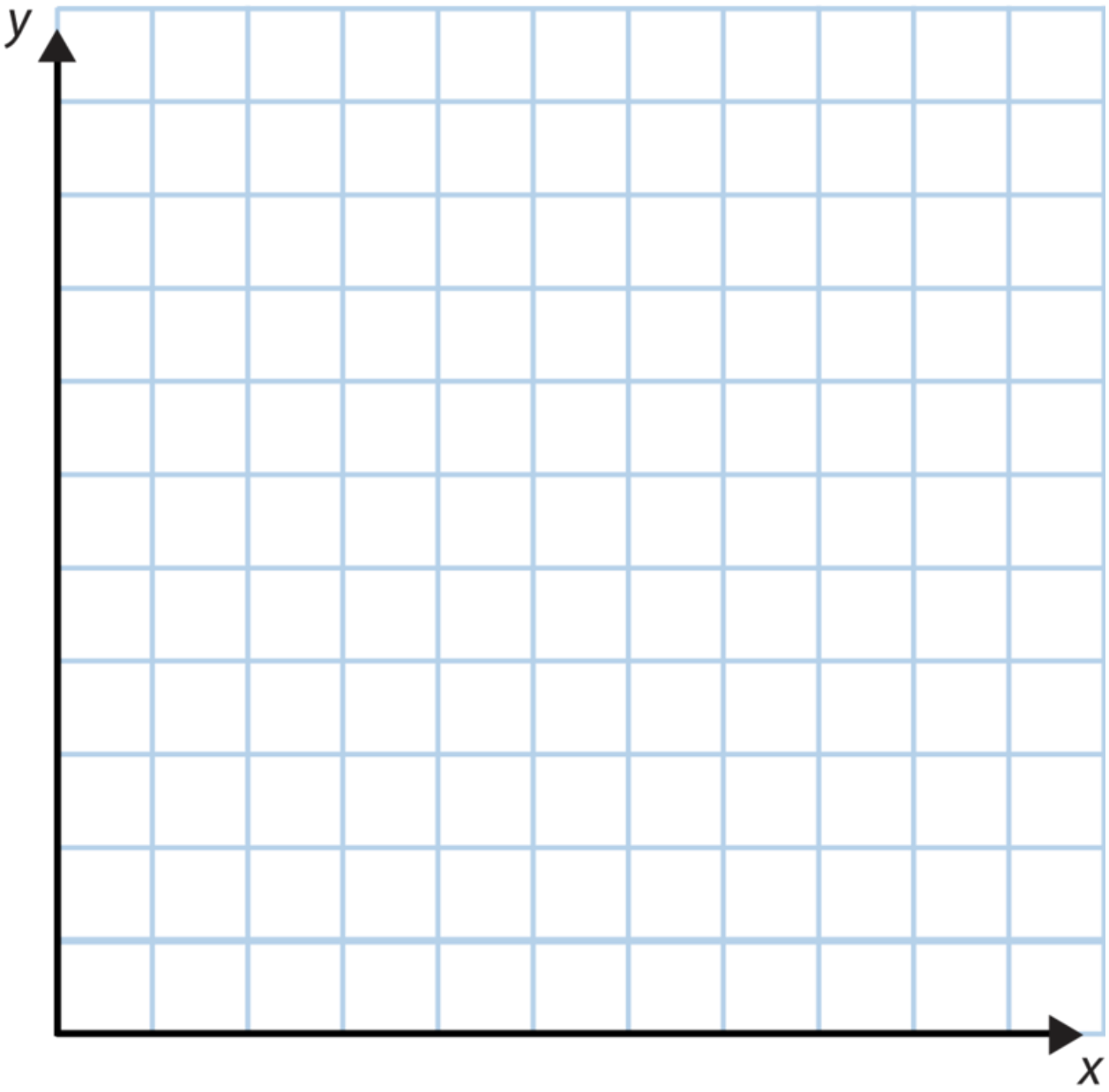
Lesson #1 - Predicting and Drawing Graphs **Procedure and Analysis Worksheet**

Phenomenon: In the winter time there are days where the air in Utah appears cloudy or foggy all day.

OPTION C

1. Click here to open the MesoWest website.
2. Follow the steps below VERY carefully. They will walk you through how to use the MesoWest website to generate a graph of an inversion event.
    a. Zoom in on the map to find the Hawthorne Elementary sensor (QHW). It is a square on 700 East just North of the 215 Belt Route.
    b. Click on the square and then click on the QHW link at the top of the box. This will take you to the data page for that specific sensor. The Hawthorne sensor is a Department of Air Quality sensor and is the longest running sensor on the MesoWest network, which are the reasons we have chosen this sensor to work with for this activity.
    c. This page shows real time data so we now need to select the data set for the PM 2.5 event we want to examine. Click on the option in the left hand column “Change Date/Time.”
    d. Choose 16 December 2017 at 23:00.
    e. Click on the option in the left hand column “Change to Graphical Display.”
    f. For the time period, select “Previous 14 Days” for the variable select “PM_2.5 Concentration.” Then click “Change Graph.” The graph should display two lines (one for each of the two sensors on the QHW device).
3. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General patterns in the data
    f. High and Low data points
    g. Is there anything else you notice?
4. Develop questions from the patterns you see in the data.
5. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #3.
6. What was the maximum PM 2.5 concentration during this inversion event?
7. Look at the recess guidance tool linked here. What would schools in the valley have chosen for recess that day?
8. Over what period of time did the PM 2.5 concentrations exceed the acceptable level for all students?
9. Create an argument for evidence from your prediction verses other data.
10. This graph represents a typical inversion event in the valley. Answer the following questions to describe this event.
    a. How long did the event last?
    b. Over what period of time were PM 2.5 concentrations increasing?
    c. Over what period of time were PM 2.5 concentrations decreasing?

    d. How many times bigger is the max event as compared to the minimum event?
    e. Did PM 2.5 concentrations increase and decrease at the same rate or different rates?
11. On the graph paper below, create a graph/model that represents an inversion event during which students with respiratory symptoms would have been advised to stay indoors. Be sure to scale and label both axes. *Optional* to help with planning your graph, complete the prompts below.
    a. Over what period of time will your inversion event occur (what dates/times)?
    b. What will be the max PM 2.5 concentration?
    c. What will be the min PM 2.5 concentration?
    d. How long will it take for PM 2.5 to reach the max concentration?
12. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.


y
x

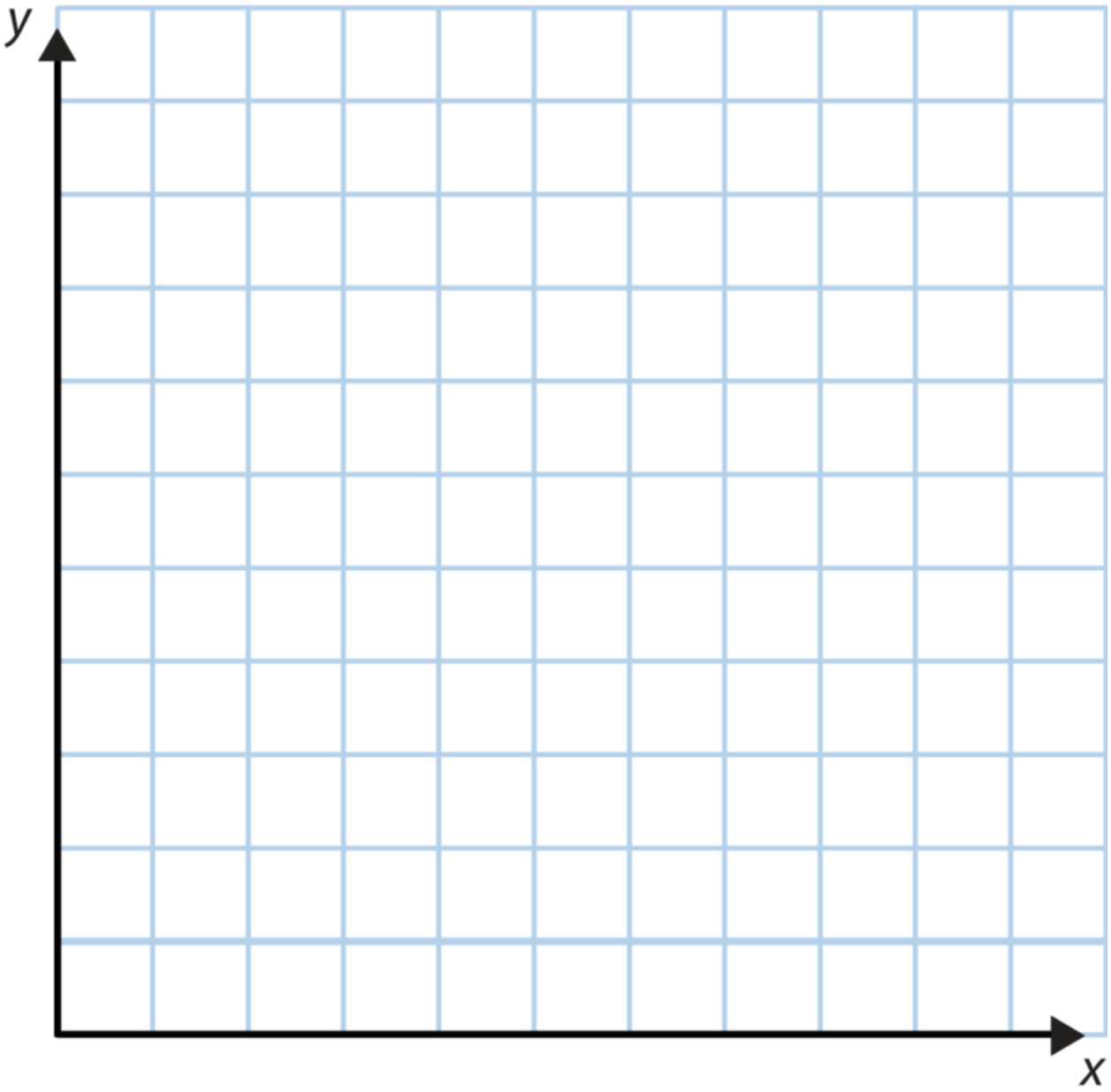
Student Worksheets

Lesson #2 - Relationships Between Two Variables

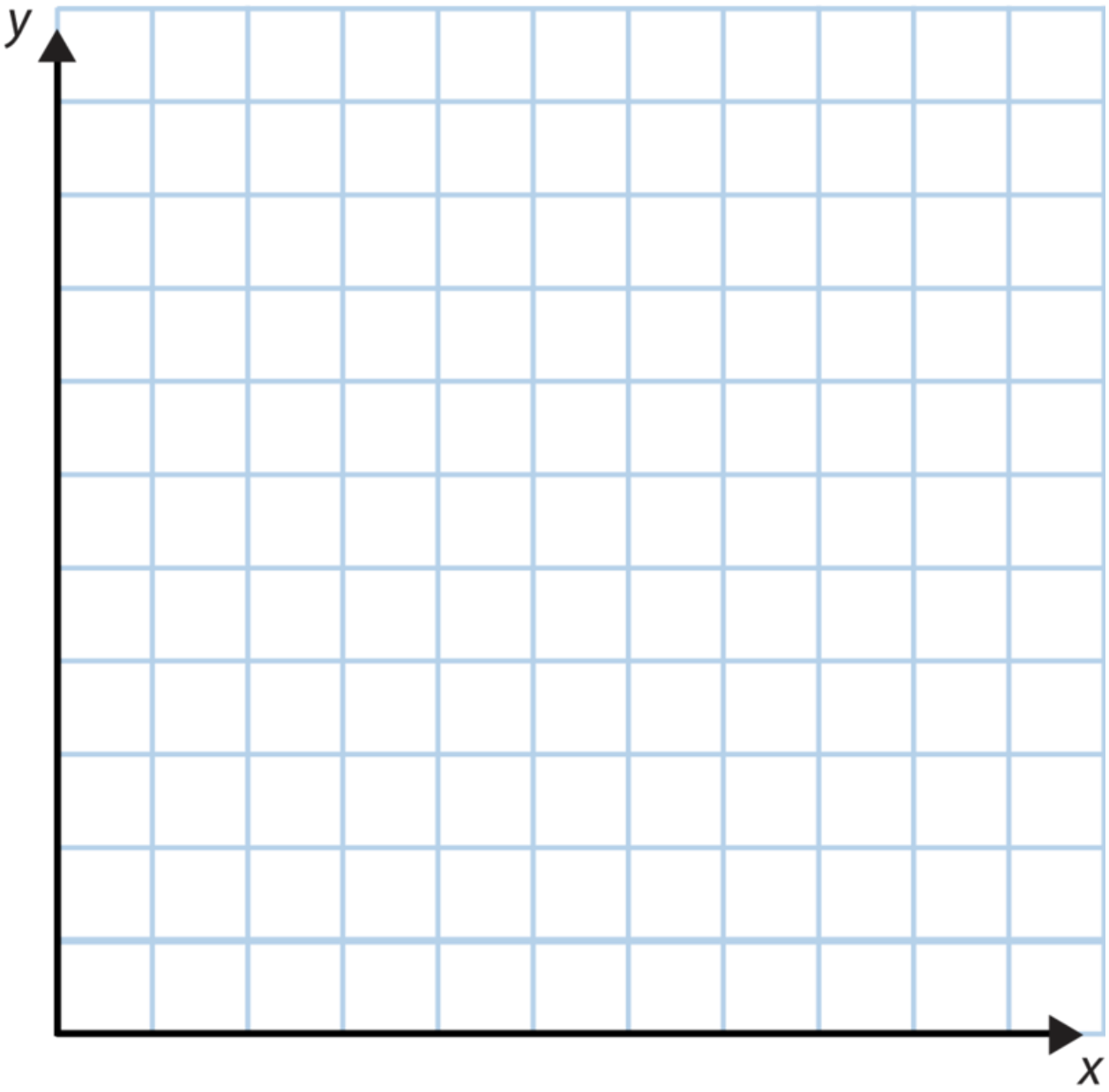
Name _____ **Date** _____

Lesson #2 - Relationships Between Two Variables **Prediction Worksheet**

Phenomenon: ‘Bad air days’ and other changes in our sky have a pattern, every winter they reoccur.



<u>Prediction</u> - draw two graphs that predict what happens to PM 2.5 concentrations and temperature before, during and after an inversion event. Use the front and back of this page.

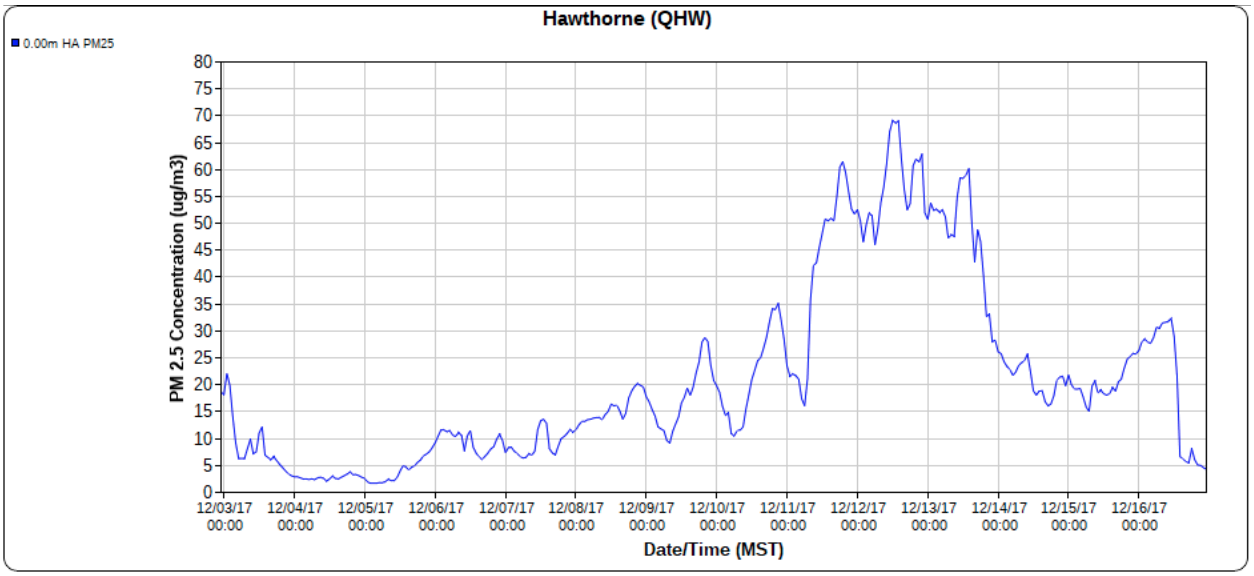

y
x

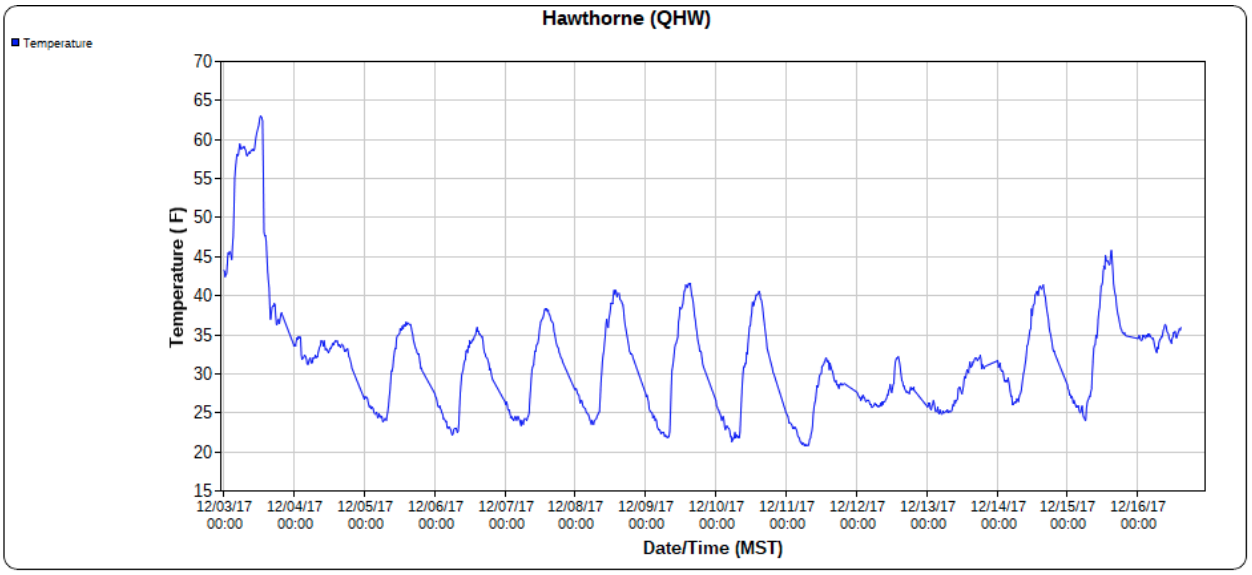
Name _____ **Date** _____

Lesson #2 - Relationships Between Two Variables **Procedure and Analysis Worksheet**

Phenomenon: 'Bad air days' and other changes in our sky have a pattern, every winter they reoccur.

OPTION A





1. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General patterns in the data
    f. High and Low data points
    g. Is there anything else you notice?
2. Develop questions from the patterns you see in the data.

3. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #1.
4. What relationship do you see between PM 2.5 and Temperature in the graphs?
5. How did your predictions compare to the actual graphs?
6. Create an argument for evidence from your prediction.
7. Make predictions about the relationship between PM 2.5 and other variables such as humidity or wind speed.
8. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.

Name _____ **Date** _____

Lesson #2 - Relationships Between Two Variables **Procedure and Analysis Worksheet**

Phenomenon: 'Bad air days' and other changes in our sky have a pattern, every winter they reoccur.

OPTION B

1. Use the data set provided by your teacher to create two graphs, one of PM 2.5 concentration and the other for temperature over time for this inversion event. Follow your teacher's instructions to graph this data.
2. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General patterns in the data
    f. High and Low data points
    g. Is there anything else you notice?
3. Develop questions from the patterns you see in the data.
4. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #2.
5. How did your prediction compare to the actual graphs?
6. What relationship do you see between PM 2.5 and Temperature in the graphs?
7. Create an argument for evidence from your prediction.
8. Make predictions about the relationship between PM 2.5 and other variables such as humidity or wind speed.
9. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.

Name _____ **Date** _____

Lesson #2 - Relationships Between Two Variables **Procedure and Analysis Worksheet**

Phenomenon: 'Bad air days' and other changes in our sky have a pattern, every winter they reoccur.

OPTION C

1. Click here to open the MesoWest website.
2. Follow the steps below VERY carefully. They will walk you through how to use the MesoWest website to generate a graph of an inversion event.
    a. Zoom in on the map to find the Hawthorne Elementary sensor (QHW). It is a square on 700 East just North of the 215 Belt Route.
    b. Click on the square and then click on the QHW link at the top of the box. This will take you to the data page for that specific sensor. The Hawthorne sensor is a Department of Air Quality sensor and is the longest running sensor on the MesoWest network, which are the reasons we have chosen this sensor to work with for this activity.
    c. This page shows real time data so we now need to select the data set for the PM 2.5 event we want to examine. Click on the option in the left hand column "Change Date/Time."
    d. Choose 16 December 2017 at 23:00.
    e. Click on the option in the left hand column "Change to Graphical Display."
    f. For the time period, select "Previous 14 Days" for the variable in the top graph select "PM_2.5 Concentration." Then click "Change Graph." The graph should display two lines (one for each of the two sensors on the QHW device).
3. Use the data set provided by your teacher to create two graphs, one of PM 2.5 concentration and the other for temperature over time for this inversion event. Follow your teacher's instructions to graph this data.
4. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General patterns in the data
    f. High and Low data points
    g. Is there anything else you notice?
5. Develop questions from the patterns you see in the data.
6. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #4.
7. What relationship do you see between PM 2.5 and Temperature in the graphs?
8. Create an argument for evidence from your prediction.
9. Make predictions about the relationship between PM 2.5 and other variables such as humidity or wind speed.
10. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.
11. As an extension, use the MesoWest website to create graphs of relative humidity and wind speed for the same time frame and compare the results to the PM 2.5 graph

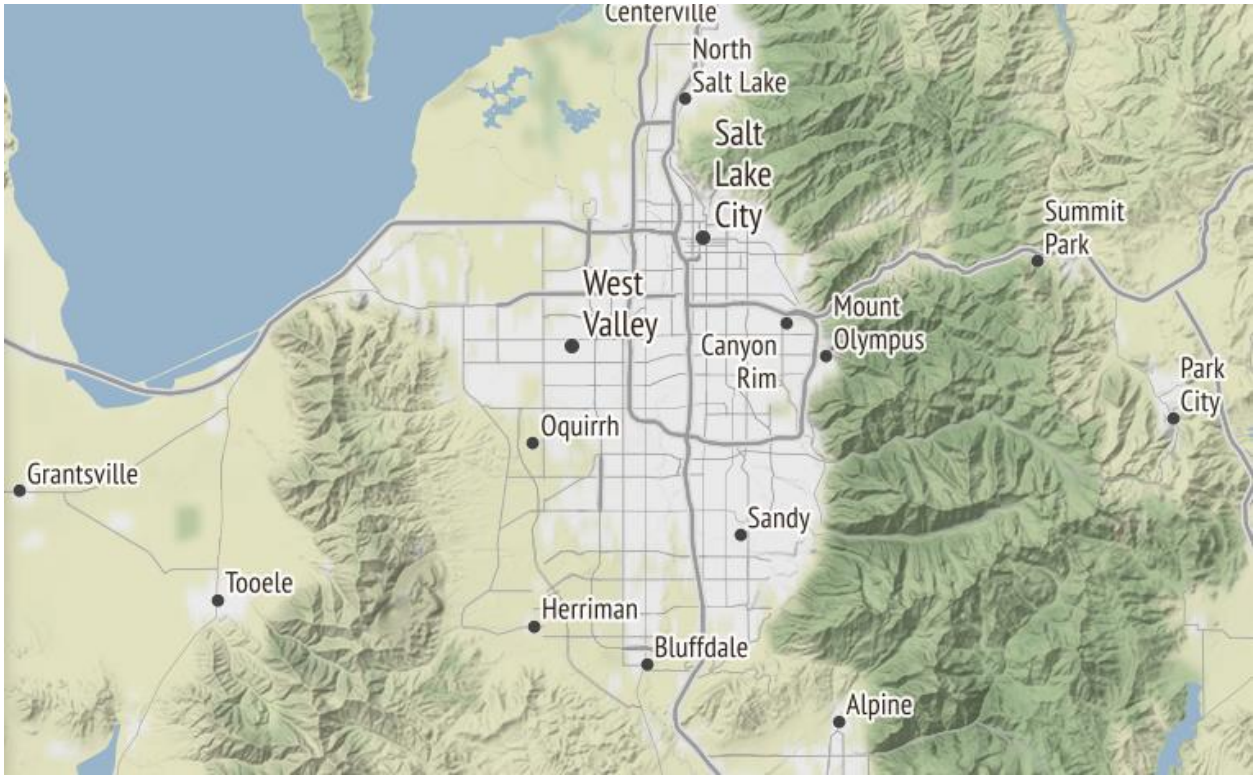
Student Worksheets

Lesson #3 - Spatial Variation of a Variable

Name _____ **Date** _____

Lesson #3 - **Spatial Variation of a Variable** **Prediction Worksheet**

Phenomenon: On bad air days, the pollution starts from the north part of town and moves to the south, so is the air cleaner in the south?



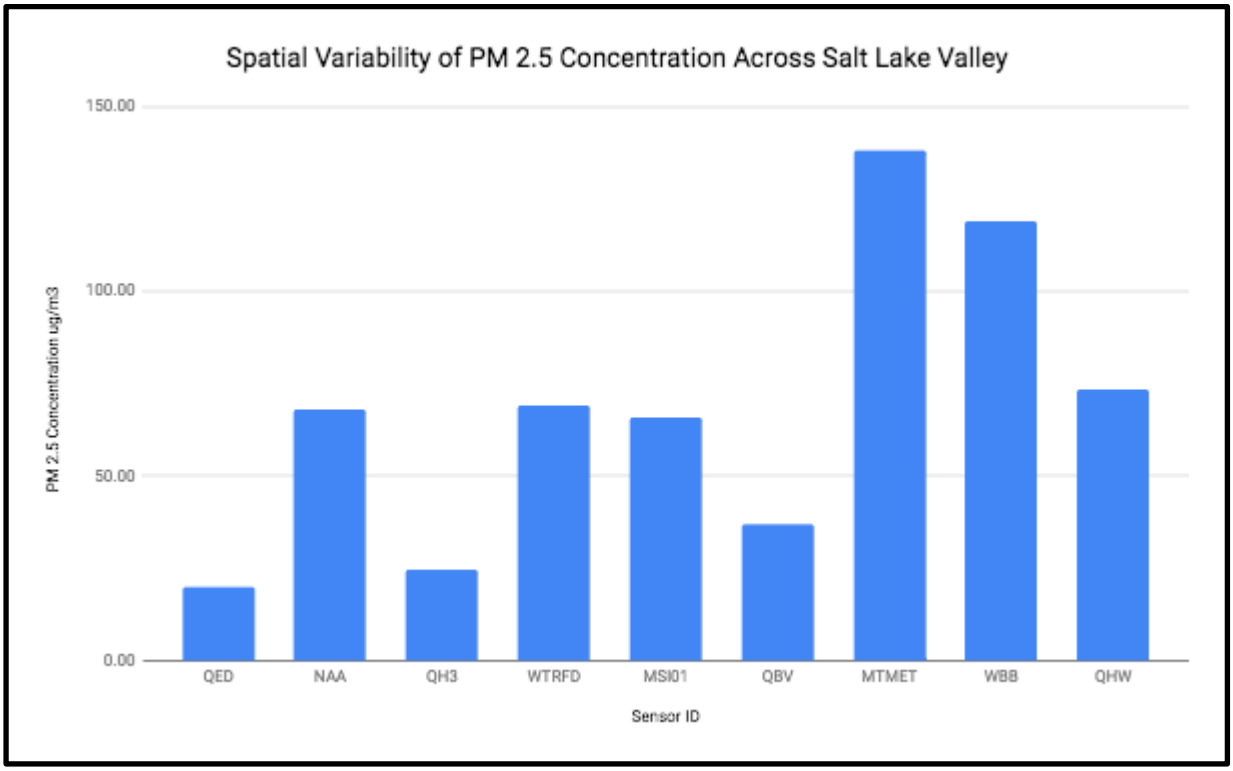
<u>Prediction</u> - create a color coded map that predicts how PM 2.5 concentrations will vary across the Salt Lake Valley during an inversion event. Construct an explanation with a minimum of 4-6 sentences to justify for your prediction.

Name _____ **Date** _____

Lesson #3 - Spatial Variation of a Variable **Procedure and Analysis Worksheet**

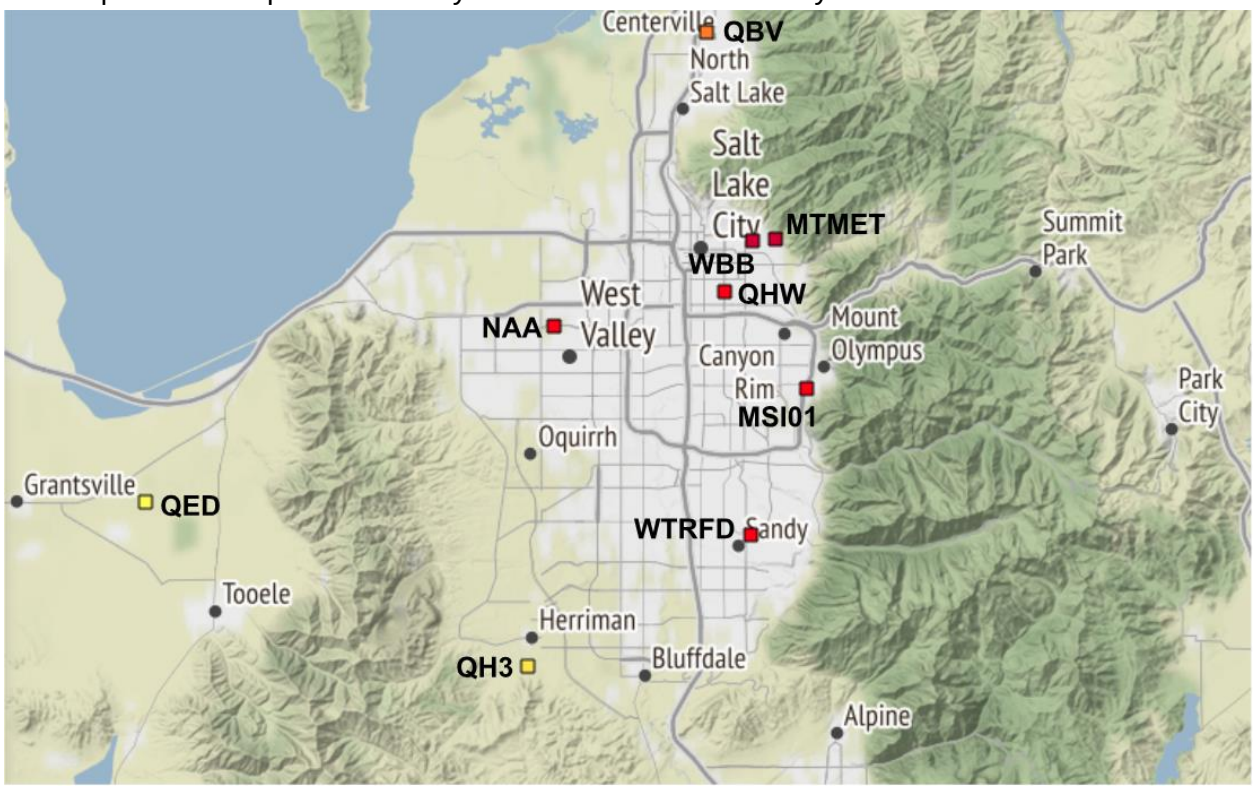
Phenomenon: On bad air days, the pollution starts from the north part of town and moves to the south, so is the air cleaner in the south?

OPTION A



1. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?
2. Develop questions from the patterns you see in the data.
3. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #1.
4. Look at your map template of the Salt Lake Valley. Each label represents a PM 2.5 sensor that collects data for the MesoWest website. Using your graph, write in the PM 2.5 concentration for each sensor during this particular inversion event.
5. Make a prediction about what you observe about PM 2.5 variation across the valley.
6. What relationships or factors might be responsible for the patterns we see in spatial variability of PM 2.5?
7. Create an argument for evidence from your prediction.

8. What other variables (weather, geographic, geologic, environmental, biological, etc) have predictable spatial variability across the Salt Lake Valley?



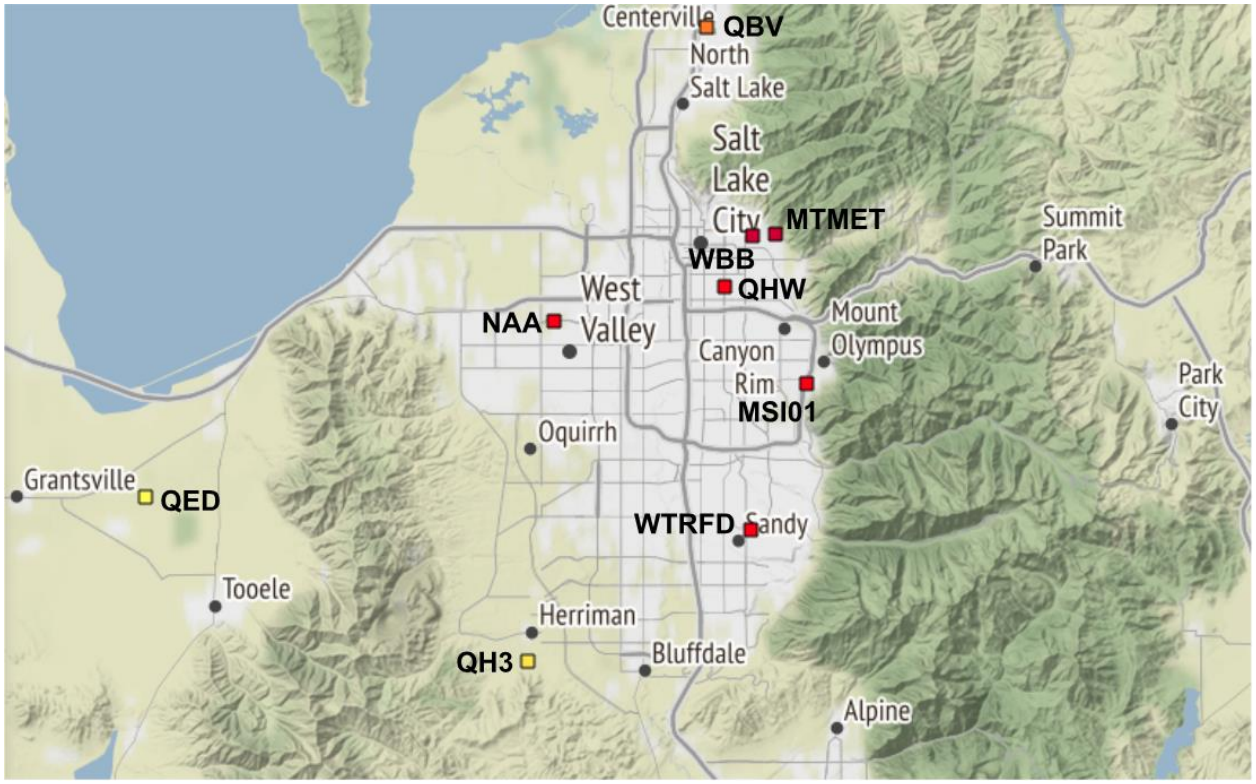
Name _____ **Date** _____

Lesson #3 - **Spatial Variation of a Variable** **Procedure and Analysis Worksheet**

Phenomenon: On bad air days, the pollution starts from the north part of town and moves to the south, so is the air cleaner in the south?

OPTION B

1. Use the data set provided by your teacher to create a graph of PM 2.5 concentration at different sensor locations in the Salt Lake Valley during this inversion event. Follow your teacher's instructions to graph this data.
2. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?
3. Develop questions from the patterns you see in the data.
4. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #2.
5. Look at your map template of the Salt Lake Valley. Each label represents a PM 2.5 sensor that collects data for the MesoWest website. Using your graph, write in the PM 2.5 concentration for each sensor during this particular inversion event.
6. Make a prediction about what you observe about PM 2.5 variation across the valley.
7. What relationships or factors might be responsible for the patterns we see in spatial variability of PM 2.5?
8. Create an argument for evidence from your prediction.
9. What factors might be responsible for the patterns we see in spatial variability of PM 2.5?
10. What other variables (weather, geographic, geologic, environmental, biological, etc) have predictable spatial variability across the Salt Lake Valley?


Centerville
QBV
North
Salt Lake
Salt
Lake
City
MTMET
WBB
QHW
West
Valley
NAA
Canyon
Rim
MSI01
Mount
Olympus
Summit
Park
Park
City
Oquirrh
Grantsville
QED
WTRFD
Sandy
Tooele
Herriman
QH3
Bluffdale
Alpine

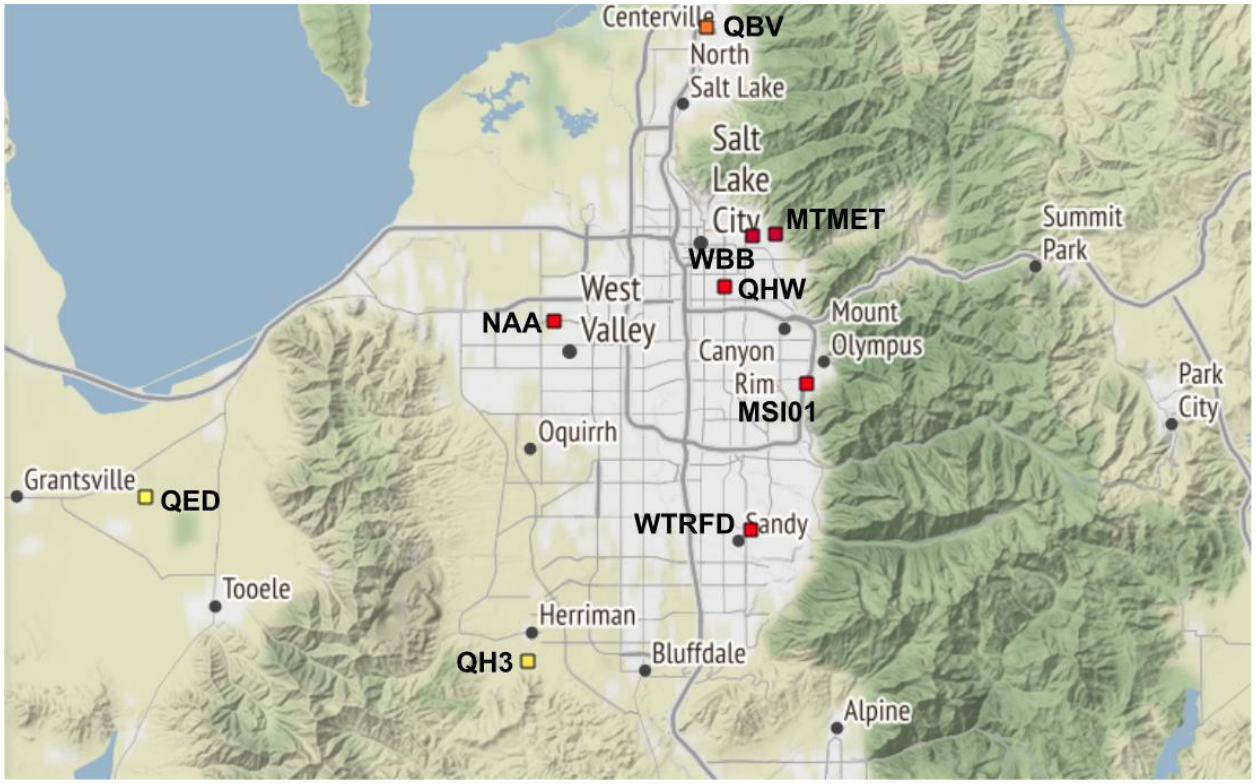
Name _____ **Date** _____

Lesson #3 - Spatial Variation of a Variable **Procedure and Analysis Worksheet**

Phenomenon: On bad air days, the pollution starts from the north part of town and moves to the south, so is the air cleaner in the south?

OPTION C

1. Click here to open the MesoWest website.
2. Follow the steps below VERY carefully. They will walk you through how to use the MesoWest website to gather data to create a graph of PM 2.5 concentration at different sensor locations in the Salt Lake Valley during this inversion event. Follow your teacher's instructions to graph this data.
    a. At the top of the page, hover over "Air Quality Data" and then click on "Map Archive."
    b. Select the parameters for December 12, 2017 at 12:00 for PM 2.5 Concentration. Click "Update Time and Primary Options."
    c. Center the map around Salt Lake City and click the zoom button once.
    d. Notice the color coded squares, each corresponds to an air quality sensor.
    e. Click on each sensor and record the sensor label and PM 2.5 concentration in a spreadsheet. You should have data for 9 different sensors.
    f. Use this data to create a bar graph showing PM 2.5 concentration for the 9 different sensors in the Salt Lake Valley.
3. Use the data set provided by your teacher to create a graph of PM 2.5 concentration at different sensor locations in the Salt Lake Valley during this inversion event. Follow your teacher's instructions to graph this data.
4. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?
5. Develop questions from the patterns you see in the data.
6. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #4.
7. Look at your map template of the Salt Lake Valley. Each label represents a PM 2.5 sensor that collects data for the MesoWest website. Using your graph, write in the PM 2.5 concentration for each sensor during this particular inversion event.
8. Make a prediction about what you observe about PM 2.5 variation across the valley.
9. What relationships or factors might be responsible for the patterns we see in spatial variability of PM 2.5?
10. Create an argument for evidence from your prediction.
11. What other variables (weather, geographic, geologic, environmental, biological, etc) have predictable spatial variability across the Salt Lake Valley?


Centerville
QBV
North
Salt Lake
Salt
Lake
City
MTMET
WBB
QHW
West
Valley
NAA
Canyon
Rim
MSI01
Mount
Olympus
Summit
Park
Park
City
Oquirrh
Grantsville
QED
WTRFD
Sandy
Tooele
Herriman
QH3
Bluffdale
Alpine

Student Worksheets - Printable PDF Version

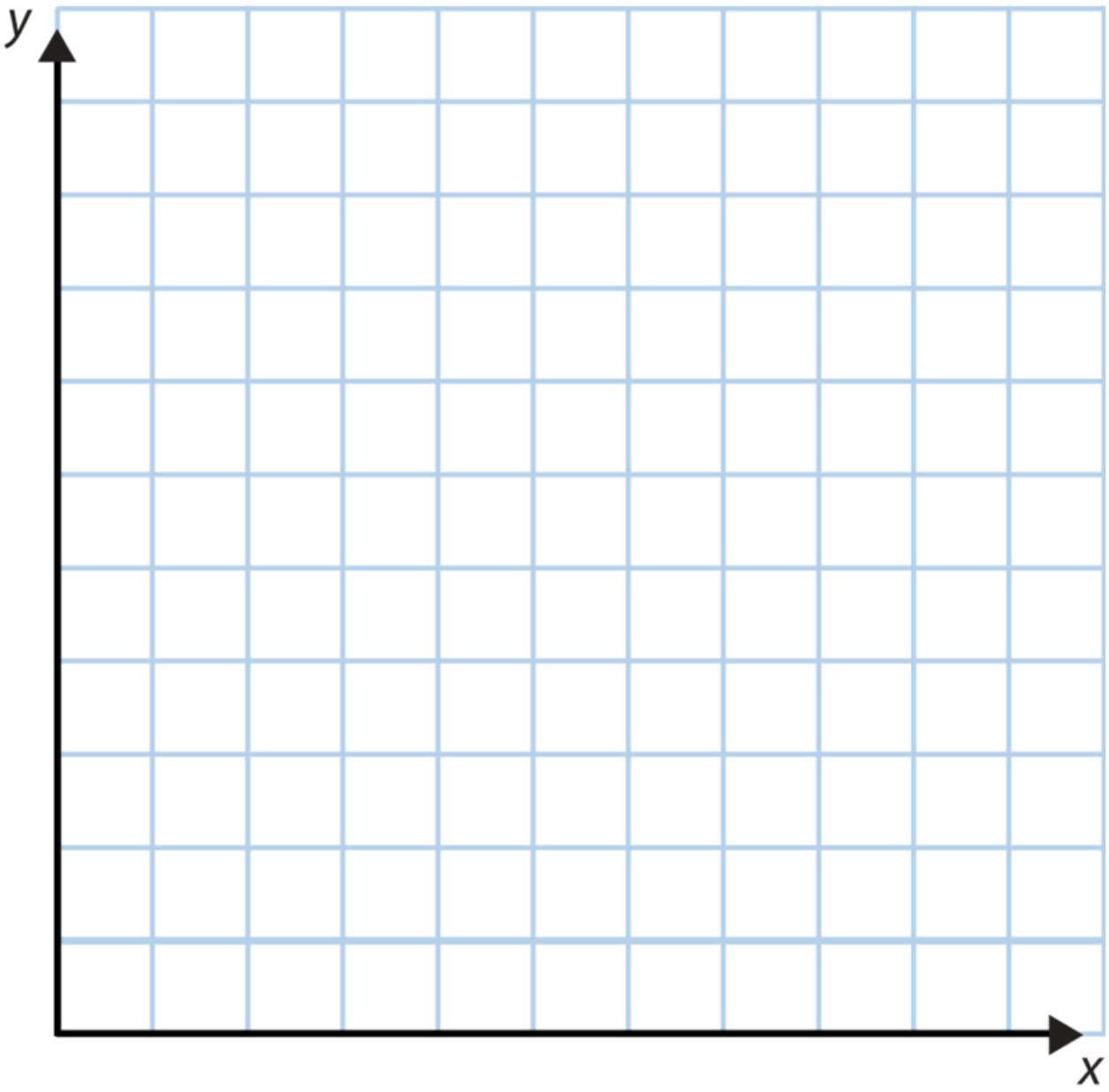
Student Worksheets

Lesson #1 - Predicting and Drawing Graphs

Name _____ **Date** _____

Lesson #1 - Predicting and Drawing Graphs **Prediction Worksheet**

Phenomenon: In the winter time there are days where the air in Utah appears cloudy or foggy all day.



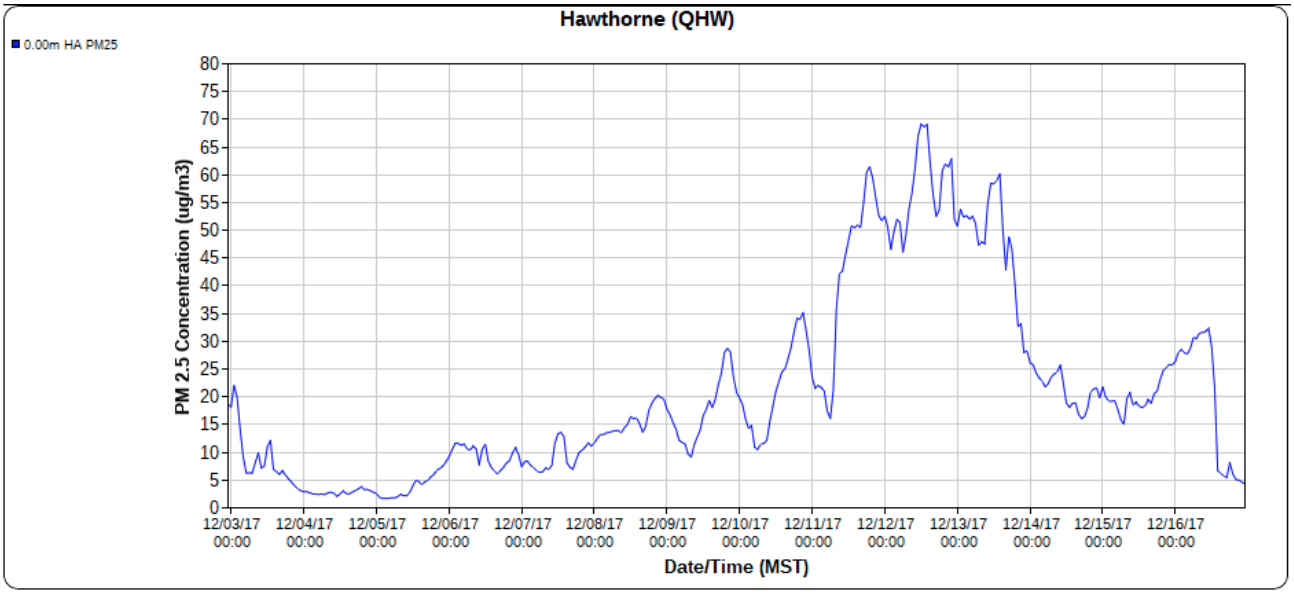
<u>Prediction</u> - draw a graph that predicts what happens to PM 2.5 concentrations during an inversion event. Be sure to label both axes with the appropriate variables and units.

Name _____ **Date** _____

Lesson #1 - Predicting and Drawing Graphs **Procedure and Analysis Worksheet**

Phenomenon: In the winter time there are days where the air in Utah appears cloudy or foggy all day.

OPTION A



1. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?

2. Develop questions from the patterns you see in the data.

3. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #1.

4. How did your prediction compare to the actual graph?

5. What was the maximum PM 2.5 concentration during this inversion event? _____

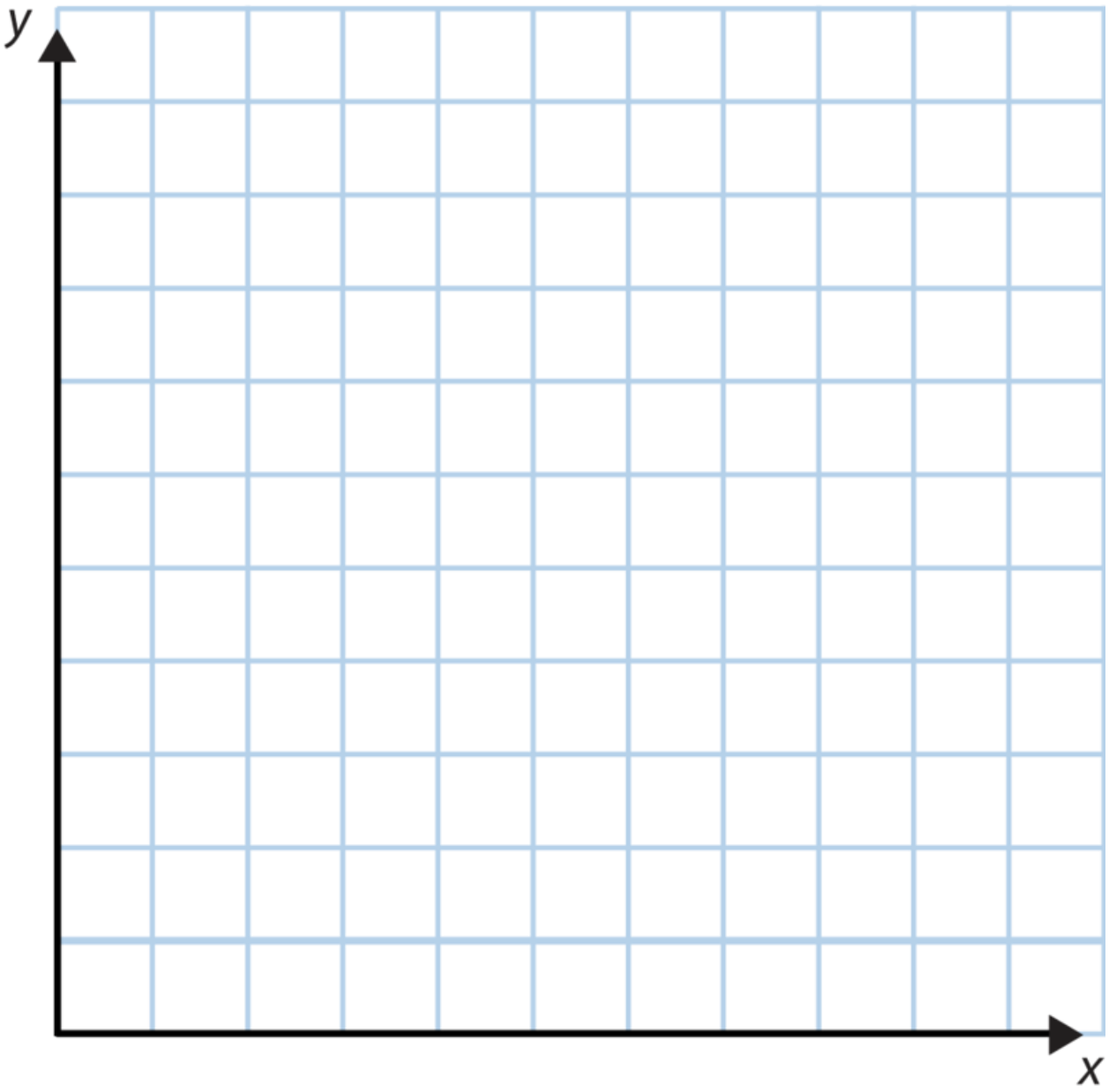
6. Look at the recess guidance tool linked here. What would schools in the valley have chosen for recess that day?

7. Over what period of time did the PM 2.5 concentrations exceed the acceptable level for all students?

8. Create an argument for evidence from your prediction verses other data.

9. This graph represents a typical inversion event in the valley. Answer the following questions to describe this event.
    a. How long did the event last? _____
    b. Over what period of time were PM 2.5 concentrations increasing? _____
    c. Over what period of time were PM 2.5 concentrations decreasing? _____
    d. How many times bigger is the max event as compared to the minimum event? _____
    e. Did PM 2.5 concentrations increase and decrease at the same rate or different rates?

10. On the graph paper below, create a graph that represents an inversion event during which students with respiratory symptoms would have been advised to stay indoors. Be sure to scale and label both axes. *Optional* to help with planning your graph, complete the prompts below.
    a. Over what period of time will your inversion event occur (what dates/times)?
    b. What will be the max PM 2.5 concentration?
    c. What will be the min PM 2.5 concentration?
    d. How long will it take for PM 2.5 to reach the max concentration?
11. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.


y
x

Name _____ **Date** _____

Lesson #1 - Predicting and Drawing Graphs **Procedure and Analysis Worksheet**

Phenomenon: In the winter time there are days where the air in Utah appears cloudy or foggy all day.

OPTION B

1. Use the data set provided by your teacher to create a graph of PM 2.5 concentration over time for this inversion event. Follow your teacher's instructions to graph this data.

2. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General patterns in the data
    f. High and Low data points
    g. Is there anything else you notice?

3. Develop questions from the patterns you see in the data.

_____

_____

_____

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_____

_____

_____

4. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #2.

_____

_____

_____

_____

5. What was the maximum PM 2.5 concentration during this inversion event? _____

6. Look at the recess guidance tool linked here. What would schools in the valley have chosen for recess that day?

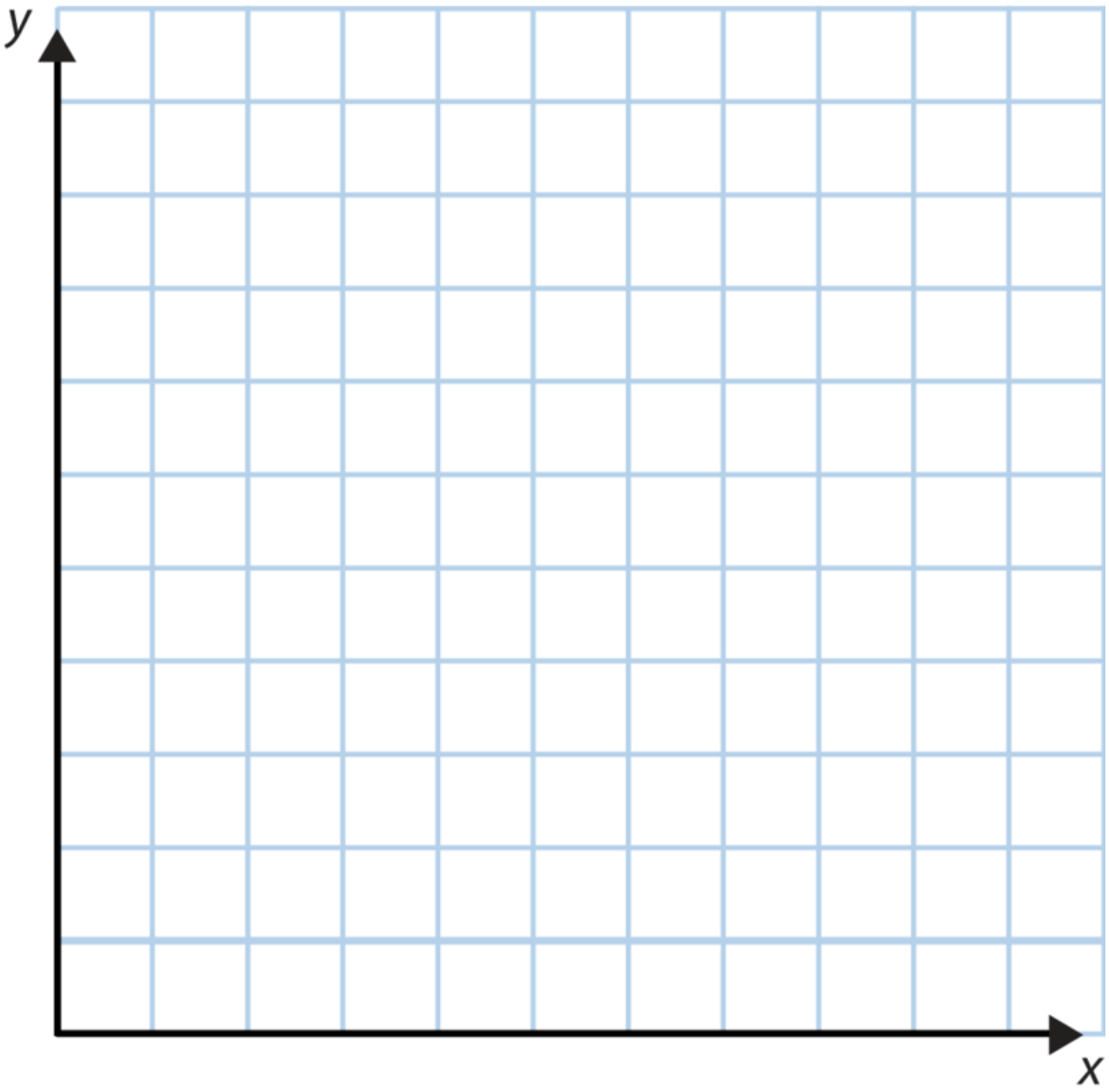
7. Over what period of time did the PM 2.5 concentrations exceed the acceptable level for all students?

8. Create an argument for evidence from your prediction verses other data.

9. This graph represents a typical inversion event in the valley. Answer the following questions to describe this event.
    a. How long did the event last? _____
    b. Over what period of time were PM 2.5 concentrations increasing? _____
    c. Over what period of time were PM 2.5 concentrations decreasing? _____
    d. How many times bigger is the max event as compared to the minimum event?_____
    e. Did PM 2.5 concentrations increase and decrease at the same rate or different rates?

10. On the graph paper below, create a graph/model that represents an inversion event during which students with respiratory symptoms would have been advised to stay indoors. Be sure to scale and label both axes. *Optional* to help with planning your graph, complete the prompts below.
    a. Over what period of time will your inversion event occur (what dates/times)?
    b. What will be the max PM 2.5 concentration?
    c. What will be the min PM 2.5 concentration?
    d. How long will it take for PM 2.5 to reach the max concentration?

11. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.


y
x

Name _____ **Date** _____

Lesson #1 - Predicting and Drawing Graphs **Procedure and Analysis Worksheet**

Phenomenon: In the winter time there are days where the air in Utah appears cloudy or foggy all day.

OPTION C

1. Click here to open the MesoWest website.
2. Follow the steps below VERY carefully. They will walk you through how to use the MesoWest website to generate a graph of an inversion event.
    a. Zoom in on the map to find the Hawthorne Elementary sensor (QHW). It is a square on 700 East just North of the 215 Belt Route.

    b. Click on the square and then click on the QHW link at the top of the box. This will take you to the data page for that specific sensor. The Hawthorne sensor is a Department of Air Quality sensor and is the longest running sensor on the MesoWest network, which are the reasons we have chosen this sensor to work with for this activity.

    c. This page shows real time data so we now need to select the data set for the PM 2.5 event we want to examine. Click on the option in the left hand column "Change Date/Time."

    d. Choose 16 December 2017 at 23:00.

    e. Click on the option in the left hand column "Change to Graphical Display."

    f. For the time period, select "Previous 14 Days" for the variable select "PM_2.5 Concentration." Then click "Change Graph." The graph should display two lines (one for each of the two sensors on the QHW device).

3. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?

4. Develop questions from the patterns you see in the data.

_____

_____

_____

5. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #3.

6. What was the maximum PM 2.5 concentration during this inversion event? _____

7. Look at the recess guidance tool linked here. What would schools in the valley have chosen for recess that day?

8. Over what period of time did the PM 2.5 concentrations exceed the acceptable level for all students?

9. Create an argument for evidence from your prediction verses other data.

10. This graph represents a typical inversion event in the valley. Answer the following questions to describe this event.
    a. How long did the event last? _____
    b. Over what period of time were PM 2.5 concentrations increasing? _____
    c. Over what period of time were PM 2.5 concentrations decreasing? _____
    d. Did PM 2.5 concentrations increase and decrease at the same rate or different rates?

_____

_____

11. On the graph paper below, create a graph that represents an inversion event during which students with respiratory symptoms would have been advised to stay indoors. Be sure to scale and label both axes. *Optional:* to help with planning your graph, complete the prompts below.
    a. Over what period of time will your inversion event occur (what dates/times)?
    b. What will be the max PM 2.5 concentration?
    c. What will be the min PM 2.5 concentration?
    d. How long will it take for PM 2.5 to reach the max concentration?

12. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.

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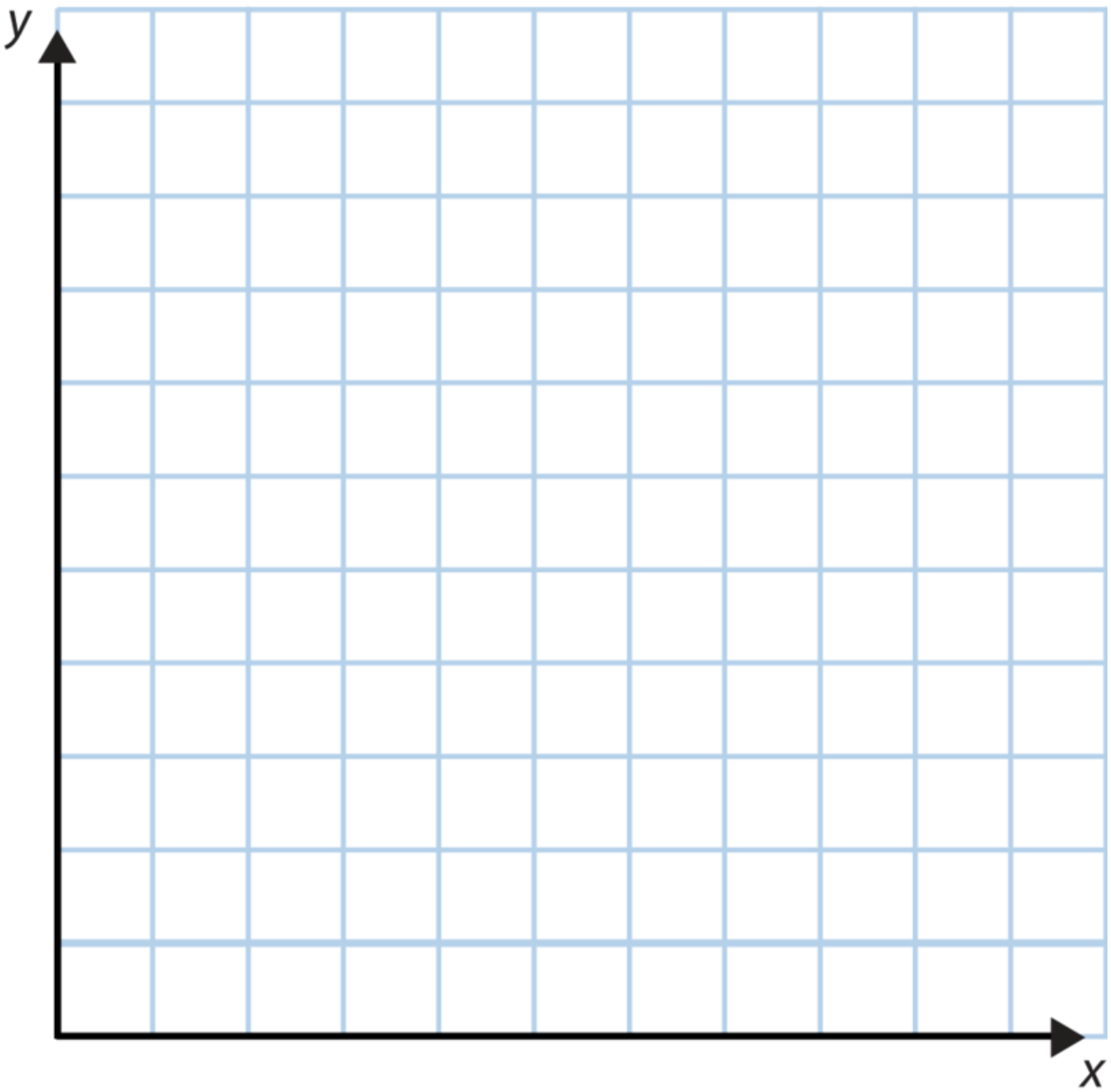

y
x

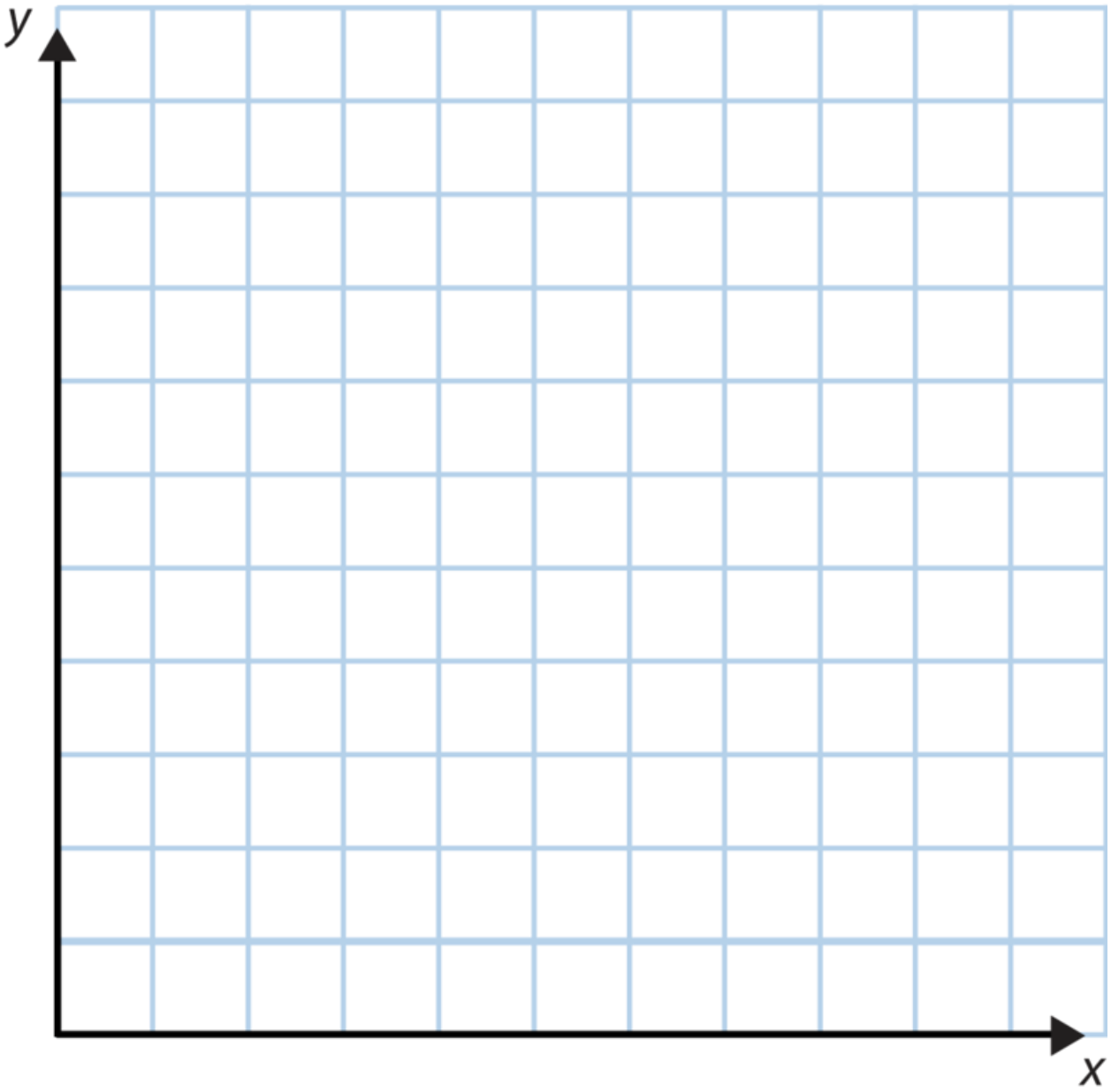
Student Worksheets

Lesson #2 - Relationships Between Two Variables

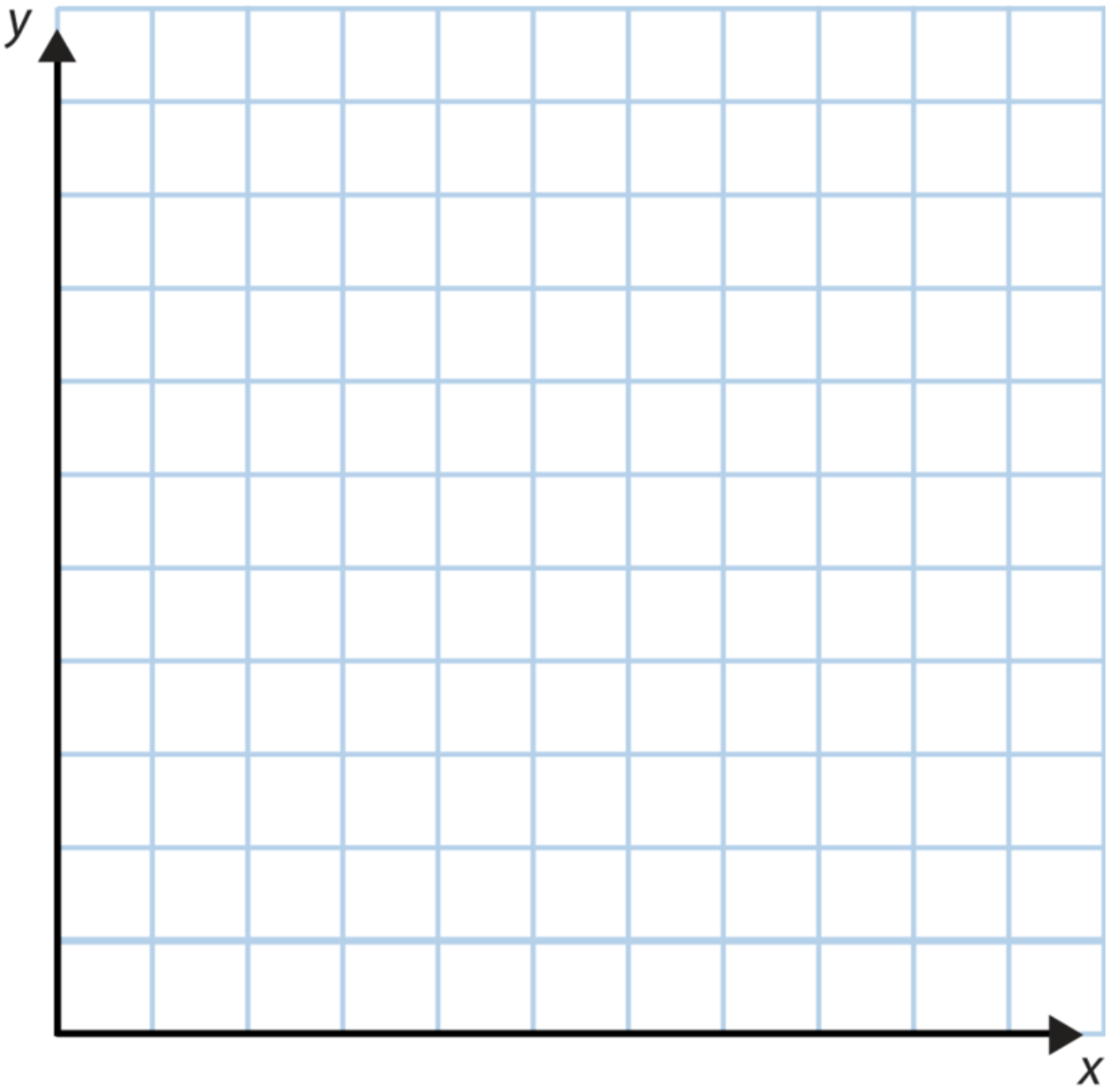
Name _____ **Date** _____

Lesson #2 - Relationships Between Two Variables **Prediction Worksheet**

Phenomenon: ‘Bad air days’ and other changes in our sky have a pattern, every winter they reoccur.



<u>Prediction</u> - draw two graphs that predict what happens to PM 2.5 concentrations and temperature before, during and after an inversion event. Use the front and back of this page.

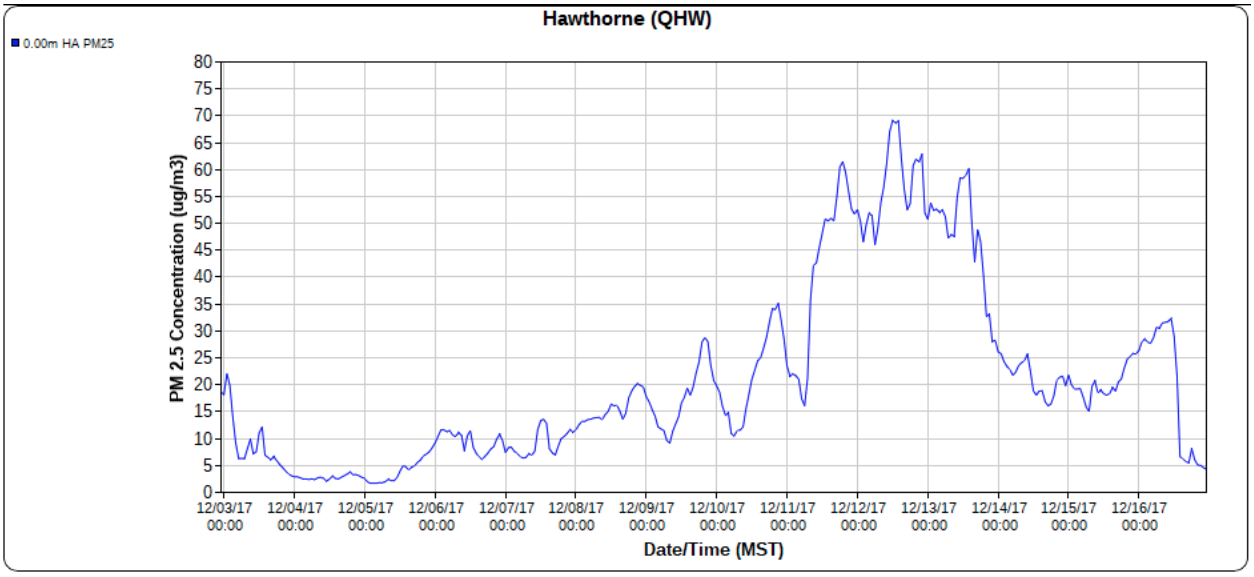

y
x

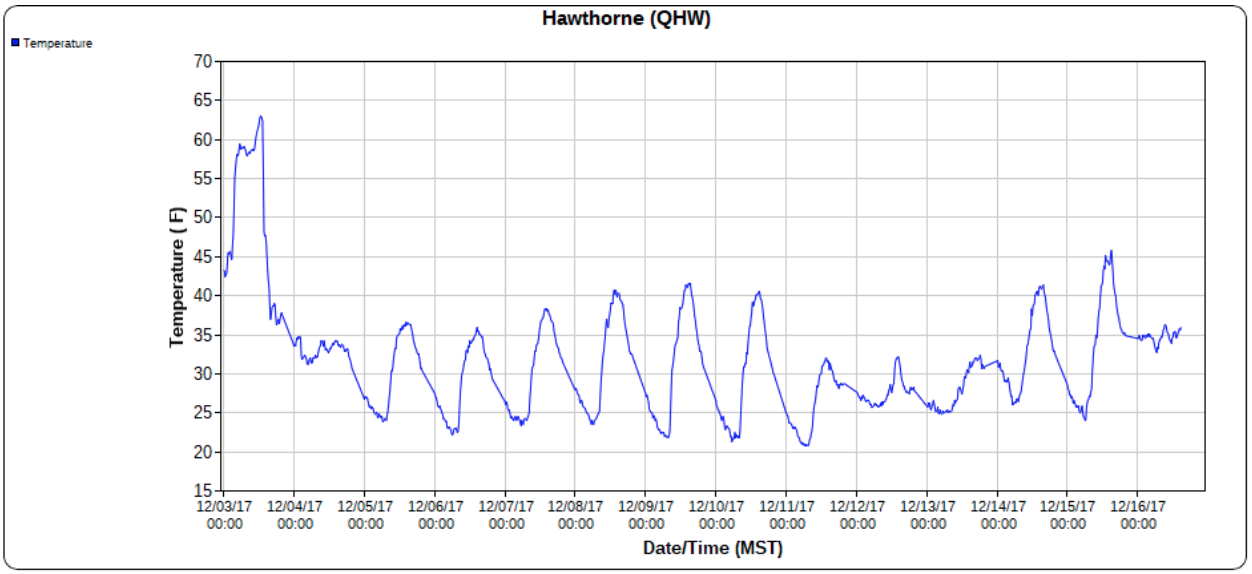
Name _____ **Date** _____

Lesson #2 - Relationships Between Two Variables **Procedure and Analysis Worksheet**

Phenomenon: 'Bad air days' and other changes in our sky have a pattern, every winter they reoccur.

OPTION A





1. Examine the graphs. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?
2. Develop questions from the patterns you see in the data.

3. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #1.

4. How did your predictions compare to the actual graphs?

5. What relationship do you see between PM 2.5 and Temperature in the graphs?

6. Create an argument for evidence from your prediction.

7. Make predictions about the relationship between PM 2.5 and other variables such as humidity or wind speed.

8. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.

Name _____ **Date** _____

Lesson #2 - Relationships Between Two Variables **Procedure and Analysis Worksheet**

Phenomenon: ‘Bad air days’ and other changes in our sky have a pattern, every winter they reoccur.

OPTION B

1. Use the data set provided by your teacher to create two graphs, one of PM 2.5 concentration and the other for temperature over time for this inversion event. Follow your teacher’s instructions to graph this data.

2. Examine the graphs. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?

3. Develop questions from the patterns you see in the data.

4. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #2.

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5. How did your prediction compare to the actual graphs?

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6. What relationship do you see between PM 2.5 and Temperature in the graphs?

7. Create an argument for evidence from your prediction.

8. Make predictions about the relationship between PM 2.5 and other variables such as humidity or wind speed.

9. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.

Name _____ **Date** _____

Lesson #2 - Relationships Between Two Variables **Procedure and Analysis Worksheet**

Phenomenon: 'Bad air days' and other changes in our sky have a pattern, every winter they reoccur.

OPTION C

1. Click here to open the MesoWest website.

2. Follow the steps below VERY carefully. They will walk you through how to use the MesoWest website to generate graphs of PM 2.5 Concentration and Temperature during an inversion event.

    a. Zoom in on the map to find the Hawthorne Elementary sensor (QHW). It is a square on 700 East just North of the 215 Belt Route.

    b. Click on the square and then click on the QHW link at the top of the box. This will take you to the data page for that specific sensor. The Hawthorne sensor is a Department of Air Quality sensor and is the longest running sensor on the MesoWest network, which are the reasons we have chosen this sensor to work with for this activity.

    c. This page shows real time data so we now need to select the data set for the PM 2.5 event we want to examine. Click on the option in the left hand column "Change Date/Time."

    d. Choose 16 December 2017 at 23:00.

    e. Click on the option in the left hand column "Change to Graphical Display."

    f. For the time period, select "Previous 14 Days" for the variable in the top graph select "PM_2.5 Concentration." Then click "Change Graph." The graph should display two lines (one for each of the two sensors on the QHW device).

    g. For the variable in the bottom graph select "Temperature." Then click "Change Graph."

3. Use the data set provided by your teacher to create two graphs, one of PM 2.5 concentration and the other for temperature over time for this inversion event. Follow your teacher's instructions to graph this data.

4. Examine the graphs. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?

5. Develop questions from the patterns you see in the data.
6. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #4.

7. What relationship do you see between PM 2.5 and Temperature in the graphs?

8. Create an argument for evidence from your prediction.

9. Make predictions about the relationship between PM 2.5 and other variables such as humidity or wind speed.

10. With information from above and the lecture, evaluate and communicate your findings and design a set of solutions.

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11. As an extension, use the MesoWest website to create graphs of relative humidity and wind speed for the same time frame and compare the results to the PM 2.5 graph.

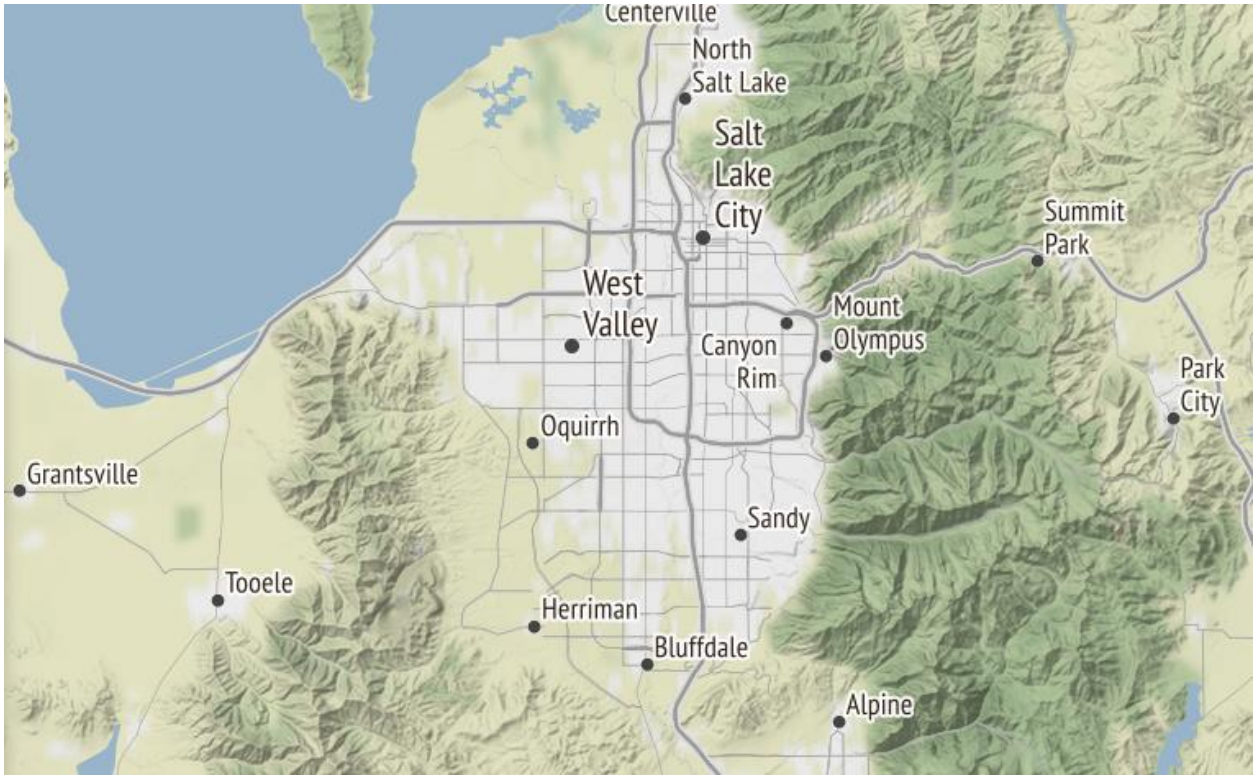
Student Worksheets

Lesson #3 - Spatial Variation of a Variable

Name _____ **Date** _____

Lesson #3 - **Spatial Variation of a Variable** **Prediction Worksheet**

Phenomenon: On bad air days, the pollution starts from the north part of town and moves to the south, so is the air cleaner in the south?



Prediction - create a color coded map that predicts how PM 2.5 concentrations will vary across the Salt Lake Valley during an inversion event. Construct an explanation with a minimum of 4-6 sentences to justify for your prediction.

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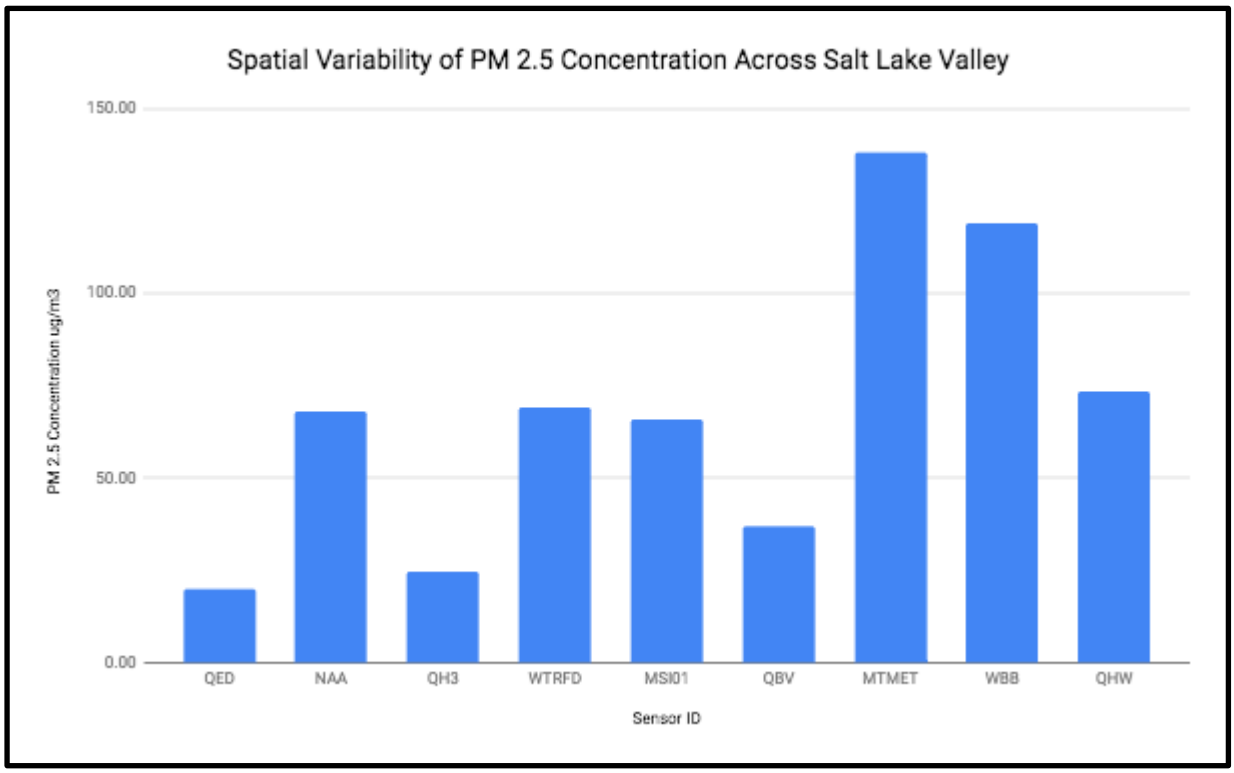
Name _____ **Date** _____

Lesson #3 - Spatial Variation of a Variable **Procedure and Analysis Worksheet**

Phenomenon: On bad air days, the pollution starts from the north part of town and moves to the south, so is the air cleaner in the south?

OPTION A



1. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?

2. Develop questions from the patterns you see in the data.

3. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #1.

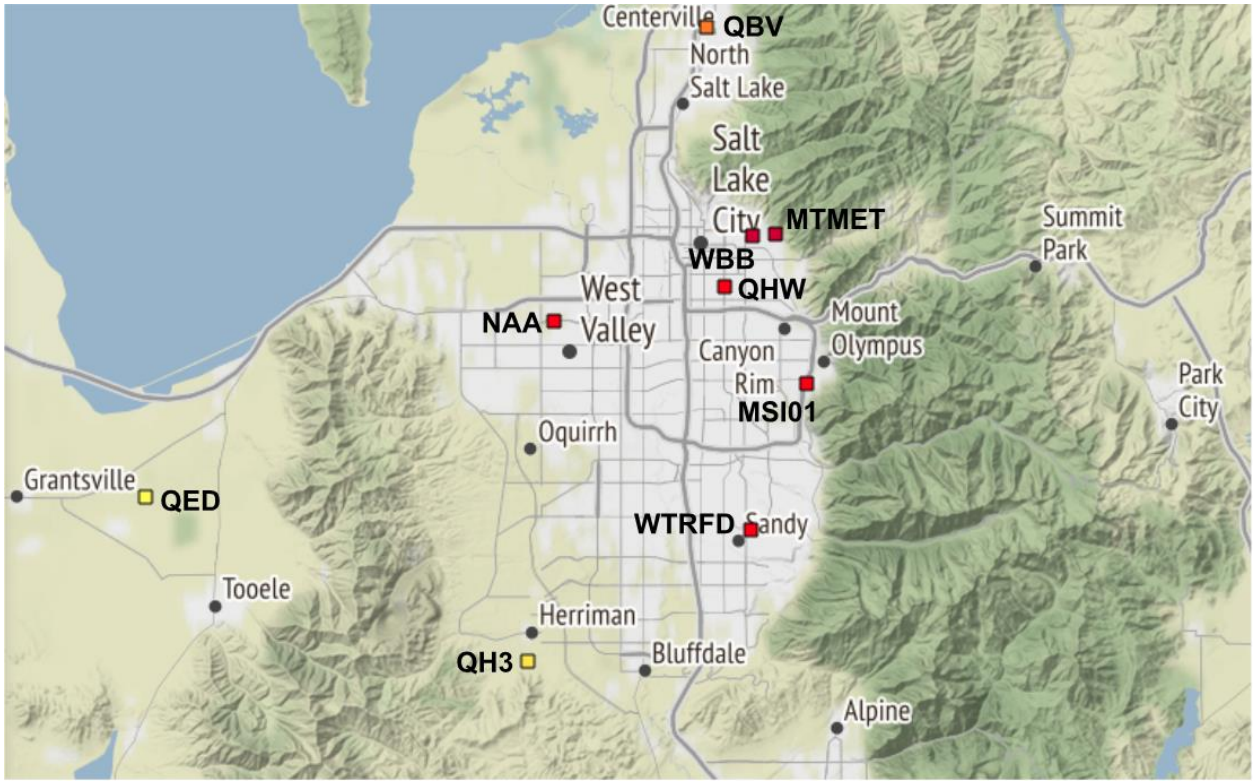
4. Look at your map template of the Salt Lake Valley. Each label represents a PM 2.5 sensor that collects data for the MesoWest website. Using your graph, write in the PM 2.5 concentration for each sensor during this particular inversion event.

5. Make a prediction about what you observe about PM 2.5 variation across the valley.

6. What relationships or factors might be responsible for the patterns we see in spatial variability of PM 2.5?

7. Create an argument for evidence from your prediction.

8. What other variables (weather, geographic, geologic, environmental, biological, etc) have predictable spatial variability across the Salt Lake Valley?



Name _____ **Date** _____

Lesson #3 - **Spatial Variation of a Variable** **Procedure and Analysis Worksheet**

Phenomenon: On bad air days, the pollution starts from the north part of town and moves to the south, so is the air cleaner in the south?

OPTION B

1. Use the data set provided by your teacher to create a graph of PM 2.5 concentration at different sensor locations in the Salt Lake Valley during this inversion event. Follow your teacher's instructions to graph this data.

2. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?

3. Develop questions from the patterns you see in the data.

4. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #2.

5. Look at your map template of the Salt Lake Valley. Each label represents a PM 2.5 sensor that collects data for the MesoWest website. Using your graph, write in the PM 2.5 concentration for each sensor during this particular inversion event.

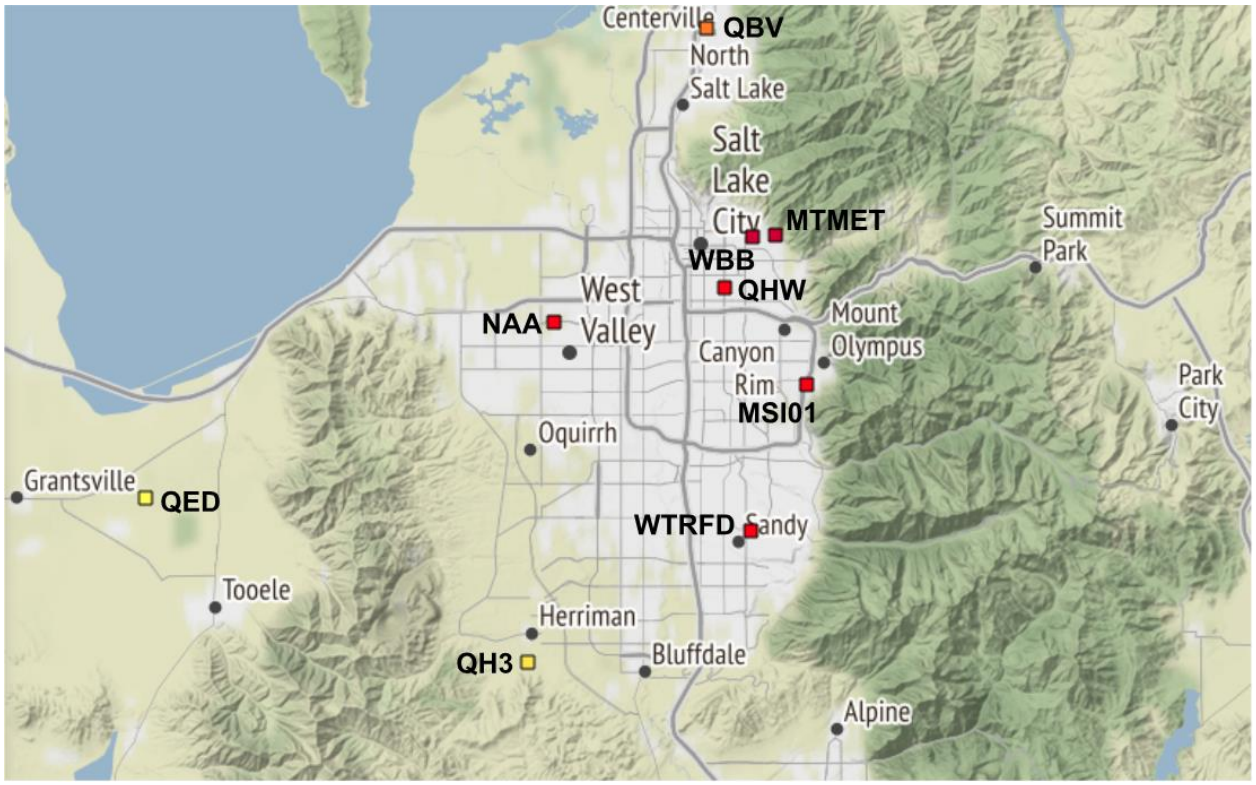
6. Make a prediction about what you observe about PM 2.5 variation across the valley.

7. What relationships or factors might be responsible for the patterns we see in spatial variability of PM 2.5?

8. Create an argument for evidence from your prediction.

9. What factors might be responsible for the patterns we see in spatial variability of PM 2.5?

10. What other variables (weather, geographic, geologic, environmental, biological, etc) have predictable spatial variability across the Salt Lake Valley?


Centerville
QBV
North
Salt Lake
Salt
Lake
City
MTMET
WBB
QHW
Summit
Park
West
Valley
NAA
Mount
Olympus
Canyon
Rim
MSI01
Park
City
Oquirrh
Grantsville
QED
WTRFD
Sandy
Tooele
Herriman
QH3
Bluffdale
Alpine

Name _____ **Date** _____

Lesson #3 - Spatial Variation of a Variable **Procedure and Analysis Worksheet**

Phenomenon: On bad air days, the pollution starts from the north part of town and moves to the south, so is the air cleaner in the south?

OPTION C

1. Click here to open the MesoWest website.

2. Follow the steps below VERY carefully. They will walk you through how to use the MesoWest website to gather data to create a graph of PM 2.5 concentration at different sensor locations in the Salt Lake Valley during this inversion event. Follow your teacher's instructions to graph this data.

    a. the link "To view additional data, please visit our full air quality website here."

    b. At the top of the page, hover over "Air Quality Data" and then click on "Map Archive."

    c. Select the parameters for December 12, 2017 at 12:00 for PM 2.5 Concentration. Click "Update Time and Primary Options."

    d. Center the map around Salt Lake City and click the zoom button once.

    e. Notice the color coded squares, each corresponds to an air quality sensor.

    f. Click on each sensor and record the sensor label and PM 2.5 concentration in a spreadsheet. You should have data for 9 different sensors.

    g. Use this data to create a bar graph showing PM 2.5 concentration for the 9 different sensors in the Salt Lake Valley.

3. Use the data set provided by your teacher to create a graph of PM 2.5 concentration at different sensor locations in the Salt Lake Valley during this inversion event. Follow your teacher's instructions to graph this data.

4. Examine the graph. Be sure to notice the following (you are not drawing any conclusions, just making observations):
    a. Variable(s) on the X axis
    b. Variable(s) on the Y axis
    c. Title of the graph
    d. Location or Date/Time of Data
    e. General pattern in the data
    f. High and Low data points
    g. Is there anything else you notice?

5. Develop questions from the patterns you see in the data.

6. Construct an explanation for what you think could be occurring (6-8 sentences) that summarizes your findings in the graph. This summary (predictions) should include many of the observations you made in #4.

7. Look at your map template of the Salt Lake Valley. Each label represents a PM 2.5 sensor that collects data for the MesoWest website. Using your graph, write in the PM 2.5 concentration for each sensor during this particular inversion event.

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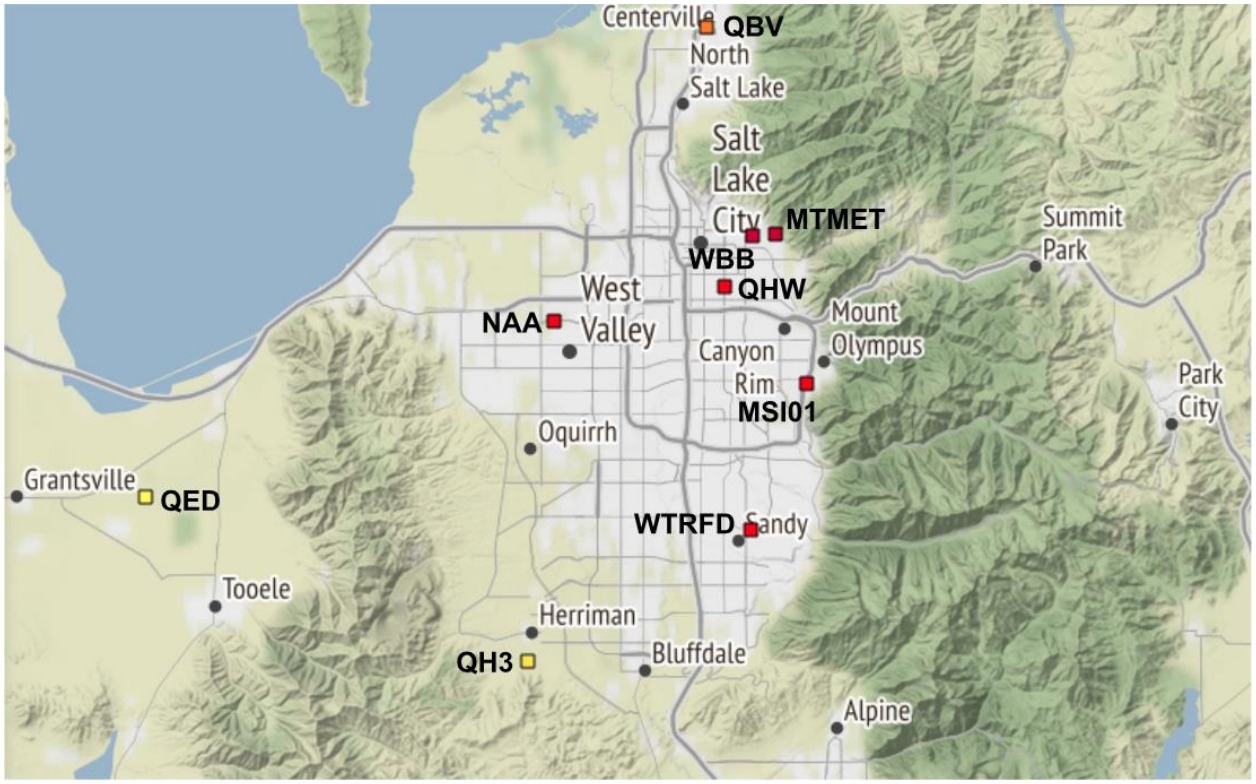
Centerville
QBV
North
Salt Lake
Salt
Lake
City
MTMET
WBB
QHW
Summit
Park
West
Valley
NAA
Mount
Olympus
Canyon
Rim
MSI01
Park
City
Oquirrh
Grantsville
QED
WTRFD
Sandy
Tooele
Herriman
QH3
Bluffdale
Alpine