Student Data Analysis Student responses will vary for many of these questions. Target/possible example responses have been added to applicable prompts.

1. What trends or patterns do you see when you first look at the data?
2. Consider the numeric values next to each data point.
   a. What do these values tell us? The exact concentration of the Cl^- in the Pennypack at that location.
   b. Of the samples taken from the Pennypack Creek, what is:
      i. The highest value? 280.6 mg/L
      ii. The lowest value? 52.77 mg/L
   c. Do the two values listed above fall within the range of Cl^- considered "normal" for freshwater ecosystems? The lowest value does fall within the normal range, but not the highest value.
3. The concentration of Cl in the Pennypack nearly doubles between sampling station #8 and #9 (going from 159.72 mg/L to 280.6 mg/L).
   a. With reference to the ArcGIS map and the background information provided (including Figures 2.1 and 2.3), what is one factor that could have influenced this change in Cl^- concentration? The highway divides these two sampling locations - in March, there is the likelihood of road salt being washed off of the highway into the watershed.
   b. What additional data or information might you need to collect to determine whether your previous prediction is accurate?
      i. Weather data (was there a precipitation or melting event that would have provided water flow to carry the road salt to the Pennypack Creek.
      ii. Is there any infrastructure used to direct the melt and rainwater coming from the highway that would either prevent it from reaching or channeling directly to the Pennypack Creek.
   c. Turn this prediction into a hypothesis and outline the design of an investigation that would allow you to gather data to answer your scientific question.
      i. Hypothesis: Melting snow and/or rainwater transports salts that the used on the roads in the winter to local
      ii. Investigation
         1.
4. Propose one potential explanation for the decrease and then increase in Cl- concentration from sample stations #35 to #36 to #37.
   a. Human error
      i. The researcher collecting the sample collected it from the wrong location or labeled it incorrectly
      ii. The sample analyst used the wrong sample or reported an incorrect location
      iii. The machine that measured Cl^- concentration was not functioning properly
   b. Environmental explanations
      i. There could be an outflow from the Nazareth Hospital that may cause dilution upriver from that sampling station.
5. Refer to the ArcGIS map and the background information provided (including Figures 2.1 and 2.3, and the map of the Delaware River Basin) to determine the validity of the following claim:

   "The relatively high Cl^- concentration at sampling site #38 is likely due to the accumulation of dissolved ions from the watersheds in New York and New Jersey polluting the Pennypack Creek as these dissolved ions move down the Delaware River and reach the mouth of the Pennypack Creek in Philadelphia."

This claim is not valid because the phenomenon described above would require water from the Delaware River flowing upstream into the Pennypack Creek. Elevation markers between sample site #38 indicate that elevation rises from less than 7 feet to approximately 100 feet at sampling site #38. All water within a watershed flows from higher to lower elevations, therefore the higher concentrations at sampling site #38 must have been caused by an event that occurred up river.

6. The researchers who collected these samples from the Pennypack Creek are interested in the *urban processes* that influence the water quality and flow of the Pennypack Creek.
    a. What urban process(es) can you think of that could influence the concentration of Cl^- in the Pennypack Creek?
        i. Application of road and sidewalk salt during winter months.
    b. Why do you think they chose to collect data about Cl^-?
        i. Adding road salt to roads is a significant activity that occurs multiple months out of the year in northern climates, and road salt is a source of Cl^-.
    c. Why do you think they chose a synoptic sampling method?
        i. If they took the samples from the same locations but on different days, different weather conditions, changes in land use (new construction, etc.), or other variables may have been different.
    d. Which of the sampling stations, if any, do you think the researchers used (or could have used) as a control? Explain your reasoning.
        i. The headwaters could have been used as a control; though the headwaters are located in developed areas, there are limited opportunities for dissolved ions to enter the Pennypack.
    e. Propose a hypothesis that the researchers may have been investigating in this study.
        i. Does an increase in development of infrastructure and urbanization cause an increase in the concentration of dissolved Cl^- in the Pennypack creek?
    a. To what use might someone be able to put the results of this study?
        i. Determining if urban processes are responsible for elevated levels of Cl^- in the Pennypack Creek, and if so what impacts, if any, is that elevated Cl^- having on the local ecosystems.
        ii. To advocate for the use of less road salt or alternative options.
7. This synoptic sample was collected on one day in March of 2022. How might the patterns and trends you observed in the data be different if this samples had instead been collected in:
    a. August of 2022? Explain your reasoning.
        i. There will still probably be some trace Cl^- in the stream, because ions will move through the soils more slowly, but will still move with water into the creek (a delayed deposit), but the concentration of Cl^- will likely be lower than compared to March's samples. If this is the case, it would provide support for the claim that the application of road and sidewalk salt leads to elevated levels of Cl^- in the Pennypack Creek.
    b. March of 1850? Explain your reasoning.
        i. There were no roads in the 1850s, so there would be no need for the application of road salt. So, if road salt is the cause of elevated Cl^- in the Pennypack, I would predict that samples taken in March of 1850 would have only the Cl^- that is naturally present from weathered rock - much lower concentrations than we see in this study.
8. Are the results of this study important to you?
    a. If yes:

    i. Explain why you say so, and
    ii. Propose one follow-up investigation that would build off of this study an help you learn more about issues that might impact Pennypack Creek.

b. If no:
    i. Explain why not, and
    ii. Propose a different body of freshwater in which you could carry out a similar study to make the results more personal to you, include an explanation of your choice!