Module 9: Using High-Frequency Data to Manage Water Quality - Student Handout

eddie
environmental data-driven inquiry & exploration

Name:

Student ID:

Completed on:

Macrosystems EDDIE Module 9: Using High-Frequency Data to Manage Water Quality

Focal Question:

How can we use high-frequency data to improve water quality?

Summary:

In recent decades, there have been substantial improvements in our ability to monitor water quality in real time using sensors that measure variables at a high frequency (every few minutes).

In this module, you will explore data collected using high-frequency sensors and learn how to interpret these data to inform water quality management.

Learning Objectives:

By the end of this module, you will be able to:

- Define key measures of surface freshwater quality (water temperature, dissolved oxygen, and turbidity).
- Explain how water temperature changes over the course of a year in a temperate reservoir and how these changes affect water quality.
- Interpret high-frequency water quality data to make decisions about water extraction depth for a drinking water reservoir.
- Evaluate water quality data and forecasts to make decisions about drinking water treatment.

Module overview:

- Introductory presentation on concepts related to assessing water quality and collecting high-frequency water quality data
- Activity A: Access and explore high-frequency water quality data from a drinking water reservoir in southwest Virginia
- Activity B: Use high-frequency water quality data to make water treatment plant operation decisions
- Activity C: Make water treatment decisions using water quality forecasts

Module materials:

The lesson content is hosted on an interactive R Shiny web application at https://macrosystemseddie.shinyapps.io/module9/

This can be accessed via any internet browser and allows you to navigate through the lesson via this app. You will fill in the questions below on this handout as you complete the lesson activities. Some instructors may ask students to enter their answers to module questions using a Canvas quiz. Confirm with your instructor as to how to submit your answers.

Module workflow:

1. Watch the introductory presentation provided in Canvas and embedded in the interactive R Shiny web application if you have not already done so.
2. Watch the "Guide to Module" video embedded in the interactive R Shiny web application to learn about key features of the module that will help you complete module activities and answer questions. Optionally, you can also go through the "Quick-start" guide to the module using the button at the top right corner of the module web page.
3. Select a focal reservoir.
4. Open the Canvas quiz questions associated with the reservoir you have chosen OR if you are not using Canvas, download a copy of all the questions as a Word document by clicking the "Download student handout" button.
5. Work through the module to complete the Introduction questions and Activities A, B, and C in this web app. When you are prompted to answer questions, enter your answers in the Canvas quiz. Be sure to fill in the Canvas quiz that corresponds to the reservoir site you have chosen! If you are not completing the module using Canvas, you may type your answers into the Word document.
6. If you would like to take a break and come back later, or if you lose internet connection, all you have to do is re-load this web app, re-select your reservoir site in the Introduction, and you will be able to resume your progress. On Canvas, you can save your quiz responses using the "Save" button. In Word, you can save your answers in the document on your computer.
7. When you have finished the module activities, be sure to submit your Canvas quiz for grading. If you are completing the module by answering the questions in a Word document, be sure to submit the document to your instructor for grading.

Module Questions:

Introduction

Think about it!

Answer the following questions:

1. Which of the following are components of water quality? You may select more than one answer.

    a. suitability of water for human use
    b. ability of a water body to support aquatic life
    c. the amount of water available for human use
    d. the geographic region in which the water body is located
    e. all of the above

2. Which of the following is a benefit of collecting high-frequency water quality data?

    a. high-frequency data prevents water quality from becoming degraded
    b. high-frequency data requires many automated sensors to be deployed in a reservoir
    c. high-frequency data allows managers and scientists to observe patterns that are not visible from low-frequency data

Activity A - Build A Model and Generate A Forecast

Access and explore high-frequency water quality data from a drinking water reservoir in southwest Virginia

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Objective 1: Learn about your focal drinking water reservoir

Be sure you have answered questions 1 and 2 in the previous Introduction section before you begin Activity A!

3. What is the name of your selected reservoir?

    Answer:

4. What is the four-letter site identifier of your selected reservoir? Use lower case (e.g., ‘fcre’).

    Answer:

5. What are the uses of your selected reservoir?

    a. recreation

b. irrigation
c. hydropower
d. drinking water supply

6. What is the reservoir area in square feet of your selected reservoir? Provide your answer as a whole number (without decimal points) and with no spaces or commas (e.g., 123456).

   Answer:

7. What is the maximum depth of your reservoir in feet? Round your answer to the nearest whole number.

   Answer:

Virginia's Water Quality Assessment Guidance Manual gives the following guidance on water quality evaluation using a trophic state index (TSI), which may be calculated from Secchi depth (SD), chlorophyll-a (CA), or total phosphorus (TP):

A trophic state index value of 60 or greater for any one of the 3 indices will indicate that nutrient enrichment from anthropogenic sources are adversely interfering, directly or indirectly, with the designated uses. A TSI value of 60 corresponds to a CA concentration of 20 ug/l, a SD of 1 meter, and a TP concentration of 48 ug/l.

8. Does your chosen reservoir site exceed a TSI of 60 (indicating negative human impacts on water quality) according to average total phosphorus levels?

   Answer:

Objective 2: Explore high-frequency water quality data from your chosen reservoir

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Water temperature

9. Water is most dense at 4 degrees Celsius. What temperature is this in degrees Fahrenheit? Round your answer to the nearest whole number.

   Answer:

10. Which of the following are possible effects turnover can have on water quality?

    a. metals from the bottom waters mixing to the surface
    b. nutrients from the bottom waters mixing to the surface
    c. harmful algal blooms
    d. taste and odor concerns

11. The water temperatures on the plot are in degrees Celsius. What is the warmest observed water temperature at your reservoir in degrees Fahrenheit? Round your answer to the nearest whole number.

    Answer:

12. What is the coldest observed water temperature at your reservoir in degrees Fahrenheit?

    Answer:

13. Fall turnover can be defined as the day when the temperature difference between the shallowest and deepest depths in the reservoir is less than 1 degree Celsius. What day did fall turnover occur in the reservoir? Write out the full month name and day (e.g., September 20).

    Answer:

Dissolved oxygen

14. During summer thermal stratification, dissolved oxygen in the bottom waters of a reservoir may become depleted. Which statement correctly explains why this occurs?

    a. cold water cannot contain as much dissolved oxygen as warm water
    b. oxygen becomes trapped in the lake sediments and cannot be replenished from the atmosphere
    c. oxygen is lost when water is extracted for drinking water treatment
    d. oxygen is consumed by organisms and chemical reactions and cannot be replenished from the atmosphere

15. Which statement best describes how low dissolved oxygen levels can affect the raw water quality for a drinking water treatment plant?

    a. low dissolved oxygen can lead to release of metals and nutrients from the sediments, potentially causing algal blooms and taste and odor concerns
    b. ability of a water body to support aquatic life
    c. high-frequency sensors can become fouled more easily in water with low dissolved oxygen, causing inaccurate readings
    d. low dissolved oxygen can increase treatment costs for a drinking water treatment plant

16. The dissolved oxygen data on the plot are in ppm. What is lowest observed dissolved oxygen concentration in the surface waters of the reservoir in mg/L? Round your answer to the nearest whole number.

    Answer:

17. What is the lowest observed dissolved oxygen concentration in the bottom waters of the reservoir in mg/L?

    Answer:

18. Two mg/L is a commonly used threshold to indicate that dissolved oxygen concentrations are low enough to cause water quality concerns. Does your reservoir exhibit dissolved oxygen concentrations less than 2 mg/L?

    Answer:

19. If your reservoir exhibits dissolved oxygen concentrations less than 2 mg/L, at which depth does this occur?

    Answer:

20. If your reservoir exhibits dissolved oxygen concentrations less than 2 mg/L, during which months does this occur? In the Canvas quiz, select all months that exhibit dissolved oxygen concentrations less than 2 mg/L.

    Answer:

Turbidity

21. Which of the following factors can contribute to high turbidity in a raw water source? You may select more than one answer.

    a. particles such as silt and clay
    b. microorganisms
    c. dissolved organic matter
    d. NA

22. What is the regulatory limit on bottom filter turbidity in NTU? Round your answer to the nearest tenth (e.g., 0.1).

    Answer:

23. The turbidity data on the plot are in FNU. What is the highest observed turbidity in the surface waters of the reservoir in NTU? Round your answer to the nearest tenth.

    Answer:

24. On what date does the highest observed turbidity occur? Write out the full month name and day (e.g., September 20).

    Answer:

Activity B - Use high-frequency water quality data to make water treatment plant operation decisions

Use high-frequency water quality data to explore how water quality changes and make decisions about water withdrawal depth over the course of a year

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Objective 3: Use high-frequency water quality data to make water withdrawal depth decisions at different times of year

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Summer

25. Is the reservoir currently thermally stratified or mixed?

    Answer:

26. Do you observe hypoxia at any depth(s) in the reservoir? If so, which depth(s)? You may select more than one answer in the Canvas quiz.

    Answer:

27. At what depth is the turbidity sensor deployed? Select the correct depth in the Canvas quiz.

    Answer:

28. Which depth do you choose for water extraction on July 31? Select the depth in the Canvas quiz.

    Answer:

29. Explain your reasoning behind your decision in Question 28.

    Answer:

Fall

30. Fall turnover occurs when water temperatures are within 1 degree C of each other across all the depths of the reservoir. On what date did fall turnover occur this past fall? Write out the full month name and day (e.g., September 20).

    Answer:

31. Which statement best describes what happens to dissolved oxygen concentrations around the time of fall turnover? Compare dissolved oxygen values one week before vs. one week after turnover. Select the best answer in the Canvas quiz.

    Answer:

32. Which statement best describes what happens to turbidity around the time of fall turnover? Compare turbidity values one week before vs. one week after turnover. Select the best answer in the Canvas quiz.

    Answer:

33. Which depth would you choose for water extraction TWO DAYS BEFORE the day of fall turnover? Explain your reasoning.

    Answer:

34. Explain your reasoning behind your decision in Question 33.

    Answer:

35. Which depth would you choose for water extraction TWO DAYS AFTER the day of fall turnover?

    Answer:

36. Explain your reasoning behind your decision in Question 35.

    Answer:

37. Compare your answers to Question 33 and Question 35. Were your choices different before and after turnover? If so, explain why.

    Answer:

Winter

38. Is the reservoir currently thermally stratified or mixed?

    Answer:

39. Compare dissolved oxygen concentrations at the deepest depth in your reservoir (29.5 ft for Falling Creek and 42.7 ft for Beaverdam) between the summer and winter data. Do they differ? If so, how? Select the best answer in the Canvas quiz.

    Answer:

40. Compare turbidity concentrations in your reservoir between the summer and winter data. Do they differ? If so, how? Select the best answer in the Canvas quiz.

    Answer:

41. Which depth do you choose for water extraction on Jan. 31?

    Answer:

42. Explain your reasoning behind your decision in Question 41.

Answer:

Objective 4: Define water quality forecasting and interpret a fall turnover forecast

43. What is the forecasted percent chance of turnover on Oct. 15? Provide your answer as a whole number (e.g., 15).

    Answer:

44. Is it likely that turnover will occur on or before Oct. 15?

    Answer:

45. What is the forecasted percent chance of turnover on Oct. 27? Provide your answer as a whole number (e.g., 15).

    Answer:

46. Is it likely that turnover will occur on or before Oct. 27?

    Answer:

Activity C - Make water treatment decisions using water quality forecasts

Make water treatment decisions using high-frequency water quality data and water quality forecasts

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Objective 5: Make water treatment decisions using water quality forecasts

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47. Do you think you will need to enact additional treatment measures in the coming week (next 7 days)?

    Answer:

48. Explain your reasoning behind your decision in Question 47.

    Answer:

49. Do you think you will need to enact additional treatment measures in the coming week (next 7 days)?

    Answer:

50. Explain your reasoning behind your decision in Question 49.

    Answer:

51. Compare the decisions you made in Question 47 and Question 49. Are they the same or different, and why?

    Answer:

52. Do you think you will need to enact additional treatment measures in the coming week (next 7 days)?

    Answer:

53. Explain your reasoning behind your decision in Question 52.

    Answer:

54. Do you think you will need to enact additional treatment measures in the coming week (next 7 days)?

    Answer:

55. Explain your reasoning behind your decision in Question 54.

    Answer:

56. Compare the decisions you made in Question 52 and Question 54. Are they the same or different, and why?

Answer:

57. Using the data plotted in the figures above, do you think you made the right treatment decisions in Questions 52 and 54? Explain your reasoning.

    Answer:

58. Evaluate the usefulness of the turnover forecasts. Did having a forecast available affect your decision-making compared to using real-time data?

    Answer:

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