Management Challenge – Part 1

In this section of the report you will write a three paragraph summary that describes the limnological features of your lake and describes the water quality problem. Use the guidance below to write each paragraph for the first section of your report. Consider each of the points and questions below as suggested content for the paragraphs.

Paragraph 1: Describing the physical, chemical, and biological features of the lake

1. What are the lake's main morphological features (e.g., surface area, maximum depth)? HINT: All values should be reported in SI units (e.g., hectares, meters)
2. How was the lake formed? HINT: look at the background information
3. What is the mixing regime (e.g., dimictic, polymictic, etc)? HINT: check out the "Thermocline Detection" tab in the data spreadsheet
    a. Dimictic - stratified all summer; thermocline almost always detected
    b. Polymictic - sometimes stratified, sometimes fully mixed; thermocline only sometimes detected
    c. Monomictic - never stratified in the summer; thermocline never detected
4. Are the bottom waters hypoxic most of the time? HINT: check out the "Profiles" tab in the data spreadsheet and look for dissolved oxygen concentrations less than 2 mg/L
5. What is the dominant phytoplankton group? HINT: check out the "Phytoplankton & Zooplankton" tab in the data spreadsheet, phytoplankton groups have green column headers. Calculate the mean over time for each group to identify the most common
6. What is the dominant zooplankton group? HINT: same as above, zooplankton groups have blue column headers
7. What are 2-3 of the most common fish species in the lake? HINT: on the Iowa DNR website for your lake, check out the "Fish Survey Data" tab at the bottom, click on "Summary Survey Data"

Paragraph 2: Ecosystem Services

1. Where in Iowa is the lake located and what major towns are near the lake?
2. What is the land use in the watershed?
3. How do people use the lake for recreation? HINT: check out the amenities list for each lake on the DNR website.
4. What other ecosystem services are provided by the lake that are not related to recreation?
5. Based on this lake use survey, how have mean household visits to your lake changed from 2002 to 2014?

Paragraph 3: Identify the Water Quality Problem

1. What is the Trophic State Index (TSI) for your lake?
    a. Calculate the average Secchi depth (SD), chlorophyll (Chl), and total phosphorus (TP) values for the most recent 3 years of data in your data set
    b. Use the average values calculated above in the following three equations to calculate the trophic state index (TSI) for each variable:
        i. $TSI(SD)=60-14.41\times\ln(SD)$
        ii. $TSI(Chl)=9.81\times\ln(Chl)+30.6$
        iii. $TSI(TP)=14.42\times\ln(TP)+4.15$
    c. Calculate the average of the three trophic state index values from above [TSI(SD), TSI(Chl), TSI(TP)]
    d. Use the "Relating Trophic State to the State of the Waterbody" table on this website (Links to an external site.) to determine:
    e. What is the trophic state of your lake (i.e., oligotrophic, mesotrophic, eutrophic, hypereutrophic)?
    f. What are the expected effects on the fishery and recreation given the trophic state of your lake?
2. Are there contaminants of concern in your lake?
    a. Has the concentration of microcystin (a toxin produced by cyanobacteria) ever exceeded 8 µg/L (the threshold value over which it's dangerous to swim)? HINT: check the "Beach Monitoring" data tab
    b. Has the concentration of E. coli bacteria (a potential human pathogen) exceeded 135 MPN (the threshold value over which it's dangerous to recreate)? HINT: check the "Beach Monitoring" data tab
3. Are dissolved oxygen concentrations in the surface waters too low to support fish?
    a. Using the data in the "Water Quality" tab of the spreadsheet, tally the number of times that dissolved oxygen concentrations (mg/L) were less than 5 mg/L. This concentration is too low to sustain robust fish populations in the lake.
    b. Consider how frequently (or infrequently) the dissolved oxygen concentration is less than 5 mg/L over the period of study (15-20 years) by the Iowa DNR.
4. How do the water quality issue that you identified effect the ecosystem services that the lake provides?

Management Challenge – Part 2

In this section you will use data to diagnose the external and internal mechanisms contributing to the water quality issues you identified in Part 1. Based on information from the land use in the watershed, water chemistry, the depth of the lake and likelihood for internal loading, and the food web configuration, identify all of the possible sources of water quality issues. Use the guidance below to write each paragraph for the first section of your report. Consider each of the points and questions below as suggested content for the paragraphs.

Paragraph 1: Temporal patterns in water quality problems

1. Identify the 1-2 most important variables related to the water quality problems you identified in the previous section. For example, if the trophic state in your lake is high, potentially causing toxic algal blooms, nutrient concentration data (e.g., total phosphorus, total nitrogen) might be important variables to examine. **State what variables are related to the water quality problem and why they are related** (show off your limnological knowledge!).

2. **Long-term patterns:** Instead of only focusing on the current state of the lake, we have the benefit of examining 20 years of data to help us understand how conditions have changed over time, potentially leading to these water quality issues.
    a. Plot the key variables identified in #1 (above) over time.
    HINT: Use the "Year Fraction" column for the x-axis and the important variable for the y-axis of a scatterplot in Excel.
        i. Make sure you include axis labels with units (and ***don't*** include a title!).
        ii. The figures should be ordered and placed at the end of the document, not embedded in the text.
        iii. Each figure should have a caption, placed below the figure that briefly describes the data. For example, "Figure 1. A time series of total phosphorus concentrations in Lake X."
    b. Describe the long-term patterns of these key variables in the text
        i. Have they been steadily increasing? Decreasing? Become more variable over time?
        ii. Be sure to parenthetically reference the figure in the text of the paragraph.
            1. Here's an example for a 20-year time series of total phosphorus: "Total phosphorus concentrations increased sharply in Lake X from 2004-2006, and have remained at a constant, high concentrations since that time (Figure 1)."
            2. Note how ***I DIDN'T WRITE***: "Figure 1 shows that total phosphorus concentrations...". Don't discuss the figure, discuss the data and what it tells you about the ecosystem.

3. **Seasonal patterns:** In addition to long-term patterns, seasonal patterns can help us distinguish the source of a water quality problem. For example, if nitrate concentrations are high in the spring and nearly zero later in the summer, it is likely that the source of nitrate is coming from the watershed with spring snow melt.
    a. Plot the key variables identified in #1 (above) by day of year. Day of year (DOY) is a variable we use to create a continuous value for the x-axis in a time series: January 1st = DOY 1, January 2nd = DOY 2, etc.
    HINT: Use the "DOY" column for the x-axis and the important variable for the y-axis of a scatterplot in Excel.
        i. Make sure you include axis labels with units (and ***don't*** include a title!).
        ii. The figures should be ordered and placed at the end of the document, not embedded in the text.
        iii. Each figure should have a caption, placed below the figure that briefly describes the data.
    b. Describe the seasonal patterns of these key variables in the text
        i. Are the concentrations higher in the spring? Fall? Consistent throughout the season (no seasonal pattern)?
        ii. Be sure to parenthetically reference the figure in the text of the paragraph.

Paragraph 2: External sources/drivers of the water quality problem(s)

Based on what you know about the watershed, long-term and seasonal dynamics of important variables, propose ***two possible external sources*** or drivers of the identified water quality problem in your lake. External sources and drivers could include watershed land use leading to high nutrient and/or sediment loading, population, lack of riparian buffer, etc.

1. **Your proposed external sources or drivers need to be grounded in the data** you have available to you (i.e., what evidence do you have that this is a reasonable hypothesis?). This can include the figures you made for the previous paragraph, other numeric data in the spreadsheets provided to you, or other pieces of information in the materials you've been given. If you make more figures be sure to reference them in the text and add them to the list of figures at the end of the text.

2. **Cite a paper from the peer-reviewed scientific literature that supports your hypothesized external source or driver.** This paper could be an example from another ecosystem of the same external driver or a study that investigated the external driver in many ecosystems.
    a. Be sure to parenthetically reference the paper in your text
    b. List the full citation at the end of the text, before the figures.
    c. For more information on how to reference literature and format citations see the "Helpful Resources" page on Canvas.

Paragraph 3: Internal sources/drivers of the water quality problem(s)

Based on what you know about the stratification patterns, dissolved oxygen dynamics, internal loading, and the food web, propose ***two possible internal sources*** or drivers of the identified water quality problem in your lake. Internal sources and drivers could include internal phosphorus loading, polymictic stratification, lack of algal grazers such as *Daphnia*, etc.

1. **Your proposed internal sources or drivers need to be grounded in the data** you have available to you (i.e., what evidence do you have that this is a reasonable hypothesis?). This can include the figures you made for the first paragraph, other numeric data in the spreadsheets provided to you, or other pieces of information in the materials you've been given. If you make more figures be sure to reference them in the text and add them to the list of figures at the end of the text.

2. **Cite a paper from the peer-reviewed scientific literature that supports your hypothesized internal source or driver.** This paper could be an example from another ecosystem of the same internal driver or a study that investigated the internal driver in many ecosystems.
    a. Be sure to parenthetically reference the paper in your text
    b. List the full citation at the end of the text, before the figures.
    c. For more information on how to reference literature and format citations see the "Helpful Resources" page on Canvas.

Management Challenge – Part 3

Based on your diagnoses of the scope and source of the water quality issues in the lake, you must now make evidenced-based management recommendations to improve the water quality. You will need to research the potential strategies in the table below and use your budget to prioritize the management recommendations that will have the most impact while remaining cost effective. ***Write a 3 paragraph management and restoration recommendation*.** In this section you will need to include:

1. **Paragraphs 1 & 2:** An evidence-based justification for each of your management recommendations. Be sure to explain for each strategy:
    a. How the strategy will address the cause of the water quality issue
    b. What the expected outcomes will be when implementing this strategy based on your understanding of the physical, chemical, and biological mechanisms operating in the lake
    c. Recommend one paragraph on watershed strategies and one paragraph on in-lake strategies, mirroring the potential mechanisms you identified in Part 2 of the report.
    d. Cite at least two peer-reviewed scientific papers about your suggested restoration strategies. This paper could be an example from another ecosystem of the same management strategy or a study that investigates the mechanisms underlying the management strategy.
        i. Be sure to parenthetically reference the paper in your text
        ii. List the full citation at the end of the text, before the figures.
        iii. For more information on how to reference literature and format citations see the "Helpful Resources" page on Canvas.
2. **Paragraph 3:** A budget summary for your recommendations, presented as a table.
    a. Create a table of your selected management and restoration recommendations and the budget based on implementation in your particular lake.
        i. The table should have four columns: Strategy, Unit Cost, Units, Total Cost. The unit cost is listed in the table below. The number of units for some strategies will be 1 (e.g., one dredging), but >1 for other strategies (e.g., 300 ft of shoreline armoring).
        ii. The purpose of these columns in the table is to "show your work" behind the final budget numbers.
    b. The total budget cannot exceed $3 million USD
    c. If you have another management strategy that is not on this list, send the plans to the contractor (Dr. Wilkinson) through a message on Canvas and it will be priced out for your restoration proposal. ***Requests for pricing must be received by 5 PM on November 15th.***

Management and Restoration Recommendations and Budget:

IN-LAKE STRATEGIES	Unit Cost
Dredging (including purchase of spoil site)	$2,100,000
Fish barriers	$300,000
Fish stocking	$350/100 fish
Fish removal (rotenone)	$100/acre
Shoreline Armoring (riprap) a portion of the shoreline	$100 per ft
Water level manipulation structure	$40,000
Aquatic plant management for 3 years	$36,000 per year
Alum Additions	$10,000/acre
Aeration Installation	$50,000
Aeration Operation for 3 years	$15,000 per year
WATERSHED STRATEGIES	**Unit Cost**
Sediment retention pool installed in the watershed	$200,000
Watershed BMPs installed for erosion	$200,000 per site
Watershed BMPs installed for nutrient retention	$50,000 per site
Riparian restoration for inlet stream to the lake	$150,000
CREP Wetland installed in the watershed	$300,000
Wetland Restoration in the watershed	$150,000
MONITORING	**Unit Cost**
Water quality monitoring for 3 years	$40,000 per year
Continued fish monitoring for 3 years	$50,000 per year