# WATERSHED TESTING WITH LABQUEST

## LAB 20

From *Biology with Vernier*

# INTRODUCTION



**Westminster College**

There are many reasons for determining water quality. You may want to compare the water quality upstream and downstream to locate a possible source of pollutants along a river or stream. Another reason may be to track the water quality of a watershed over time by making measurements periodically. When comparing the quality of a watershed at different times, it is important that measurements be taken from the same location and at the same time of day.

In 1970, the National Sanitation Foundation, in cooperation with 142 state and local environmental specialists and educators, devised a standard index for measuring water quality. This index, known as the Water Quality Index, or WQI, consists of nine tests to determine water quality. These nine tests are; temperature, pH, turbidity, total solids, dissolved oxygen, biochemical oxygen demand, phosphates, nitrate and fecal coliform. A graph for each of the nine tests indicates the water quality value (or Q-value)

corresponding to the data obtained. Once the Q-value for a test has been determined, it is multiplied by a weighting factor. Each of the tests is weighted based on its relative importance to a stream’s overall quality. The resulting values for all nine tests are totaled and used to gauge the stream’s health (excellent, good, medium, poor, or very poor).

While the WQI can be a useful tool, it is best used in light of historical data. Not all streams are the same, and without historical data it is difficult to determine if a stream is truly at risk. For example, a stream may earn a very low WQI value and appear to be in poor health. By looking at historical data, however, you may find that samples were collected just after a heavy rain with an overflow from the local city sewer system and do not accurately reflect the stream’s health.

For the purpose of this exercise, you will perform only four of the WQI tests: water temperature, dissolved oxygen, pH, and total dissolved solids. A modified version of the WQI for these four tests will allow you to determine the general quality of the stream or lake you are sampling.

# OBJECTIVE

* Use a Dissolved Oxygen Probe, Temperature Probe, Conductivity Prove, and a pH sensor to make on-site measurements.
* Calculate the water quality based on your findings.

# MATERIALS

LabQuest Dissolved Oxygen Probe

Temperature Probe Conductivity Probe 4 water sampling bottles-stoppered pH Probe

# PROCEDURE

1. Choose a desirable location to perform your measurements. It is best to take your samples as far from the shore edge as is safe. Your site should be representative of the whole watershed.
2. Rinse the sampling bottle a few times with stream water. Place the sample bottle below the surface, allowing water to flow into the opening for two to three minutes.
3. Fill the sampling bottle so it is completely full and then stopper the bottle under water. This should minimize the amount of atmospheric oxygen that gets dissolved in the water prior to making measurements.
4. Measure the temperature of your sample. **Important:** Place only one probe in the water at a time.
	1. Place the Temperature Probe into the water sample.
	2. Monitor the temperature value. Record the temperature in Table 1 when the value has stabilized for Site 1a.
	3. Remove the probe from the water.
5. Measure the dissolved oxygen of your water sample.
	1. Place the tip of the Dissolved Oxygen Probe into the water sampling bottle and stir gently until you have recorded the dissolved oxygen concentration.
	2. Monitor the values displayed on the screen. When the value has stabilized, record the dissolved oxygen concentration in Table 1 for Site 1a.
	3. Remove the probe from the water, and place it back into the storage bottle.
6. Measure the pH of your water sample.
	1. Disconnect the Temperature Probe from LabQuest. **Note:** Keep the Dissolved Oxygen Probe connected to LabQuest.
	2. Connect the pH Sensor to LabQuest.
	3. Remove the pH Sensor from its storage bottle. Rinse the pH electrode thoroughly with the stream water.
	4. Place the sensor into the sample.
	5. Monitor the pH value displayed on the screen. Record the pH in Table 1 when the value has stabilized for Site 1a.
	6. Remove the sensor from the water and place it back into the storage bottle.
7. Measure the TDS of your sample.
	1. Disconnect the pH Sensor from LabQuest.
	2. Set the switch on the Conductivity Probe box to 0-2000 µS/cm and connect the probe to LabQuest.
	3. If the Conductivity Probe is reading in a unit other than mg/L, change units to mg/L by choosing Change Units from the Sensors menu.
	4. Place the tip of the Conductivity Probe into the water sample. The hole near the tip of the probe should be submerged completely.
	5. Monitor the TDS value. Record the TDS value in Table 1 when the value has stabilized for Site 1a.
	6. Remove the probe from the water.
	7. Disconnect the Conductivity Probe and reconnect the Temperature Probe to LabQuest.
8. Repeat Steps 2-7 at a second location 6 meters from Site 1a. The second location will be designated Site 1b.
9. Repeat Steps 1-7 at two locations 1.6 km from Site 1a that are approximately 6 meters apart. These sites will be designated Site 2a and Site 2b.

# DATA

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| --- |
| Table 1 |
| Location | Dissolved oxygen (mg/L) | pH | Total dissolved solids | Temperature (°C) |
| Site 1a |  |  |  |  |
| Site 1b |  |  |  |  |
| Average |  |  |  |  |
| Site 2a |  |  |  |  |
| Site 2b |  |  |  |  |
| Average |  |  |  |  |

Temperature Difference:

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| --- |
| Table 2DO (% Saturated) |
|  | Dissolved oxygen (mg/L) | DO in saturated water | Percent saturated |
| Site 1 |  |  |  |
| Site 2 |  |  |  |

# PROCESSING THE DATA

1. Calculate the averages for measurements at each location and record the results in Table 1.
2. Determine the % saturation of dissolved oxygen.
	1. Copy the value of dissolve oxygen measured at each site from Table 1 to Table 2.
	2. Obtain the barometric pressure in mm Hg, using either barometer or a table of barometric pressure values according to elevation (your instructor will provide either the barometer reading or the table of values).
	3. Note the water temperature at each site.
	4. Using the pressure and temperature values, look up the level of dissolved oxygen for air-saturated water (in mg/L) from a second table provided by your instructor. Record the results for each site in Table 2.
	5. Use this formula to determine the % saturation, and record the % saturation of dissolved oxygen in Table 2.



1. Using Tables 3-5, determine the water quality value (Q-value) for each of the following measurements: dissolved oxygen, pH, and TDS. You may need to interpolate to obtain the correct Q-values. Record your result in Table 7 for Site 1 and in Table 8 for Site 2.
2. Subtract the two average temperatures from the sites that are about 1.6 km apart. Record the result as the temperature difference in the blank below Table 1.
3. Using Table 6 and the value you calculated above, determine the water quality value (Q-value) for the temperature difference measurement. You may need ot interpolate to obtain the correct Q-values. Record your result in Table 7 and Table 8. The temperature Q-value will be the same in both tables.
4. Multiply each Q-value by the weighting factor in Table 7 for Site 1 and in Table 8 for Site 2. Record the total Q-value in Tables 7-8.
5. Determine the overall water quality of your stream by adding the four total Q- values in Table 7 for Site 1 and in Table 8 for Site 2. Record the result in the line next to the label “Overall Quality.” The closer this value is to 100, the better the water quality of the stream at this site. **Note:** This quality index is not a complete one—this value uses only four measurements. For a more complete water quality determination, you should measure fecal coliform counts, biological oxygen demand, phosphate and nitrate levels, and turbidity. It is also very valuable to do a “critter count”—that is, examine the macroinvertebrates in the stream.

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| Table 3: DO Test Results |  |
| DO (% saturation) | Q-Value |
| 0 | 0 |
| 10 | 5 |
| 20 | 12 |
| 30 | 20 |
| 40 | 30 |
| 50 | 45 |
| 60 | 57 |
| 70 | 75 |
| 80 | 85 |
| 90 | 95 |
| 100 | 100 |
| 110 | 95 |
| 120 | 90 |
| 130 | 85 |
| 140 | 80 |

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| Table 4: pH Test Results |
| pH | Q-Value |
| 2.0 | 0 |
| 2.5 | 1 |
| 3.0 | 3 |
| 3.5 | 5 |
| 4.0 | 8 |
| 4.5 | 15 |
| 5.0 | 25 |
| 5.5 | 40 |
| 6.0 | 54 |
| 6.5 | 75 |
| 7.0 | 88 |
| 7.5 | 95 |
| 8.0 | 85 |
| 8.5 | 65 |
| 9.0 | 48 |
| 9.5 | 30 |
| 10.0 | 20 |
| 10.5 | 12 |
| 11.0 | 8 |
| 11.5 | 4 |
| 12.0 | 2 |

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| Table 5: TDS Test Results |
| TDS (mg/L) | Q-Value |
| 50 | 90 |
| 100 | 85 |
| 150 | 78 |
| 200 | 72 |
| 250 | 65 |
| 300 | 60 |
| 350 | 52 |
| 400 | 46 |
| 450 | 40 |
| 500 | 30 |

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| Table 6: Temperature Test Results |
| ΔTemp (°C) | Q-Value |
| 0 | 95 |
| 5 | 75 |
| 10 | 45 |
| 15 | 30 |
| 20 | 20 |
| 25 | 15 |
| 30 | 10 |

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| Table 7: Site 1 |
| Test | Q-Value | Weight | Total Q-Value |
| DO |  | 0.38 |  |
| pH |  | 0.24 |  |
| TDS |  | 0.16 |  |
| Temperature |  | 0.22 |  |

Overall Quality

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| Table 8: Site 2 |
| Test | Q-Value | Weight | Total Q-Value |
| DO |  | 0.38 |  |
| pH |  | 0.24 |  |
| TDS |  | 0.16 |  |
| Temperature |  | 0.22 |  |

# QUESTIONS

1. Using your measurements, what is the quality of the watershed? Explain
2. How do you account for each of the measurements? For example, if the pH of the downstream site is very low, and you took measurements above and below an auto repair station, perhaps battery acid leaked into the stream.
3. How did measurements between the two sites compare? How might you account for any differences, if any?
4. Compare the measurements you obtained with those from previous months or years. Has the water quality improved, remained about the same, or declined? Explain.
5. Why would you expect the DO in a pond to be less than in a rapidly moving stream? If applicable, did your measurements confirm this assumption? Explain.
6. What could be done to improve the quality of the watershed?

# CALIBRATION TABLES

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| Table 9: 100% Dissolved Oxygen Capacity (mg/L) |
|  | 770mm | 760mm | 750mm | 740mm | 730mm | 720mm | 710mm | 700mm | 690mm | 680mm | 670mm | 660mm |
| 0°C | 14.76 | 14.57 | 14.38 | 14.19 | 13.99 | 13.80 | 13.61 | 13.42 | 13.23 | 13.04 | 12.84 | 12.65 |
| 1°C | 14.38 | 14.19 | 14.00 | 13.82 | 13.63 | 13.44 | 13.26 | 13.07 | 12.88 | 12.70 | 12.51 | 12.32 |
| 2°C | 14.01 | 13.82 | 13.64 | 13.46 | 13.28 | 13.10 | 12.92 | 12.73 | 12.55 | 12.37 | 12.19 | 12.01 |
| 3°C | 13.65 | 13.47 | 13.29 | 13.12 | 12.94 | 12.76 | 12.59 | 12.41 | 12.23 | 12.05 | 11.88 | 11.70 |
| 4°C | 13.31 | 13.13 | 12.96 | 12.79 | 12.61 | 12.44 | 12.27 | 12.10 | 11.92 | 11.75 | 11.58 | 11.40 |
| 5°C | 12.97 | 12.81 | 12.64 | 12.47 | 12.30 | 12.13 | 11.96 | 11.80 | 11.63 | 11.46 | 11.29 | 11.12 |
| 6°C | 12.66 | 12.49 | 12.33 | 12.16 | 12.00 | 11.83 | 11.67 | 11.51 | 11.34 | 11.18 | 11.01 | 10.85 |
| 7°C | 12.35 | 12.19 | 12.03 | 11.87 | 11.71 | 11.55 | 11.39 | 11.23 | 11.07 | 10.91 | 10.75 | 10.59 |
| 8°C | 12.05 | 11.90 | 11.74 | 11.58 | 11.43 | 11.27 | 11.11 | 10.96 | 10.80 | 10.65 | 10.49 | 10.33 |
| 9°C | 11.77 | 11.62 | 11.46 | 11.31 | 11.16 | 11.01 | 10.85 | 10.70 | 10.55 | 10.39 | 10.24 | 10.09 |
| 10°C | 11.50 | 11.35 | 11.20 | 11.05 | 10.90 | 10.75 | 10.60 | 10.45 | 10.30 | 10.15 | 10.00 | 9.86 |
| 11°C | 11.24 | 11.09 | 10.94 | 10.80 | 10.65 | 10.51 | 10.36 | 10.21 | 10.07 | 9.92 | 9.78 | 9.63 |
| 12°C | 10.98 | 10.84 | 10.70 | 10.56 | 10.41 | 10.27 | 10.13 | 9.99 | 9.84 | 9.70 | 9.56 | 9.41 |
| 13°C | 10.74 | 10.60 | 10.46 | 10.32 | 10.18 | 10.04 | 9.90 | 9.77 | 9.63 | 9.49 | 9.35 | 9.21 |
| 14°C | 10.51 | 10.37 | 10.24 | 10.10 | 9.96 | 9.83 | 9.69 | 9.55 | 9.42 | 9.28 | 9.14 | 9.01 |
| 15°C | 10.29 | 10.15 | 10.02 | 9.88 | 9.75 | 9.62 | 9.48 | 9.35 | 9.22 | 9.08 | 8.95 | 8.82 |
| 16°C | 10.07 | 9.94 | 9.81 | 9.68 | 9.55 | 9.42 | 9.29 | 9.15 | 9.02 | 8.89 | 8.76 | 8.63 |
| 17°C | 9.86 | 9.74 | 9.61 | 9.48 | 9.35 | 9.22 | 9.10 | 8.97 | 8.84 | 8.71 | 8.58 | 8.45 |
| 18°C | 9.67 | 9.54 | 9.41 | 9.29 | 9.16 | 9.04 | 8.91 | 8.79 | 8.66 | 8.54 | 8.41 | 8.28 |
| 19°C | 9.47 | 9.35 | 9.23 | 9.11 | 8.98 | 8.86 | 8.74 | 8.61 | 8.49 | 8.37 | 8.24 | 8.12 |
| 20°C | 9.29 | 9.17 | 9.05 | 8.93 | 8.81 | 8.69 | 8.57 | 8.45 | 8.33 | 8.20 | 8.08 | 7.96 |
| 21°C | 9.11 | 9.00 | 8.88 | 8.76 | 8.64 | 8.52 | 8.40 | 8.28 | 8.17 | 8.05 | 7.93 | 7.81 |
| 22°C | 8.94 | 8.83 | 8.71 | 8.59 | 8.48 | 8.36 | 8.25 | 8.13 | 8.01 | 7.90 | 7.78 | 7.67 |
| 23°C | 8.78 | 8.66 | 8.55 | 8.44 | 8.32 | 8.21 | 8.09 | 7.98 | 7.87 | 7.75 | 7.64 | 7.52 |
| 24°C | 8.62 | 8.51 | 8.40 | 8.28 | 8.17 | 8.06 | 7.95 | 7.84 | 7.72 | 7.61 | 7.50 | 7.39 |
| 25°C | 8.47 | 8.36 | 8.25 | 8.14 | 8.03 | 7.92 | 7.81 | 7.70 | 7.59 | 7.48 | 7.37 | 7.26 |
| 26°C | 8.32 | 8.21 | 8.10 | 7.99 | 7.89 | 7.78 | 7.67 | 7.56 | 7.45 | 7.35 | 7.24 | 7.13 |
| 27°C | 8.17 | 8.07 | 7.96 | 7.86 | 7.75 | 7.64 | 7.54 | 7.43 | 7.33 | 7.22 | 7.11 | 7.01 |
| 28°C | 8.04 | 7.93 | 7.83 | 7.72 | 7.62 | 7.51 | 7.41 | 7.30 | 7.20 | 7.10 | 6.99 | 6.89 |
| 29°C | 7.90 | 7.80 | 7.69 | 7.59 | 7.49 | 7.39 | 7.28 | 7.18 | 7.08 | 6.98 | 6.87 | 6.77 |
| 30°C | 7.77 | 7.67 | 7.57 | 7.47 | 7.36 | 7.26 | 7.16 | 7.06 | 6.96 | 6.86 | 6.76 | 6.66 |
| 31°C | 7.64 | 7.54 | 7.44 | 7.34 | 7.24 | 7.14 | 7.04 | 6.94 | 6.85 | 6.75 | 6.65 | 6.55 |

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| Table 10: Approximate Barometric Pressure at Different Elevations |
| Elevation (m) | Pressure (mm Hg) | Elevation (m) | Pressure (mm Hg) | Elevation (m) | Pressure (mm Hg) |
| 0 | 760 | 800 | 693 | 1600 | 628 |
| 100 | 748 | 900 | 685 | 1700 | 620 |
| 200 | 741 | 1000 | 676 | 1800 | 612 |
| 300 | 733 | 1100 | 669 | 1900 | 604 |
| 400 | 725 | 1200 | 661 | 2000 | 596 |
| 500 | 717 | 1300 | 652 | 2100 | 588 |
| 600 | 709 | 1400 | 643 | 2200 | 580 |
| 700 | 701 | 1500 | 636 | 2300 | 571 |