Watershed Testing

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 overall health.

For the purpose of this exercise, you will perform only four of the WQI tests: dissolved oxygen, water temperature, 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.

OBJECTIVES

In this experiment, you will

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

MATERIALS

TI-Nspire handheld **or**
  computer and TI-Nspire software
data-collection interface
Vernier Dissolved Oxygen Probe
Vernier pH Sensor
Vernier Conductivity Probe
Vernier Temperature Probe
4 water sampling bottles
large plastic cup or beaker
D.O. calibration bottle
distilled water
tap water

PRE-LAB PROCEDURE

1. Connect the temperature probe to your interface. Connect the interface to the TI-Nspire handheld or laptop computer. Monitor the temperature probe reading. When the reading is stable, record the room temperature value. This value is used in Step 7h.
2. Set up the data-collection mode.
   a. Choose New Experiment from the Experiment menu.
   b. Choose Collection Mode ► Events with Entry from the Experiment menu.
   c. Enter **Sensor** as the Name and leave the Units blank. Select OK.
3. Take a sample temperature reading.
   a. Obtain a sample of tap water and place the temperature probe in the water.
   b. Start data collection ( ).
   c. Monitor the readings displayed on the screen. When the reading is stable, click the Keep button ( ) and enter **Temp** as the sensor.
   d. Stop data collection ( ).
4. Prepare the Dissolved Oxygen Probe for use.
   a. Remove the protective cap.
   b. Unscrew the membrane cap from the tip of the probe.
   c. Using a pipet, fill the membrane cap with 1 mL of DO Electrode Filling Solution.
   d. Carefully thread the membrane cap back onto the electrode.
   e. Place the probe into a 250 mL beaker containing distilled water.

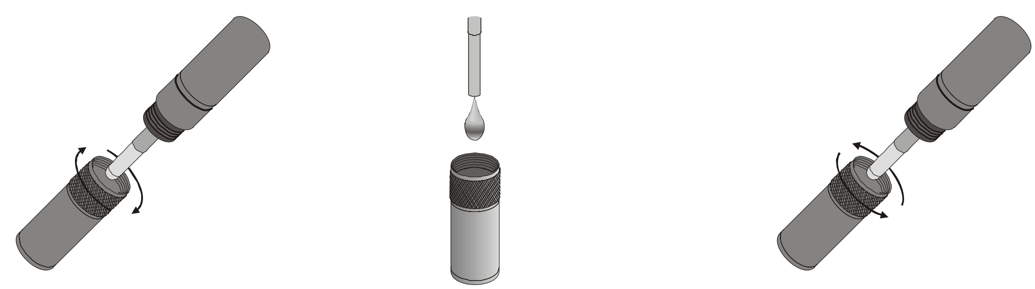

Figure 1

5. Disconnect the temperature probe and connect the Dissolved Oxygen Probe to the data collection interface.
6. It is necessary to warm up the Dissolved Oxygen Probe for 10 minutes before taking readings. With the probe still in the distilled water beaker, wait 10 minutes while the probe warms up. The probe must stay connected at all times to keep it warmed up. (Note: If you are using the TI-Nspire Lab Cradle, the meter will display the sensor values in light gray until the sensor has warmed up. At that time, the sensor values will display in black.)
7. Calibrate the Dissolved Oxygen Probe.
   - If your instructor directs you to perform a new calibration, continue with this step to calibrate your sensor. Otherwise, proceed directly to Step 8.

Zero-Oxygen Calibration Point

a. Choose Set Up Sensors ► Calibrate ► Two Point from the Experiment menu.
b. Remove the probe from the water bath and place the tip of the probe into the Sodium Sulfite Calibration Solution. **Important:** No air bubbles can be trapped below the tip of the probe or the probe will sense an inaccurate dissolved oxygen level. If the voltage does not rapidly decrease, tap the side of the bottle with the probe to dislodge the bubble. The readings should be in the 0.2 to 0.6 V range.
c. Enter **0** as the first reference value.
d. When the voltage stabilizes (~1 minute), select OK.

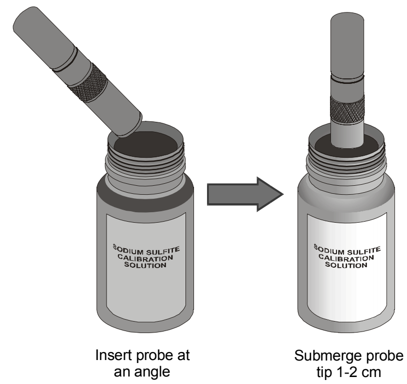

Figure 2

Saturated DO Calibration Point

e. Rinse the probe with distilled water and gently blot dry.
f. Unscrew the lid of the calibration bottle provided with the probe. Slide the lid and the grommet about 1/2 inch onto the probe body.

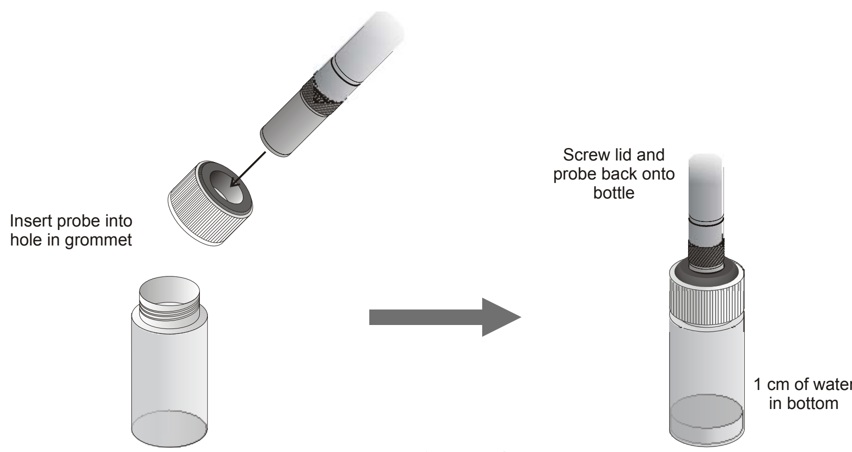

Figure 3

g. Add water to the bottle to a depth of about 1 cm (1/4 inch) and screw the bottle into the cap, as shown. **Important:** Do not touch the membrane or get it wet during this step.
h. Enter the correct saturated dissolved-oxygen value (in mg/L) from Table 9 using the current barometric pressure and air temperature values (for example, at 18 °C and atmospheric pressure of 690 mmHg enter **8.66**). If you do not have the current barometric pressure, use Table 10 to estimate the barometric pressure at your altitude.
i. Keep the probe in this position for about a minute. The readings should be above 2.0 V. When the voltage reading stabilizes, select OK.
j. If directed by your instructor, record the values for K0 and K1. Select the Save Calibration with Document option, and then select OK.

8. Take a sample DO reading.
   a. Start data collection (▶) and select the **Append** option.
   b. Monitor the readings displayed on the screen. When the reading is stable, click the Keep button () and enter **DO** as the sensor.

c. Stop data collection ( ).
d. Prepare the Dissolved Oxygen probe for transport by filling the calibration bottle half full with water. Secure the Dissolved Oxygen Probe far enough down in the bottle that the membrane is completely covered by water. Screw the calibration bottle lid completely onto the bottle so that no water will leak out.

9. Set up the pH sensor and take a sample reading.
    a. Disconnect the Dissolved Oxygen Sensor and connect the pH sensor to the data collection interface.
    b. Start data collection ( ) and select the **Append** option.
    c. Remove the pH sensor from it storage bottle and place it in your sample of tap water.
    d. Monitor the readings displayed on the screen. When the reading is relatively stable, click the Keep button ( ) and enter **pH** as the sensor.
    e. Stop data collection ( ).
    f. Return the pH sensor to its storage bottle.
10. Set up the Conductivity Probe and take a sample reading.
    a. Set the switch on the Conductivity Probe box to 0–2000 µS/cm.
    b. Disconnect the pH sensor and connect the Conductivity probe to the data-collection interface.
    c. If the Conductivity Probe is reading in a unit other than mg/L, change units to mg/L by choosing Set Up Sensors ► Change Units ► Conductivity ► mg/L from the Experiment menu.
    d. Start data collection ( ) and select the **Append** option.
    e. Place the Conductivity probe in your sample of tap water.
    f. Monitor the readings displayed on the screen. When the reading is relatively stable, click the Keep button ( ) and enter **Cond** as the sensor.
    g. Stop data collection ( ).
11. Final Preparations for the field
    a. Click the Table View tab ( ). Record your readings for tap water in Table 1.
    b. Click the Store Latest Run button ( ) to save your tap water data and prepare for data collection in the field.
    c. Double click on the run1 heading in the table and change the name to Tap Water.
    d. Double click on the run2 heading in the table and change the name to Site 1.
    e. Save the file to retain the calibration settings.
    f. Mark the sensors you used in this set up. It is important that you use the same sensors for all of your measurements.

PROCEDURE

You will measure dissolved oxygen concentration, water temperature, pH, and total dissolved solid (TDS) concentration at four different sites.

12. Open the file saved in Step 11. Be sure the data-collection interface is connected to the handheld or laptop computer. Connect the Dissolved Oxygen probe to your interface. This will start the 10 minute warm up of the sensor.

13. 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.

14. 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. 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. Label the sample bottle Site 1.

15. Measure the dissolved oxygen of your water sample. Perform the following steps to prepare the Dissolved Oxygen Probe.

    Important: Prior to each use, the Dissolved Oxygen Probe must warm up for a period of 10 minutes. If the probe is not warmed up properly, inaccurate readings will result. If using the TI-Nspire Lab Cradle, the values for this sensor will display in black only after the sensor has warmed up.

    a. Start data collection ().
    b. Remove the Dissolved Oxygen Probe from its storage bottle. Place the probe into the water and gently swirl to allow water to move past the probe's tip.
    c. Monitor the readings displayed on the screen. When the reading is stable, click the Keep button () and enter **DO** as the sensor.
    d. Stop data collection ().
    e. Remove the probe from the water, rinse it with distilled water, and place it back into the storage bottle.

16. Measure the temperature of your water sample.

    a. Disconnect the Dissolved Oxygen Probe and connect the Temperature Probe.
    b. Start data collection () and select the **Append** option.
    c. Place the Temperature Probe into the water sample.
    d. Monitor the temperature reading. When the reading has stabilized, click the Keep button () and enter **Temp** as the sensor. Remove the probe from the water.
    e. Stop data collection ().

17. Measure the pH of your water sample.

    a. Disconnect the Temperature Probe and connect the pH Sensor.
    b. Start data collection () and select the **Append** option.
    c. Remove the pH Sensor from its storage bottle. Place the sensor into the sample.
    d. Monitor the pH reading displayed on the screen. When the reading has stabilized, click the Keep button () and enter **pH** as the sensor. Remove the sensor from the water, rinse the probe with distilled water, and place it back into the storage bottle.
    e. Stop data collection ().

18. Measure the TDS of your water sample.

    a. Disconnect the pH Sensor and connect the Conductivity Probe.
    b. Start data collection () and select the **Append** option.
    c. Place the tip of the Conductivity Probe into the water sample. The hole near the tip of the probe should be submerged completely.

d. Monitor the TDS reading. When the reading has stabilized, click the Keep button ( ) and enter **Cond** as the sensor. Remove the probe from the water and rinse it with distilled water.

e. Stop data collection ( ).

19. Click the Store Latest Run button ( ) to save the data for Site 1. Disconnect the Conductivity probe and connect the Dissolved Oxygen probe. This will start the 10 minute warm up period required for the Dissolved Oxygen probe.

20. Repeat Steps 13–19 at a location 6 meters from Site 1. This second location will be designated Site 2.

21. Repeat Steps 13–19 at a location 1.6 km (1 mile) from Site 1. This third location will be designated Site 3.

22. Repeat Steps 13–18 at a location 6 m from Site 3. This fourth location will be designated Site 4. Note: it is not necessary to store the latest data set after collecting the Site 4 data.

23. Click the Table View tab ( ). If desired, double click on the site name and use the notes field to record the location of the sites.

24. Record the data in Table 1.

25. Save the file to ensure data will not be lost.

DATA

Room Temperature (°C) ____________

Table 1

Location	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Total dissolved solids (mg/L)
Tap Water				
Site 1				
Site 2				
Average Sites 1 & 2				
Site 3				
Site 4				
Average Sites 3 & 4				

Temperature Difference: ____________

Table 2 - DO (% Saturated)			
	Average Dissolved Oxygen (mg/L)	DO in saturated water	% Saturated
Sites 1 & 2			
Sites 3 & 4			

Table 3 – use with Sites 1 & 2			
Test	Q-Value	Weight	Total Q-value
DO		0.38	
pH		0.24	
TDS		0.16	
Temperature		0.22	

Overall Quality: ____________

Table 4 – use with Sites 3 & 4			
Test	Q-Value	Weight	Total Q-value
DO		0.38	
pH		0.24	
TDS		0.16	
Temperature		0.22	

Overall quality: ____________

PROCESSING THE DATA

1. Calculate the averages for measurements at sites that are 6 meters apart (sites 1 & 2 and sites 3 & 4) record the results in Table 1.

2. Subtract the two average temperatures from the sites. Record the result as the temperature difference in the blank below Table 1. This value will be used in Step 5.

3. Determine the % saturation of dissolved oxygen:
   a. Copy the value of the average dissolved oxygen from Table 1 to Table 2.
   b. Obtain the barometric pressure, in mm Hg. If you do not have the current barometric pressure, use Table 10 to estimate the barometric pressure at your altitude.
   c. Note the average water temperature at each site.
   d. Using the pressure and temperature values, look up the level of dissolved oxygen for air-saturated water (in mg/L) using Table 9. Record the results in Table 2.

e. Determine the % saturation using the formula:

$$\% \text{ saturation} = \frac{\text{measured D.O. level}}{\text{saturated D.O. level}} \times 100$$

f. Record the % saturation of dissolved oxygen in Table 2.

4. Using Tables 5 – 7, 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 3 for Sites 1 & 2 and in Table 4 for Sites 3 & 4.
5. Using Table 8 and the value you calculated in Processing the Data Step 2, determine the water quality value (Q value) for the temperature difference measurement. You may need to interpolate to obtain the correct Q values. Record your result in Table 3 for Sites 1 & 2 and in Table 4 for Sites 3 & 4. The temperature Q-value will be the same in both tables.
6. Multiply each Q-value by the weighting factor listed in Tables 3 and 4. Record the total Q-value in each Table.
7. Determine the overall water quality of your stream by adding the four total Q-values in Table 3 for Sites 1 & 2 and in Table 4 for Sites 3 & 4. 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.

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.

   DO:

   pH:

   TDS:

   Temperature:
3. How did measurements between the two sites 1 mile apart compare? How might you account for any differences?
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?

WATER QUALITY VALUE TABLES

Table 5
Dissolved oxygen (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

Table 6
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

Table 7
Total dissolved solids (TDS) test results

TDS (mg/L)	Q Value
0	80
50	90
100	85
150	78
200	72
250	65
300	60
350	52
400	46
450	40
500	30

Table 8
Temperature test results

ΔTemp (°C)	Q Value
0	95
5	75
10	45
15	30
20	20
25	15
30	10

DISSOLVED OXYGEN CALIBRATION TABLES

Table 9: 100% Dissolved Oxygen Capacity (mg/L)												
	770 mm	**760 mm**	**750 mm**	**740 mm**	**730 mm**	**720 mm**	**710 mm**	**700 mm**	**690 mm**	**680 mm**	**670 mm**	**660 mm**
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

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