Additional Problems for the Streeter-Phelps Equation

1. A river has a flow of approximately 410 million gallons per day (mpd), a temperature of 18 °C, a BOD_5 of 3.0 mg/L, a dissolved oxygen at 90 % of saturation, and an average velocity of 2 miles per hour. There is a domestic sewage plant (15 mgd) located near this point that has an influent BOD_5 of 250 mg/L. The plant removes 95 % of the BOD, has a effluent temperature of 20 °C, and an effluent dissolved oxygen concentration of 0 mg/L. Experiments conducted at 20 °C yield a k' of 0.4/d and a k'_2 of 0.55/d. (Use the temperature coefficients of 1.135 for k' and 1.024 for k'_2.)

Determine the critical-oxygen deficit, its location downstream, and how long it will take water to reach this point.

Estimate the 20 °C BOD_5 of a sample taken at the critical point.

Plot the dissolved-oxygen curve in km from the point source.

Determine the dissolved concentration at 5 miles downstream from the sewage plant.

2. Assume that the city in problem 1 has a combined sanitary and storm sewer. After a large series of storms, the treatment plant is flooded and the sewage is subsequently dumped directly into the river without treatment.

Using the data in problem 1, what would the D.O. sag curve look like if the sewage was not treated.

Determine the critical-oxygen deficit, its location downstream, and how long it will take water to reach this point.

3. A small stream receives the run off from a stock yard. Characteristics of the stream include a flow of 0.05 million gallons per day (mgd), a temperature of 15 °C, a dissolved oxygen concentration at 95 % of the saturation value, an average velocity of 8 miles per hour, and a BOD_5 of 0.3 mg/L. The waste enters the stream (without treatment) with a flow of 500 gallons per day, a BOD_5 of 1500 mg/L, a temperature of 22 °C, and a D.O. of 0 mg/L. Experiments conducted at 20 °C yield a k' of 0.4/d and a k'_2 of 0.7/d. (Use the temperature coefficients of 1.135 for k' and 1.024 for k'_2.)

Determine the critical-oxygen deficit, its location downstream, and how long it will take water to reach this point.

Estimate the 20 °C BOD_5 of a sample taken at the critical point.

Plot the dissolved-oxygen curve in km from the point source.

Determine the dissolved concentration at 1 mile downstream from the stock yard.

4. Evaluate the affects of stream size and k'_2 on the oxygen sag curve. Do this by assuming that streams of different size are receiving the waste and vary k'_2 in your calculations. Vary k'_2 from 0.7 down to 0.3 in increments of 0.1 and describe the affects on $x_{(c)}$, $D_{(c)}$, and $t_{(c)}$.

5. A cheese processing plant releases waste to an adjacent river. The waste has a BOD_5 of 10000 mg/L, a flow of 0.25 million gallons per day, a temperature of 20 °C, and a dissolved oxygen of 0 mg/L. The river has a flow of 100 million gallons per day, a velocity of 6 miles per hour, a temperature of 16 °C, a dissolved oxygen of 9.0 mg/L, and a BOD_5 of 1 mg/L. Experiments conducted at 20 °C yield a k' of 0.4/d and a k'_2 of 0.75/d. (Use the temperature coefficients of 1.135 for k' and 1.024 for k'_2.)

Determine the critical-oxygen deficit, its location downstream, and how long it will take water to reach this point.

Estimate the 20 °C BOD_5 of a sample taken at the critical point.

Plot the dissolved-oxygen curve in km from the point source.

Determine the dissolved concentration at 10 mile downstream from the release.

5. Evaluate the effect of installing a treatment plant to handle of the waste generated from the cheese processing plant in problem 4. Specifics of the treatment facility are that it will remove 95 % of the BOD_5 from the water and that the effluent water has a temperature of 22 °C and a dissolved oxygen concentration of 0 mg/L.