

Hands-On Exercise #2: Q2K Simulation of Boulder Creek CBOD, DO and Ammonium

The present hands-on example is intended to show you how oxidizable loads (CBOD and ammonium) are added to the model and how this effects dissolved oxygen levels.

Getting Started

- Get Q2K up and running on your computer.
- Open the file: HOQ2KBODDO.q2k.
- Change the directory where the file is saved (cell b10 on the QUAL2K Worksheet) to the appropriate directory on your computer.
- Change the saved file name (cell b9 on the QUAL2K Worksheet) to HO2Q2KXXX, where XXX are your initials.
- Run the program.
- Look at the following spatial plots: CBODslow, CBODfast, Dissolved Oxygen, NH₄, and NO₃. Notice that all of these except oxygen are zero. The oxygen plot starts at zero and then increases towards saturation due to reaeration.

Adding constant CBOD and oxygen boundary conditions

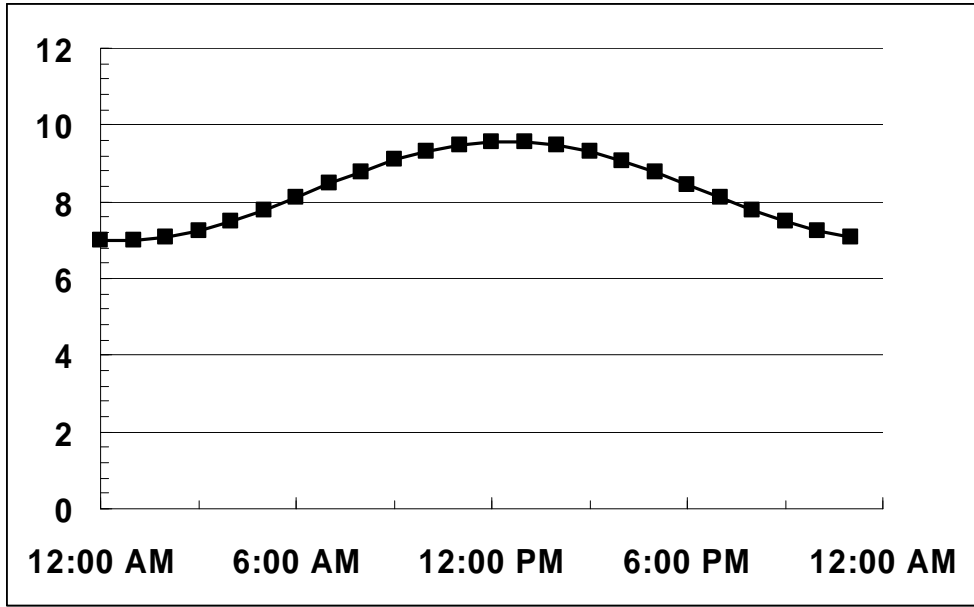
Go to the Headwater Worksheet. Add the following constant boundary conditions in the appropriate cells. Note that for constant boundary conditions all you have to do is enter a single value in column C (at 12:00 AM). If the remainder of the times are left blank, Q2K will automatically apply this value to the other times of day.

Dissolved Oxygen = 8.28 mg/L
CBODslow = 1.34 mg/L
CBODfast = 1.34 mg/L

Run the program. Look at the CBODslow, CBODfast and the Dissolved Oxygen spatial plots to verify that these graphs no longer start at zero.

Adding diel varying oxygen boundary conditions

Note that the dissolved oxygen at the headwater is not constant, but rather varies from hour to hour as in the following plot:



- Go to the Headwater Worksheet. Add these values for oxygen:

12:00 AM	6.98
1:00 AM	6.98
2:00 AM	7.08
3:00 AM	7.25
4:00 AM	7.49
5:00 AM	7.79
6:00 AM	8.12
7:00 AM	8.46
8:00 AM	8.79
9:00 AM	9.09
10:00 AM	9.33
11:00 AM	9.49
12:00 PM	9.58
1:00 PM	9.58
2:00 PM	9.48
3:00 PM	9.31
4:00 PM	9.07
5:00 PM	8.77
6:00 PM	8.44
7:00 PM	8.10
8:00 PM	7.77
9:00 PM	7.47
10:00 PM	7.23
11:00 PM	7.07

- Run the program. Look at the Dissolved oxygen spatial plot to verify that the boundary now has a distinct minimum and maximum reflecting the data we just put in.

Adding CBOD and oxygen loadings

QUAL2K allows the temperature and concentrations of each point source to be entered as a sinusoid that varies over the diel cycle. Figure 1 shows an example for the temperature of the Boulder CO WWTP.

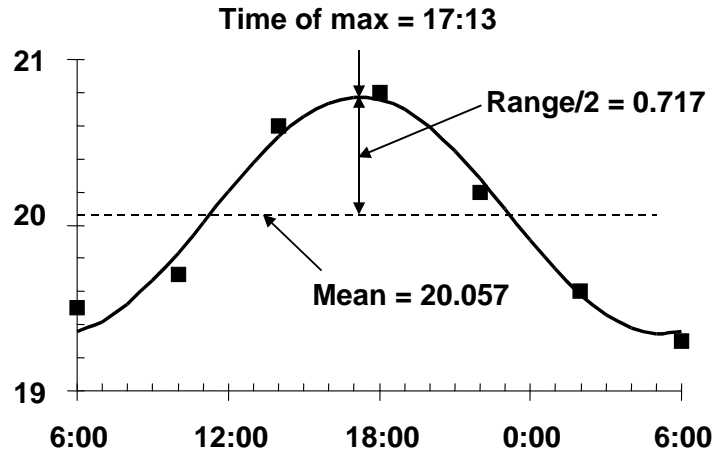


Figure 1. Temperature for the Boulder, CO wastewater treatment plant effluent on Sept. 21-22, 1987 along with a sinusoidal fit to the data.

- Go to the Point Sources Worksheet. Add the following concentrations for the loading for the Boulder WWTP:

Pollutant	Mean	Range/2	Time of Max
Dissolved oxygen	3.57	0.42	8:52 AM
Slow CBOD	13.35		
Fast CBOD	13.35		

- Run the program. Look at the Dissolved oxygen, CBODslow and CBODfast spatial plots to verify that the effluent from the Boulder WWTP has been included. In particular, notice that there is now a distinct minimum and maximum of DO at the point that the WWTP effluent enters the system. Also, observe how the slow and fast CBOD decrease at different rates as we progress downstream reflective of their different decay rates. Look at the Rates Worksheet to see these rates. Do they seem high or low to you?

Adding ammonium boundary conditions and loads

Note that the dissolved oxygen depletion due to CBOD loads is relatively negligible for Boulder Creek. The impact of ammonium and nitrification is stronger.

- Add the following boundary conditions and loads for ammonium:

Headwater Boundary Condition: 87.59 $\mu\text{gN/L}$

Boulder WWTP Loading: Mean = 11221 $\mu\text{gN/L}$, range/2 = 2743 $\mu\text{gN/L}$ and time of max = 5:09 PM

- Run the program. Look at the plots for ammonium (NH_4) and dissolved oxygen to see the impact of ammonium. In addition, look at the nitrate (NO_3) plot. It should no longer be zero, but should now indicate a build-up of nitrate due to nitrification. Thus, as the ammonia is lost via nitrification (which uses up oxygen), the nitrate increases.

Changing Reaeration

- Inspect the Reaeration Chart. These values were computed using the USGS (pool-riffle) formulas. Let's investigate how these values change if we use another method of computing reaeration.

Record the reaeration rate at the headwater: _____

Record the reaeration rate at the downstream end: _____

- Go to the Rates Worksheet and in cell B17 select the Internal option. This will make Q2K utilize the scheme proposed by Covar that uses the O'Connor-Dobbins formula, the Churchill (TVA) formula or Owens-Gibbs formula depending on the depth and velocity of each reach.
- Run the model. Look at the Reaeration sheet to see how the reaeration rates changed. Compare the values with those you recorded above. Also look at the dissolved oxygen plot.