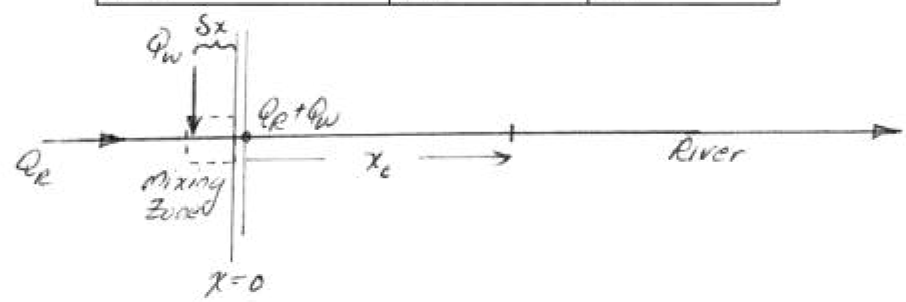
Exercise_007-1

(These exercises requires calculation and plotting of results)

For the following waste and river characteristics at the mixing zone, find the minimum downstream DO and the location downstream of this minimum. Plot the DO Sag curve as a function of distance, and on the curve include a horizontal line for the saturation DO.

Parameter	Wastewater	River
Flow (m^3/sec)	0.3	0.9
Ultimate BOD(mg/L)	6.4	7.0
DO(mg/L)	1.0	6.0
k_D(day^{-1})	--	0.2
k_R(day^{-1})	--	0.37
Q/A (m/s)	--	0.65
DO_{sat}	8.0	8.0

Sketch:



Mixing Zone

$$L_0 = \frac{Q_w L_w + Q_R L_R}{Q_w + Q_R} = \frac{(0.3)(6.4)+(0.9)(7.0)}{(0.3+0.9)} = 6.85\ mg/L$$

$$D_0 = DO_{sat} - \frac{(Q_w DO_0 + Q_R DO_R)}{Q_w + Q_R} = 8.0 - \frac{(0.3)(1.0)+(0.9)(6.0)}{1.2} = 3.25\ mg/L$$

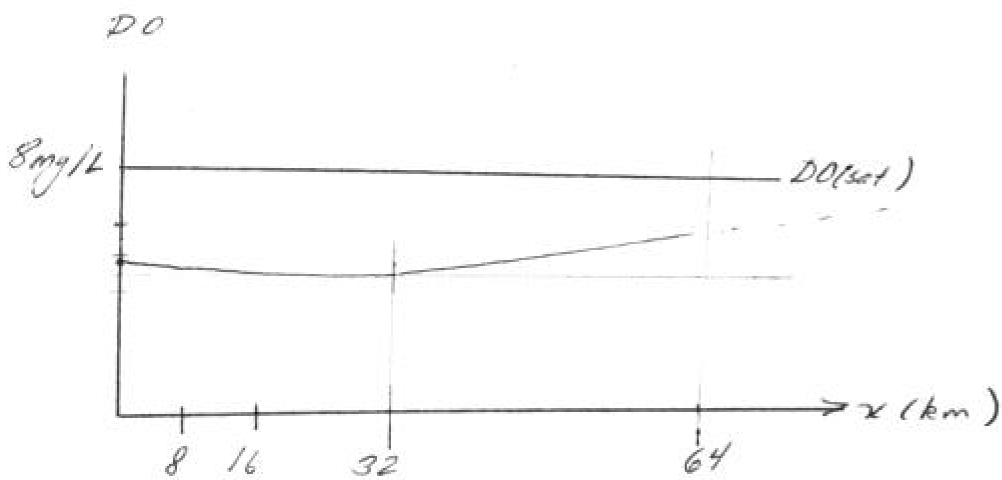
$$\frac{x_c}{U} = \frac{1}{k_r-k_d}\ln\left(\frac{k_r}{k_d}\left(1-\frac{D_0(k_r-k_d)}{k_d L_0}\right)\right) = \frac{1}{0.37-0.2}\ln\left(\frac{0.37}{0.2}\left(1-\frac{3.25(0.37-0.2)}{0.2(6.85)}\right)\right) = 0.581\ days$$

$$x_c = 0.581\ day\left(\frac{86400 s}{day}\right)(0.65 m/s) = \underline{\underline{32.6\ km}} \leftarrow \text{distance to min DO}$$

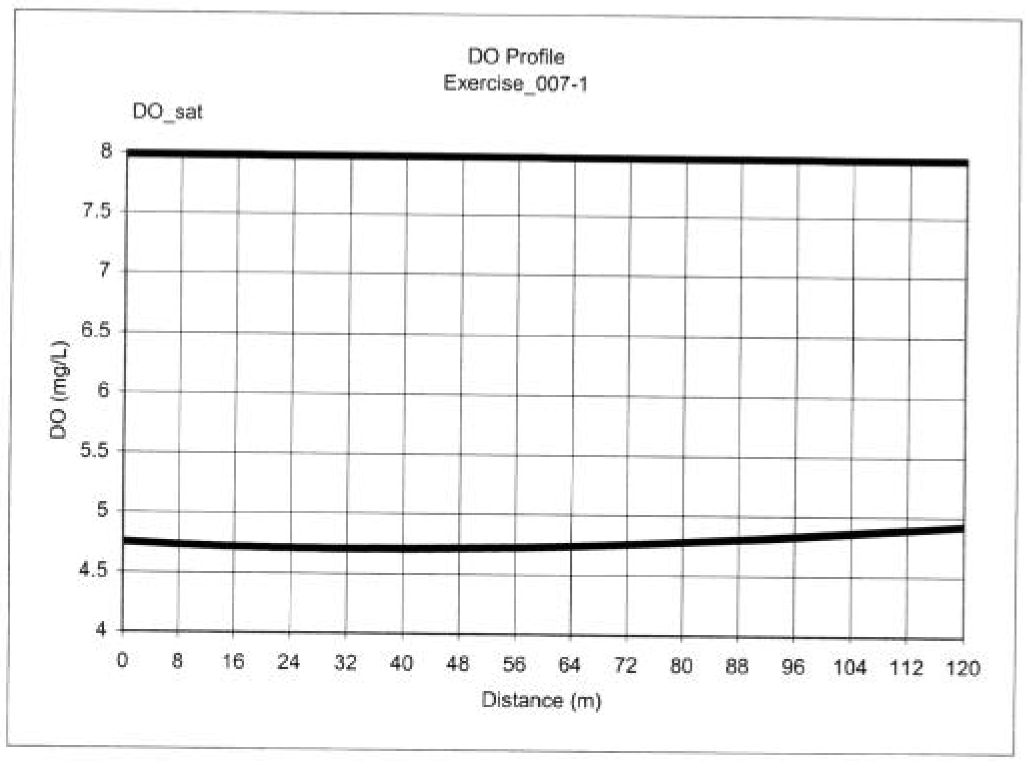
$$D(x_c) = \frac{k_d L_0}{k_r-k_d}\left(e^{-k_d x/U} - e^{-k_r x/U}\right) + D_0 e^{-k_r x/U} = \left\{\frac{(0.2)(6.85)}{(0.17)}\left(e^{-0.2(0.581)} - e^{-0.37(0.581)}\right) + 3.25 e^{-(0.37)(0.58)}\right.$$

$$= 3.29\ mg/L$$

$$DO(x_c) = 8.0\ mg/L - 3.29\ mg/L = 4.7\ mg/L \leftarrow \text{min DO}$$



Sketch of DO Sag



Plot using DOSag.XLS

(Solution 007 -

CIVE 3331 Environmental Engineering

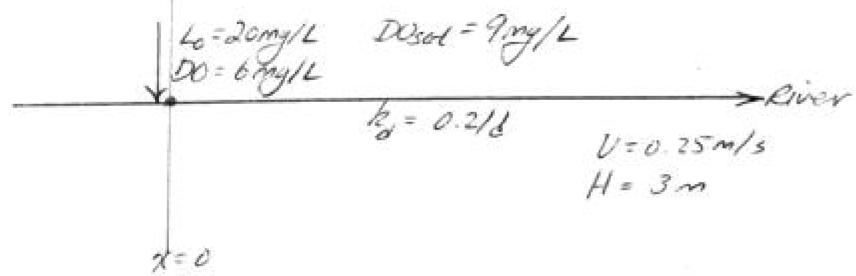
Exercise_007-2

(These exercises requires calculation and plotting of results)

Just downstream of the outfall from a point source of pollution the DO of a river is 6 mg/L and the mix of the river and wastes has a BOD of 20 mg/L. The saturation value of DO is 9.0 mg/L. The de-oxygenation constant is $k_d = 0.2$/day.

a) Estimate the re-aeration coefficient using the O'Conner-Dobbin model assuming the river speed is 0.25 m/s and the average depth is 3 m.
b) Find the critical point downstream (in distance units)
c) Find the critical point downstream (in travel time units)
d) Find the minimum DO value.
e) If the outfall is the only source of BOD, what percent removal is needed to assure a minimum DO value of 5.0 mg/L or greater?
f) Plot the DO curve with and without the treatment required. (on back)
g) Does the location of the minimum change with treatment?

Sketch:



a) $k_r = \frac{3.9U^{1/2}}{H^{3/2}} = \frac{3.9(0.25)^{1/2}}{3^{(3/2)}} = \underline{\underline{0.375/d}}$

$x_c = (2.79d)(86400s/d)(.25m/s) = \underline{60.26km}$

b) Solve c first. Use U to find x_c

c) $t_c = \frac{1}{k_r - k_d} \ln\left(\frac{k_r}{k_d}\left(1 - \frac{D_0(k_r - k_d)}{k_d L_0}\right)\right)$

$= \frac{1}{0.375 - 0.2} \ln\left(\frac{0.375}{0.2}\left(1 - \frac{3(0.375 - 0.2)}{(0.2)(20)}\right)\right) = \underline{\underline{2.79d}}$

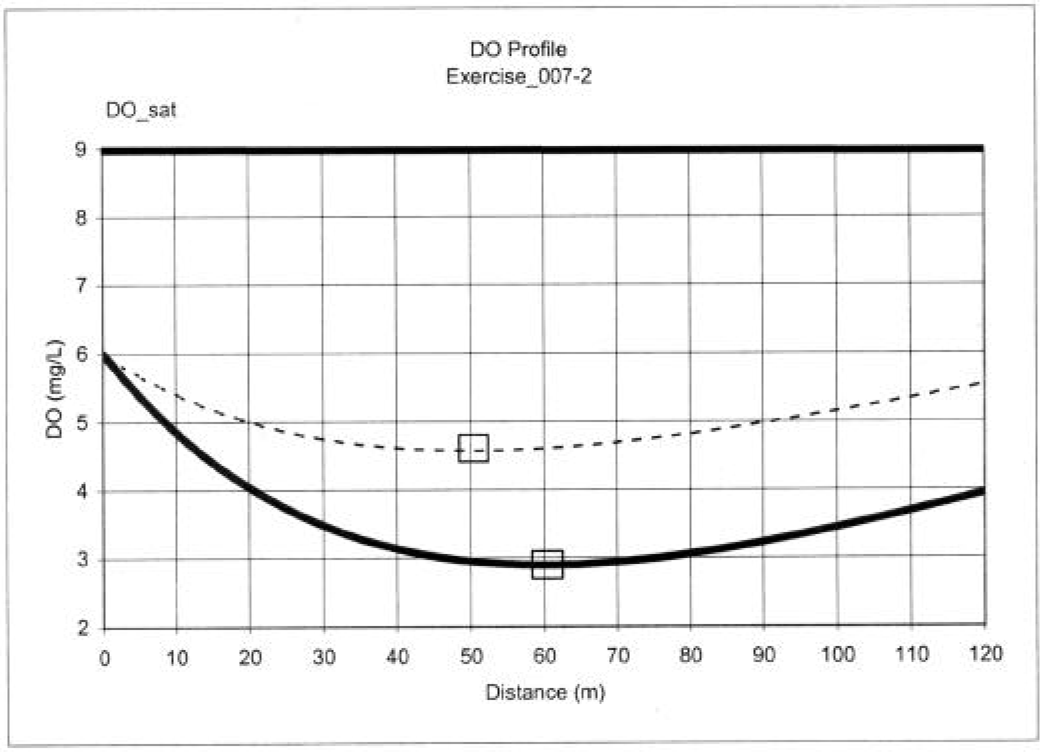
d) $D_c = \frac{k_d L_0}{k_r - k_d}\left(e^{-k_d t} - e^{-k_r t}\right) - D_0 e^{-k_r t} = \frac{(0.2)(20)}{(0.375)(0.20)}\left(e^{-0.2(2.79)} - e^{-.375(2.79)}\right) + 3.0e^{-0.375(2.7}$

$= 6.1 mg/L$

$DO_{min} = DO_{sat} - D_c = 9.0 - 6.1 = 2.9mg/L$

e) $\frac{D_{max-target}}{D_{max-current}} = \frac{9.0 - 5.0}{6.1} = 0.66$ ∴ Must remove $1.0 - 0.66 = 0.34$
∴ Need 34% removal increase to

f)



g) Yes, location of minimum changes