# Homework 5 Solutions

**28.1** First, the system's flow rate can be calculated as

$$Q = \frac{1\times 10^5\ \text{m}^2(2\ \text{m})}{3\ \text{week}}\cdot\frac{\text{week}}{7\ \text{d}} = 9524\ \frac{\text{m}^3}{\text{d}}$$

A phosphorus mass balance can be written as

$$0 = QP_{in} - QP - r_{pa}vAa$$

and solved for

$$P = \frac{QP_{in} - r_{pa}vAa}{Q} = \frac{9524(5) + 1(0.5)1\times 10^5(0.2)}{9524} = 3.95\frac{\text{mg}}{\text{L}}$$

Because the a/p ratio is 1, the n/a ratio should be the same as the n/p ratio

$$r_{na} = r_{np} = \frac{16\ \text{atomsN}}{1\ \text{atomsP}}\cdot\frac{14\ \text{gN / atomN}}{31\ \text{gP / atomP}}P = 7.23\frac{\text{gN}}{\text{gP}}$$

A mass balance for nitrogen can be written and solved for

$$0 = QN_{in} - QN - r_{na}vAa - kVN$$

which can be solved for

$$N = \frac{QN_{in} - r_{na}vAa}{Q + kV} = \frac{9524(5) + 7.23(0.5)1\times 10^5(0.2)}{9524 + 0.05(2\times 10^5)} = 20.69\frac{\text{mg}}{\text{L}}$$

The N/P ratio can be computed as

$$\frac{N}{P} = \frac{20.69}{3.95} = 5.24$$

Therefore, the system would tend to be nitrogen limited.

**28.3** (*a*) The N/P ratio is less than 10 and therefore phosphorus should limit growth. Therefore, the amount of phytoplankton that could potentially be produced is

$$a = 10\frac{\text{mgP}}{\text{m}^3}\cdot 40\frac{\text{mgC}}{\text{mgP}}\cdot 25\frac{\mu\text{gChl}a}{\text{mg C}}\cdot\frac{\text{mgChl}a}{1000\ \mu\text{gChl}a} = 10\frac{\text{mgChl}a}{\text{m}^3}$$

(*b*) $C = 10\dfrac{\text{mgP}}{\text{m}^3}\cdot 40\dfrac{\text{mgC}}{\text{mgP}}\dfrac{\text{gC}}{1000\,\text{mgC}} = 0.4\dfrac{\text{gC}}{\text{m}^3}$

(*c*) $N = 10\dfrac{\text{mgP}}{\text{m}^3}\cdot 7.2\dfrac{\text{mgN}}{\text{mgP}} = 720\dfrac{\text{mgN}}{\text{m}^3}$

$$o = 720\frac{\text{mgN}}{\text{m}^3}\cdot 4.57\frac{\text{mgO}}{\text{mg N}}\cdot\frac{\text{gO}}{1000\,\text{mgO}} = 0.329\frac{\text{gO}_2}{\text{m}^3}$$

**29.1** The runoff flow rate

$$Q_d = 25\frac{\text{cm}}{\text{yr}}6{,}070{,}000\ \text{m}^2\frac{\text{m}}{100\ \text{cm}} = 1{,}517{,}500\frac{\text{m}^3}{\text{yr}}$$

and the groundwater flow rate

$$Q_g = 100\frac{\text{m}^3}{\text{d}}\frac{365\ \text{d}}{\text{yr}} = 36{,}500\frac{\text{m}^3}{\text{yr}}$$

can be combined to yield a total flow of 1,554,000 $\text{m}^3$/yr. The total loading can be calculated as

$$W_d = 40(6{,}070{,}000) = 2.428\times 10^8\ \frac{\text{mg}}{\text{yr}}$$

$$W_a = 24(4{,}050{,}000) = 0.972\times 10^8\ \frac{\text{mg}}{\text{yr}}$$

The total phosphorus concentration can be computed as

$$p = \frac{2.428\times 10^8 + 0.972\times 10^8}{1{,}554{,}000 + 12(4050000)} = 3.44\frac{\text{mg}}{\text{m}^3}$$

**36.1** Terminal kinetic losses might be justified by assuming that the recycle rate from non-living organic matter is slow relative to the other model rates. Terminal settling losses might be justified if the water were always oxygenated. This would tend to diminish the feedback of both nitrogen and phosphorus. In addition, low flows might also support this assumption because low flow conditions would tend to diminish scour of bottom sediments.

If the assumptions were erroneous, it would mean that the losses would be fed back into the available nutrient pools. This would tend to allow growth to persist longer.

**36.2**

$$a = 500\frac{\text{g - dry}}{\text{m}^2}10\frac{\text{mgChl}a}{\text{gC}}0.4\frac{\text{gC}}{\text{g - dry}}\frac{1}{1\,\text{m}} = 2000\frac{\text{mgChl}a}{\text{m}^3}$$