Updated: 25 September 2017

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CEE 577: Surface Water Quality Modeling

Lecture #6

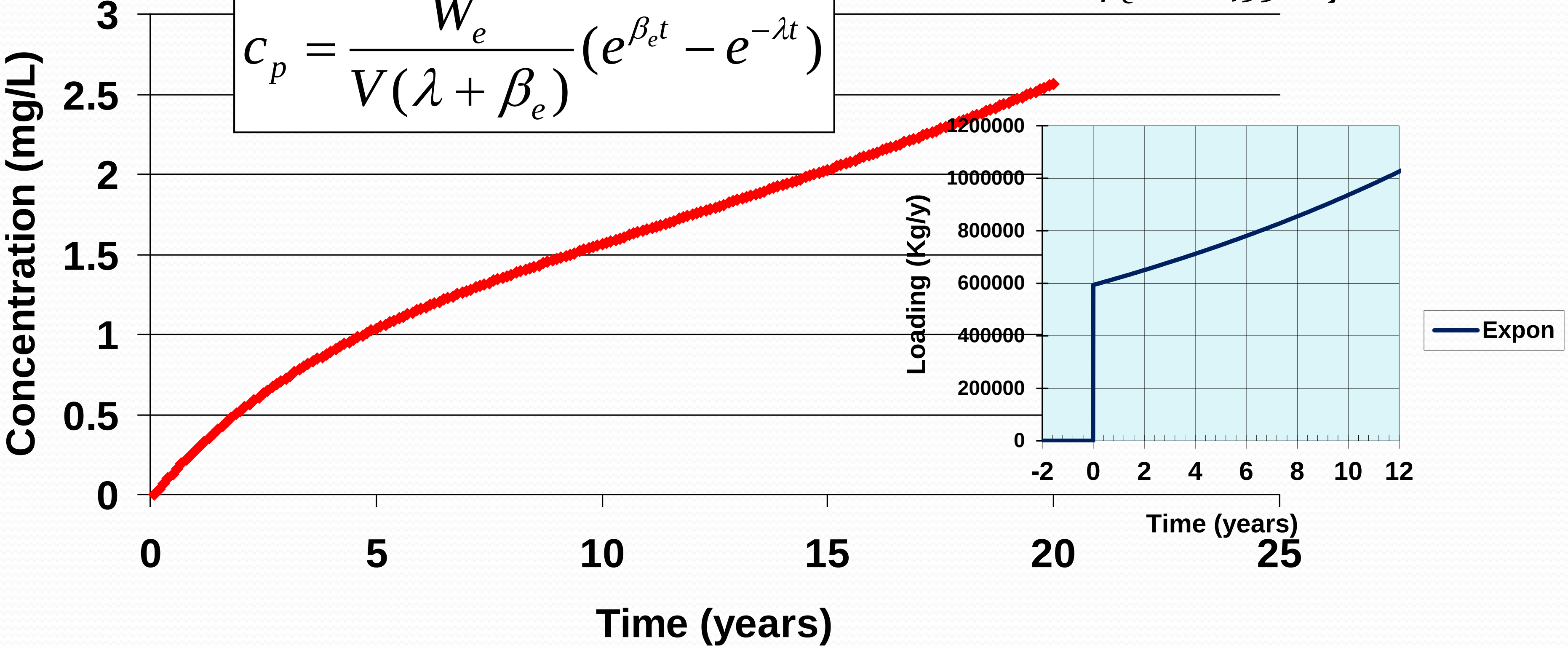
(particular solutions, cont.)

Chapra L4 (cont.)

Exponential Loading

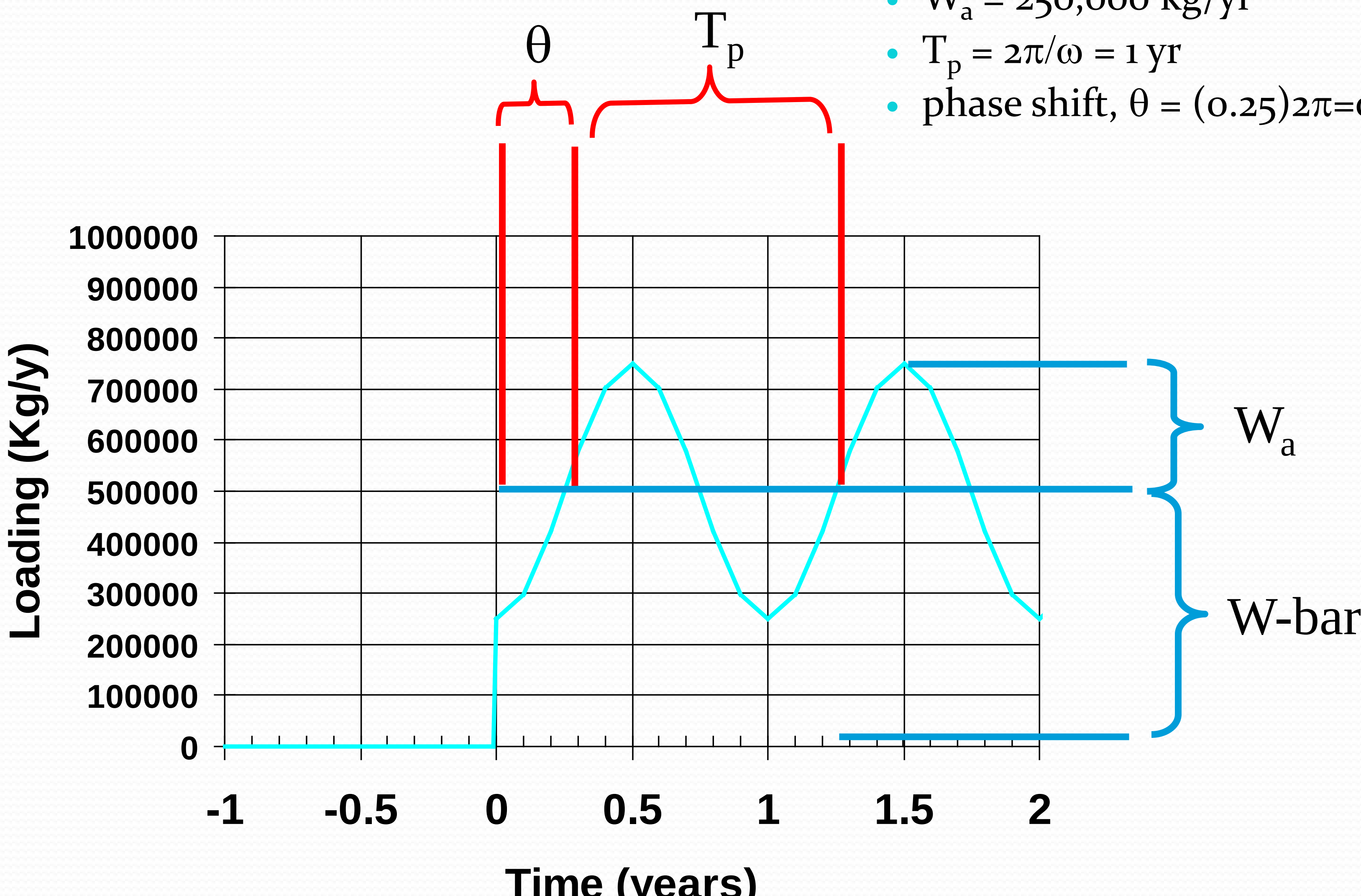
- $W(t) = W_e e^{\beta_e t}$
  - W_e = 1625 kg/d
  - β_e = 0.04558 /yr

$$c_p = \frac{W_e}{V(\lambda + \beta_e)}\left(e^{\beta_e t} - e^{-\lambda t}\right)$$



Sinusoidal Loading

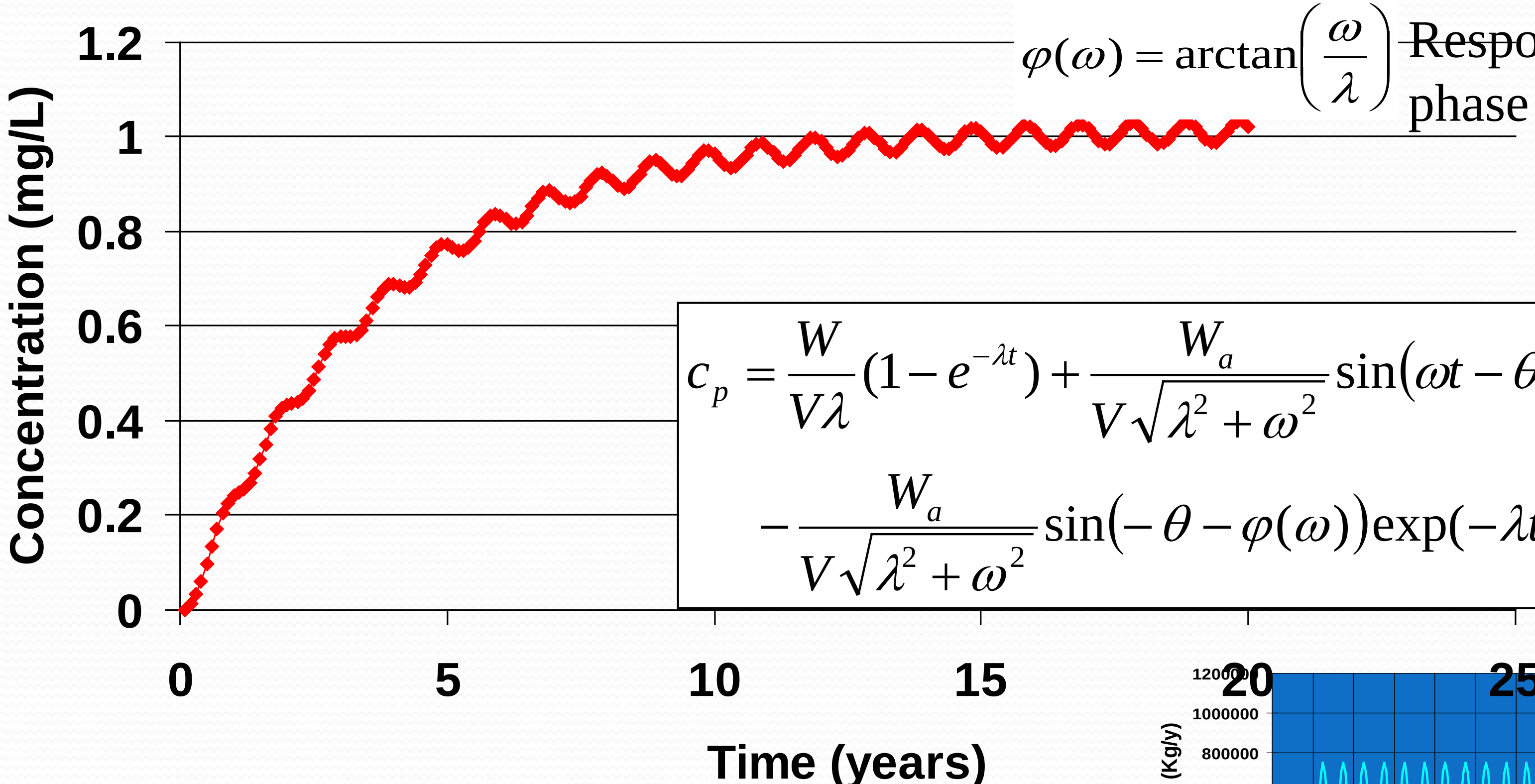
- $W(t) = \text{W-bar} + W_a \sin(\omega t - \theta)$
  - W-bar= 500,000 kg/yr
  - W_a = 250,000 kg/yr
  - $T_p = 2\pi/\omega = 1$ yr
  - phase shift, $\theta = (0.25)2\pi = 0.5\pi$



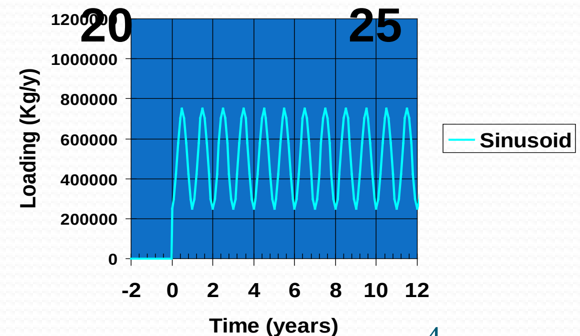
Sinusoidal Loading

W-bar= 500,000 kg/yr
W_a = 250,000 kg/yr
$T_p = 2\pi/\omega = 1$ year
phase shift , $\theta = 0.5\pi$

$$\varphi(\omega) = \arctan\left(\frac{\omega}{\lambda}\right)$$ Response phase shift



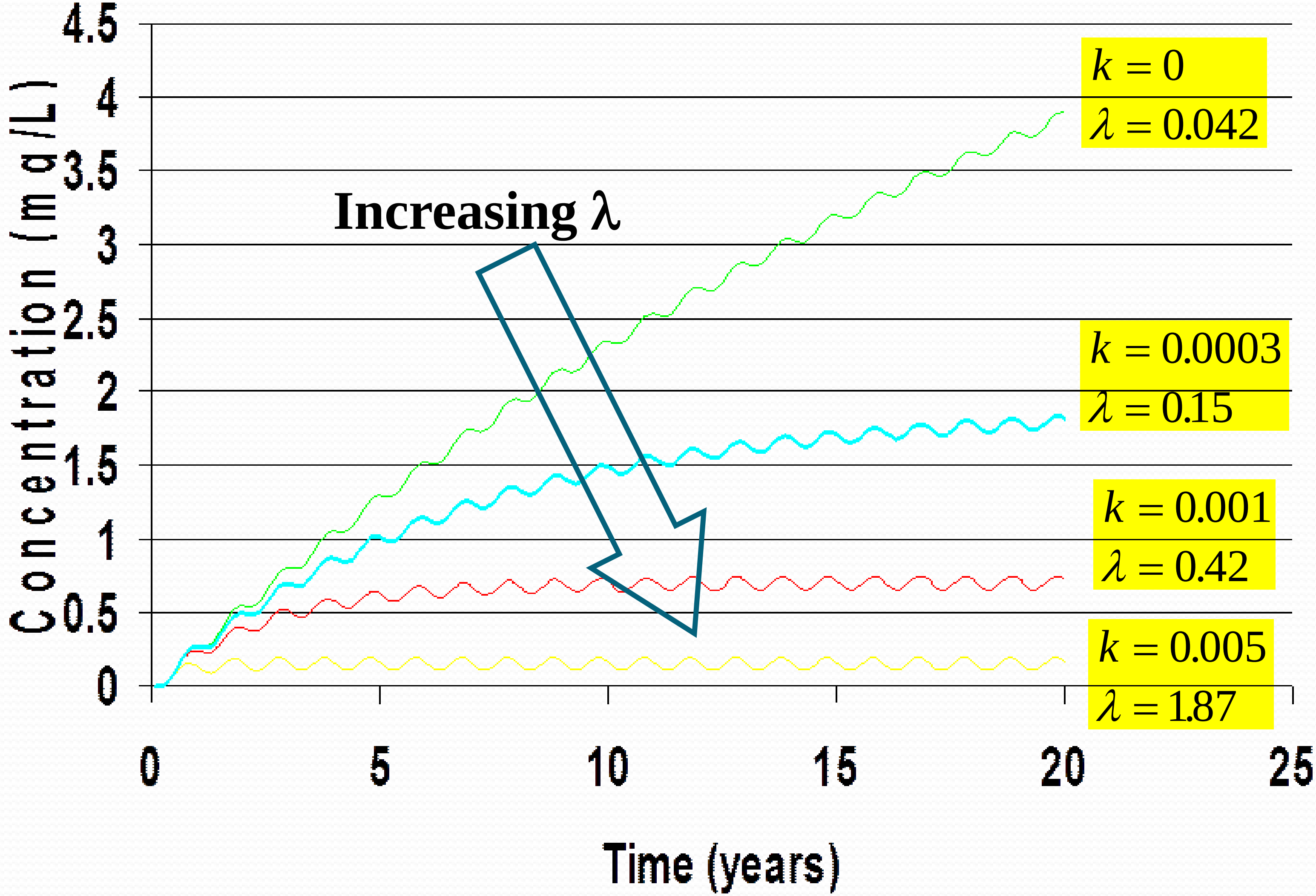
$$c_p = \frac{W}{V\lambda}(1-e^{-\lambda t}) + \frac{W_a}{V\sqrt{\lambda^2+\omega^2}}\sin\left(\omega t - \theta - \varphi(\omega)\right)$$
$$-\frac{W_a}{V\sqrt{\lambda^2+\omega^2}}\sin\left(-\theta - \varphi(\omega)\right)\exp(-\lambda t)$$



Return

Sinusoidal Loading

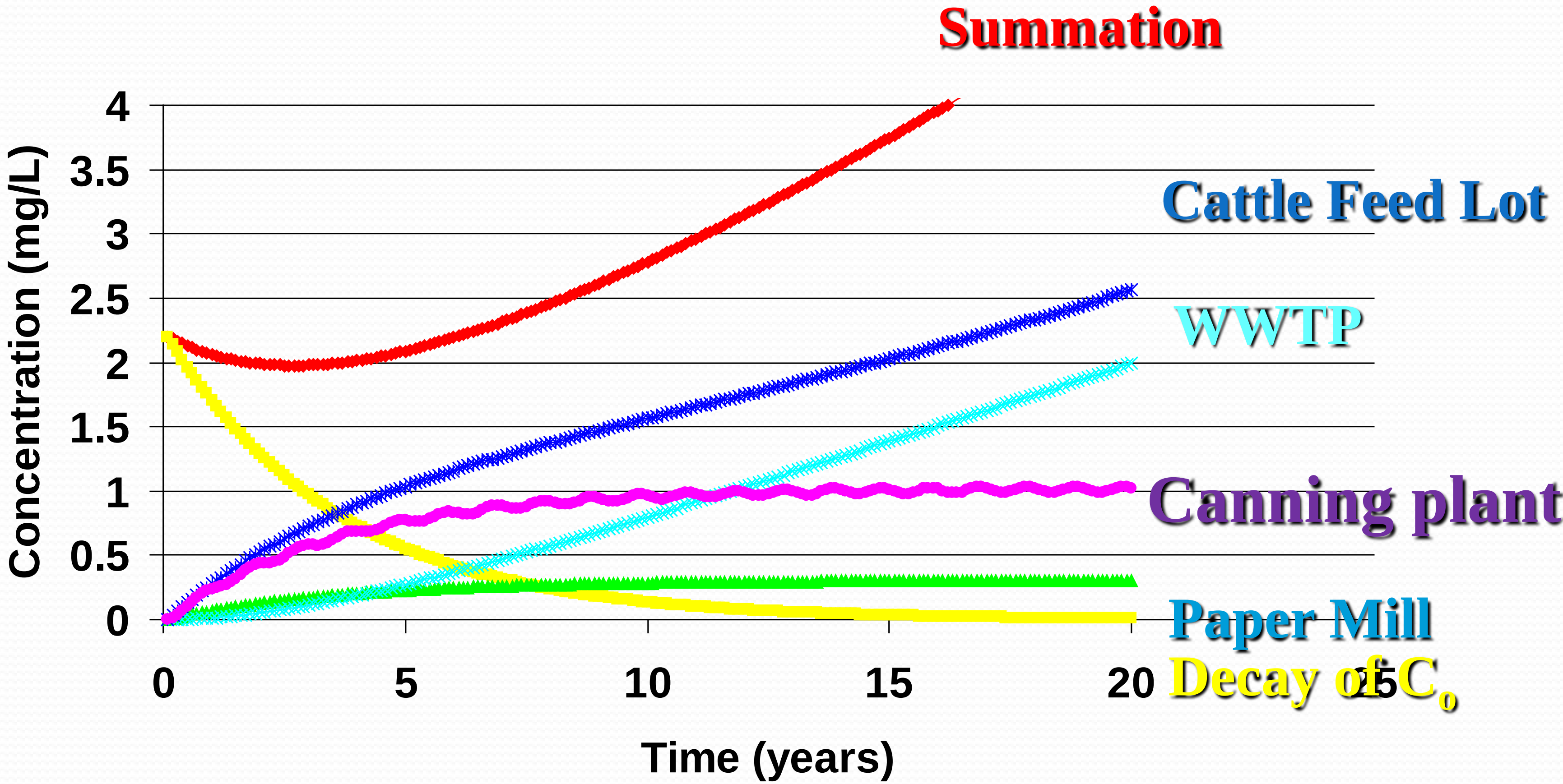
$Q=2x10^5\ m^3/d$
$A=1.1x10^8\ m^2$
$V=1.75x10^9\ ^3$



Example (similar to: 11.1 from Reckhow & Chapra)

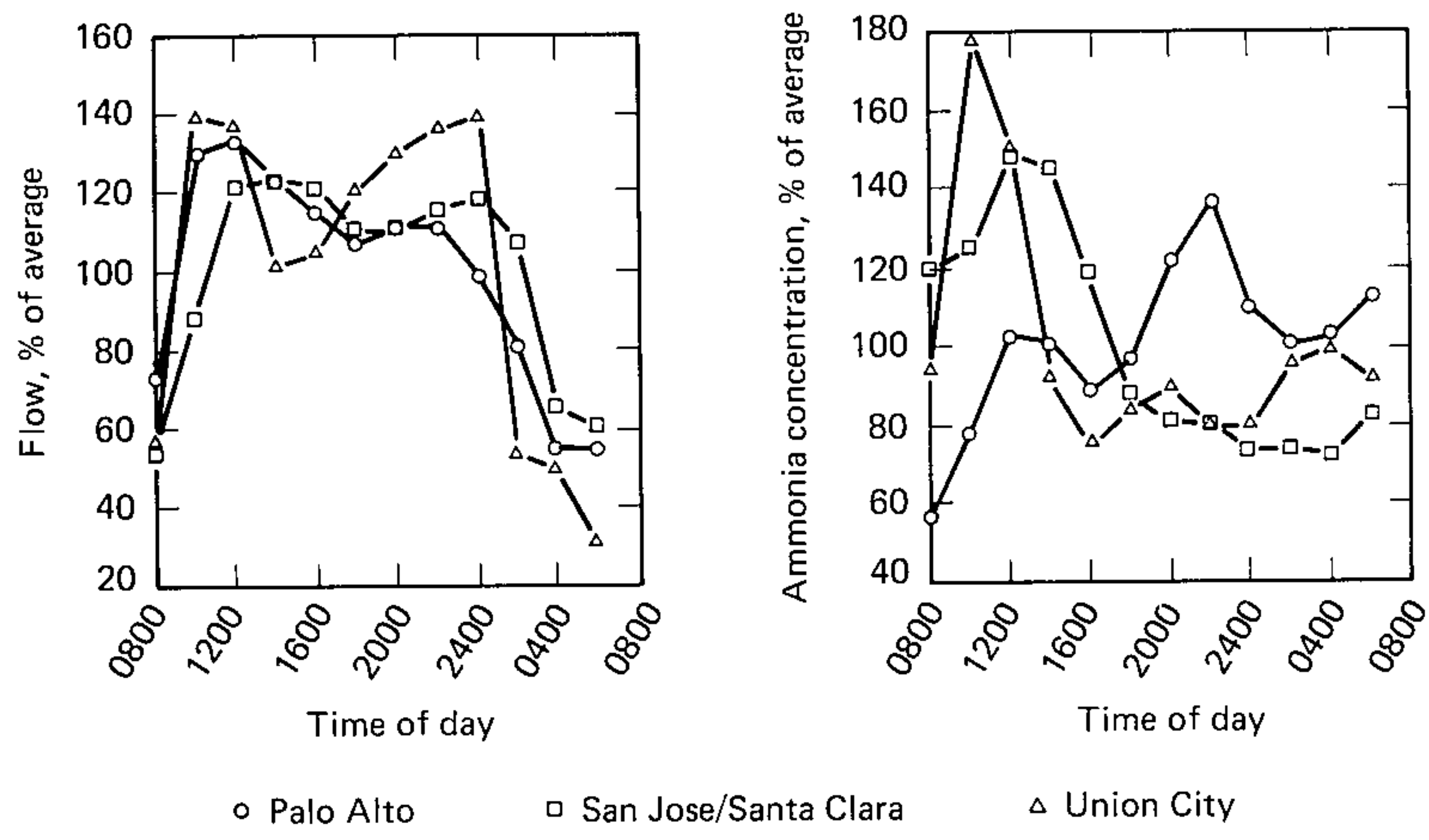
- Green Lake & Happy Valley
  - Hydraulic Parameters
    - $Q=20x10^6\ m^3/yr$, $V=100x10^6\ m^2$, $A_s=10x10^6\ m^2$, $H=10m$
  - Decay: k=1.05/yr
  - Loading
    - local WWTP: $0.115x10^4$ g/capita/yr, 20,000 people (long term, but at t=0, WW is pumped to regional plant)
    - new paper mill: $50x10^6$g/yr
    - new cattle feed lot: 150 animals, increasing by 100 cattle each year, $0.1x10^6$ g/animal
    - New scenario: regional WWTP cannot accept new WW, town of Happy Valley is growing exponentially at 0.3/yr
    - New canning plant: annual cycle, avg=$30x10^6$ g/yr
      - max on Oct 1; min on Apr 1 (half of average)

Summation of Loading



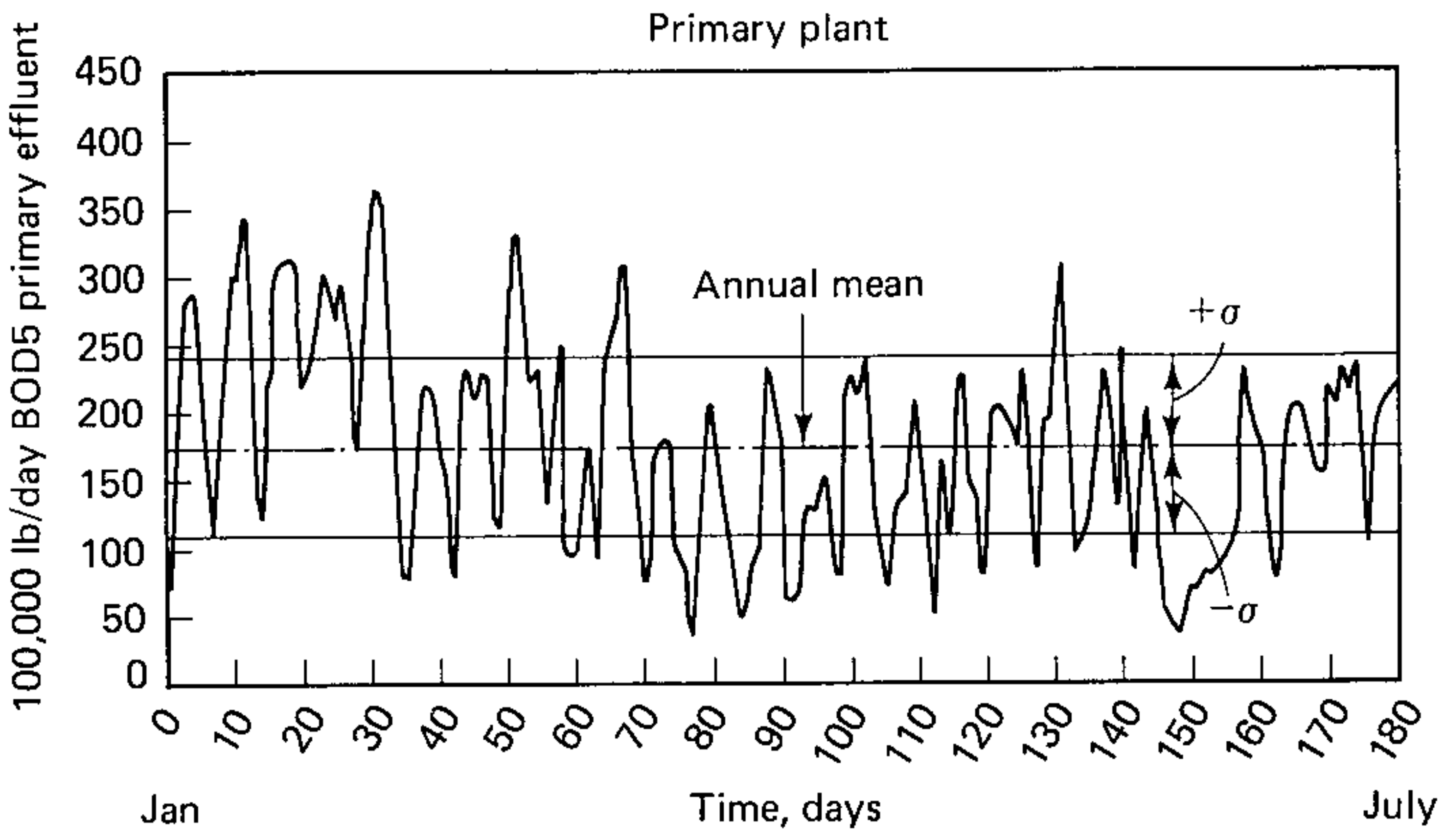
WWTP: dirunal variations

- Figures 1.6 a & b, from Thomann & Mueller



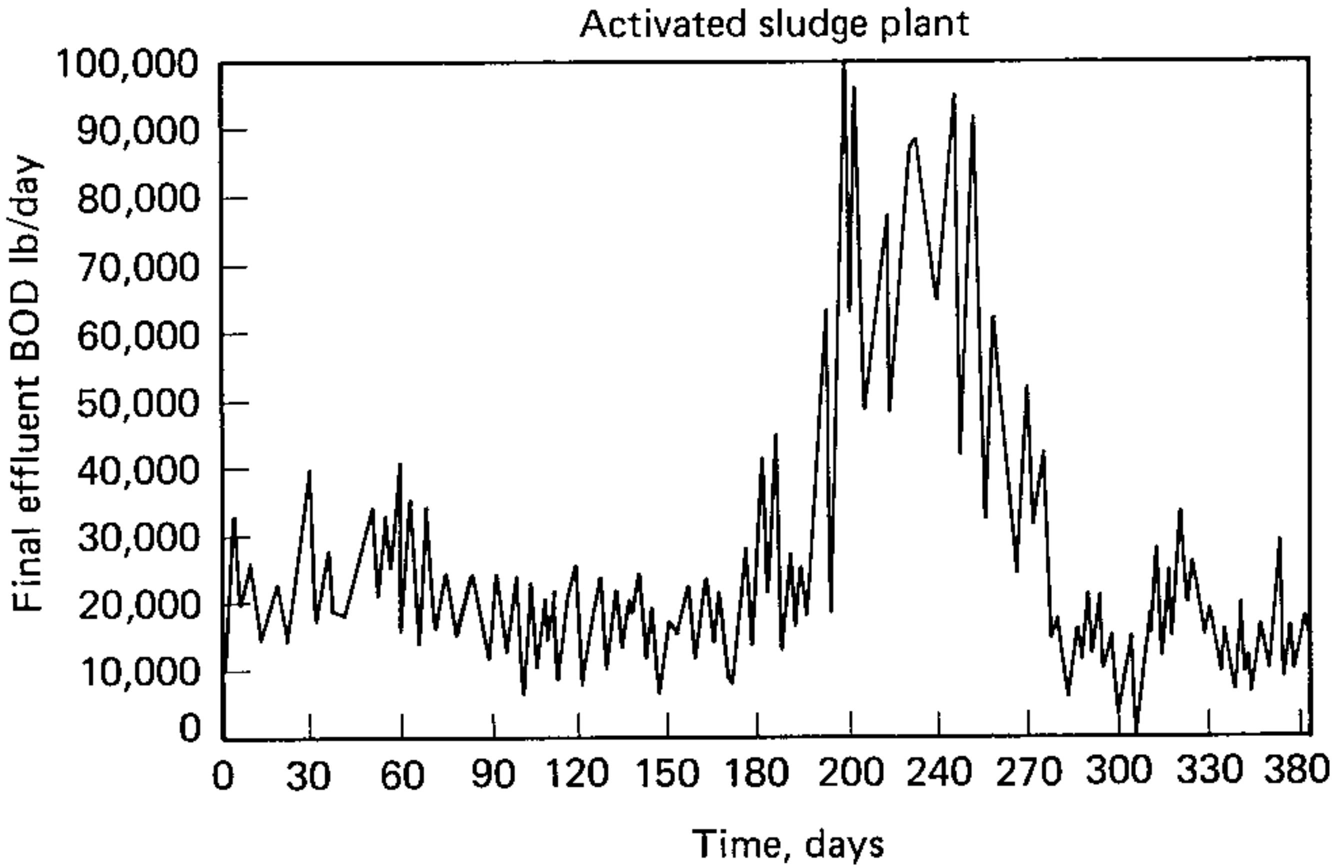
WWTP: weekly variations

- Figure 1.6 c, from Thomann & Mueller



WWTP: Seasonal Variations

- Figure 1.6 d, from Thomann & Mueller



Next: Cultural Eutrophication

- Many correlated WQ problems
  - Floating mats of algae
  - Low DO
  - High P?

- To next lecture