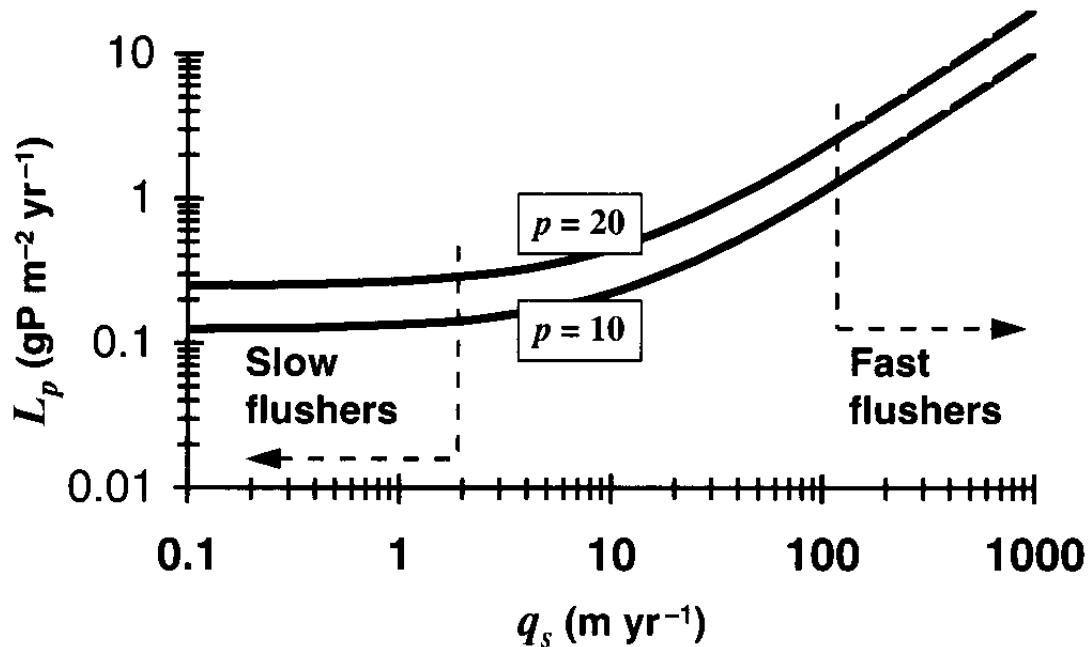# CEE 577: Surface Water Quality Modeling

Lecture #19

Streeter-Phelps: Nitrogen, Photosynthesis/Respiration

(Chapra, L23, L24)

Loading & Overflow Model

$$P = \frac{L}{11.6 + 1.2 q_s}$$

From Chapra (pg 538)

Extended Streeter Phelps

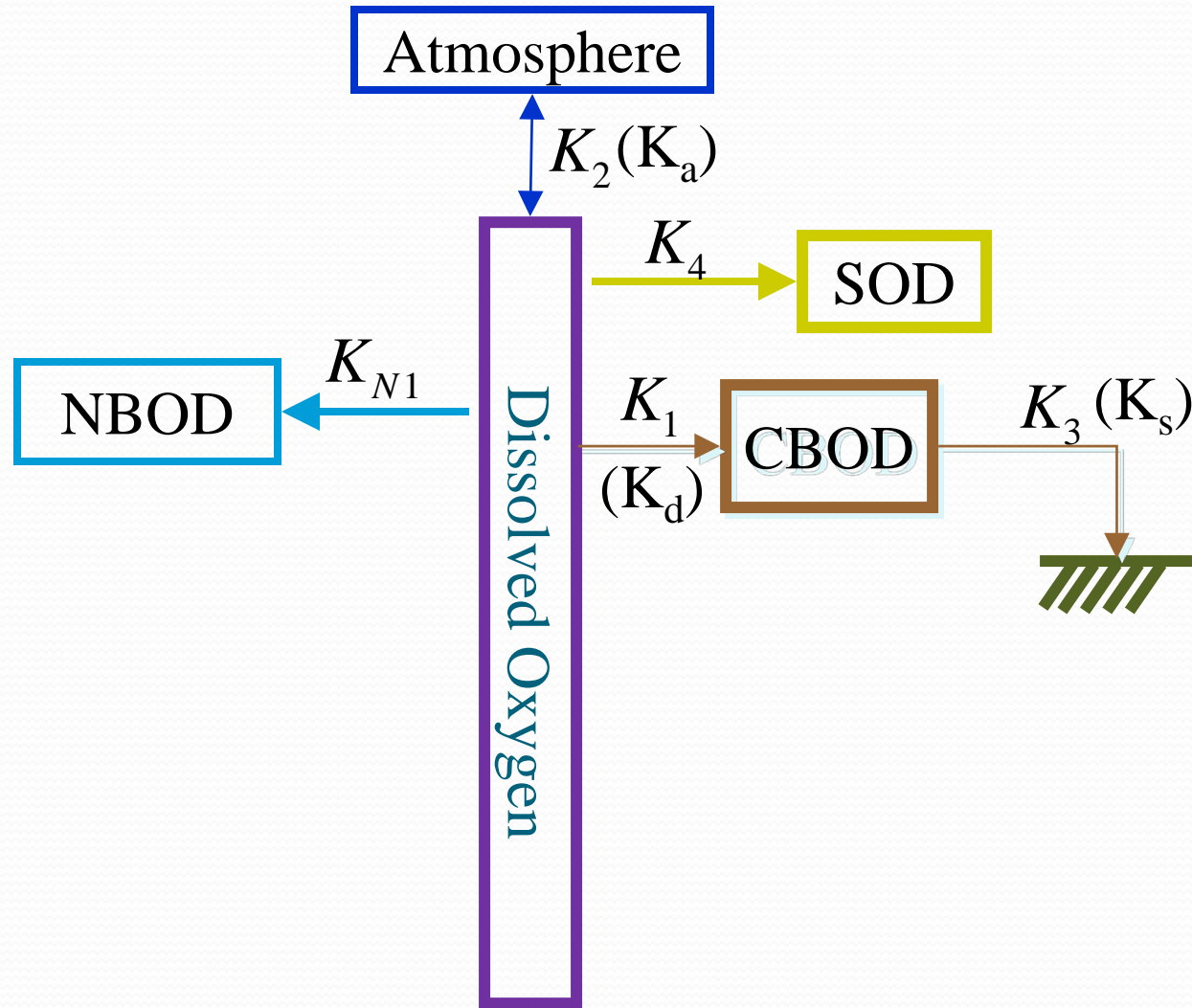$$D = D_o e^{-k_a t} + \frac{k_d L_o}{k_a - k_r}\left(e^{-k_r t} - e^{-k_a t}\right)$$

#1   **#2**

$$+ \frac{k_n L_{No}}{k_a - k_n}\left(e^{-k_n t} - e^{-k_a t}\right)$$

#3

$$\textbf{#4} \quad + \frac{-P + R + \left(\dfrac{S'_B}{H}\right)}{k_a}\left(1 - e^{-k_a t}\right)$$

$$\textbf{#5} \quad + \frac{k_d S_d}{k_r k_a}\left(1 - e^{-k_a t}\right) - \frac{k_d S_d}{k_r\left(k_a - k_r\right)}\left(e^{-k_r t} - e^{-k_a t}\right)$$

$$\textbf{#6} \quad + \frac{k_n S_{Nd}}{k_n k_a}\left(1 - e^{-k_a t}\right) - \frac{k_n S_{Nd}}{k_n\left(k_a - k_n\right)}\left(e^{-k_n t} - e^{-k_a t}\right)$$
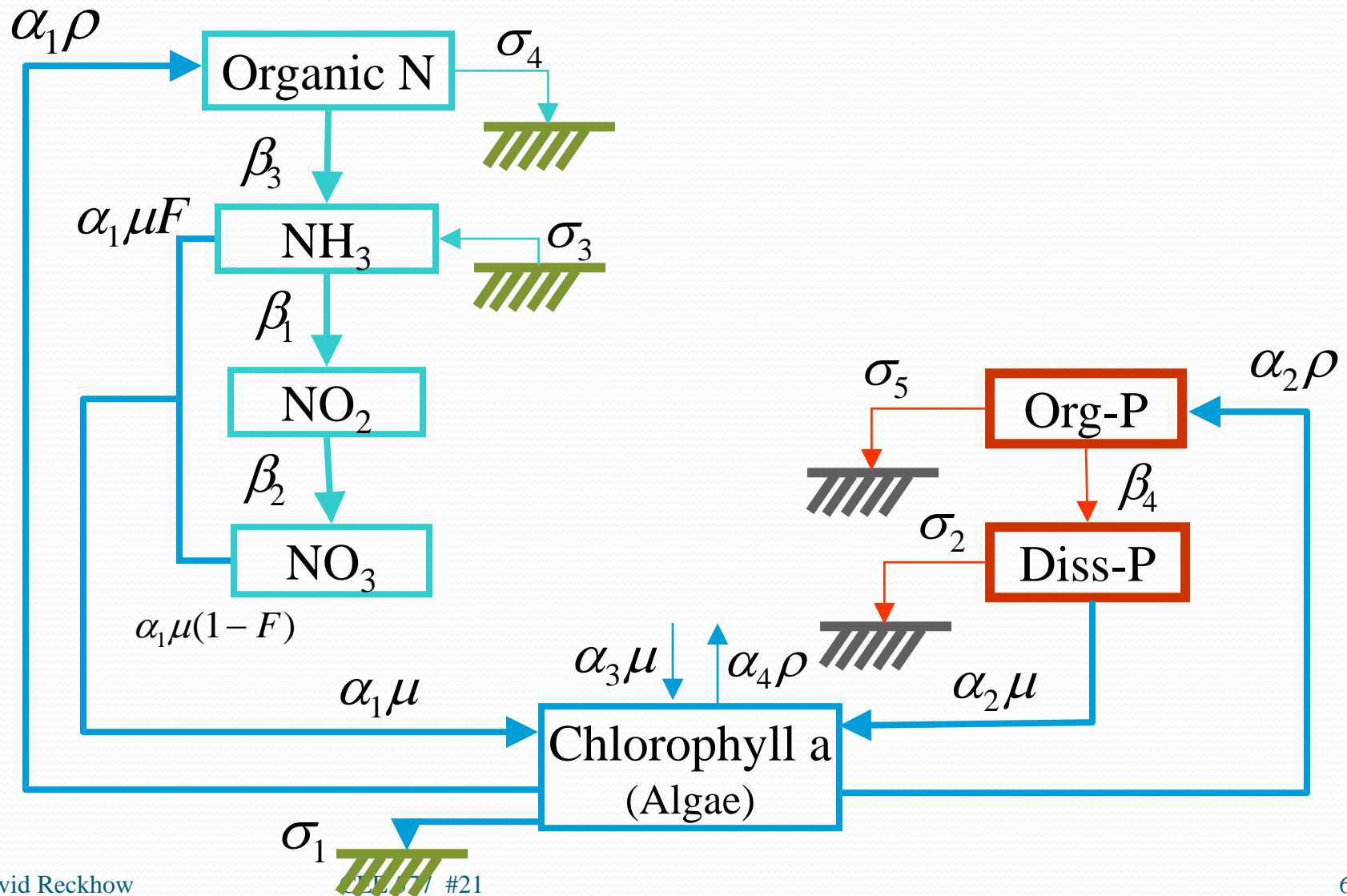
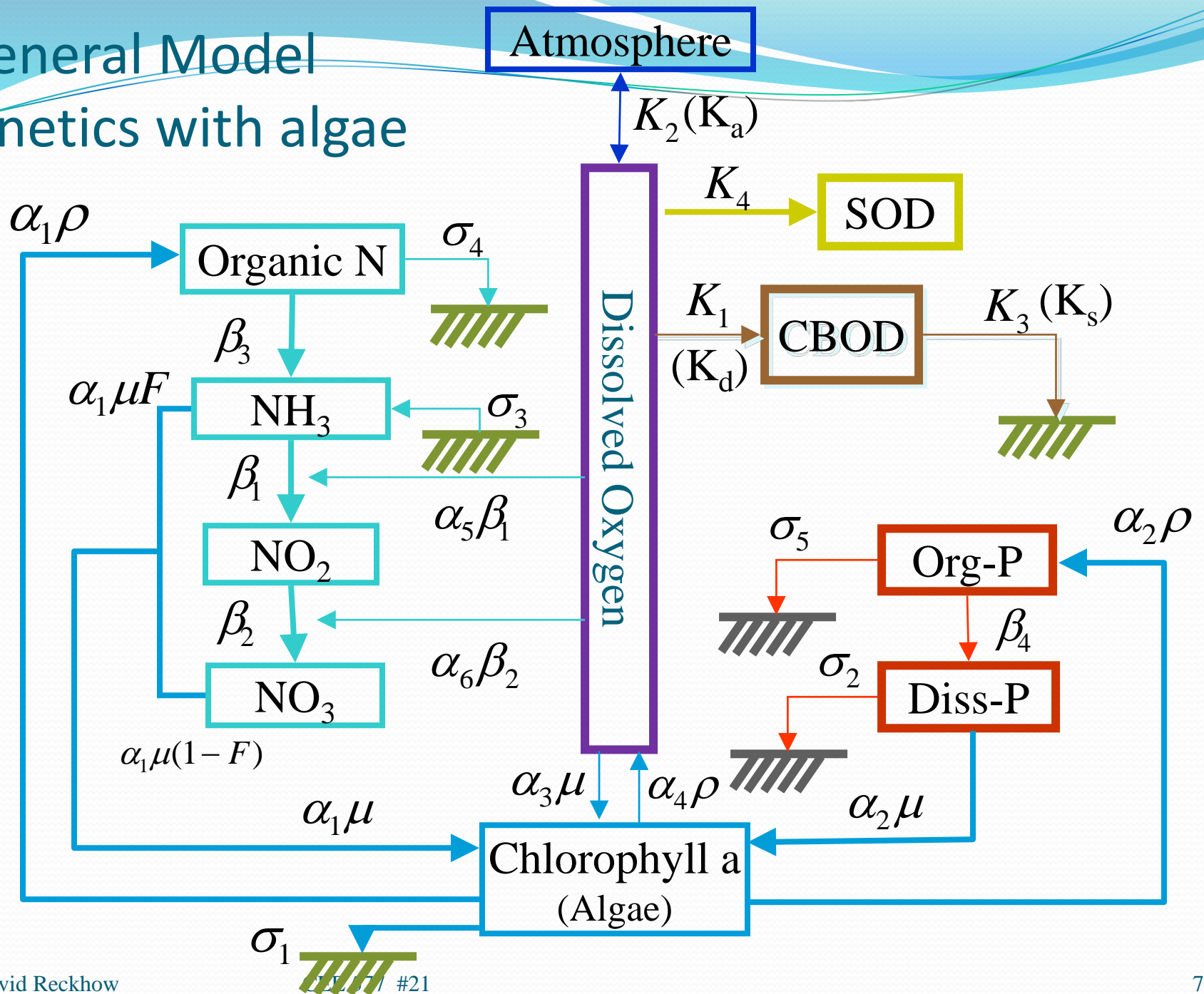# General Model Kinetics

Loading & Overflow Model

$$P = \frac{L}{11.6 + 1.2q_s}$$

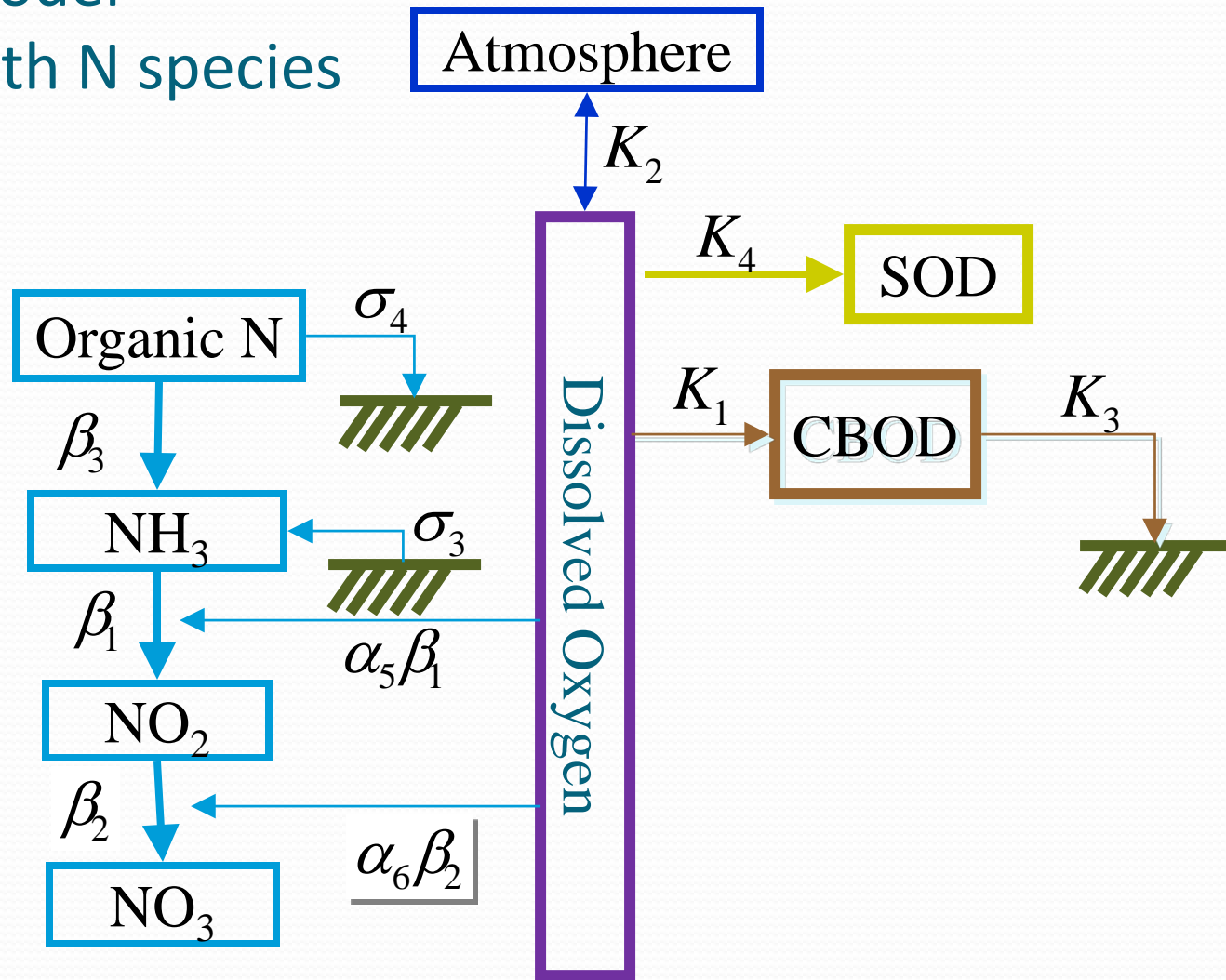From Chapra (pg 538)

Mechanistic Algal Model

General Model Kinetics with algae

Atmosphere

$K_2 (K_a)$

Dissolved Oxygen

K_4 → SOD

$K_1 (K_d)$ → CBOD → $K_3 (K_s)$

$\alpha_1 \rho$

Organic N → σ_4

β_3

$\alpha_1 \mu F$

NH$_3$ ← σ_3

β_1

$\alpha_5 \beta_1$

NO$_2$

β_2

$\alpha_6 \beta_2$

NO$_3$

$\alpha_1 \mu (1-F)$

$\alpha_1 \mu$

σ_5

Org-P → $\alpha_2 \rho$

β_4

σ_2

Diss-P

$\alpha_3 \mu$ $\alpha_4 \rho$

$\alpha_2 \mu$

Chlorophyll a (Algae)

σ_1

David Reckhow   #21   7

General Model
Kinetics with N species

Nitrogen Modeling

- Organic Nitrogen (N_4)

$$\frac{dN_4}{dt} = \alpha_1 \rho A - \beta_3 N_4 - \sigma_4 N_4$$

Org-N settling rate (d^{-1})
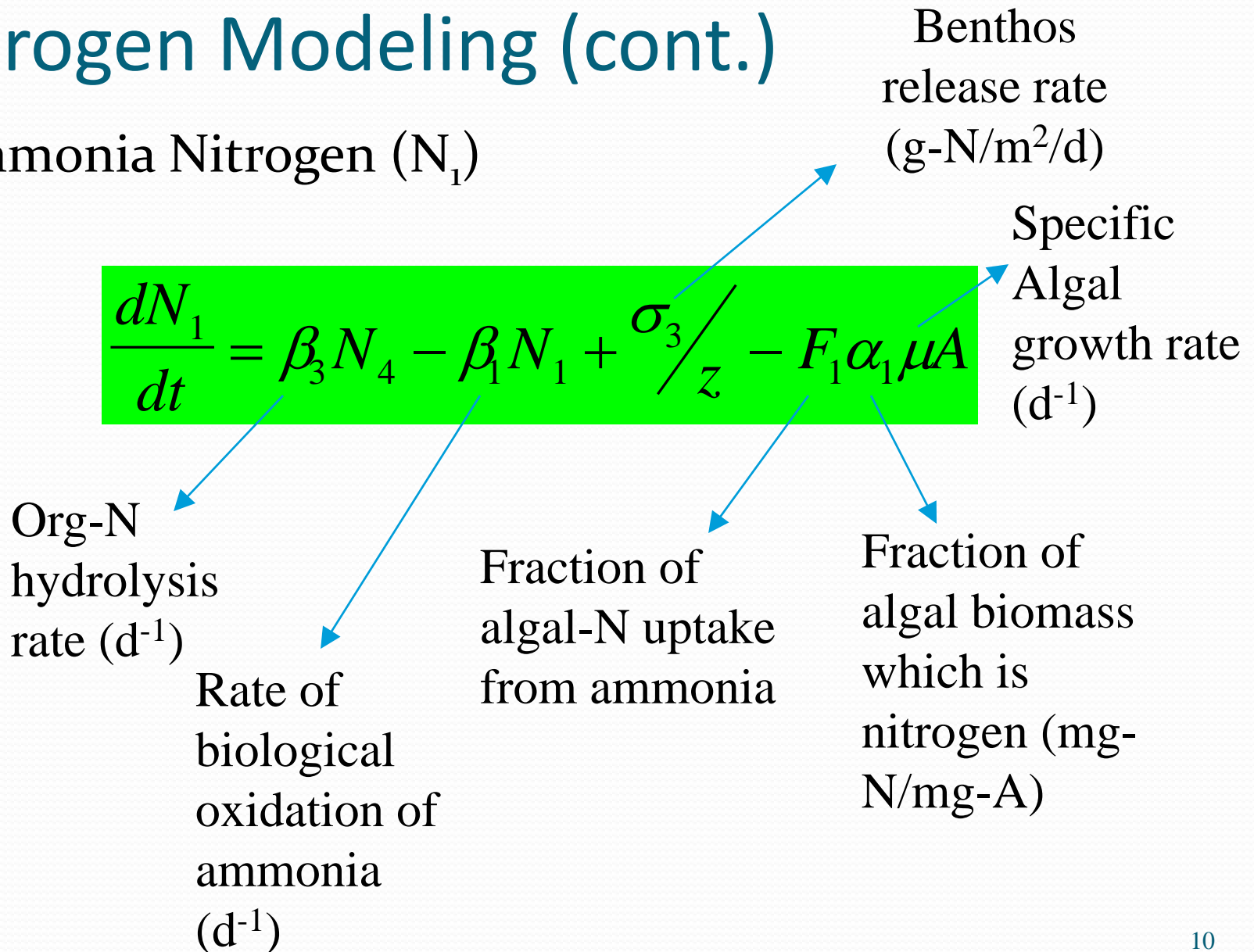
Fraction of algal biomass which is nitrogen (mg-N/mg-A)

Algal respiration rate (d^{-1})

Algal biomass (mg/L)

Org-N hydrolysis rate (d^{-1})

Nitrogen Modeling (cont.)

Benthos release rate $(g\text{-}N/m^2/d)$

- Ammonia Nitrogen (N_1)

$$\frac{dN_1}{dt} = \beta_3 N_4 - \beta_1 N_1 + \frac{\sigma_3}{z} - F_1 \alpha_1 \mu A$$

Specific Algal growth rate (d^{-1})

Org-N hydrolysis rate (d^{-1})

Rate of biological oxidation of ammonia (d^{-1})

Fraction of algal-N uptake from ammonia

Fraction of algal biomass which is nitrogen $(mg\text{-}N/mg\text{-}A)$

Nitrogen Modeling (cont.)

- Nitrite (N_2)

$$\frac{dN_2}{dt} = \beta_1 N_1 - \beta_2 N_2$$

Rate of biological oxidation of ammonia (d^{-1})

Rate of biological oxidation of nitrite (d^{-1})

Nitrogen Modeling (cont.)

- Nitrate (N_3)

$$\frac{dN_3}{dt} = \beta_2 N_2 - \left(1 - F_1\right)\alpha_1 \mu A$$
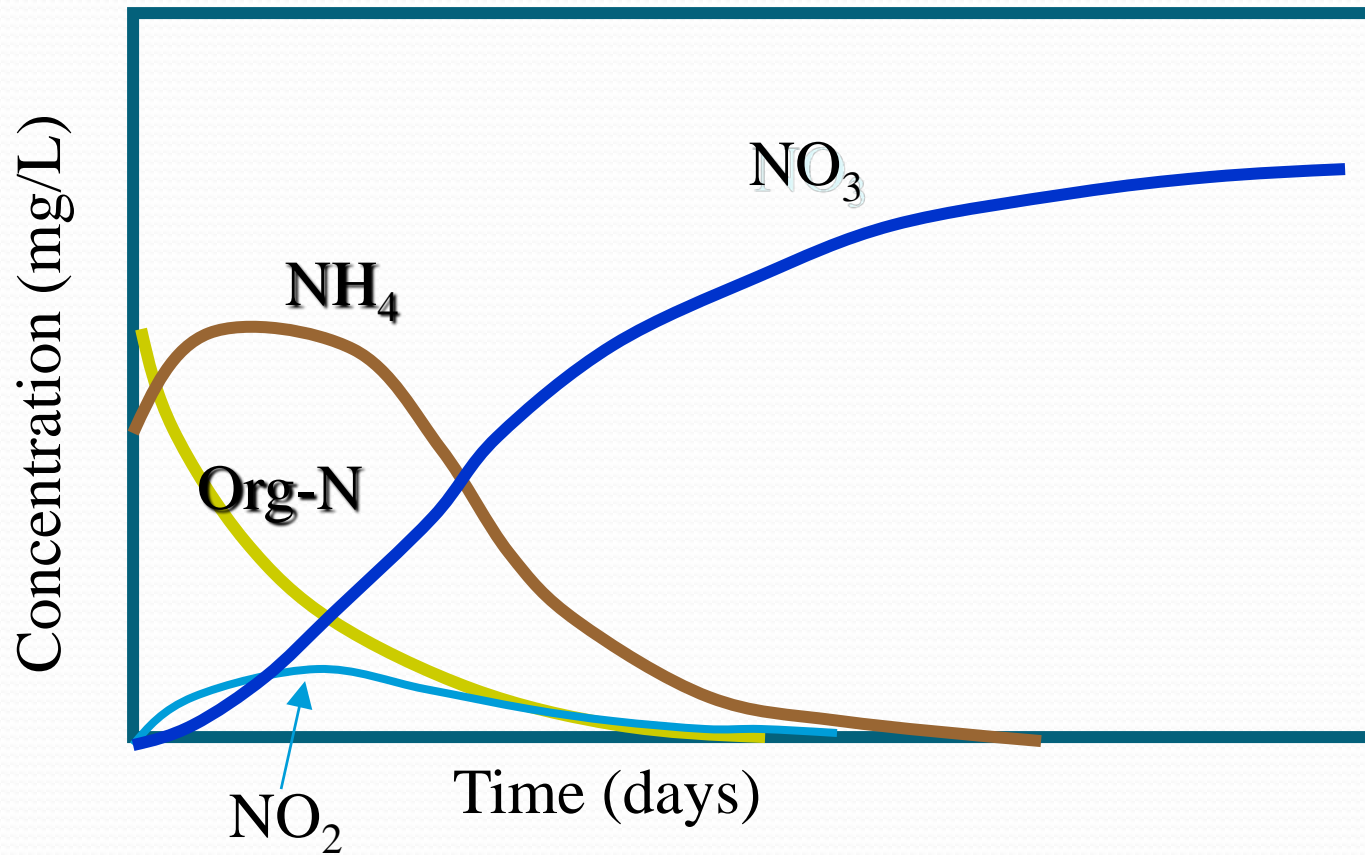
Specific Algal growth rate (d^{-1})

Rate of biological oxidation of nitrite (d^{-1})

Fraction of algal-N uptake from ammonia

Fraction of algal biomass which is nitrogen (mg-N/mg-A)

Nitrogen Modeling (cont.)

Nitrogen Modeling (cont.)

- Inhibition of Nitrification at low D.O.

$$CORDO = 1 - e^{-KNITRF*D.O.}$$

EPA

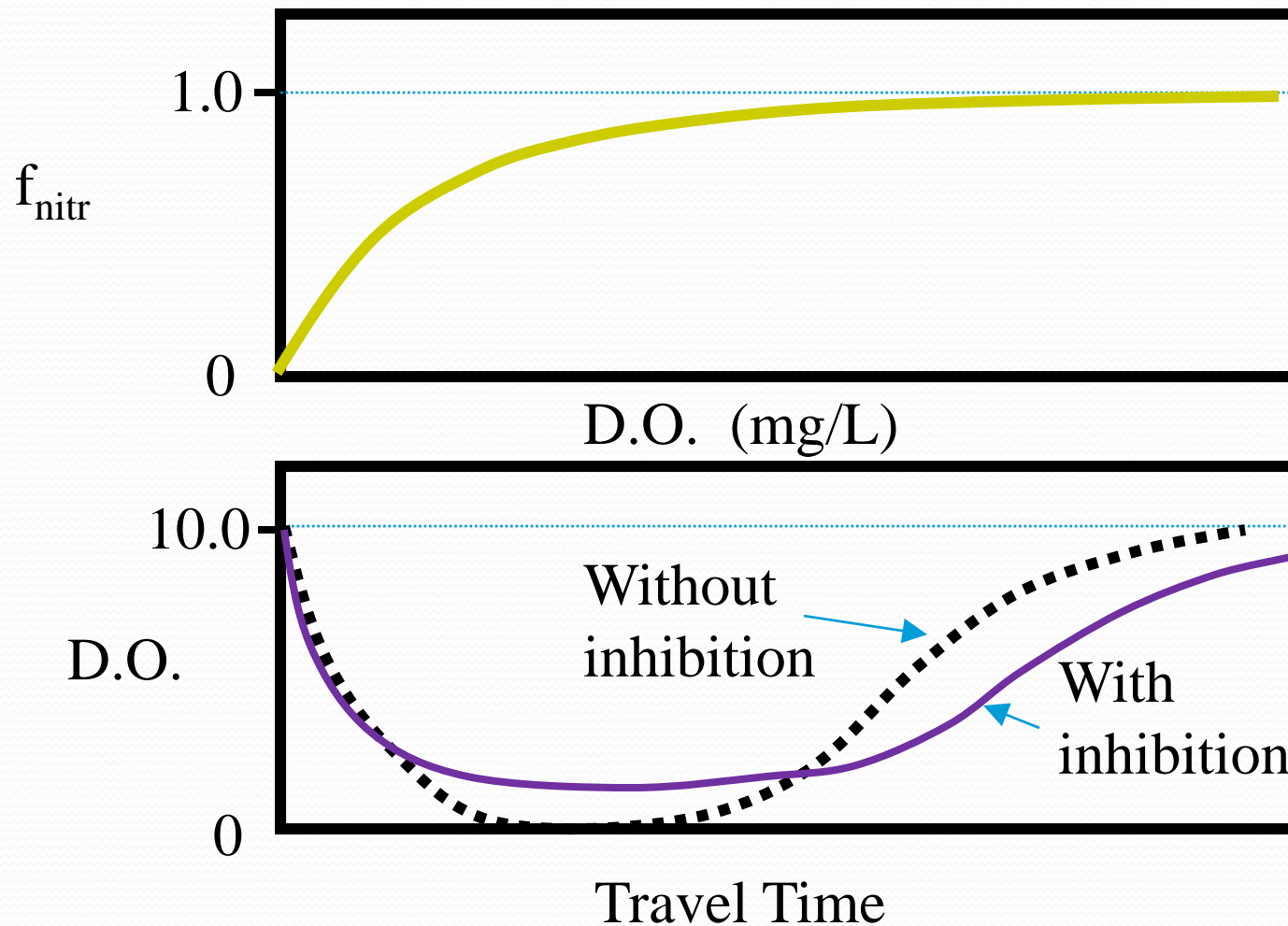Nitrification correction factor

Nitrification inhibition coefficient (0.6-0.7 L/mg)

$$f_{nitr} = 1 - e^{-k_{nitr}o}$$

Chapra

Impact of nitrification inhibition

- [To next lecture](#)