

The Phosphorus Story

Local, Regional, & National Impacts

February 24, 2006

Presented at: Hawk Creek Meeting

Presented by: Kenneth Sedmak,
Donohue & Associates, Inc.

Produced by: Amber J. Marzahl,
Donohue & Associates, Inc.



Why Remove Phosphorus?

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

➤ Eutrophication

- Impacts on Eutrophication
- Where can it Occur?
 - Watersheds
 - Impoundments
 - International Impacts

➤ Transportation of Phosphorus

- Soil / Water
- Plants / Animals



Eutrophication

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



➤ Trophic States

- Oligotrophic – minimum biological activity
- Mesotrophic – more biological activity
- Eutrophic – high biological activity, loss of some species
- Hypereutrophic – highly productive, many clearwater species cannot survive

➤ Impacts of Phosphorus on Eutrophication

- Overstimulates Growth
- Restricts Recreational Activities
- Upsets Balance of Organisms

Eutrophication, cont.

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

➤ Where can Eutrophication Occur?

- Watersheds

- National – Mississippi River Basin

- Local – Hawk Creek Watershed

- Impoundments

- Regional - Minnesota River at Shakopee

- National - Lake Pepin, MN

- International Impacts

- Hypoxic Zone “Dead Zone” – Gulf of Mexico



Mississippi River Basin

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



US EPA



Mississippi River Basin

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



USGS

80-90% of Lake Pepin's Sediment Load Comes From the Minnesota River



Hawk Creek Watershed

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Minnesota Pollution Control Agency



Impoundments

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

- Regional - Last 22 Miles of Minnesota River at Shakopee
- National - Lake Pepin, MN



Last 22 Miles: Minnesota River at Shakopee

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

➤ Turbidity & Sedimentation

- Phosphorus Attached to Sedimentation
- Inter-Related to Eutrophication



Turkey River, Iowa August 2001



Lake Pepin

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Lake Pepin

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Hypoxic Zone

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Hypoxic Zone

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Photo courtesy of NOAA



Jacques Descloitres, MODIS Land Rapid Response Team, NASA/GSFC, January 2003



Nancy Rabalais
(Louisiana Universities Marine Consortium)



Hypoxic Zone

•Why Remove Phosphorus?

- Eutrophication
 - Trophic States
 - Impacts
 - Where can it Occur?
- Transportation of Phosphorus
- Tutorial
- Phosphorus Levels
- Remove Phosphorus
 - Chemical Control
 - Biological Control
- How to Reduce?



- “Dead Zone” 8,500 mi² in 2002
 - Larger than State of Massachusetts
 - Anaerobic Conditions (without oxygen)

➤ Caused by Overabundance of Nutrients & Turbidity

- Absence of Dissolved Oxygen for Small Animals
- Turbidity Reduces Sunlight, Loss of Photosynthesis for Plant Growth
- Settling Allows Sunlight Penetration Triggering Excessive Algae Growth

Transportation of Phosphorus

•Why Remove Phosphorus?

•Eutrophication

- Trophic States
- Impacts
- Where can it Occur?

•Transportation of Phosphorus

•Tutorial

•Phosphorus Levels

•Remove Phosphorus

- Chemical Control
- Biological Control

•How to Reduce?



➤ Soil / Water

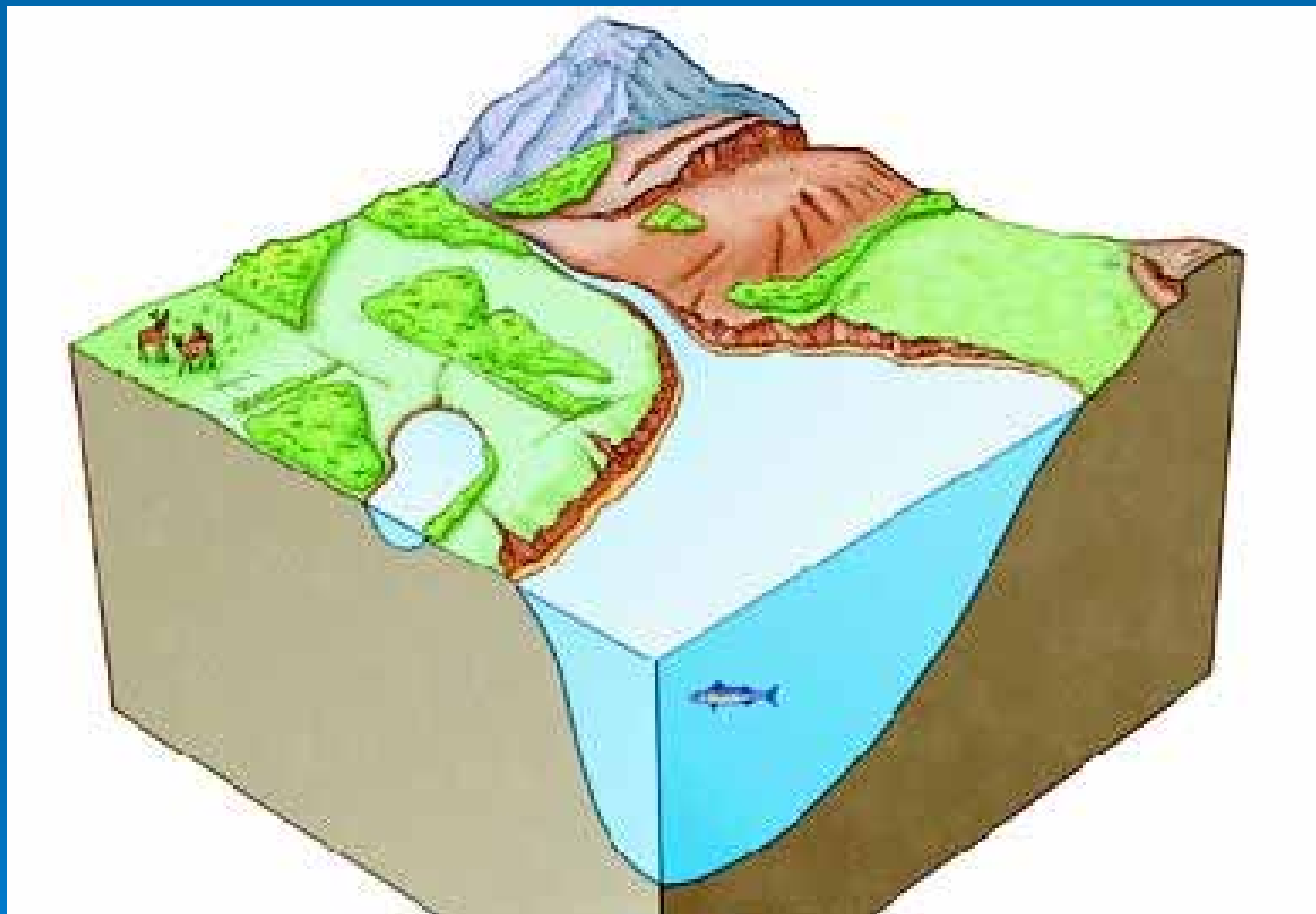
- Runoff / Leaching
- Soil Erosion
- Agricultural Fertilizers
- Onsite Sewage Systems Leaching
- Municipal Wastewater Discharge

➤ Plants / Animals

- Absorption / Consumption
- Death / Decomposition
- Animal Wastes

Tutorial

- Why Remove Phosphorus?
 - Eutrophication
 - Trophic States
 - Impacts
 - Where can it Occur?
 - Transportation of Phosphorus
- Tutorial
 - Phosphorus Levels
 - Remove Phosphorus
 - Chemical Control
 - Biological Control
 - How to Reduce?



Tutorial

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

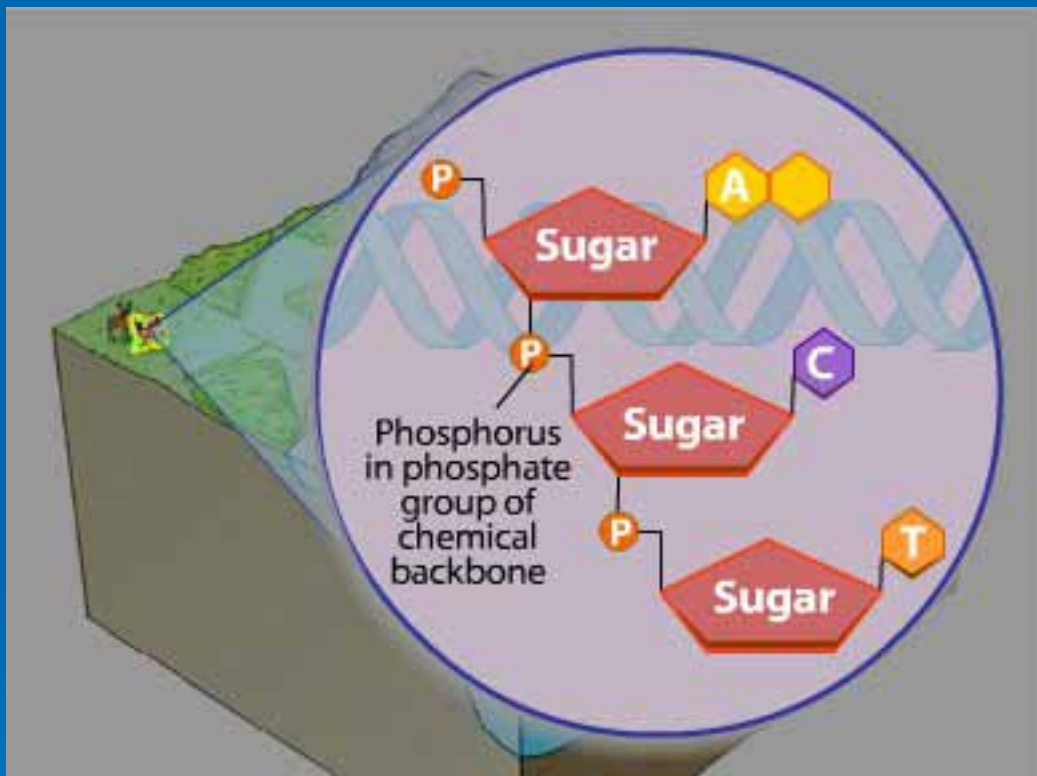
- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Tutorial

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

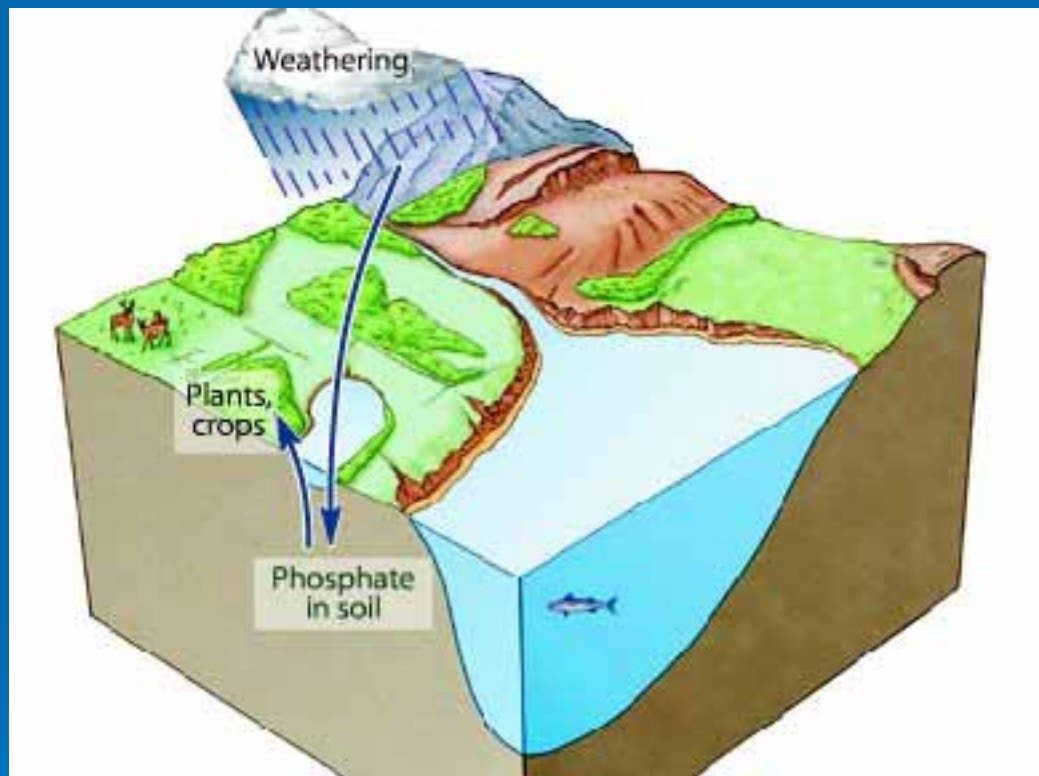
- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Tutorial

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

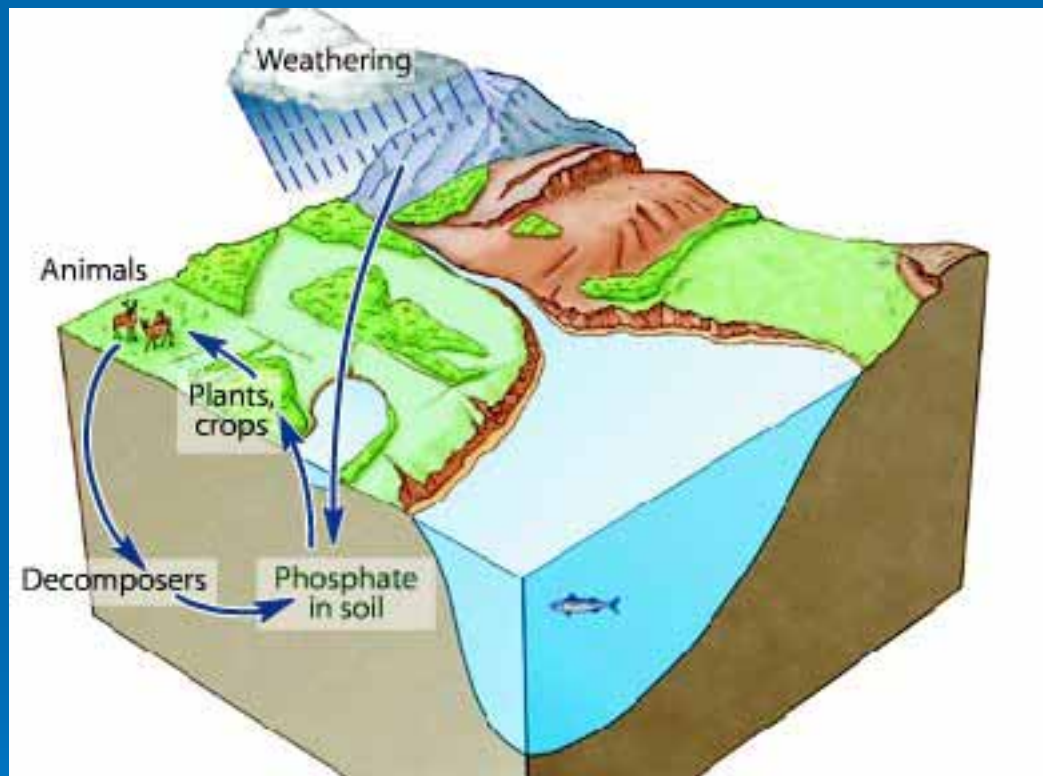
- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Tutorial

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

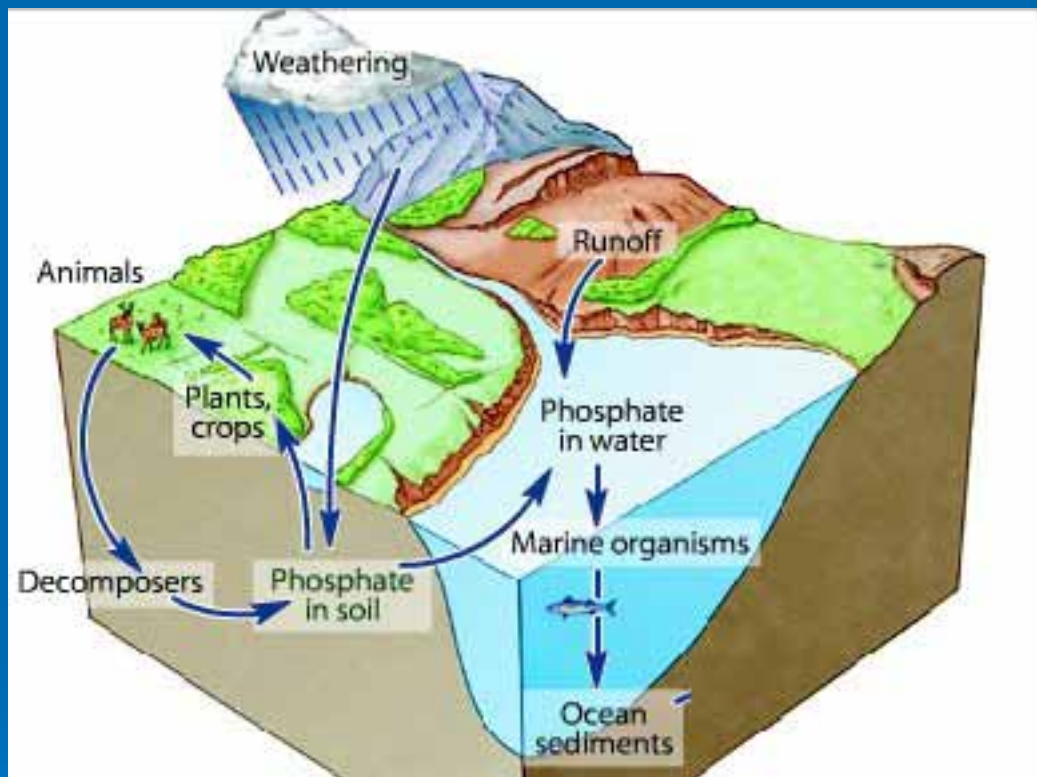
- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Tutorial

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

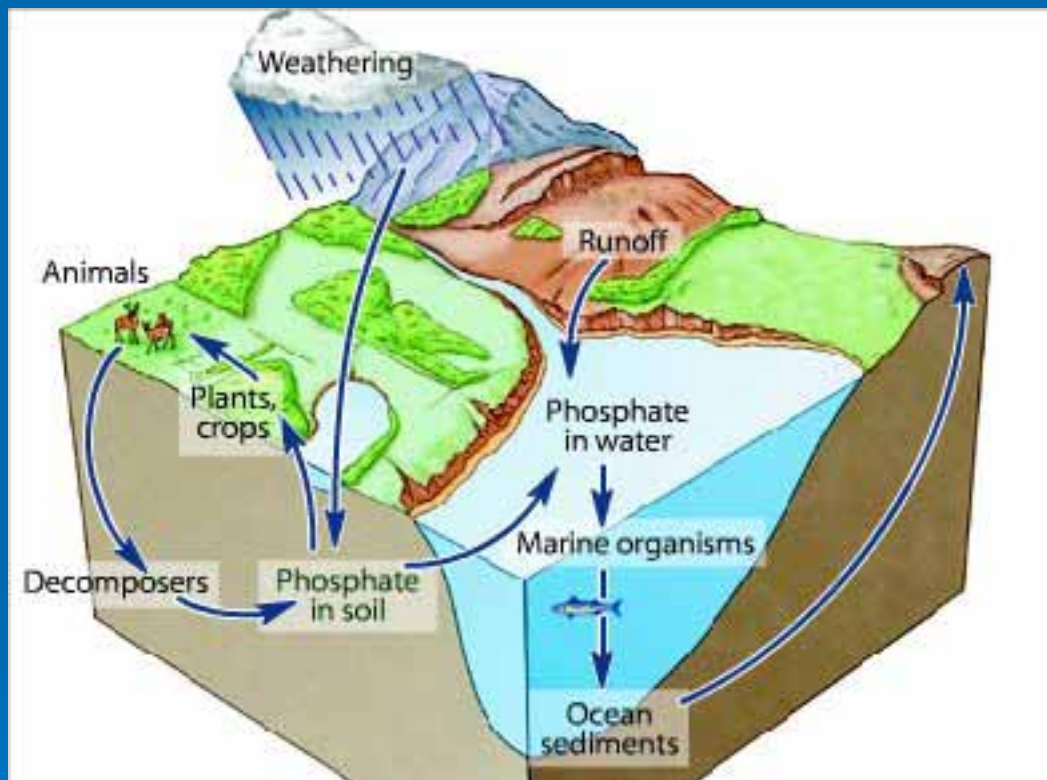
- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?



Phosphorus Levels

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

- Limiting Algae Growth

- 0.02 mg/l Phosphorus

- WWTP Effluent Limit

- 1.0 mg/l Phosphorus by 2015

- Willmar Effluent Limit

- 1.0 mg/l Phosphorus by November 2010

- Future Effluent Limits Unknown



How to Remove Phosphorus

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

- Chemical Phosphorus Control

- Definition
- Advantages / Disadvantages
- Schematic

- Biological Phosphorus Control

- Definition
- Advantages / Disadvantages
- Schematic



Chemical Phosphorus Control

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

- Addition of Metal Salt to Liquid Train
 - Alum, Ferrous Chloride, Ferric Chloride
- Metal Salts React with Dissolved Phosphorus and Settle in the Treatment Plant Clarifiers with other Wastes



Chemical Phosphorus Control

•Why Remove Phosphorus?

•Eutrophication

- Trophic States
- Impacts
- Where can it Occur?

•Transportation of Phosphorus

•Tutorial

•Phosphorus Levels

•Remove Phosphorus

- Chemical Control
- Biological Control

•How to Reduce?

➤ Advantages

- Easy to Operate
- Very Reliable
- Achieves Low Effluent Levels

➤ Disadvantages

- Chemical Costs
- Produces More Biosolids
- Reduces Alkalinity



Chemical Phosphorus Control

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

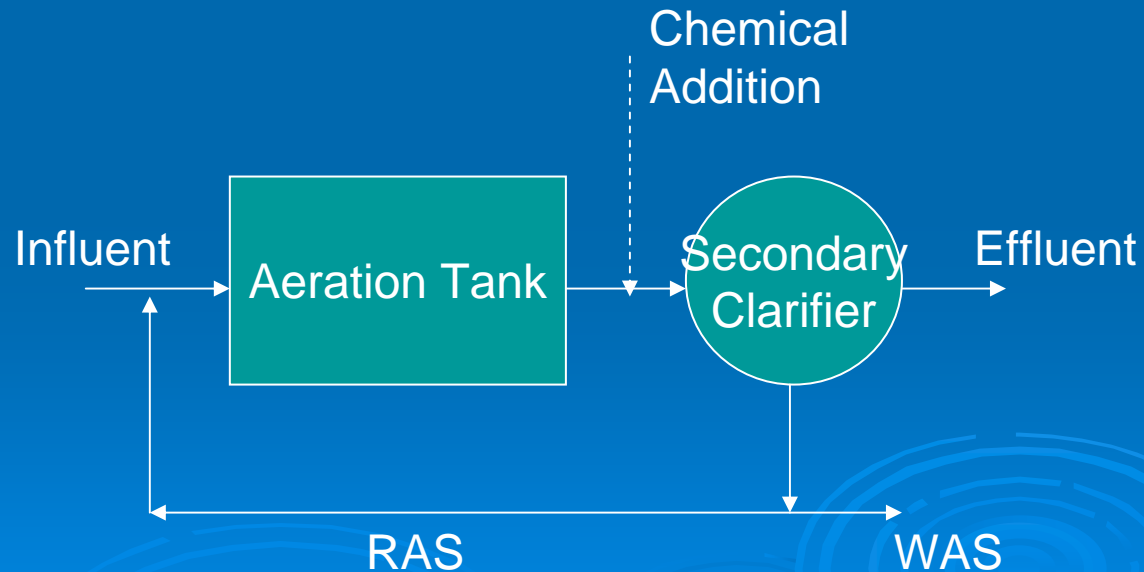
- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

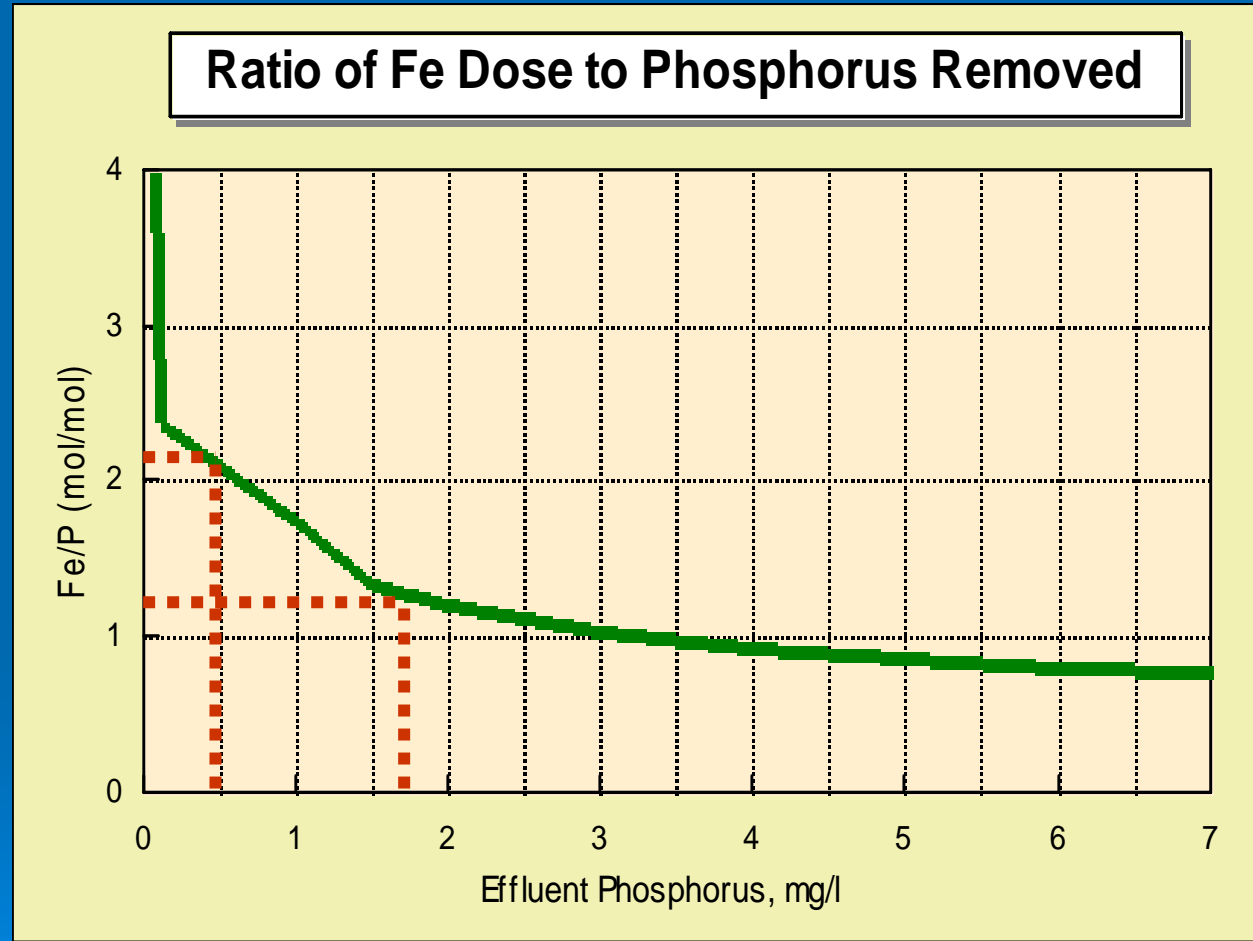
➤ Chemical Addition Point for Phosphorus Removal



Chemical Phosphorus Control

- Why Remove Phosphorus?

- Eutrophication
 - Trophic States
 - Impacts
 - Where can it Occur?
- Transportation of Phosphorus
- Tutorial
- Phosphorus Levels
- Remove Phosphorus
 - Chemical Control
 - Biological Control
- How to Reduce?



Biological Phosphorus Removal

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

➤ Modification of Activated Sludge (Biological) Process Designed to Select for Bacteria that Uptake Excess Amounts of Phosphorus.



Biological Phosphorus Removal

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

- Advantages

- Low Chemical Costs
- Low Solids Production
- Improves Secondary Clarifier Performance

- Disadvantages

- Less Reliable than Chemical Removal
- Prone to Upset, Requires Backup Chemical Addition
- More Difficult to Operate than Chemical Removal
- Requires Careful Control of Recycle Loadings



Biological Phosphorus Removal

➤ “Bio-P” Bacteria Selected by Passing Activated Sludge through an Anaerobic (no oxygen) Zone Followed by an Aerobic Zone

- “Bio-P” Bacteria Uptake Food in Anaerobic Zone
- Release Phosphorus in Aerobic Zone

•Why Remove Phosphorus?

•Eutrophication

•Trophic States

•Impacts

•Where can it Occur?

•Transportation of Phosphorus

•Tutorial

•Phosphorus Levels

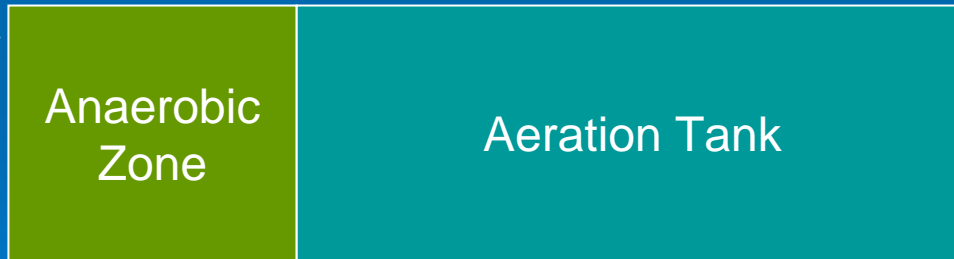
•Remove Phosphorus

•Chemical Control

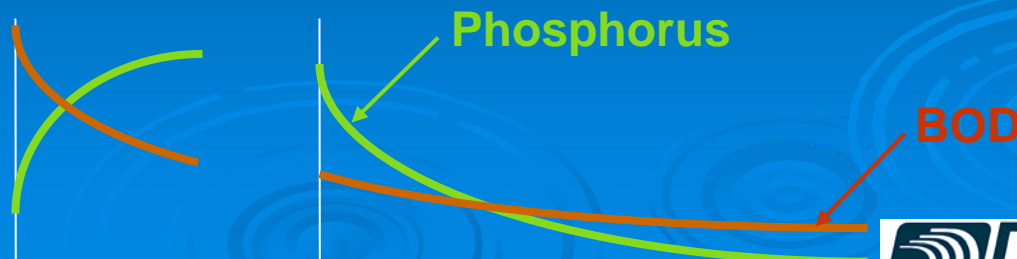
•Biological Control

•How to Reduce?

Primary Effluent



Concentration



How to Reduce?

- Why Remove Phosphorus?

- Eutrophication

- Trophic States

- Impacts

- Where can it Occur?

- Transportation of Phosphorus

- Tutorial

- Phosphorus Levels

- Remove Phosphorus

- Chemical Control

- Biological Control

- How to Reduce?

- Limit Fertilizer and Application Times
- Control Runoff & Soil Erosion
- Plant Trees & Grass Strips
- Maintain Septic Systems & Wastewater Treatment Plants

