# FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING

## CE 356

## Water Treatment

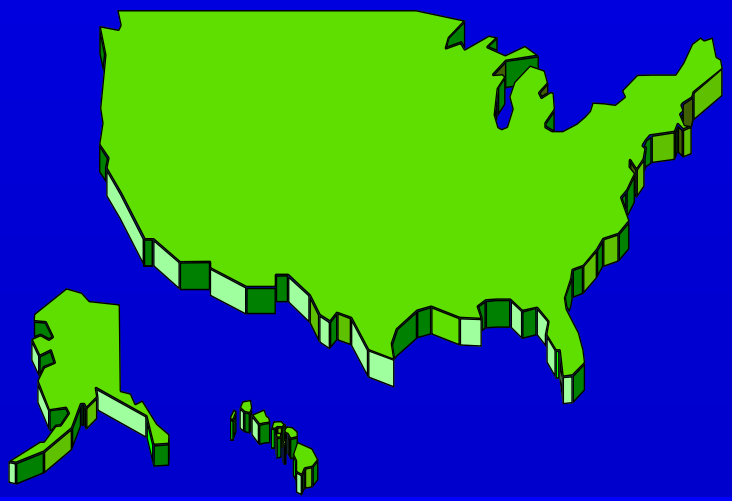

Adopted from Dr. Fernando Cadena

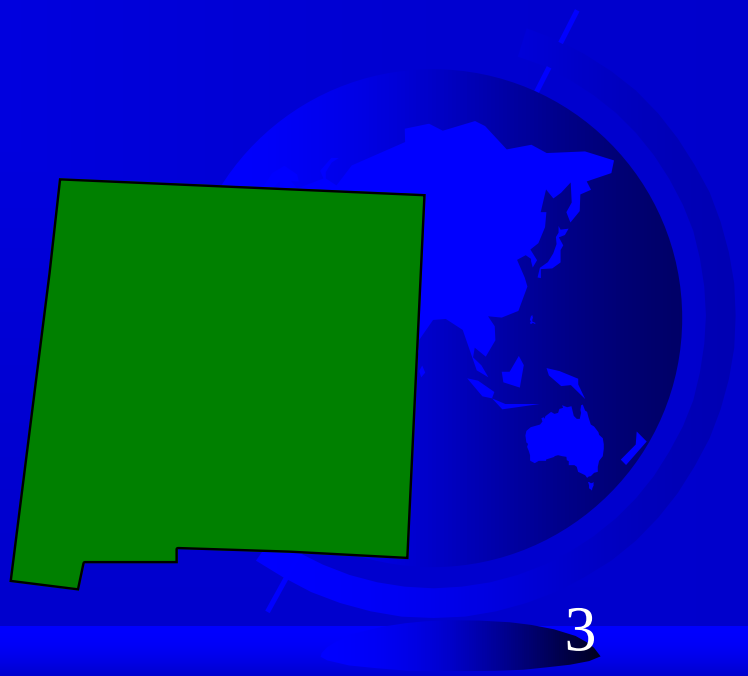
# Learning Objectives

1. Differentiate between surface and ground water treatment requirements:
   - Ground water vs surface water quality
   - Treatment technologies
2. List in appropriate order and describe the four basic unit operations used for treating surface water:
   - Rapid mix/coagulation
   - Flocculation
   - Sedimentation
   - Rapid sand filtration

# Sources of Water

- National
  - 50% surface (rivers or lakes)
  - 50% ground water
- New Mexico
  - 95% ground water





# Groundwater Quality

- Dissolved minerals & chemicals
- No turbidity, few microorganisms: filtered out by soil
- Iron & manganese
- Other specific SDWA contaminants

# Groundwater Treatment

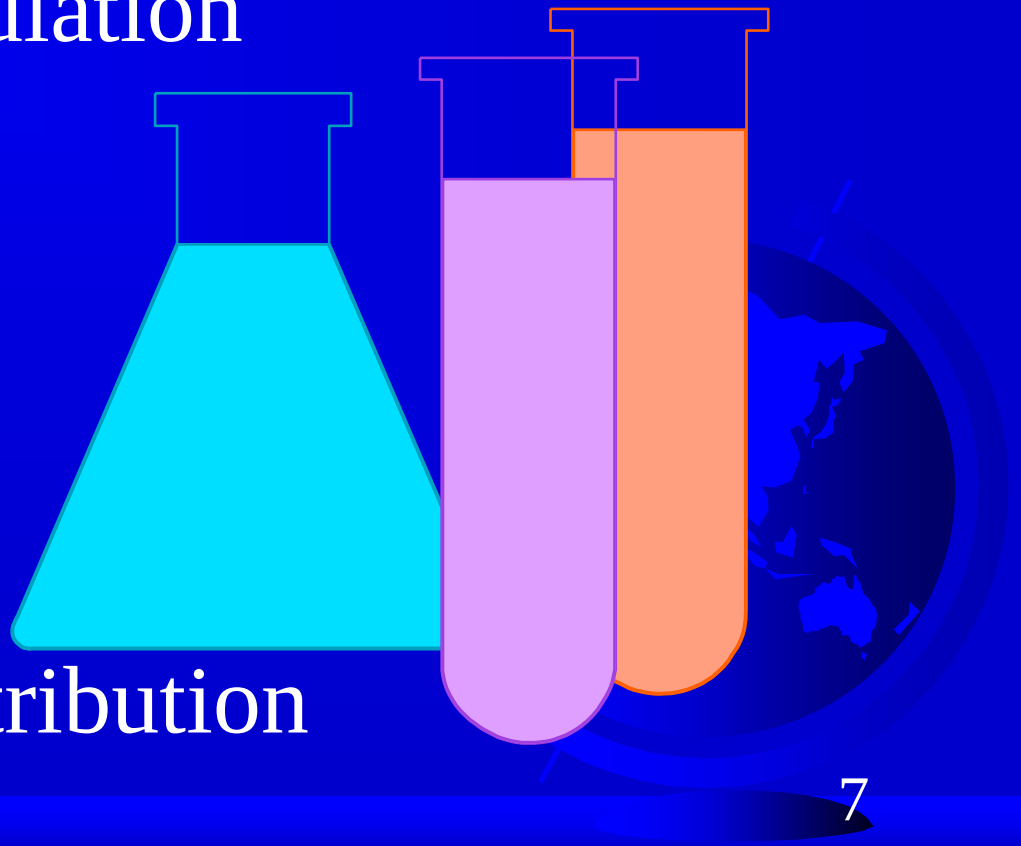
- Pump
- Disinfection
- Fluoridation (if less than 1 ppm)
- Storage and Distribution

# Surface Water Quality

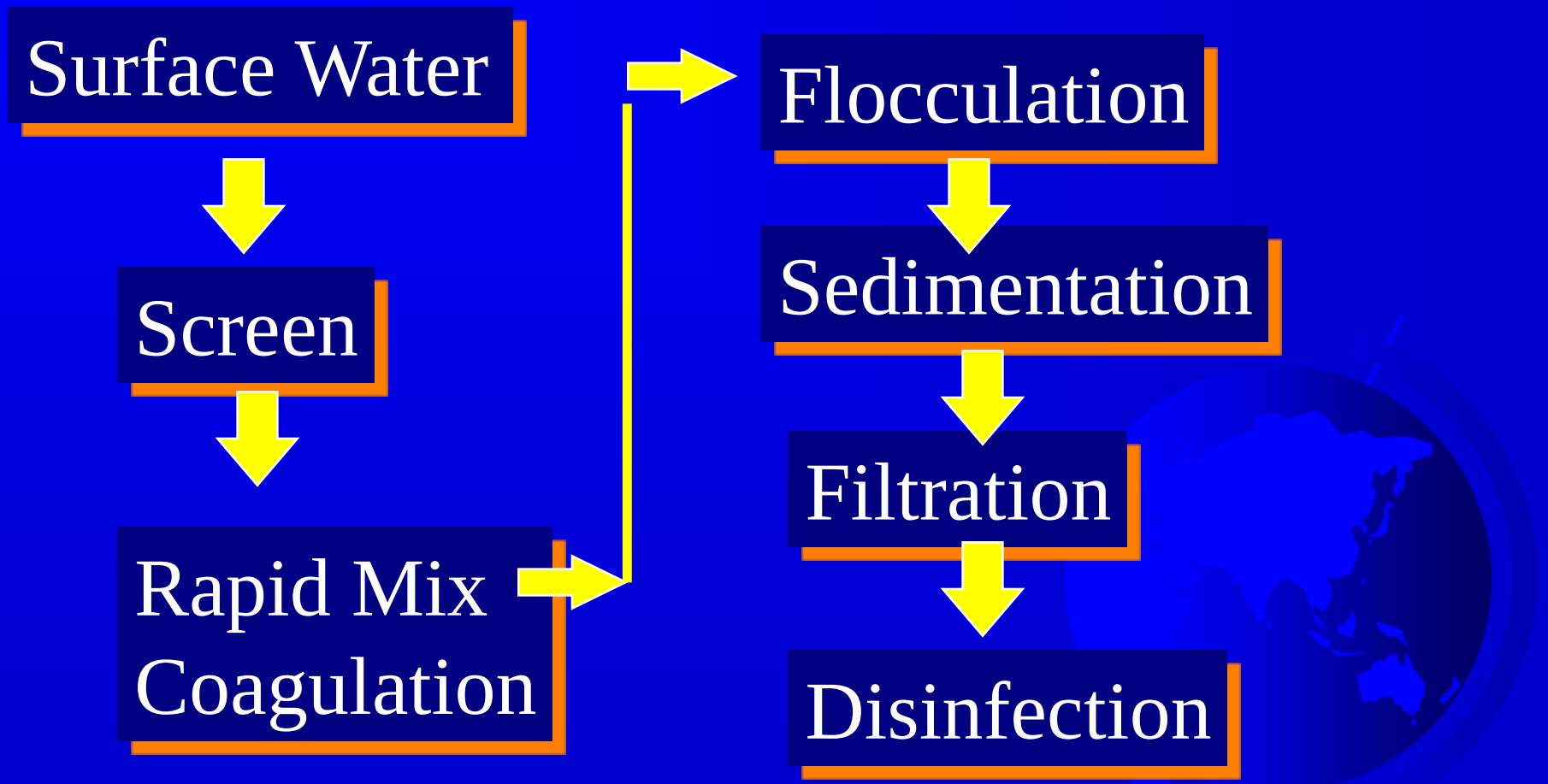
- Contaminants:
  - Suspended solids, soil (turbidity)
  - Pathogens (coliform indicator)
  - Color (decaying vegetation, algae)
  - Taste & odor
  - Other SDWA contaminants

# Surface Water Treatment

- Screening
- Rapid mix/coagulation
- Flocculation
- Sedimentation
- Sand filtration
- Disinfection
- Storage and Distribution

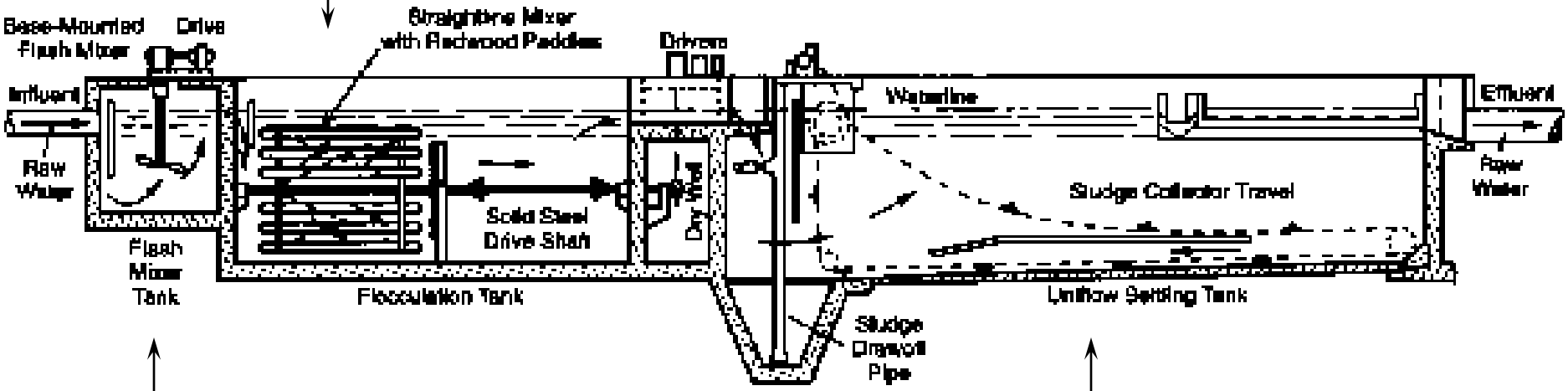


# Conventional Treatment



# Treatment Plant Layout

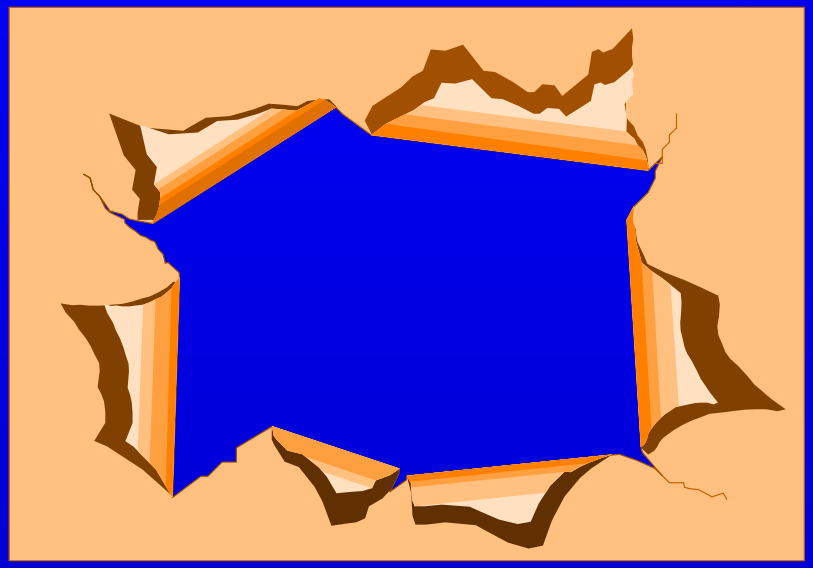
Flocculation




Rapid Mix
& Coagulation

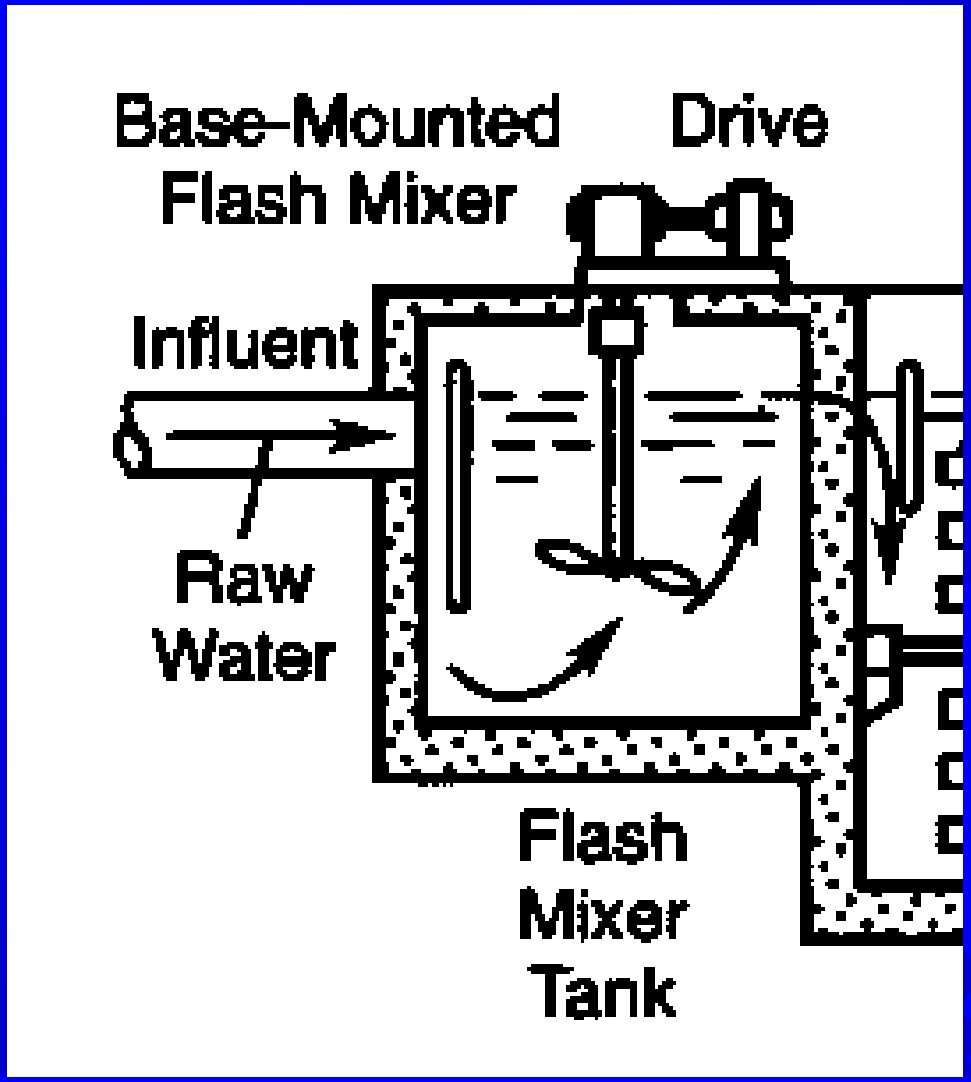
Sedimentation

# Screening

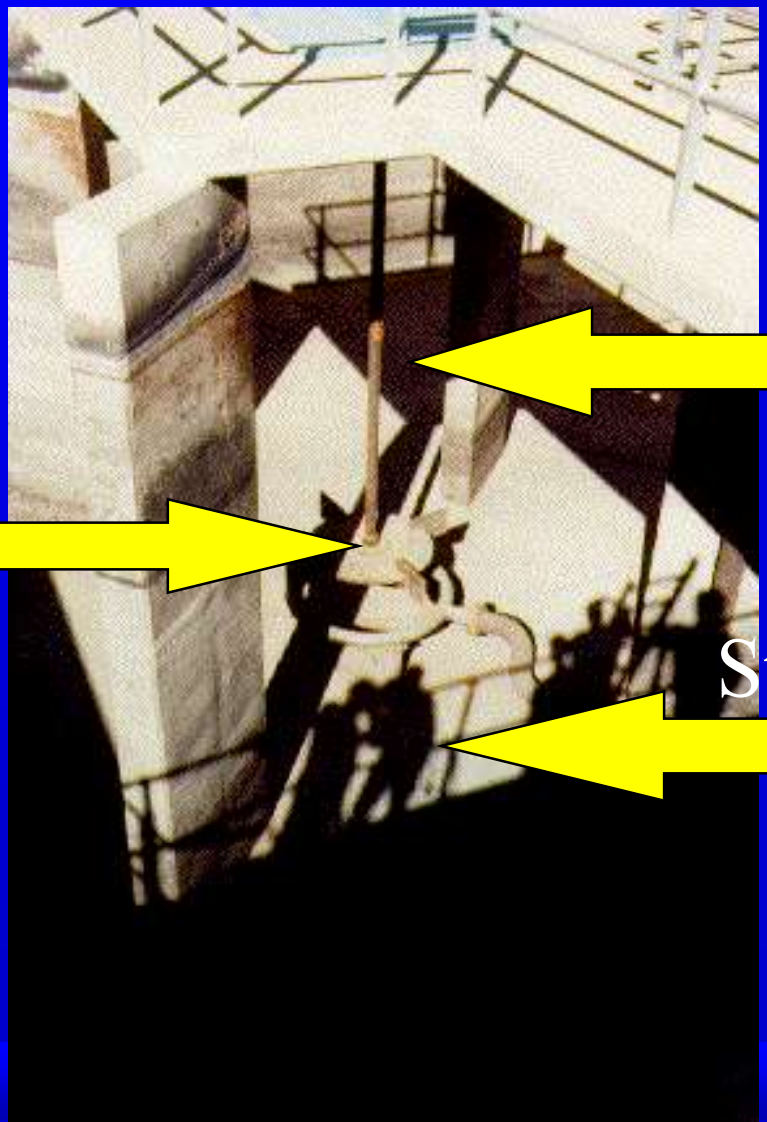


- Removes trash, leaves, fish, etc. at the water source

# Rapid Mix


Base-Mounted
Flash Mixer
Drive
Influent
Raw
Water
Flash
Mixer
Tank

# Rapid Mixer



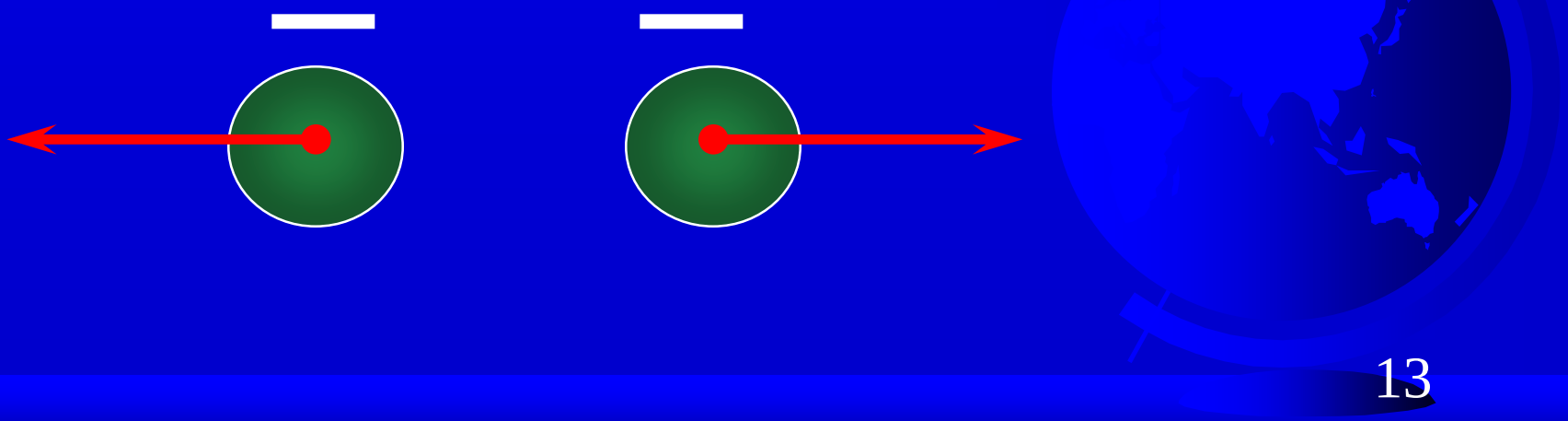
Mixer Shaft

Mixer Blade

Student's shadow

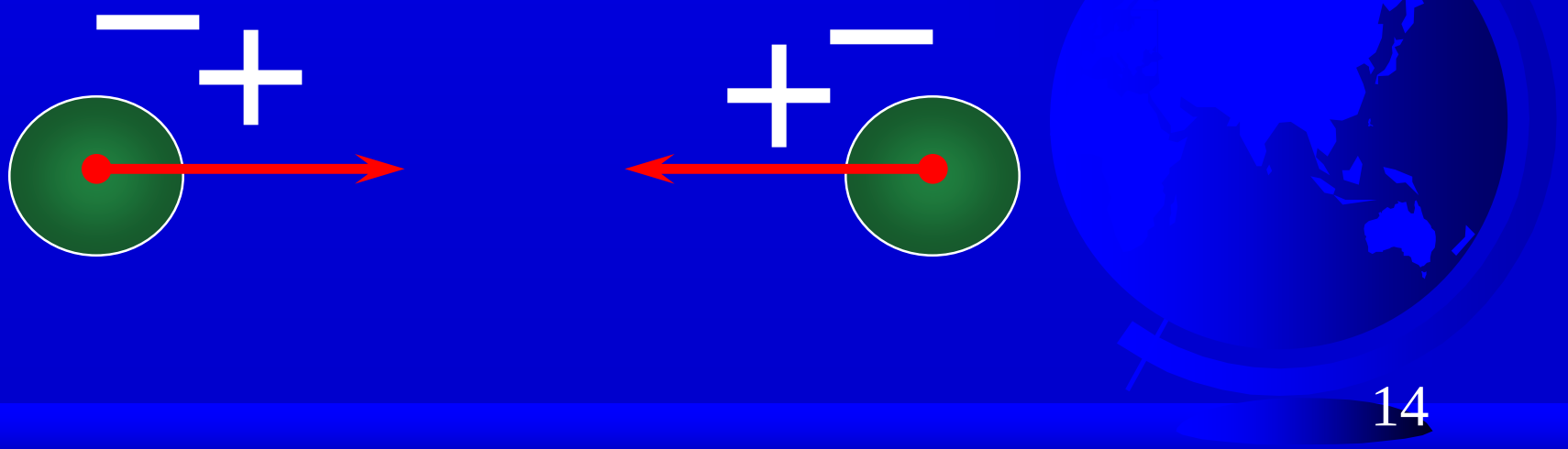
# Coagulation

- Chemicals added to remove small particles
- Particles repelled from each other by negative electric charge



# Coagulation

- Apply positive charges (ions) to colloids.
- Attractive gravitational forces
- Positive ions (cations): $Fe^{3+}$, $Al^{3+}$

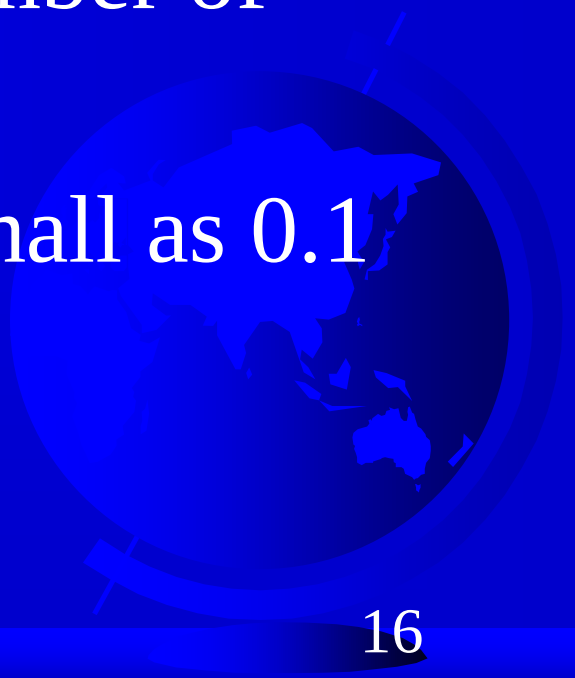


# Coagulants

- Aluminum sulfate (alum)
  - Most commonly used
  - Concerns about Alzheimer's disease
- Ferric chloride (iron chloride)
  - Effectiveness depends on the chemistry of the source water

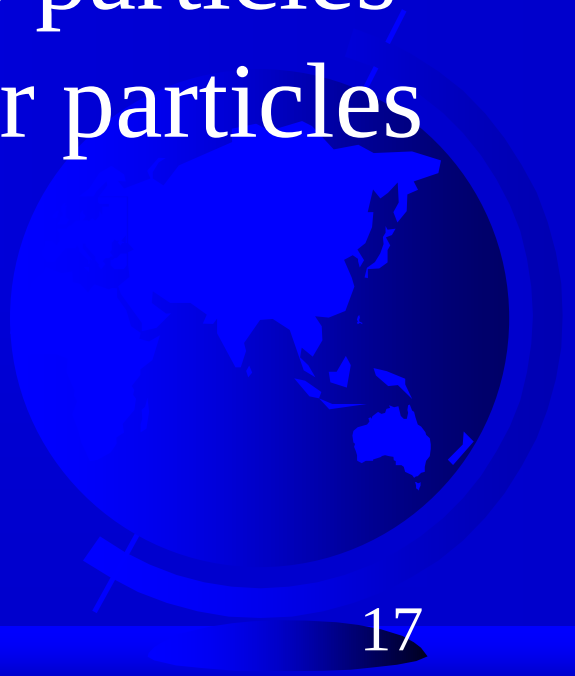
# Coagulant Aids

- Polymers
  - "Liquid plastic"
  - Highly branched, high number of "reactive" sites
  - Very effective, doses as small as 0.1 mg/l

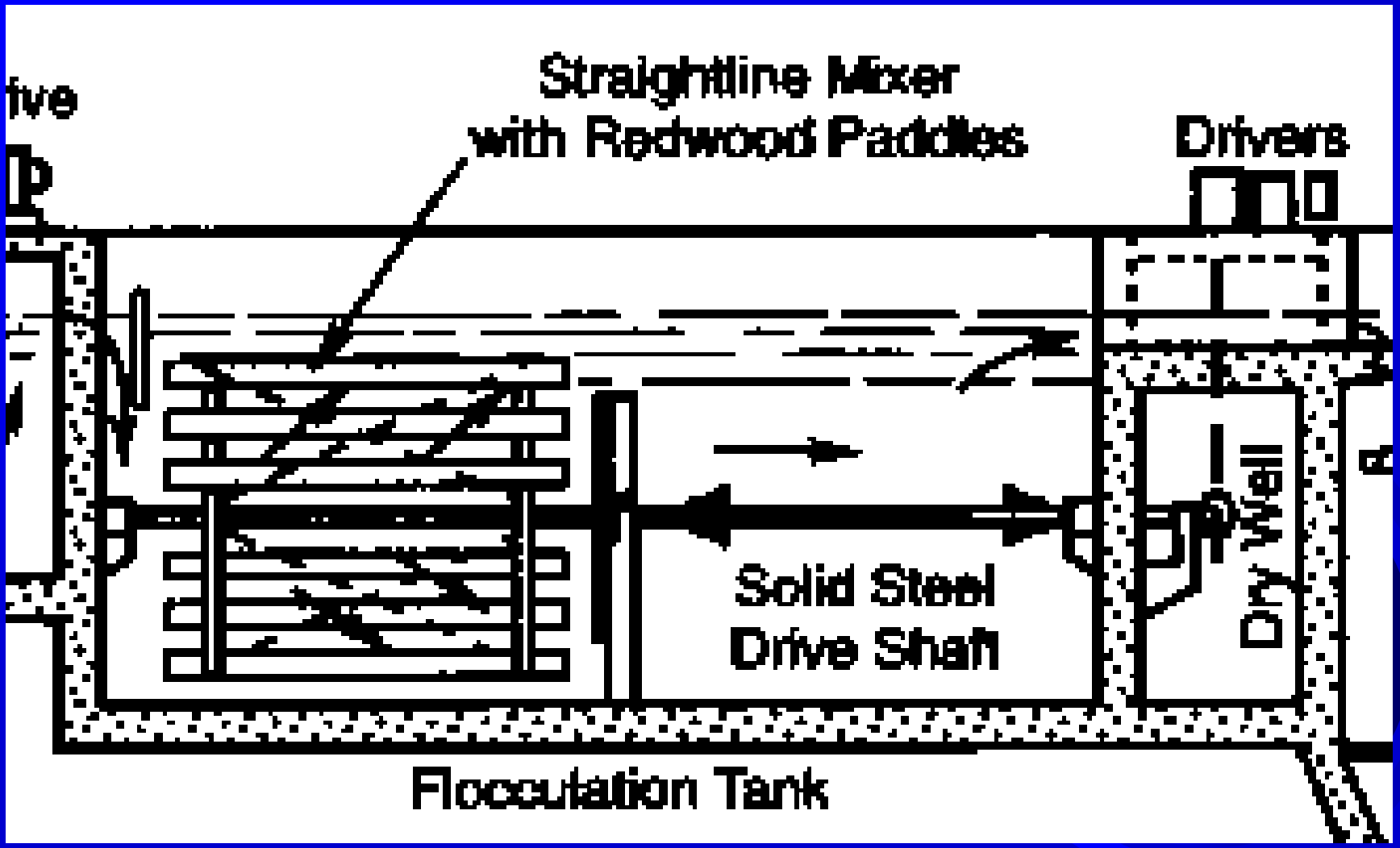


# Flocculation

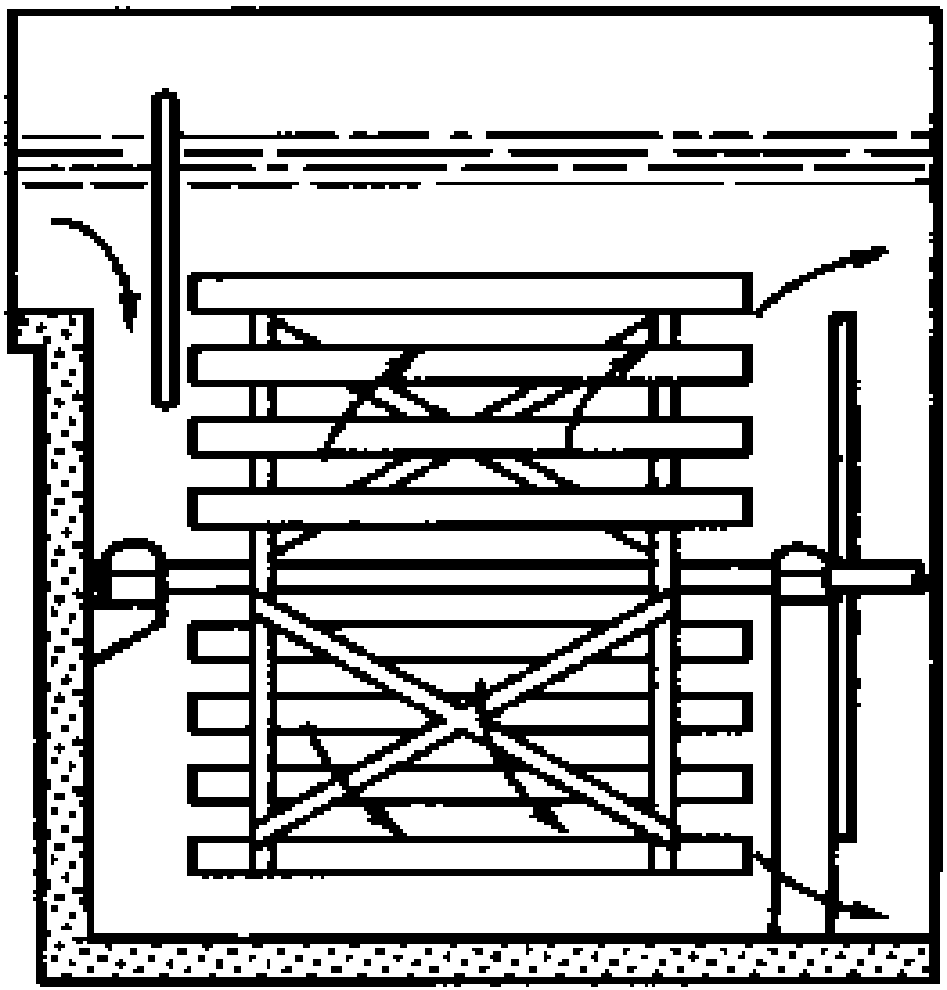
- Slow mixing encourages collision of particles
- Coagulant chemicals help particles stick together, make larger particles (flocs)



# Flocculator



# Flocculator



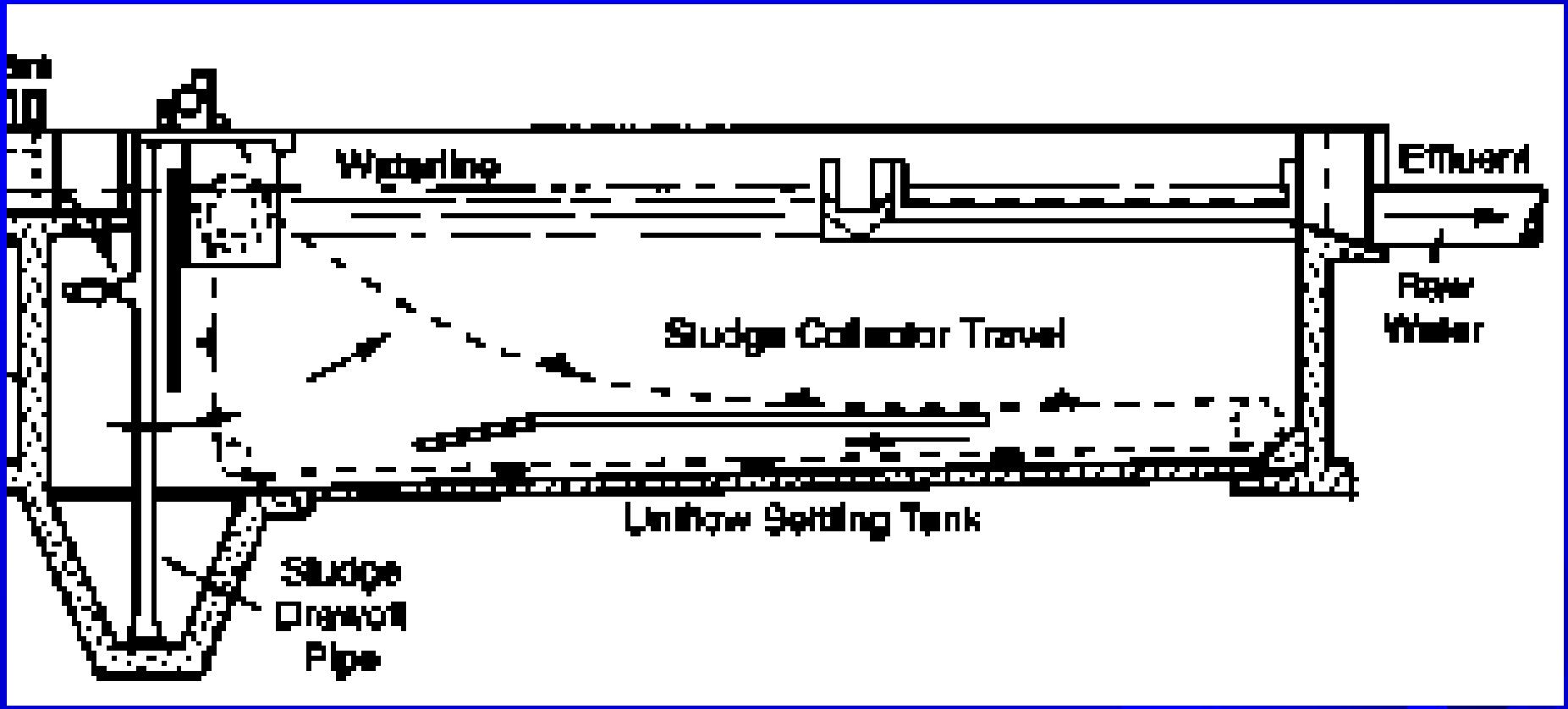
Enlarged View of Paddle Flocculator

# Flocculator Paddles

# Sedimentation

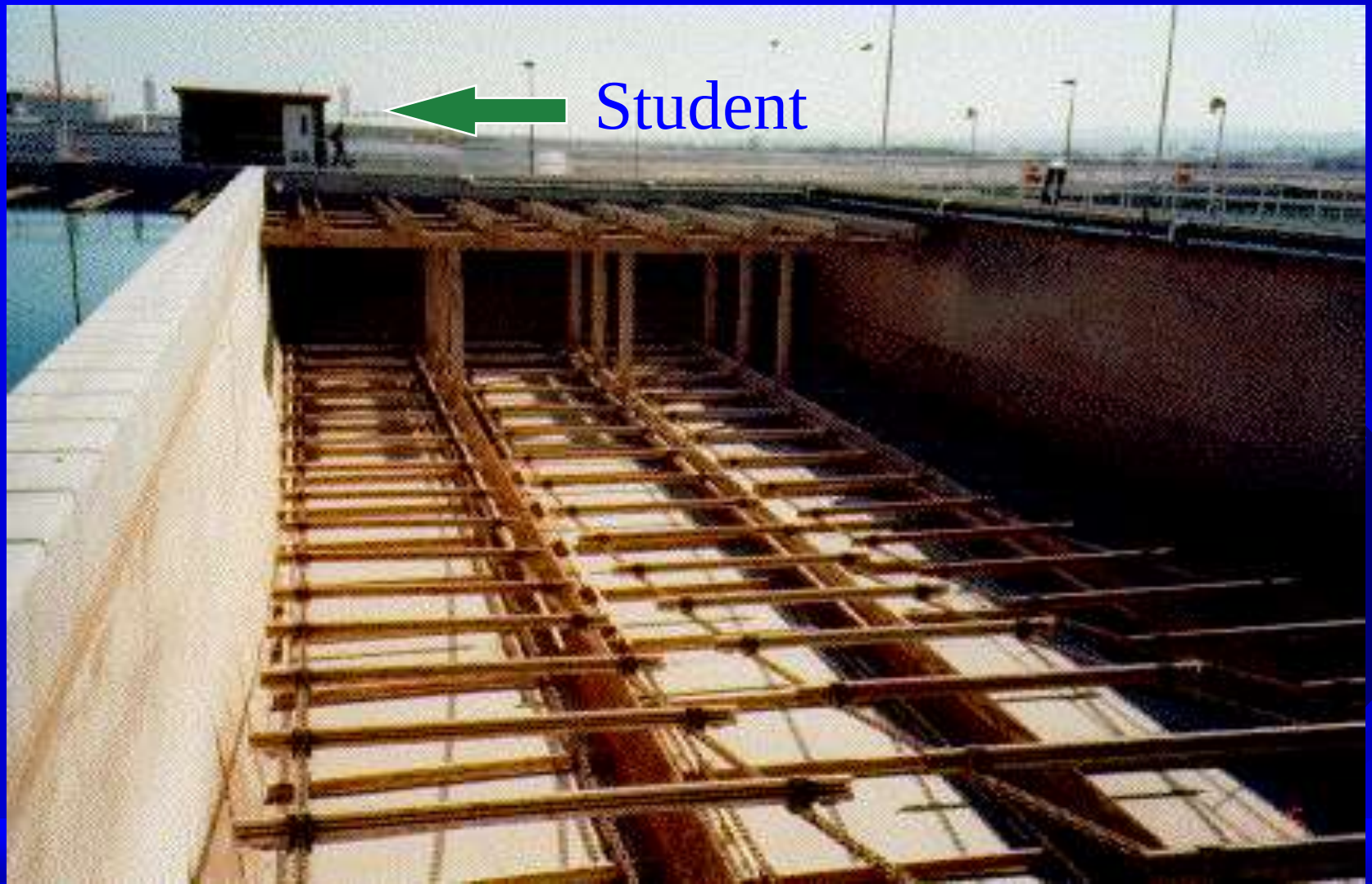
- Floc particles allowed to settle in a large basin
- Force of gravity causes settling
  - Large, dense particles settle the fastest (dependent on flocculation)
- Solid material removed as a sludge

# Settling Tank



# Rectangular Clarifier (Inlet End)

# Rectangular Clarifier (Outlet End)



# Circular Clarifier

# Sludge Treatment

- Sludge is pumped into a settling pond
- Water from settling pond is either
  - Recycled back into plant, or
  - Disposed
- Solids are either left in the pond, or removed and landfilled

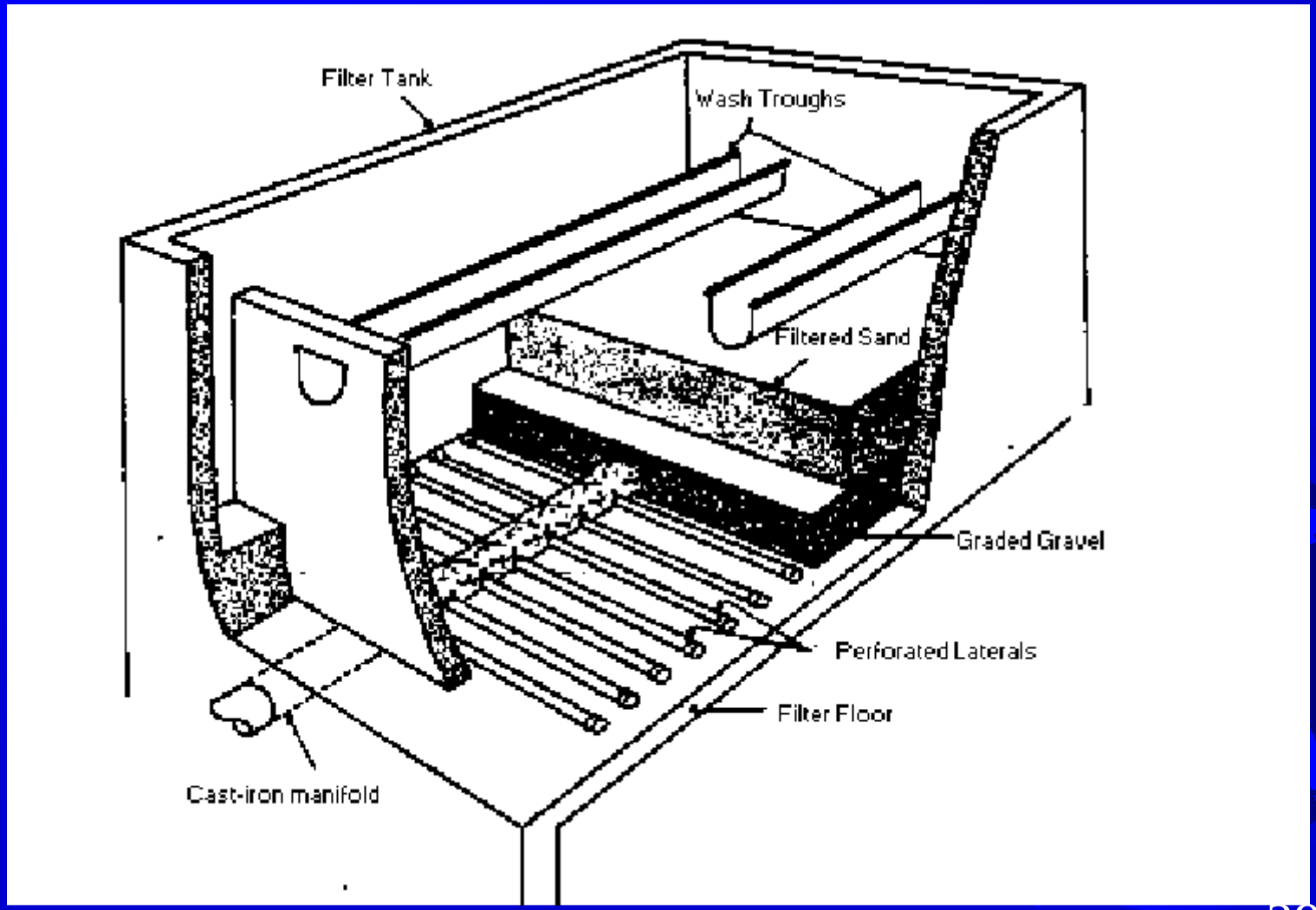
# Filtration

- Needed for fine particles not removed by sedimentation
- Filters can also capture Giardia cysts, viruses, and asbestos fibers
- Water flows downward through a bed of sand and gravel

# Filtration

- Particles are captured on and between sand grains
- Filtered water is collected in the underdrain, sent to disinfection
- Some filters also contain activated carbon, to remove dissolved organics

# Sand Filter


Filter Tank
Wash Troughs
Filtered Sand
Graded Gravel
Perforated Laterals
Filter Floor
Cast-iron manifold

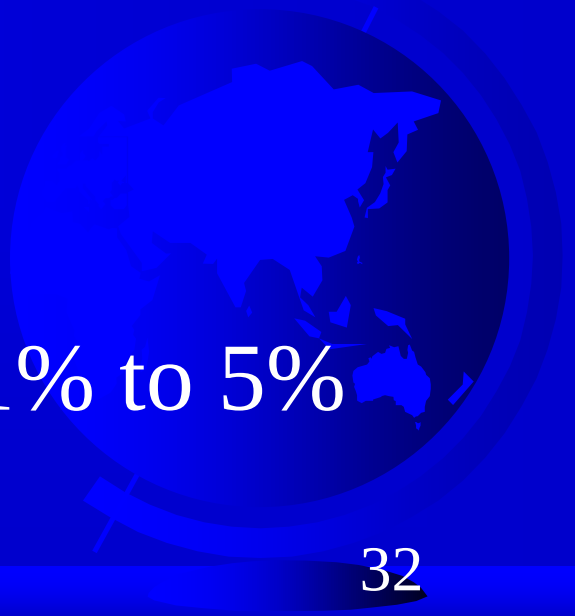
# Sand Filter

# Filter Backwash

- Sand is backwashed when
  - It becomes clogged, or
  - Turbidity of filtered water gets too high
- During backwash, water is pumped upwards through the sand bed

# Filter Backwash

- Sand becomes “fluidized”, and particles are flushed from the sand
- Dirty backwash water is pumped into a settling pond, and either
  - Recycled back into plant, or
  - Disposed
- Backwashing can consume 1% to 5% of a plant’s production



# Disinfection

- Disinfectants used in water treatment have included:
  - Chlorine, ozone, Ultra-violet light, bromine, iodine, and heat

# Chlorination

- Chlorine is most common disinfectant in water treatment
- Added at the end of treatment process. Slight excess is used, to prevent bacterial growth in distribution system.
- Typical chlorine residual is 0.5 to 1 mg/L.

# Chlorination

- Disadvantages:
  - Chlorine is a dangerous chemical
  - Can form Trihalomethanes, THMs, which are possible carcinogens.

# Other Disinfectants

- Other disinfectant chemicals:
  - Ozone gas ($O_3$)
  - Ultraviolet light (UV)
- Not as desirable because:
  - More expensive than chlorine
  - Can't maintain a residual concentration