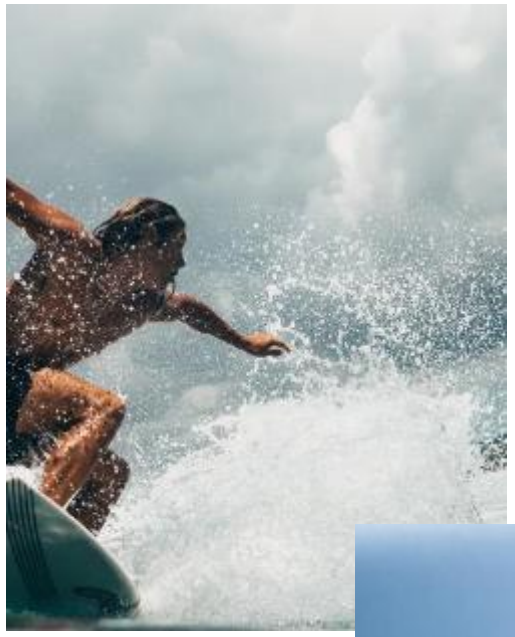
Waterpower Hydro Basics Course: Natural Resource Stewardship: Dams Effect on Water Quality

Instructor: Mark Killgore, Lead Dam Safety Engineer, Virginia Division of Dam Safety

When People Think of Water---



Outline

1. Free flowing river ecosystem
2. Lake ecosystem
3. Common dam water quality issues
4. Hydropower facility water quality obligations
5. Monitoring methods
6. Mitigation strategies and techniques

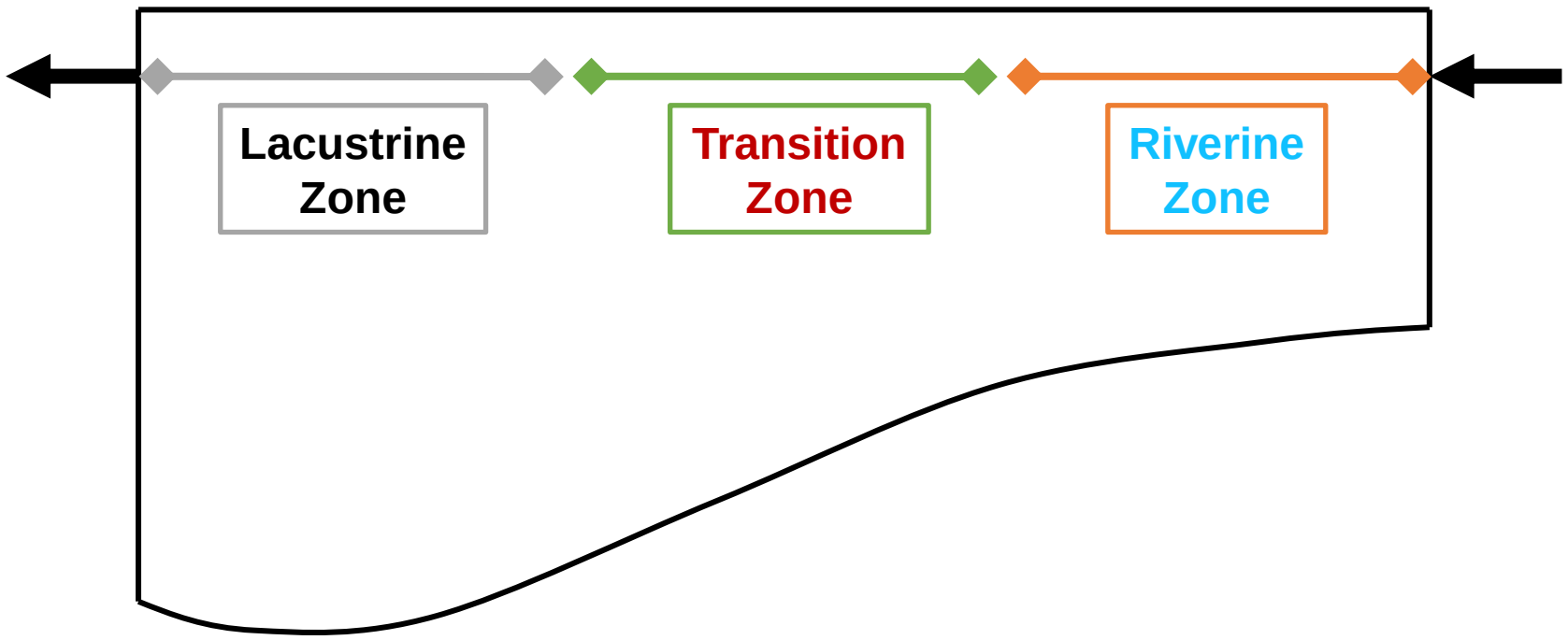
River/Stream Ecosystems

- Unidirectional flow
  - Fast (large slope)
  - Slow (small slope)
- Seasonality
  - Low flow (summer)
  - High flow (spring/fall)
- Transports
  - Sediments
  - Nutrients
- Morphology
  - Dynamic
  - Diverse aquatic habitat

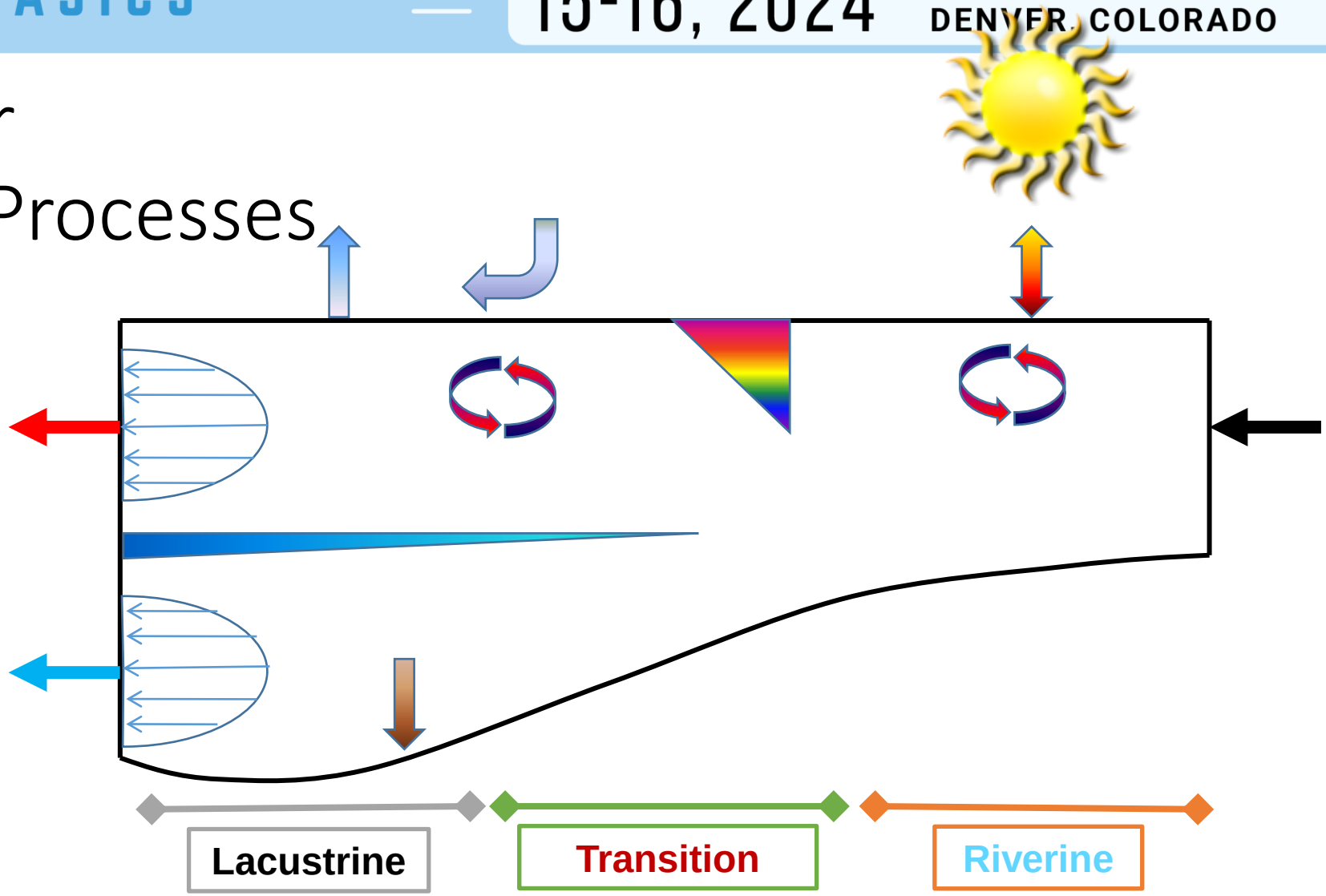
Lake/Reservoir Ecosystems

- Long Water Residence Time
- Seasonality
  - Small level changes
  - Large temperature changes
- Internal Processes
  - Sedimentation
  - Nutrient recycling
- Morphology
  - Smaller water surface to volume ratio
  - Static shoreline/habitat

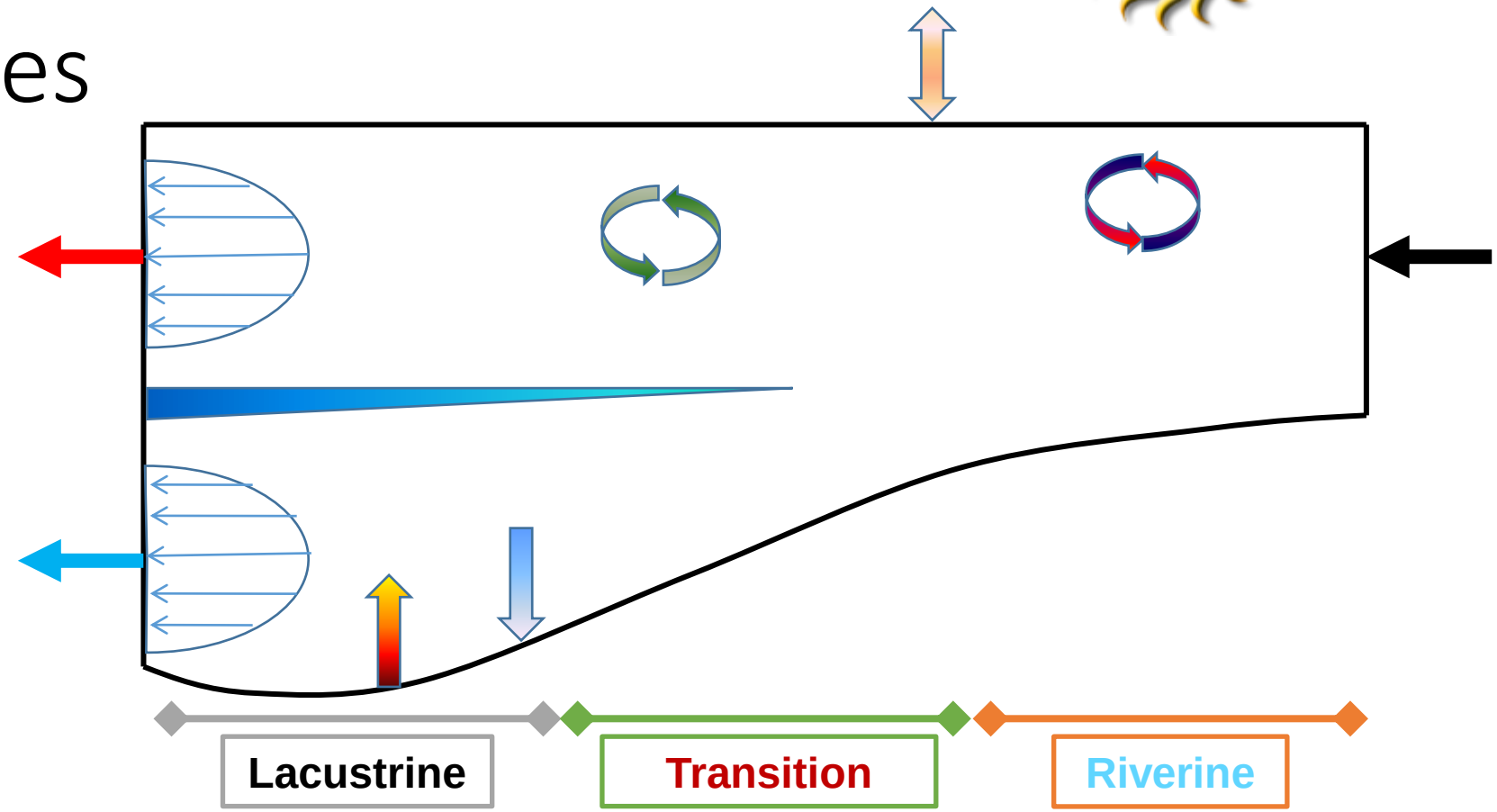
Reservoir Zones



Reservoir Physical Processes



Reservoir Chemical Processes



Summary of Reservoir Effects

Increases

- Residence time
- Sedimentation
- Temperature gradients

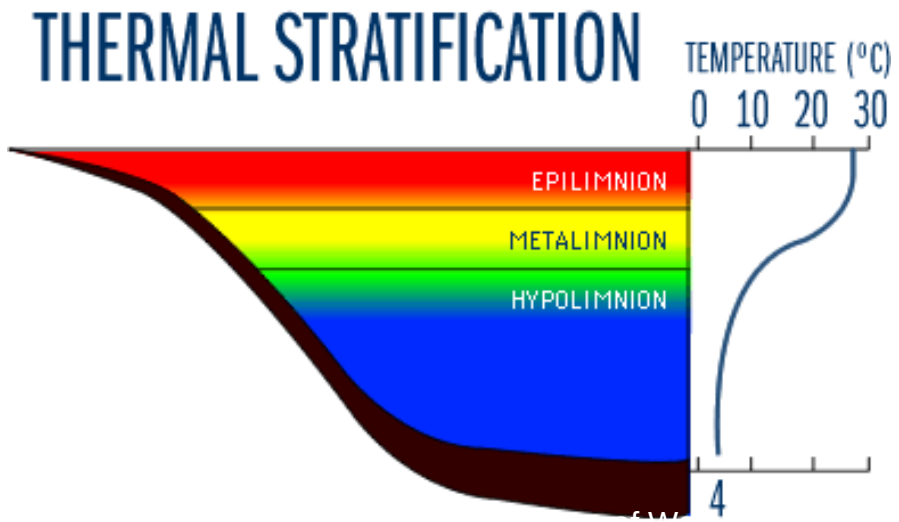
Changes

- Aquatic habitat diversity
- Connectivity
- Gas exchange

Common Water Quality Issues

Temperature

- Increased water surface to shoreline ratio
- Decreased water surface to volume ratio and increased residence time
- Evaporative losses increase



Common Water Quality Issues

Dissolved Oxygen

- Fundamental to aquatic ecosystem health as water
- Produced by photosynthetic organisms and replenished by atmospheric gas exchange
- Consumed by aerobic organisms and reduced chemical species

A healthy ecosystem has ample dissolved oxygen.

Common Water Quality Issues

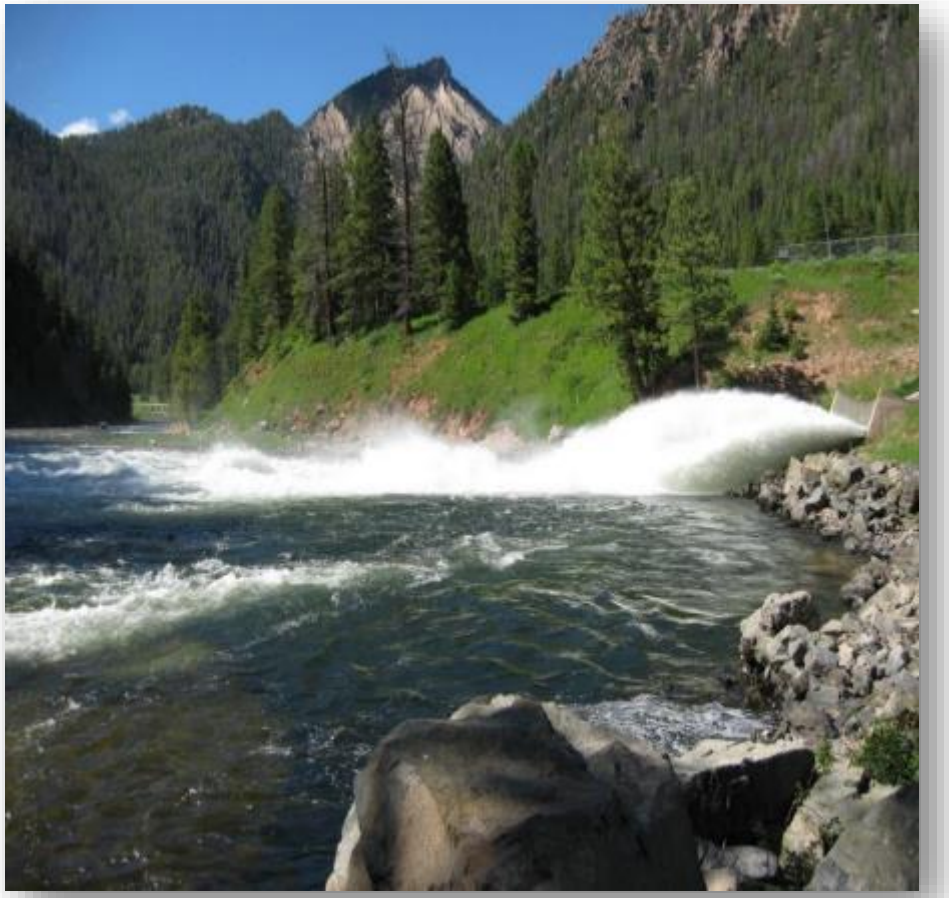
Eutrophication

- Over-productive aquatic ecosystem
- Possible higher nutrient concentrations of free flowing rivers than lakes
- High sedimentation of dead plant cells increasing oxygen demand

Common Water Quality Issues

Temperature & Dissolved Gases

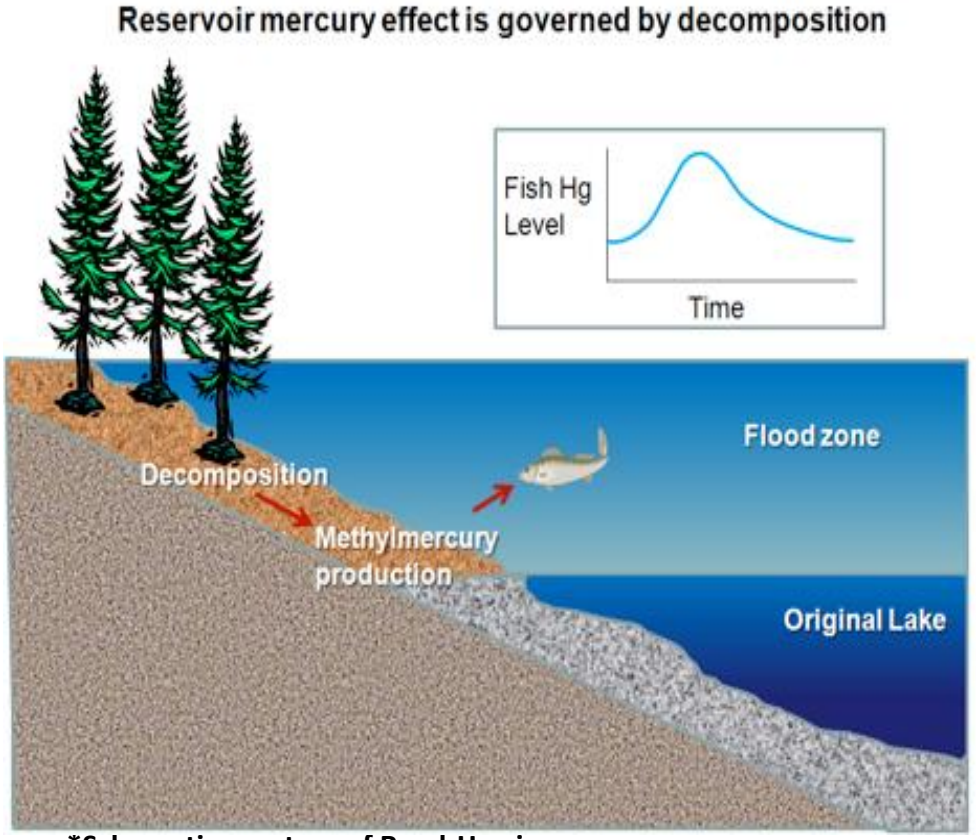
- Dam spill entrain air supersaturating the water column
- Discharge location changes character of downstream system
- Turbines NOT increasing TDG during operation



Other Water Quality Issues

Mercury (Hg)

- Heavy metal bioaccumulates in biota
- New reservoir elevates Hg levels in fish
- Potential fluctuating water levels not understood



*Schematic courtesy of Reed-Harris

Hydro Facility Water Quality Obligations

Clean Water Act—401 Certification

Federally Licensed Facility, States and Tribes

- Certify project
- Certify water quality conditions
- Deny or waive certification

Hydro Facility Water Quality Obligations

Water Quality Standards

- Vary by state and water resource type
- States Establish Standard
  - Designated uses
  - Anti-degradation policies and procedures

Water Quality Standards Database:
http://water.epa.gov/scitech/swguidance/standards/wqslibrary/index.cfm

Water Quality Monitoring

Temperature Loggers

Old Fashioned Way

Data Sondes

Mitigation Strategies and Techniques for Dissolved Oxygen Levels

Operational Changes

- Unit and/or intake preferences
- Spill options
- Gate settings

Pros

- Low capital cost
- Utilize existing equipment and infrastructure

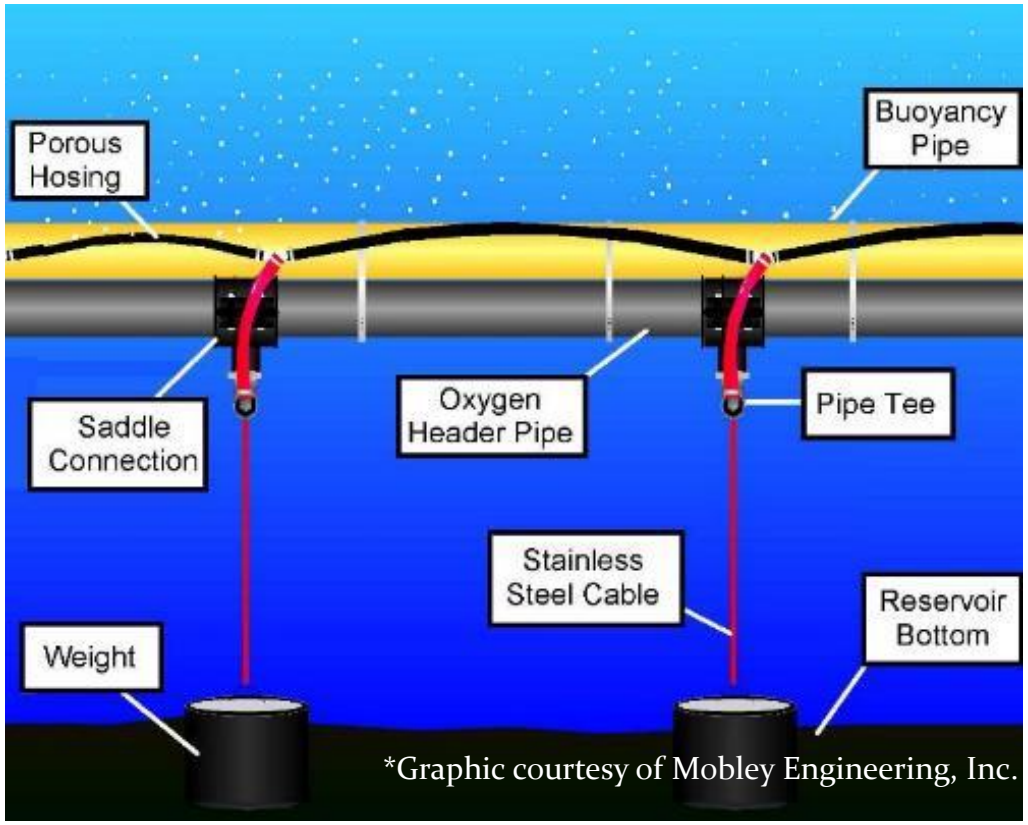
Cons

- Limit energy production
- Compensate for lost energy

Mitigation Strategies and Techniques

Oxygen Diffusers

Air diffusers installed to aerate bottom waters near vicinity of intake



*Graphic courtesy of Mobley Engineering, Inc.

Mitigation Strategies and Techniques

Turbine Aeration Technology

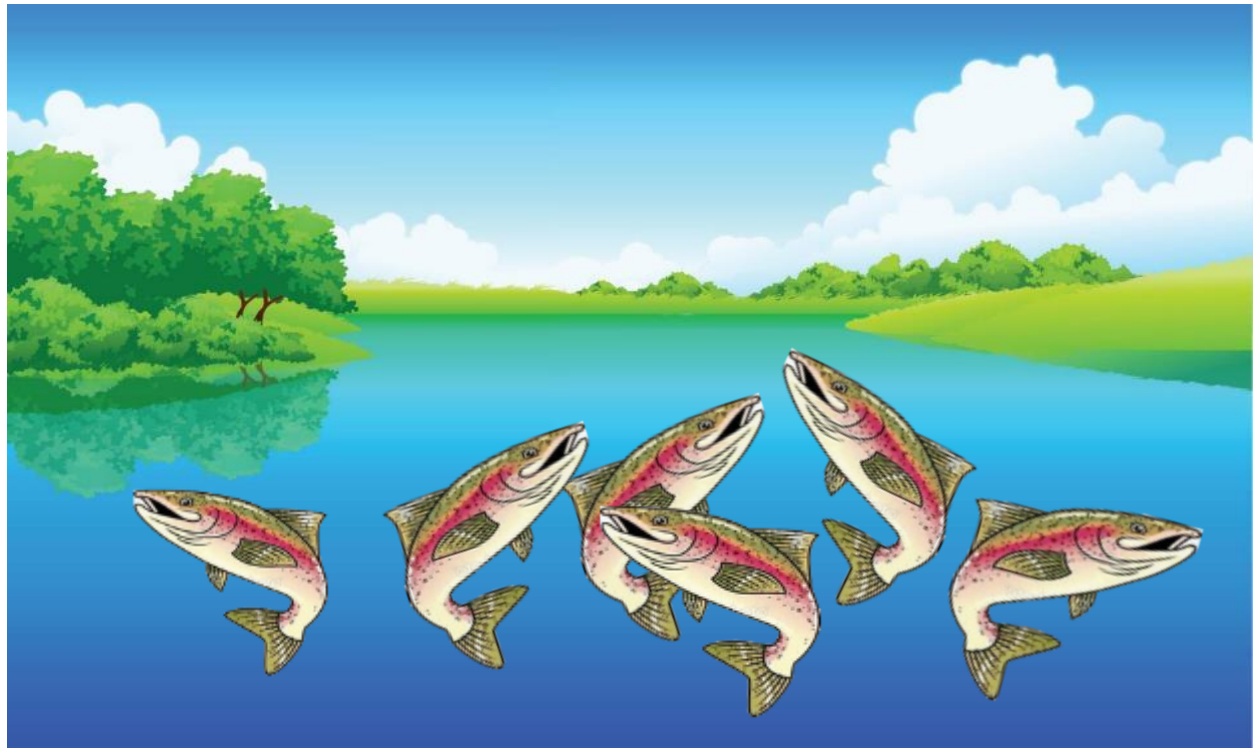
- Newer models have auto-aeration
- Older models retrofitted to introduce oxygen or air

Mitigation Strategies and Techniques

Surface Water Pumps/Mechanical Mixing

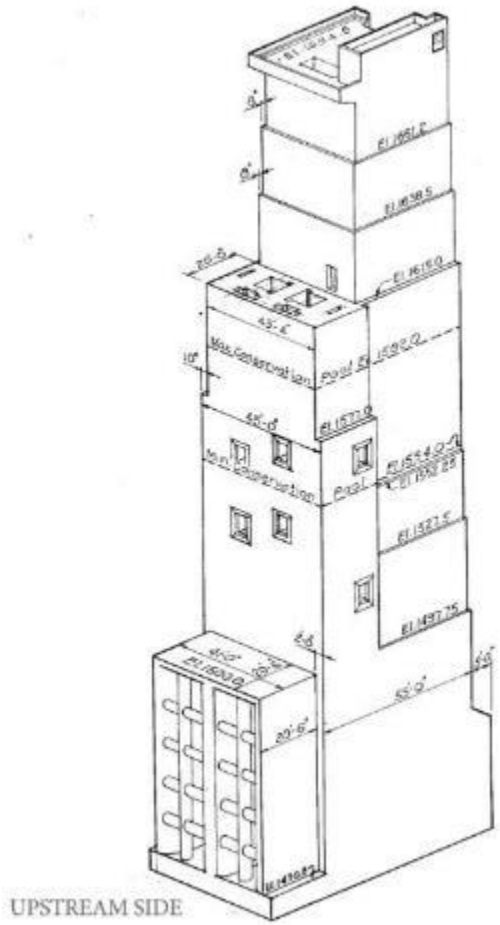
Mitigation Strategies and Techniques

Downstream Aeration

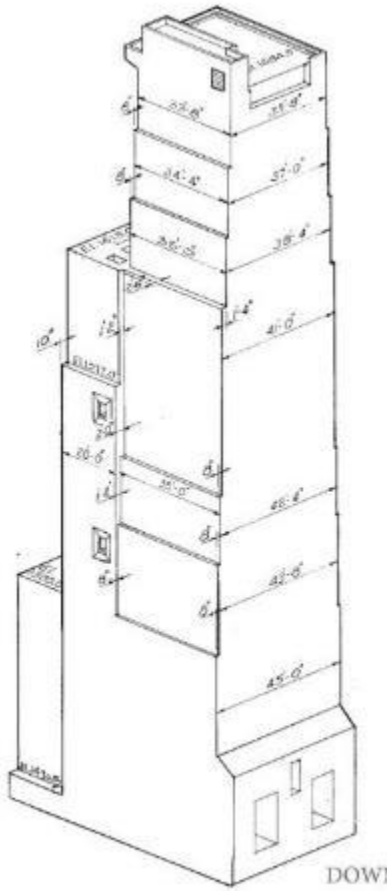


Temperature Control

- Critical component of aquatic environment
- Limits associated with biological requirements of fish community and state water body classification



UPSTREAM SIDE



DOWNSTREAM SIDE

Water Intake Towers

Mitigation Strategies and Techniques

Watershed Management

- Stormwater management
- Properly sized shoreline buffers
- Exotic controls
- Proper road maintenance
- Agricultural management
- Monitoring and development of models to understand dynamics
- Public forums to influence behaviors