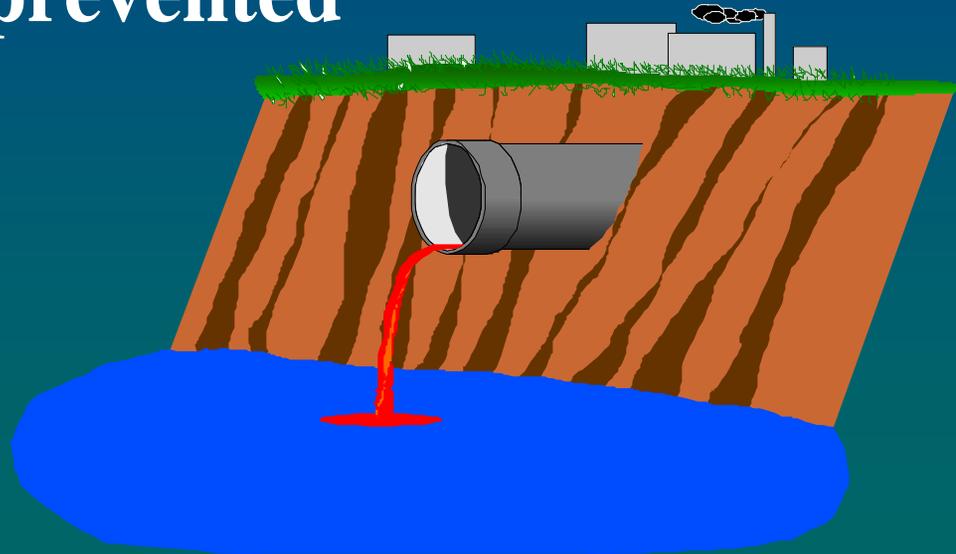


# Module 17: MIXING ZONES

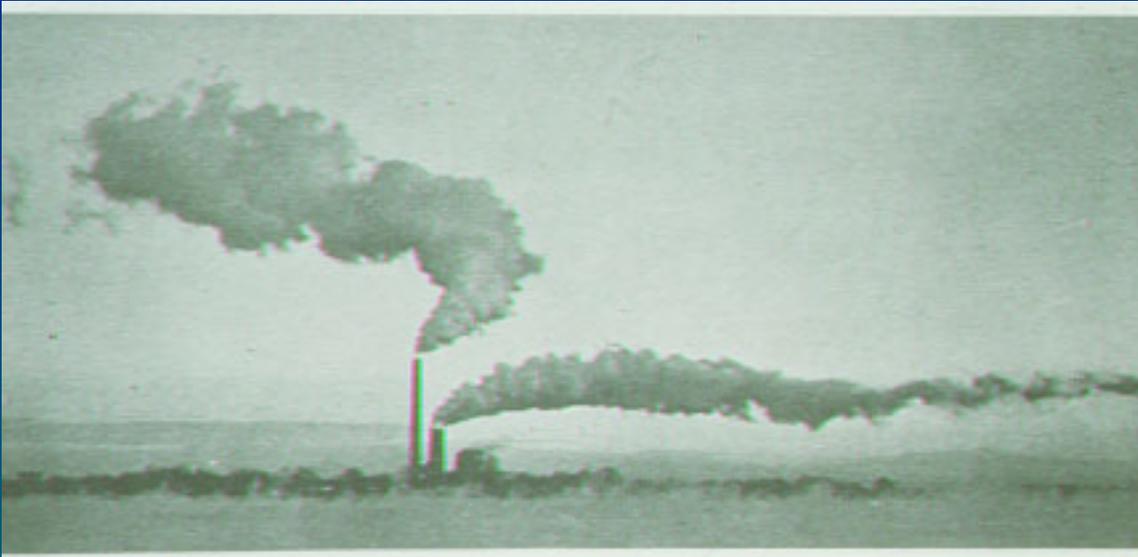
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- A limited area or volume of water where initial dilution of a discharge takes place and where numeric water quality criteria can be exceeded but acutely toxic conditions are prevented



# Mixing Zone Gallery (1)

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**Atmospheric example of turbulent buoyant jet mixing in a stratified shear flow.**

*Source: Ralph Turcotte, [Beverly \(Massachusetts\) Times](#) from [www.cormix.info](http://www.cormix.info)*



**Firebreather**

*Source: [www.cormix.info](http://www.cormix.info)*

# Mixing Zone Gallery (2)

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**Far-field plume mixing in River**

Source: [www.cormix.info](http://www.cormix.info)



**Wastewater outfall with boundary interaction**

Source: I. Wood from [www.cormix.info](http://www.cormix.info)

# Mixing Zones: Authority (1)

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- **40 CFR 131.13: General Policies:** “ States may, at their discretion, include in their state standards policies generally affecting their application and implementation, such as mixing zones, low flows and variances. Such policies are subject to EPA review and approval.”

# Mixing Zones: Authority (2)

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- **40 CFR 122.44(d)(1)(ii):** In determining whether WQBELs are needed, the permitting authority shall account for, among other factors, the dilution of the effluent in the receiving water, where appropriate.

# Mixing Zone Policy: Purpose

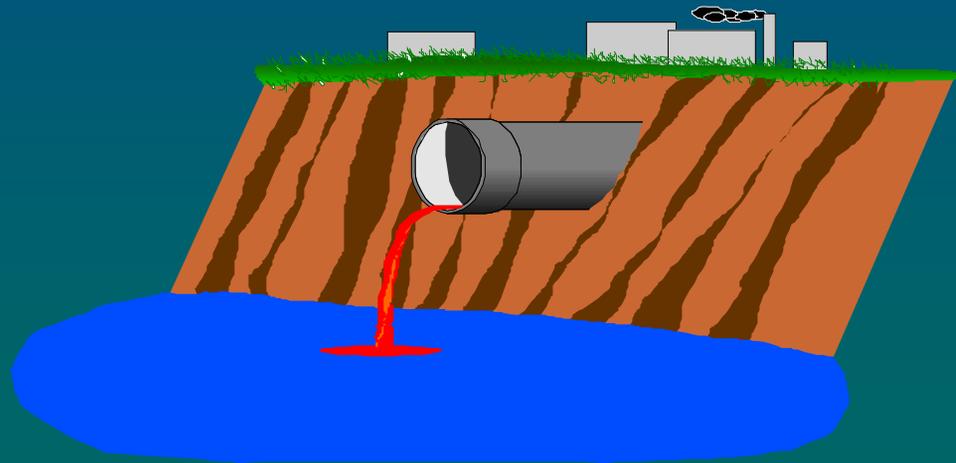
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- **Restrict areas where numeric criteria may be exceeded to known and controlled locations**
- **Reduce need for excessive wastewater treatment**

# Mixing Zones: “Shoulds”

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- **Protect the integrity of the water body as a whole**
- **Prevent lethality to passing organisms**
- **Prevent significant health risks**



# Mixing Zones: “Should NOTs”

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- **Be used as a way to lower a designated use**
- **Be used as a way of revising criteria or developing a site specific criteria outside of the water quality standards process**
- **Overlap**

# What should a Mixing Zone Policy Contain?

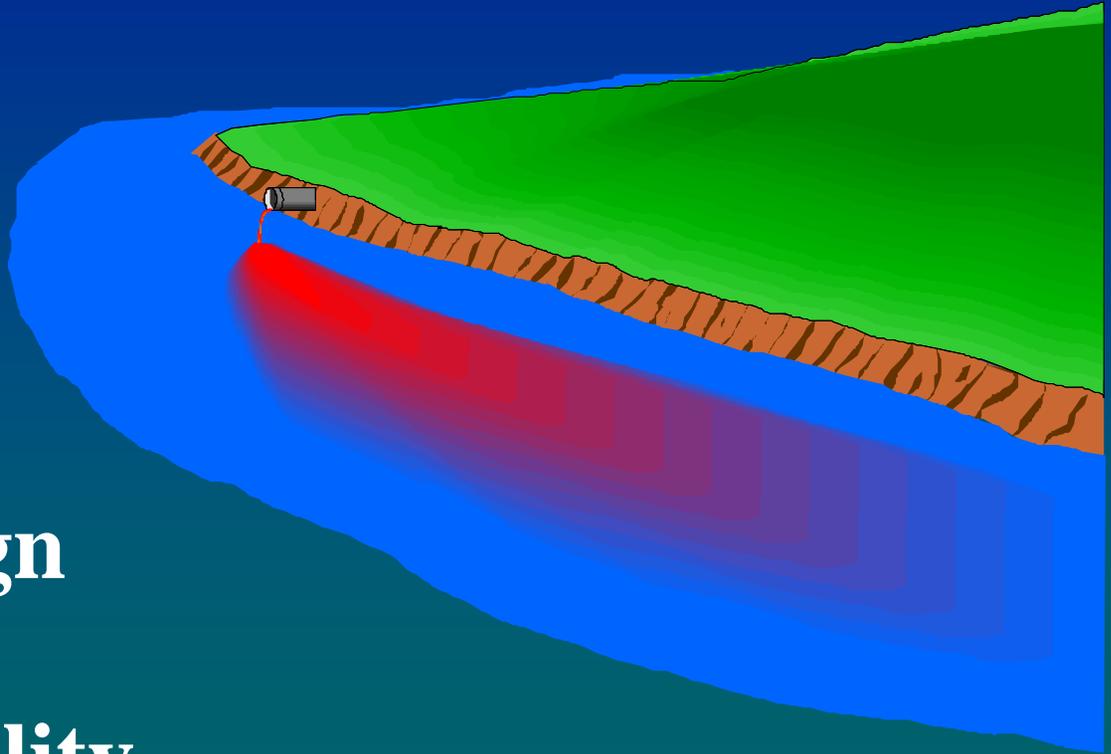
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- **Statement on when and where mixing zones are allowed (if at all)**
- **Specifics on how mixing zones will be defined**

# What Should a Mixing Zone Policy Discuss?

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- **Location**
- **Size / Shape**
- **Outfall Design**
- **In-Zone Quality**



# Mixing Zone Location: Aquatic Life

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- **Identify and protect biologically important and sensitive areas**
  - endangered species
- **Avoid locations that would block or create a too-narrow zone of passage for migrating organisms**



# Preventing Lethality to Passing Organisms

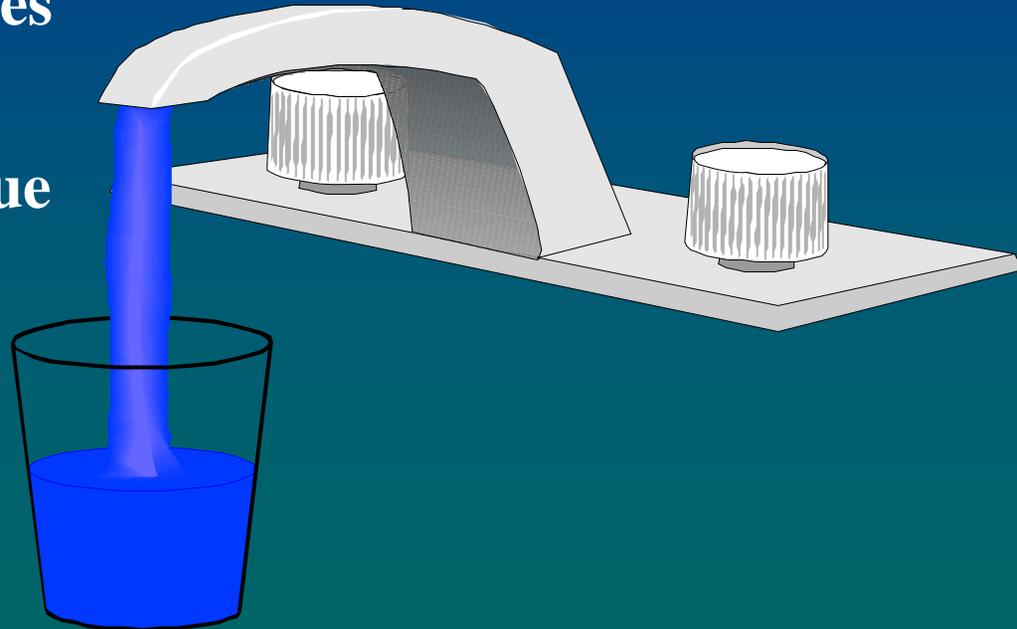
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- **Prohibit discharge pipe concentrations from exceeding CMC**
- **Require CMC attainment within a very short distance from outfall**
- **Require data from discharger demonstrating that drifting organisms do not receive harmful exposures**

# Mixing Zone Location: Human Health

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- **Restrict mixing zones from areas that would pose significant human health risks**
  - **Drinking Water Sources**
  - **Shellfishing Beds**
  - **Potential for Fish Tissue Contamination**
  - **Recreational Areas**

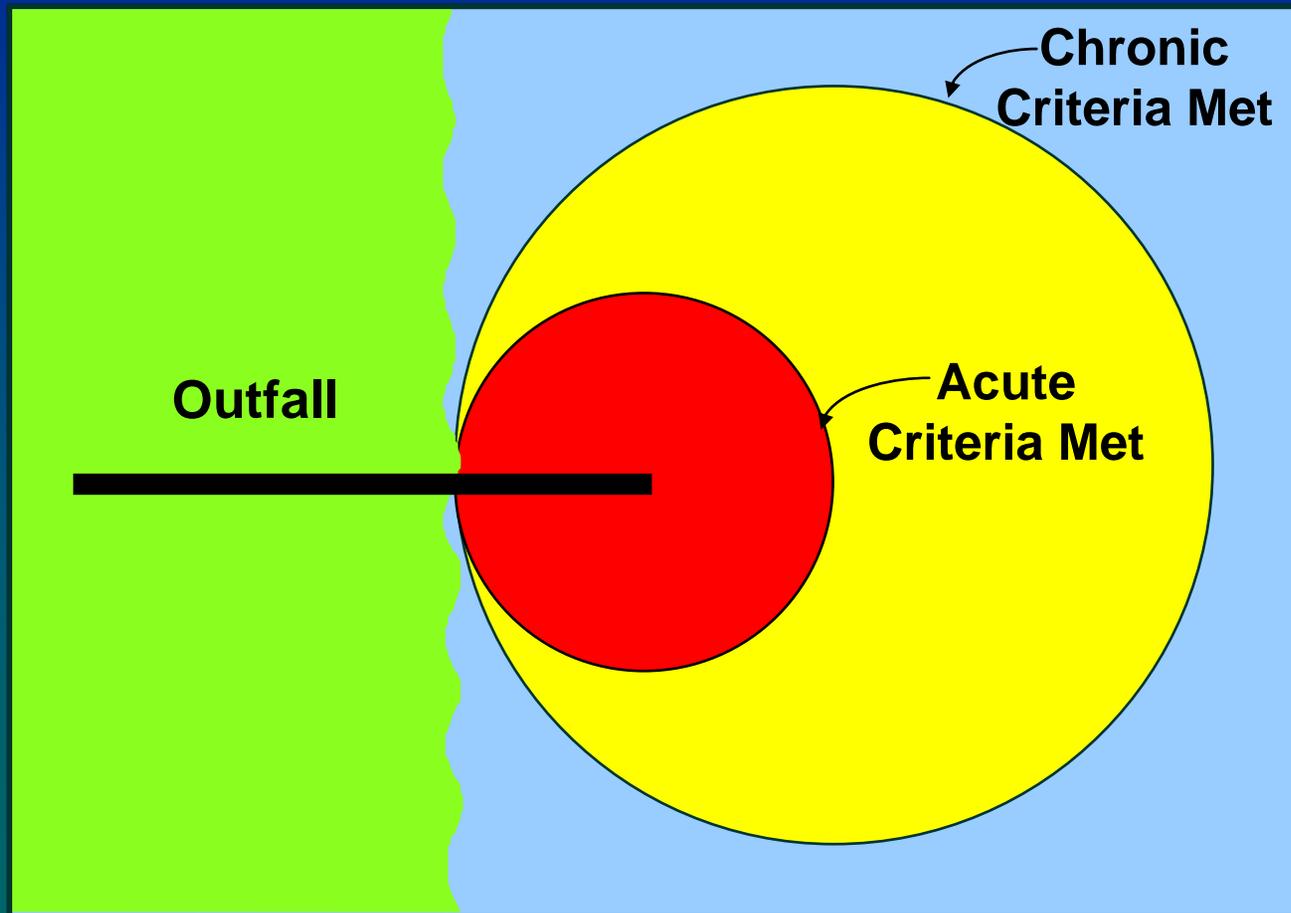


# Mixing Zone Size

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- **Maximum size should be specified in State/Tribal water quality standards**
- **Should be as small as practicable**
- **Should not impinge on movement within water body or into tributaries**
- **Consider the shape of the mixing zone**
  - **Shore-hugging plumes should be avoided**

# Mixing Zone Size: Schematic



# Mixing Zones Size: Examples

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- **<1/4 of stream width and 1/4 mile downstream**
- **<1/2 stream width and longitudinal limit of 5X stream width**
- **Default dilution of no more than 10% of critical flow**
- **No more than 5% of the lake surface**
- **Default of no more then 4:1 dilution for lake discharges**

# Mixing Zones Size and Low Flows in Streams: EPA Guidance

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- **Criteria should be met at specific flow volumes (“points of application”)**
- **Acute: 1Q10 or 1B3**
- **Chronic: 7Q10 or 4 B3**
- **Human Health: Harmonic Mean**
  - **Except for criterion based on short term effects (e.g., nitrate)**

# What are Low Flows and Why do they Matter?

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- **Dilution is the primary mechanism by which chemical concentrations are reduced**
- **Two methods to calculate low flows**
  - **Hydrologically-based (e.g., 7Q10)**
  - **Biologically-based (e.g., 4B3)**

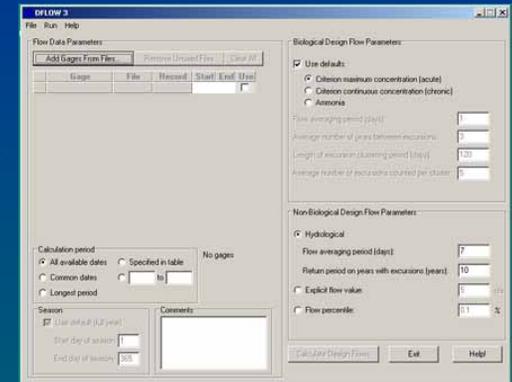
# Low Flow Calculations

- **DFLOW** is a Windows based tool that calculates:

- Hydrologically-based design flows
- Biologically-based design flows
- Harmonic mean flows
- Percentile flows

Available:

<http://www.epa.gov/waterscience/dflow/>



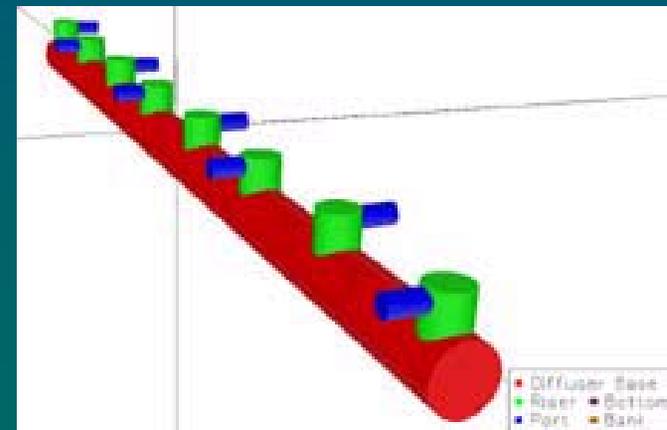
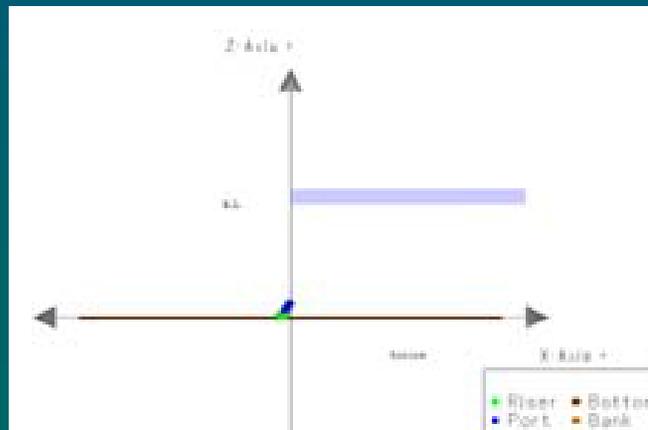
# Mixing Zone Outfall Design

- **Best Practicable Engineering Design**
  - Height of Outfall
  - Distance to Bank
  - Angle of Discharge
  - Single or Multi-Port Diffuser
- **Avoid significant adverse impacts**

3D View of  
multi-port  
alternating  
diffuser

Side view of  
single port  
discharge with  
water surface

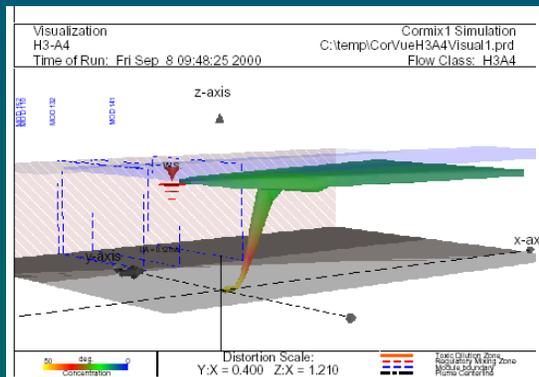
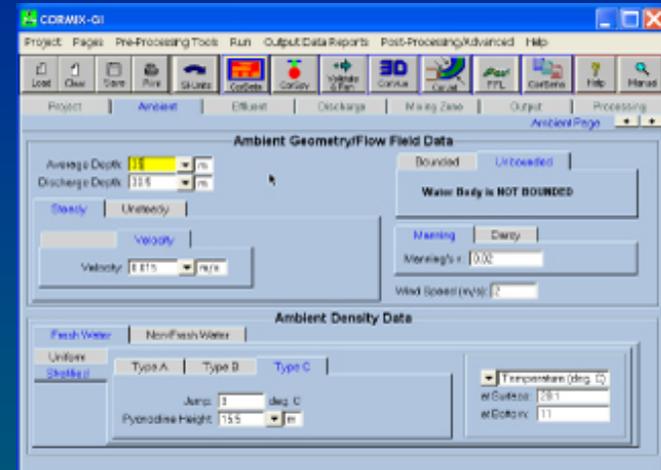
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# Mixing Zone Models

- **CORMIX** is a simulation and decision support system for the environmental impact assessment of mixing zones resulting from continuous point source discharges

[www.cormix.info](http://www.cormix.info)



- **Visual Plumes** is a software application for simulating surface water jets and plumes.

# Mixing Zone Water Quality

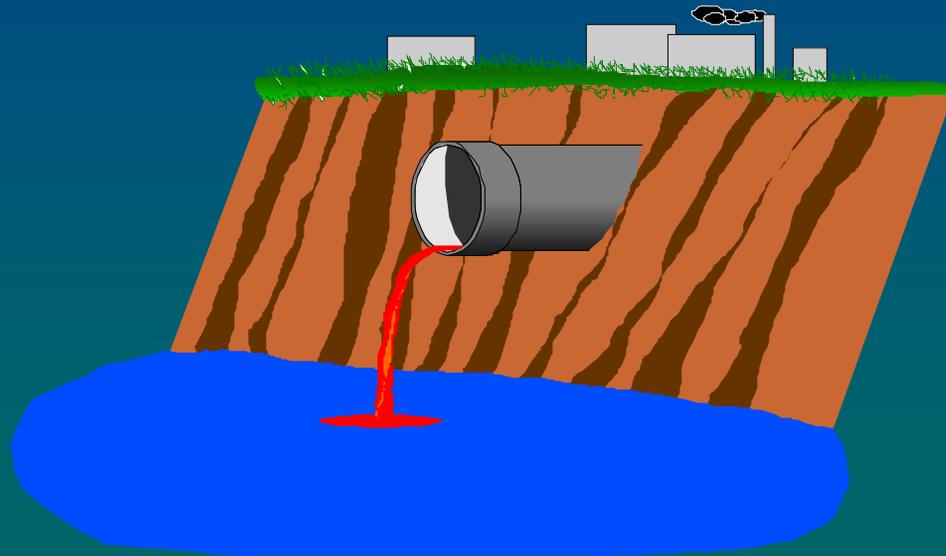
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- **Mixing Zones Should Be Free from:**
  - Concentrations causing acute toxicity
  - Concentrations forming objectionable deposits
  - Floating debris, oil, scum, and other nuisance materials
  - Substances producing objectionable color, odor, taste, or turbidity
  - Substances that result in a dominance of nuisance species

# Mixing Zones Issue (1): Is the effluent attractive ?

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- States and tribes should consider whether a mixing zone may attract aquatic life.



# **Mixing Zone Issue (2): Are there Bioaccumulative Chemicals?**

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- **Mixing zones for bioaccumulative pollutants should be carefully considered**
  - **Bioaccumulatives are more likely to affect the entire water body**
  - **Restrict mixing zones where extensive fish or shellfish harvesting takes place**
  - **GLI requires phase-out of mixing zones for bioaccumulants, except in some cases**

# Mixing Zone Issue (3): Is there Rapid and Complete Mixing?

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- **Rapid and Complete (R+C) mixing occurs when the lateral variation of instream concentration is small (e.g.,  $< 5\%$ )**
  - **Can occur when effluent flow  $>$  stream flow, or when a diffuser is used**
  - **If there is R+C mixing, use of up to 100% of the appropriate critical flow is proper**
  - **If there is NOT R + C mixing, use of some fraction of the critical flow may be justified**

# EPA Guidance

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- **Technical Support Document for Water Quality-based Toxics Control (1991)**
- **Water Quality Standards Handbook (1994)**
- **Allocated Impact Zones Guidance (1995)**
- **Great Lakes Initiative (40 CFR 132 App. F)**
- **Regional and Approved State/Tribal Mixing Zone Policies and Implementation Procedures**

# EPA Guidance

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- **Compilation of EPA Mixing Zone Documents (July, 2006) EPA 823-R-06-003**
- <http://www.epa.gov/waterscience/standards/mixingzone/>

# Module 17: Class Exercise

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- **Handout 17-1**