Stream Mixing Zones and TRC Determinations

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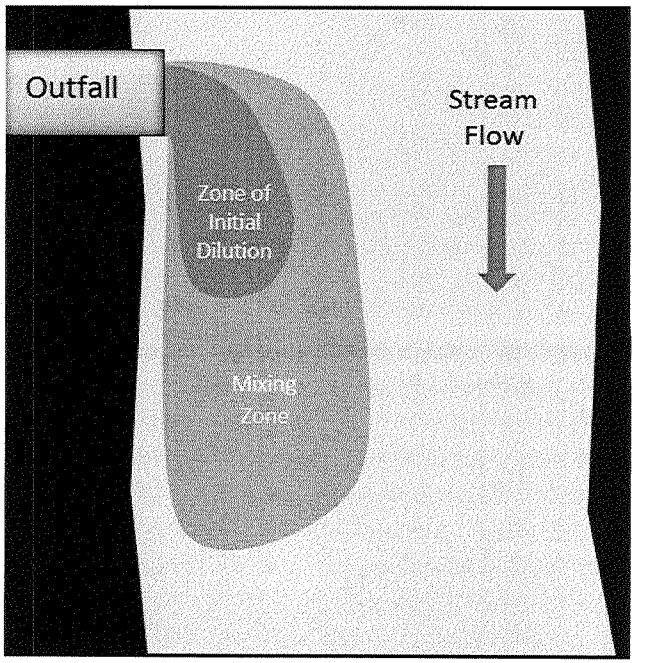
What is a Mixing Zone?

- A mixing zone is an area where an effluent discharge undergoes mixing with the receiving waterbody
- The establishment of a mixing zone for application in determining waste discharge limits is an option of the state program
  - No federal regulations establish a maximum mixing zone size
- With no mixing zone allowed, all WQS would apply at the end of the discharge pipe



Why Use Mixing Zones?

- Pollutant concentrations can be diluted by receiving waters

- APC&EC Reg. 2.508:

"Toxic substances shall not be present in receiving waters, after mixing, in such quantities as to be toxic to human, animal, plant or aquatic life or to interfere with the normal propagation, growth and survival of the indigenous aquatic biota."

- Mixing zone concentrations can be more representative of the pollutant concentrations seen by the aquatic life in the receiving stream

- Taking mixing zones into account can decrease amount of treatment needed to meet limits

Dilution= Solution to Pollution?

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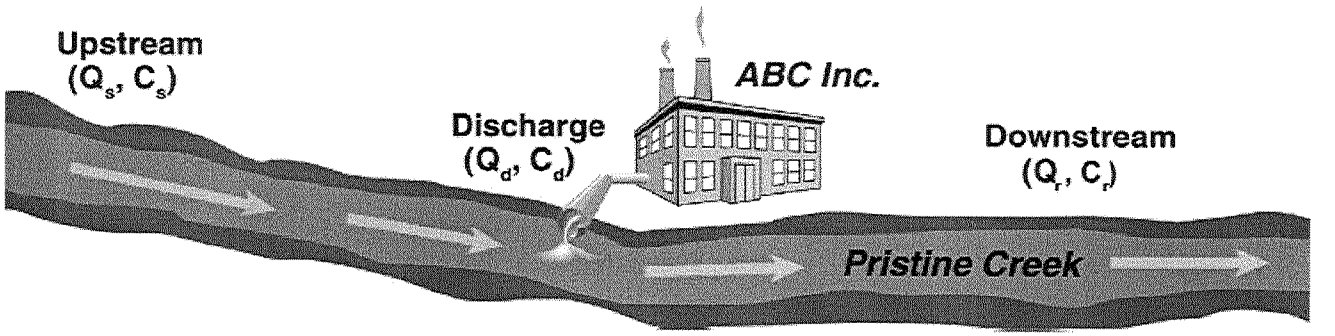
How Does ADEQ Use Mixing Zones?

- Used in determining aquatic life toxicity and human health toxicity for specific toxic pollutants
  - Mixing zones allow for adjusted critical flows for:
    - reasonable potential (RP) analyses
    - effluent limitation calculations
- Whole Effluent Toxicity Testing
  - Used in determining critical dilution and dilution series

Overview of RP/Limit Calculations

- Based on a mass-balance approach



Mass = **Flow** (Q) in million gallons per day (mgd) or cubic feet per second (cfs) X **Pollutant concentration** (C) in milligrams per liter (mg/L)

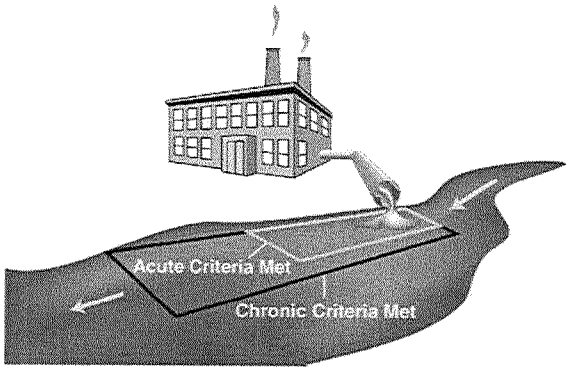
$$Q_sC_s + Q_dC_d = Q_rC_r$$

where

Q_s	=	stream flow in mgd or cfs above point of discharge
C_s	=	background in-stream pollutant concentration in mg/L
Q_d	=	effluent flow in mgd or cfs
C_d	=	effluent pollutant concentration in mg/L
Q_r	=	resultant in-stream flow, after discharge in mgd or cfs
C_r	=	resultant in-stream pollutant concentration in mg/L (after complete mixing occurs)

Types of Toxicity Criteria

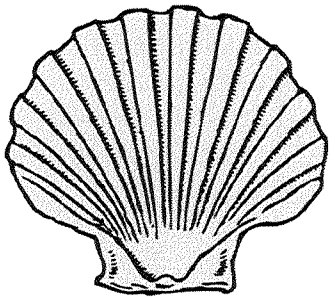
- Acute, Chronic, and Human Health
- Acute toxicity standards apply outside the zone of initial dilution (ZID)
  - Within the ZID, acute toxicity standards may be exceeded but acute toxicity may not occur
- Chronic toxicity and chronic numeric toxicity standards apply at, or beyond, the edge of the mixing zone (MZ)

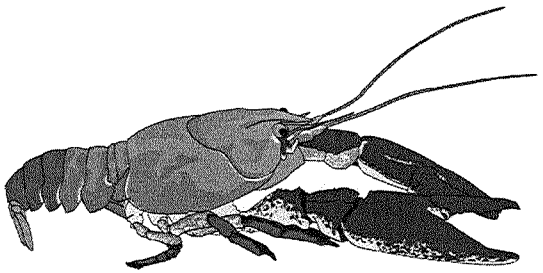


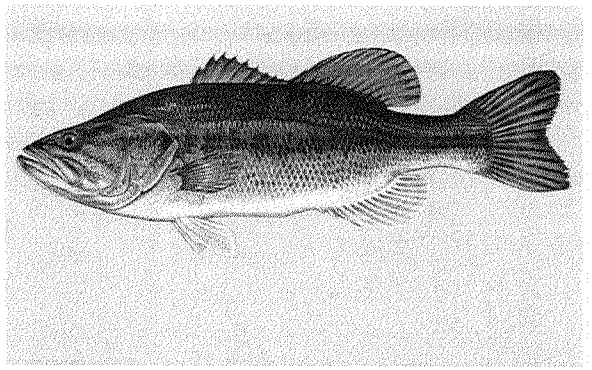
- Human health toxicity is based on the stream harmonic mean flow or long term average flow

Mixing Zones for Aquatic Life Toxicity

- Based on flow volume
- Large streams (7Q10 > 100 cfs)
  - MZ constitutes 25% of the critical flow
- Small streams (7Q10 < 100 cfs)
  - MZ constitutes 67% of the critical flow







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Zone of Initial Dilution for Aquatic Life Toxicity

- ZID is defined as 25% of the mixing zone in the following waters:
  - Mississippi River
  - Arkansas River
  - White River (below confluence with Black River)
  - Ouachita River (below confluence with Little Missouri River)
  - Missouri River
  - Red River
    - If a high rate diffuser is used, the ZID for the above waters may be 50% of the mixing zone
- ZID is defined as 50% of the mixing zone in all other streams

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Mixing Zones for Lakes and Reservoirs for Aquatic Life Toxicity

- Mixing zones for lakes must be minimized and may not be allowed in lakes heavily used for recreation
- When allowed for, mixing zone for lakes is estimated using a jet mix model:

$$Dilution\ factor = \frac{(2.8)(D)\left(\pi^{1/2}\right)}{\%\ effluent\ at\ X\ distance} \times 100$$

D= discharge pipe diameter,

Aquatic life criteria: X= 25 ft. for ZID, 100 ft. for MZ

Human health criteria: X= 25 ft. for ZID, 200 ft. for MZ

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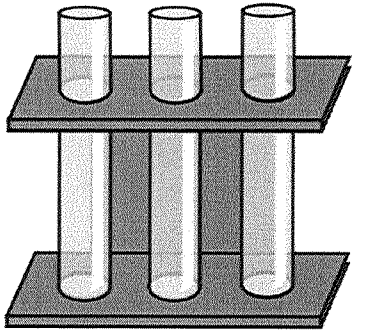
Mixing Zones for WET Testing

- Large streams (7Q10 > 100 cfs)
  - MZ constitutes 25% of the critical flow
- Small streams (7Q10 < 100 cfs)
  - MZ constitutes 67% of the critical flow
- ZID constitutes 10% of the mixing zone
  - only used in calculating critical dilution for acute WET testing



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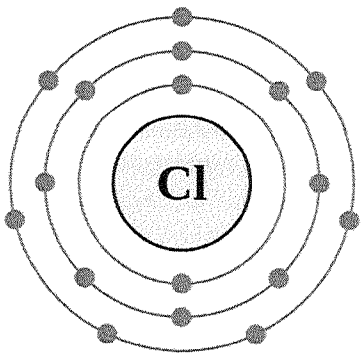
Other Notes about Mixing Zones

- Mixing zones are not allowed for:
  - The parameters bacteria, oil and grease, or pH
  - Locations where the background flow is less than the critical flow
  - Locations where the background concentration of a waste parameter exceeds the specific criteria for that waste parameter
- Mixing zones shall not prevent the free passage of fish or significantly affect aquatic ecosystems
- A mixing zone shall not include any domestic water supply intake

Total Residual Chlorine (TRC) Determination



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Why is TRC important?

- Chlorine is one of the most common disinfection technologies used
- Has been shown to be very effective
- However, residual chlorine in discharges can be toxic to aquatic life in receiving waters
- Acute criteria=0.019 mg/L, chronic criteria=0.011 mg/L

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TRC Reasonable Potential Analysis

- Mass balance is performed with the following information:
  - Critical low flow of receiving stream (7Q10)
  - Background concentration of receiving stream
  - Design flow of facility
  - Combined flows of the receiving stream and facility
  - Mixing zone % (if applicable)
  - Reported effluent concentration
- Downstream pollutant concentrations (acute and chronic) are determined and compared to the criteria
- If one of the downstream concentrations is above the criteria, the facility shows reasonable potential (RP)

How is ADEQ Addressing TRC?

- If RP is shown:
  - Monitor for TRC with other parameters
  - Develop BMPs with the goal of reducing TRC to non-toxic levels
    - Proper dosing, ensure sufficient contact time, using correct type of chlorine
  - If TRC levels are not reduced, a limit may be given with a Schedule of Compliance
  - Facility may need to look at alternatives to BMPs
    - Dosing systems, dechlorination, UV disinfection

TRC Limit Determination

- Mass balance is performed with the following information:
  - Critical low flow of receiving stream (7Q10)
  - Background concentration of receiving stream
  - Design flow of facility
  - Combined flows of the receiving stream and facility
  - Mixing zone % (if applicable)
- Maximum effluent concentration that will meet WQS is determined

TRC RP Example with Mixing Zone

- Given:
  - Design flow of facility=0.1 MGD=0.155 cfs
  - Reported effluent concentration=0.45 mg/L
  - 7Q10 of receiving stream=10 cfs
  - Background concentration=0 mg/L
  - Acute criteria=0.019 mg/L, chronic criteria=0.011 mg/L
- Is there reasonable potential for this discharge to violate WQS?

$$IWC = \frac{(C_d * Q_d) + (C_s * Q_s)}{(Q_d + Q_s)}$$

$$Q_b(acute) = (7Q10) \times (MZ) \times (ZID)$$

$$Q_b(chronic) = (7Q10) \times (MZ)$$

- IWC= Instream waste concentration
- Cd= Discharge concentration
- Qd= Discharge flow
- Cs= Stream background concentration
- Qs= Adjusted low flow of receiving stream (accounting for mixing zone)

Qd, cfs	0.155	
Cd, mg/L	0.45	
Cs, mg/L	0	
7Q10, cfs	10	
	Acute	Chronic
Mixing zone, %	67%	67%
ZID, %	50%	N/A
Qs, cfs	3.35	6.70
IWC, mg/L	0.020	0.010
Criteria, mg/L	0.019	0.011
Is RP shown?	Yes	No

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TRC Limit Determination

$$Limit = \frac{(IWC * (Q_d * Q_s)) - (C_s * Q_s)}{(Q_d)}$$

$$Q_s(acute) = (7Q10) \times (MZ) \times (ZID)$$

$$Q_s(chronic) = (7Q10) \times (MZ)$$

IWC= Instream waste concentration

Cd= Discharge concentration

Qd= Discharge flow

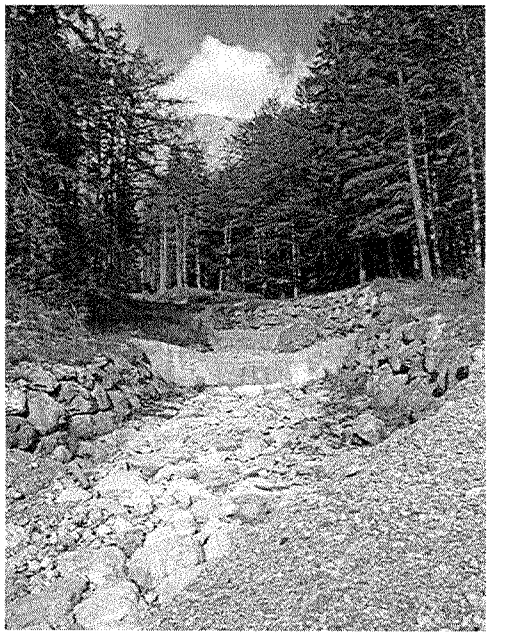
Cs= Stream background concentration

Qs= Adjusted low flow of receiving stream (accounting for mixing zone)

Qd, cfs	0.155	
Cs, mg/L	0	
7Q10, cfs	10	
	Acute	Chronic
Mixing zone, %	67%	67%
ZID, %	50%	N/A
Qs, cfs	3.35	6.70
Criteria, mg/L	0.019	0.011
Limit	0.430	0.487

What if the receiving stream had a low flow (7Q10) of 0?

- Criteria must be met at the discharge point in order to be protective of water quality
- Limit would be set at the criteria (0.011 mg/L)



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Thank you!

Any questions?

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