Mixing Zones, Metals, Translators and Other Things You Always Wanted to Know about NPDES Effluent Limits

Florida NPDES Update

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Water Quality Based Effluent Limitations

- ***Why?***
  - Impaired waterway
  - Cause or Reasonable Potential to Cause exceedance of water quality criterion
  - New more stringent water quality criteria
  - New monitoring data for receiving water or WWTP
  - Improved laboratory detection limits
- Any of above could require a water quality based effluent limitation (WQBEL)
  - acute and chronic aquatic life
  - carcinogenic and noncarcinogenic human health

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Fresh Water Criteria - Zinc

Aquatic Life *(for hardness = 100 mg/l)*		
Acute	120 ug/l	dissolved
Chronic	120 ug/l*	dissolved
Human Health		
Water + Organism	7,400 ug/l	total
Organism Only	26,000 ug/l	total

**same as FL Class I and Class III fresh water criteria*

Fresh Water Criteria - Nickel

Aquatic Life *(for hardness = 100 mg/l)*		
Acute	470 ug/l	dissolved
Chronic	52 ug/l*	dissolved
Human Health		
Water + Organism	610	total
Organism Only	4,600 ug/l	total

**same as FL Class I and Class III fresh water criteria*

Example 1: Permit Limits & Effluent Data

Parameter	***Limit***	***Avg. Period***	***Data***
Cadmium	2.9 ug/l	daily maximum	< 1 - 722
Copper	20 ug/l	daily maximum	5 - 90
Lead	7.1 ug/l	daily maximum	1 - 18
Nickel	210.6 ug/l	daily maximum	2.9 - 95
Silver	4.4 ug/l	daily maximum	< 0.5 - 6
Zinc	128.8 ug/l	daily maximum	15 - 89

Example 2: Permit Limits & Effluent Data

Parameter	***Limit***	***Avg. Period***	***Data***
Cadmium	4.4 ug/l	daily maximum	< 0.4 - 18
Copper	40.5 ug/l	daily maximum	5.8 - 50
Zinc	257 ug/l	daily maximum	14 - 590

What Do I Do?

- Evaluate operations data
  - *Are data representative?*
  - *Outliers?*
- Evaluate effluent limit
  - *Is it right?*
  - *Alternatives to remove or relax limit?*
- Evaluate ways to reduce effluent concentration
  - *Treatment alternatives?*
  - *Source reduction?*

Data Outliers

- Use statistical tests to exclude outliers from data set
- Outliers are data points that are not representative of the general population of data
  - Sampling errors
    - Sample contamination
    - Use clean techniques
  - Lab errors
  - Changed conditions

Data Outliers: Lead (ug/l)

07/14/04	<	1
08/19/04	<	1
09/16/04	<	3
10/14/04	<	1
11/30/04		12.1
12/29/04	<	3
01/21/05	<	3
02/16/05	<	3
03/15/05	<	1
04/21/05	<	2.2
05/12/05	<	1
06/08/05	<	3

Data Outliers: Cadmium (ug/l)

01/16/03	<	0.5	01/22/04	<	0.3
02/11/03		722	02/05/04		0.78
03/12/03		546	03/11/04	<	0.3
04/10/03		646	04/07/04	<	0.3
05/15/03		32	05/12/04	<	0.3
06/05/03		500	06/08/04	<	0.3
07/17/03	<	0.5	07/14/04	<	0.3
08/07/03		212	08/19/04	<	1
09/04/03	<	0.5	09/16/04	<	1
10/17/03	<	1	10/14/04	<	0.3
11/07/03	<	0.3	11/30/04	<	0.3
12/10/03		0.31	12/29/04	<	1

Data Outliers: Bis(2-ethylhexyl)phthalate (ug/l)

07/17/03	< 2	07/14/04	< 2
08/07/03	< 2	08/19/04	< 2
09/04/03	< 2	09/16/04	< 2
10/17/03	< 2	10/14/04	< 2
11/07/03	< 2	11/30/04	< 2
12/10/03	< 2	12/29/04	< 2
01/22/04	< 2	01/21/05	41
02/05/04	< 2	02/16/05	53
03/11/04	< 2	03/15/05	16
04/07/04	< 2	04/21/05	110
05/12/04	< 2	05/12/05	32
06/08/04	< 2	06/08/05	24

Critical Factors for WQBELs

- Monitoring Data
  - Effluent and receiving water characterization
- Receiving Water – dilution factor is critical
  - Critical Low Flow
  - Mixing Zone
  - Steady State vs Dynamic Modeling
- For Metals
  - Hardness - higher at low flow; limits at low flow
  - Dissolved versus Total Recoverable - Translator
  - Water Effect Ratio (WER)

Metals Water Quality Criteria

- *Criteria for Protection of Aquatic Life*
  - *Hardness dependent for several metals**
  - *Criterion basis*
    - *Acute:* $exp\ \{\ m_A\ [ln(hardness)] + b_A$
    - *Chronic:* $exp\ \{\ m_C\ [ln(hardness)] + b_C\}$

**e.g., in Florida – cadmium, chromium III, copper, lead, nickel and zinc*

Metals Water Quality Criteria

- *Recognition that criteria should be expressed as dissolved metal**
  - *Apply conversion factor (CF)*
  - *Acute: $\exp\{ m_A [\ln(\text{hardness})] + b_A\} * CF$*
  - *Chronic: $\exp\{ m_C [\ln(\text{hardness})] + b_C\} * CF$*

**e.g., in Florida – cadmium, chromium, copper, lead, nickel, silver and zinc*

Metals Water Quality Criteria

- *Recognition that site specific natural waters are less toxic than laboratory test waters*
  - *Apply Water Effect Ratio (WER)*
  - *Acute: $WER * exp\{m_A [ln(hardness)] + b_A\} * CF$*
  - *Chronic: $WER * exp\{m_C [ln(hardness)] + b_C\} * CF$*

Translators

- Translator = ratio of dissolved concentration to total recoverable concentration.
- Many water quality criteria are dissolved
- Effluent data are total recoverable
- Need method to convert
- Translator < 1.0 -- ***the smaller the better!***
  - Multiply total recoverable effluent concentration by translator to get dissolved effluent concentration
  - Divide dissolved criterion by translator to get effective site specific total recoverable criterion

Actual Translators

	Default Freshwater Acute	Default Freshwater Chronic	***Typical Actual***
Copper	0.96	0.96	***0.4 – 0.6***
Lead	0.791	0.791	***0.4 – 0.6***
Zinc	0.978	0.986	***0.6 – 0.8***

Water Effect Ratio - WER

- WER is the ratio of site specific toxicity to laboratory toxicity
- Many metals are less toxic in site specific waters than in lab waters
- WER > 1.0 -- ***the larger the better!***
- Multiply water quality criterion by WER
- WER effectively increases the water quality criterion
  - Can have dissolved WER and total WER
- Applicable to aquatic life criteria only

WER – Copper Example

	Default Criterion ***WER = 1***	Actual Criterion ***WER = 2***	Actual Criterion ***WER = 4***	Actual Criterion ***WER = 6***
Acute Aquatic Life	12.7 ug/l*	25.4 ug/l*	50.8 ug/l*	76.2 ug/l*
Chronic Aquatic Life	8.5 ug/l*	17.0 ug/l*	34 ug/l*	51 ug/l*

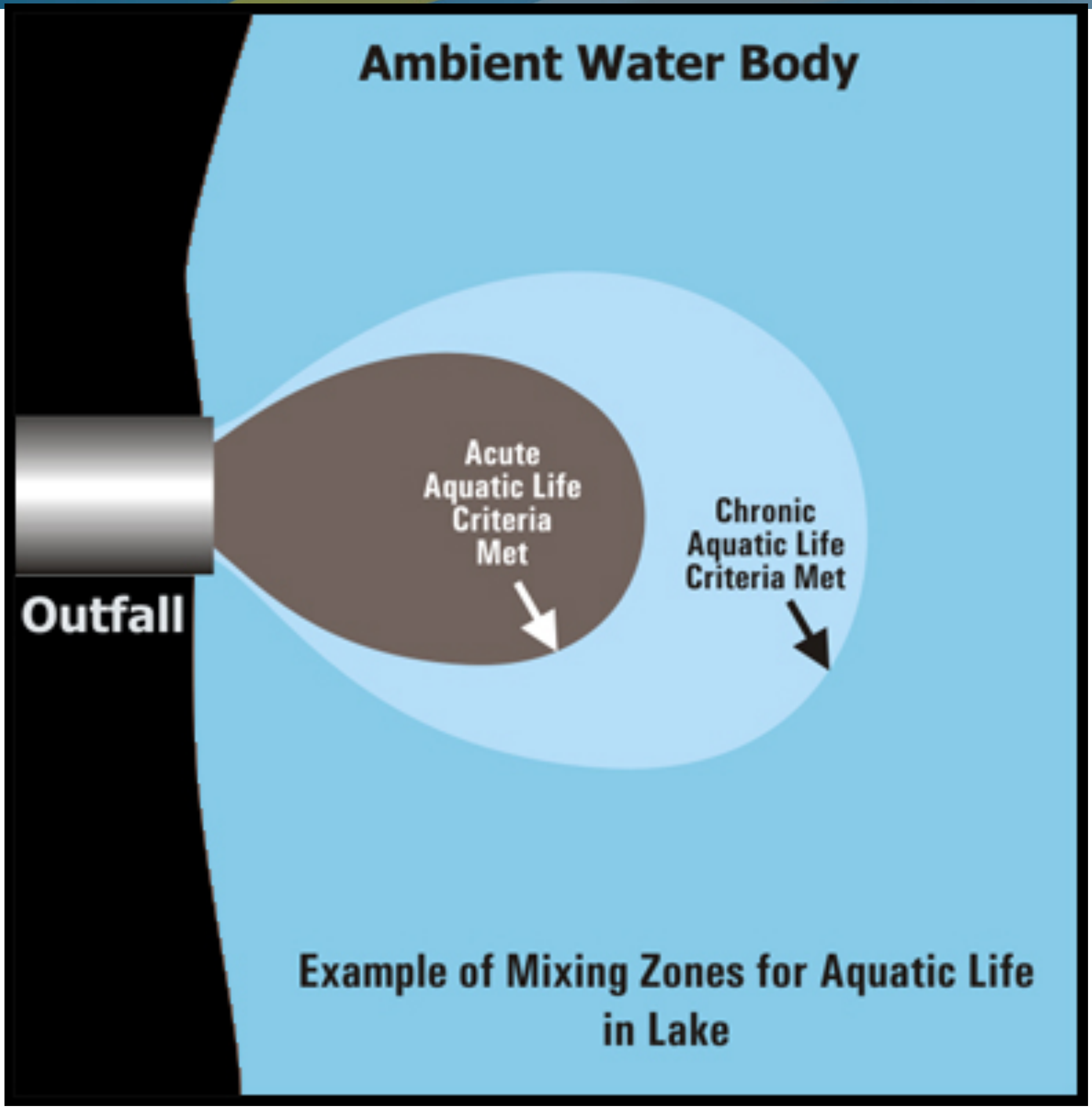
**for stream hardness of 100 mg/l*

Actual Copper WERs

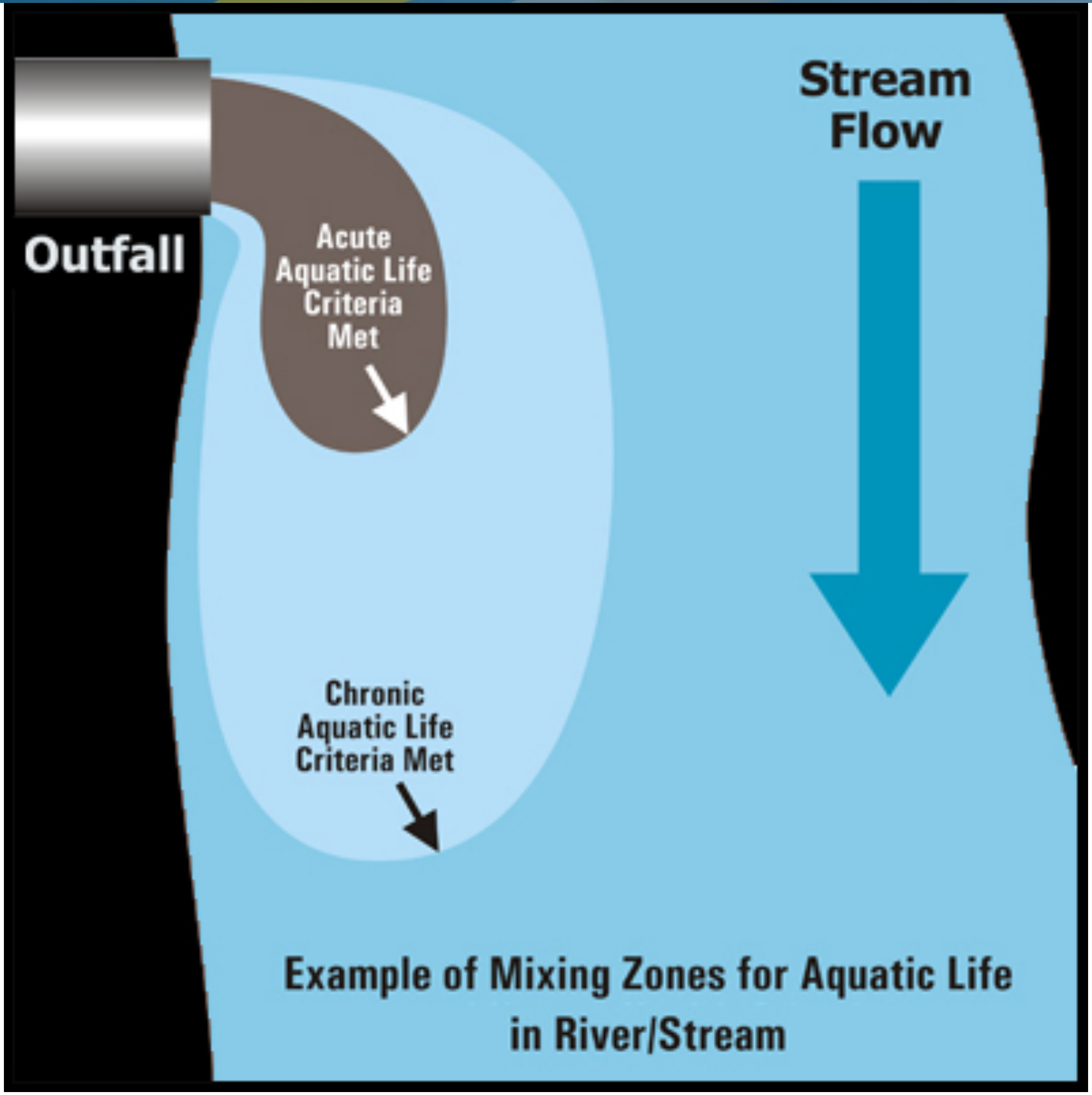
Facility	WER
SRVSA, 23 mgd, DF = 3.7	2.56
Black's Creek, 3 mgd, DF = 1.6	6.45
Mtown, 3.9 mgd, DF = 1.3	4.23
CV, 0.286 mgd, DF = 1	4.76
ELSA, 16 mgd, dynamic model	2.63

Mixing Zones

- A limited area within a receiving water adjacent to the point of discharge within which the water quality criteria are permitted to be exceeded
- Allows for mixing of the effluent with the receiving water where complete mixing across the width of the receiving water is not rapidly achieved
  - e.g., coastal areas; large rivers; lakes



http://water.epa.gov/scitech/swguidance/standards/mixingzones/pop_pic1.cfm



http://water.epa.gov/scitech/swguidance/standards/mixingzones/pop_pic1.cfm

Mixing Zones

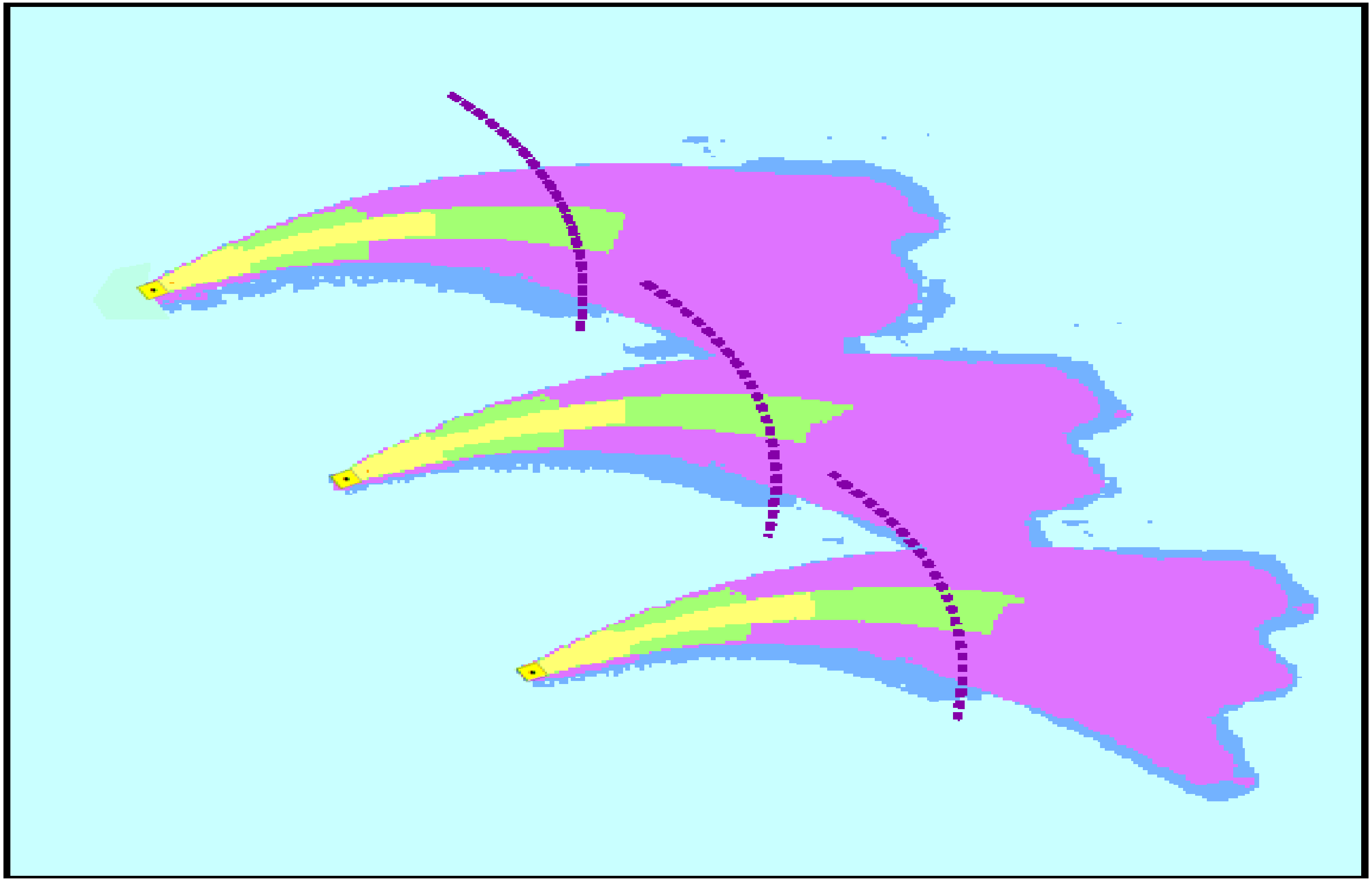
- Without a mixing zone, water quality criteria would have to be met at end-of-pipe
- Calculate dilution factor achieved at edge of mixing zone, and apply to determination of effluent limits
  - Acute and chronic mixing zones
  - Acute and chronic dilution factors
- Computer simulation model to calculate size of mixing zone and dilution factor - CORMIX
- Dye study may be needed to verify dilution factor
- If water quality criteria are met at edge of mixing zone, then no need for WQBEL

Outfall Diffuser

- Typical single outfall pipe does not provide for rapid mixing
  - Therefore, effluent limits will be based on zero dilution, i.e., meet receiving water criteria at end of pipe
- Use outfall diffuser to enhance mixing
  - Evaluate alternative diffusers with simulation model

Outfall Pipe versus Outfall Diffuser

Example A: 3 Port Outfall Diffuser



Example B: 13 Port Outfall Diffuser

Outfall Diffuser

- Select outfall diffuser configuration to achieve desired dilution factor
  - Demonstrate no need for effluent limit and no impact to aquatic life
- Factors to consider
  - Depth of receiving water
  - Number of discharge ports
  - Angle of discharge ports
  - Size of discharge ports
- Use computer simulation model to evaluate possible outfall configurations

Questions?