Options for Metals Effluent Limitations in NPDES Permits

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Raymond A. Ferrara, Ph.D.
Vice President / Principal

Why am I getting metals limits?

- Impaired waterway
- Need a water quality based effluent limitation (WQBEL)
- Need a technology based effluent limitation (TBEL)
- More stringent water quality criteria
  - some criteria are below detection limits
  - acute and chronic aquatic life
  - carcinogenic and noncarcinogenic human health
- Increased monitoring of waterways and WWTP discharges
- Improved laboratory detection limits

Fresh Water Criteria - Zinc

Aquatic Life		
Acute	120 ug/l*	dissolved
Chronic	120 ug/l*	dissolved
Human Health		
Carcinogenic	---	---
Non carcinogenic	7,400 ug/l	total recoverable

**for stream hardness of 100 mg/l*

Saline Water Criteria - Zinc

Aquatic Life		
Acute	90 ug/l	dissolved
Chronic	81 ug/l	dissolved
Human Health		
Carcinogenic	---	---
Non carcinogenic	26,000 ug/l	total recoverable

Fresh Water Criteria - Arsenic

Aquatic Life		
Acute	340 ug/l	dissolved
Chronic	150 ug/l	dissolved
Human Health		
Carcinogenic	0.018 ug/l	total recoverable
Non carcinogenic	---	---

Saline Water Criteria - Arsenic

Aquatic Life		
Acute	69 ug/l	dissolved
Chronic	36 ug/l	dissolved
Human Health		
Carcinogenic	0.14 ug/l	total recoverable
Non carcinogenic	---	---

EL Sewerage Authority

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

Borough of W

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 source loadings

Data Outliers – Lead Example

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

All concentrations in ug/l

Data Outliers – Cadmium Example

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

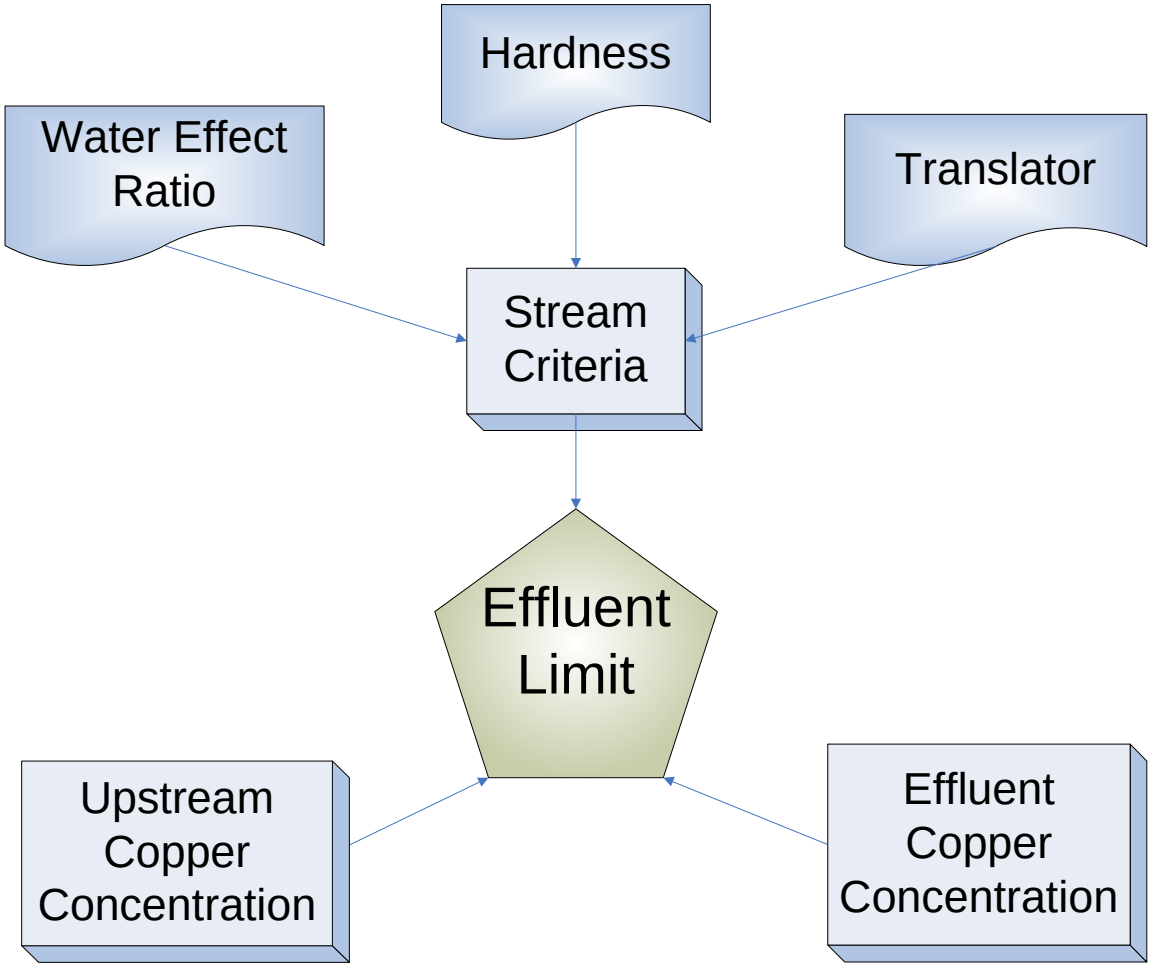
Data Outliers – Bis Example

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 Effluent Limit

- Monitoring Data
  - Effluent and receiving water characterization
  - Hardness - higher at low flow; limits at low flow
- Dissolved versus Total Recoverable - Translator
- Site specific toxicity – Water Effect Ratio (WER)
- Site Specific Criteria
- Receiving water – dilution factor is critical
  - Steady State vs Dynamic Modeling

Factors that affect your WQBEL



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: $exp\{ m_C [ln(hardness)] + b_C\}$*

Metals Water Quality Criteria

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

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!***
  - Divide dissolved criterion by translator to get effective site specific total recoverable criterion
  - Multiply total recoverable effluent concentration by translator to get dissolved effluent concentration

Default Translators

	Freshwater Acute	Freshwater Chronic	Saline Acute	Saline Chronic
Copper	0.96	0.96	0.83	0.83
Lead	0.791	0.791	0.951	0.951
Zinc	0.978	0.986	0.946	0.946
Arsenic	1.0	1.0	1.0	1.0

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

Reduce Effluent Concentration

- Sources
  - Industrial
  - Individual Residential
  - Area Residential
  - Potable Water
  - WWTP facilities / operations
- IPP Program
  - Periodic data review
  - Independent monitoring
    - *consider temporal aspects*
- Influent and sewer system monitoring

Treatment Control Strategies

- Most research done for industrial wastes with higher concentrations
  - Not always directly applicable to treatment at low concentrations
- Look for correlations with other operational control parameters
  - Temperature
  - MCRT
  - pH
  - SS concentrations

Treatment Control Strategies

- Effluent suspended solids concentrations
  - Total recoverable metals concentration generally directly proportional to SS concentration
  - Ratio of dissolved to total metals generally inversely proportional to SS concentration (i.e. at low SS, all metal is dissolved)
  - Need site specific data

Treatment Control Strategies

- pH
  - Generally better removal at higher pH
  - Potential for better metals removal with upward pH adjustment but removal may level off in pH range of 8
  - Bench tests provide easy assessment

Treatment Control Strategies

Arsenic	5 ug/l	Ferric hydroxide co-ppt
Arsenic	1 ug/l	Adsorption with metal (iron) oxide media
Copper	10 – 20 ug/l	Sulfide ppt
Zinc	100 ug/l	Hydroxide ppt at pH 11
Cadmium	8 ug/l	Sulfide ppt
Mercury	1 – 5 ug/l	Ion exchange
Mercury	0.5 – 5 ug/l	Ferric hydroxide co-ppt

Questions?