



# **WATER QUALITY-BASED EFFLUENT LIMITS**

WQBELs

Cole Gray, DrPH  
October 2023

# Water Quality-Based Effluent Limits (WQBELs)

Effluent limitations designed to protect the quality of the receiving water.

Developed for:

- Domestic discharges  $> 1$  MGD or designated as a “major” facility
- Domestic discharges with reasonable potential to have toxic pollutants present in the wastewater
- Industrial facilities
- No stormwater

The water quality goals for a water body are defined in 30 TAC Chapter 307 (TSWQS)

Permit limits apply to discharges.

Water quality criteria apply to water bodies.

*Texas Surface Water Quality Standards* criteria do not apply directly to a discharge.

# What factors influence water quality-based permit limits?

1. Numerical criteria  
(toxic pollutants)
2. Water body quality
3. Effluent fraction  
(mixing)
4. Bioavailable fraction

# Numerical criteria for aquatic life and human health protection.

Found in Texas Surface Water Quality Standards (30 TAC Chapter 307 Section 6 – Toxic Materials)

Parameter	CASRN	Freshwater Acute Criteria	Freshwater Chronic Criteria	Saltwater Acute Criteria	Saltwater Chronic Criteria
Acrolein	107-02-8	3.0	3.0	---	---
Aldrin	309-00-2	3.0	---	1.3	---
Aluminum (d)	7429-90-5	991w	---	---	---
Arsenic (d)	7440-38-2	340w	150w	149w	78w
Cadmium (d)	7440-43-9	$(1.136672 - (\ln(\text{hardness})(0.041838))) (we^{(0.9789(\ln(\text{hardness}))-3.866)})$	$(1.101672 - (\ln(\text{hardness})(0.041838))) (we^{(0.7977(\ln(\text{hardness}))-3.909)})$	33w	7.9w
Carbaryl	63-25-2	2.0	2.0	1.6	---
Chlordane	57-74-9 and 12789-03-6	2.4	0.004	0.09	0.004

# Numerical criteria for toxic materials can change over time.

Criteria revisited every three years

<b>Pollutant</b>	<b>2018 Criteria</b>	<b>2022 Criteria</b>	<b>% Change</b>
Aldrin <i>Freshwater, acute</i>	3.0 µg/L	3.0 µg/L	No change
Tetrachloroethylene <i>Human health, fish only</i>	280 µg/L	237 µg/L	-15 %
Benzo(a)anthracene <i>Human health, fish only</i>	0.025 µg/L	0.103 µg/L	+412 %

# Numerical criteria for human health protection reflect exposure.

Table 2. Criteria for Human Health Protection

Criteria in Water for Specific Toxic Materials  
HUMAN HEALTH PROTECTION

(All values are listed or calculated in micrograms per liter unless otherwise noted)

Parameter	CASRN	A	B
		Water and Fish µg/L	Fish Only µg/L
Acrylonitrile	107-13-1	1.0	115
Aldrin	309-00-2	1.146E-05	1.147E-05
Anthracene	120-12-7	1,109	1,317
Antimony	7440-36-0	6 <sup>1</sup>	1,071
Arsenic (d)	7440-38-2	10 <sup>1</sup>	---
Barium (d)	7440-39-3	2,000 <sup>1</sup>	---
Benzene	71-43-2	5 <sup>1</sup>	581

# Not all numerical criteria are expressed in the same way.

- Most criteria are for total concentrations.
- Some metals criteria are for dissolved concentrations:
  - **aluminum**
  - **arsenic**
  - **cadmium**
  - **chromium (tri and hex)**
  - **copper**
  - **lead**
  - **nickel**
  - **silver (free ion)**
  - **zinc**

Permit limits are written for total concentrations.



# Water Body Quality

Critical values for water quality parameters for each classified segment are found in *Procedures to Implement the Texas Surface Water Quality Standards (IPs)*, June 2010, Appendix D.

- TSS
- pH
- Total hardness
- Total dissolved solids (TDS)
- Chloride
- Sulfate

# Criteria for pentachlorophenol are affected by pH.

$$\text{Acute criterion} = e^{(1.005(\text{pH})-4.869)}$$

$$\text{Chronic criterion} = e^{(1.005(\text{pH})-5.134)}$$

Pentachlorophenol is more toxic at lower pH values.

For pH of 3:

Acute criterion = 0.157

Chronic criterion = 0.120

For pH of 6:

Acute criterion = 3.19

Chronic criterion = 2.45

# Some freshwater criteria depend on the hardness of the receiving water.

These include:

- cadmium
- chromium (trivalent)
- copper
- lead
- nickel
- zinc

Example: copper

$$\text{Acute criterion} = 0.960\text{me}^{(0.9422(\ln(\text{hardness})) - 1.6448)}$$

$$\text{Chronic criterion} = 0.960\text{me}^{(0.8545(\ln(\text{hardness})) - 1.6463)}$$

Metals affected by hardness are more toxic in soft water.

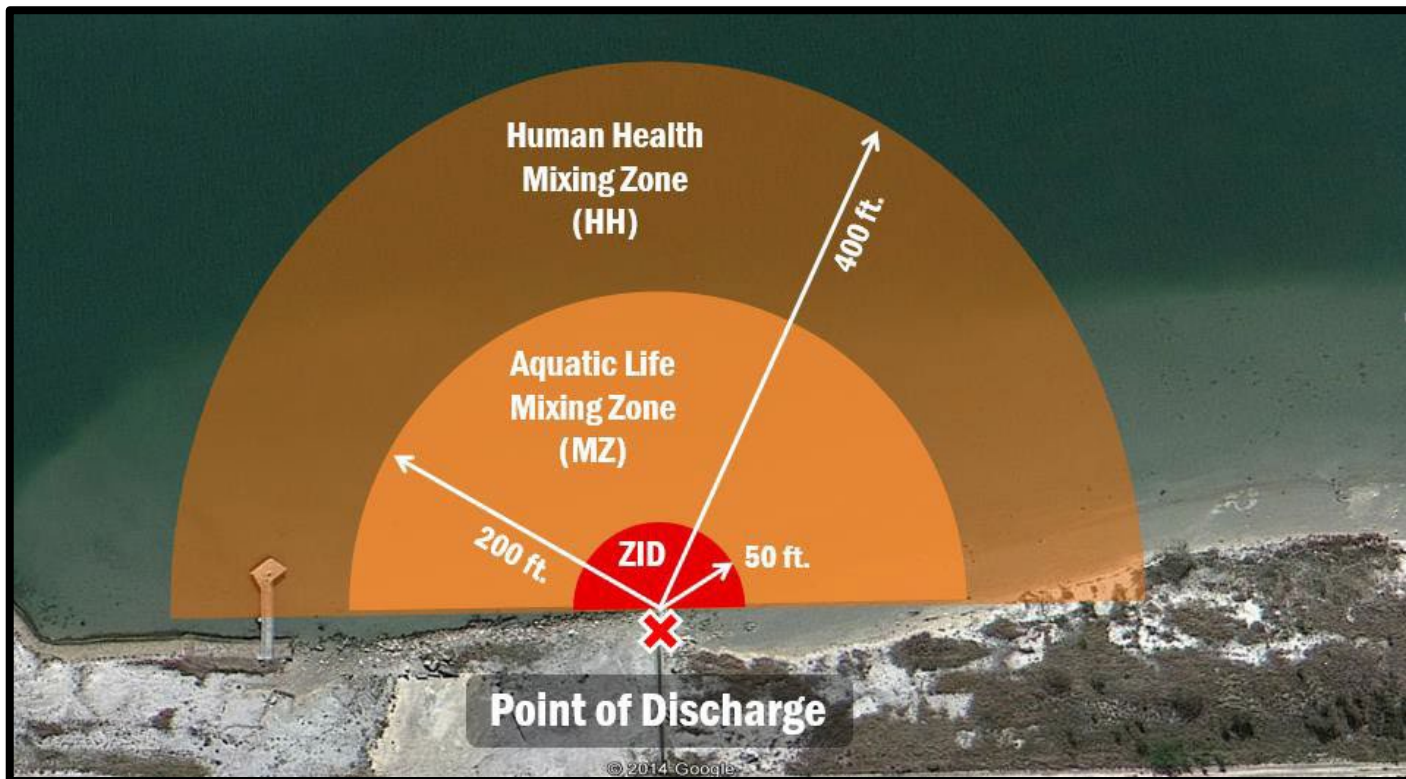
Freshwater criteria are lower at smaller hardness values.

Example: copper

<b>Segment Number</b>	<b>Water Body Name</b>	<b>Hardness (mg/L of CaCO<sub>3</sub>)</b>	<b>Acute Criterion (µg/L)</b>	<b>Chronic Criterion (µg/L)</b>
<b>0505</b>	Sabine River Above Toledo Bend Reservoir	42	6.27	4.51
<b>1412</b>	Colorado River Below Lake J. B. Thomas	310	41.2	24.8

Effluent fractions help convert numerical criteria into limits.

Numerical criteria apply at the edge of each zone:



# Texas assumes critical low flow or low mixing conditions.

Expressed as:

- ◇ Critical effluent percentages  
(lakes, bays, estuaries, wide tidal rivers)  
or
- ◇ Critical flows  
(streams, rivers, narrow tidal rivers)



Resulting effluent fractions depend on the type of water body.

Water Body	Zone of Initial Dilution (Acute)	Mixing Zone (Chronic)	Human Health Mixing Zone
Stream Least simple	$\frac{Q_E}{Q_E + 0.25(7Q_2)}$	$\frac{Q_E}{Q_E + 7Q_2}$	$\frac{Q_E}{Q_E + HM}$
Lake (default)	60 % effluent	15 % effluent	8 % effluent
Wide tidal (default)	30 % effluent	8 % effluent	4 % effluent
Intermittent Most simple	100 % effluent	100 % effluent	100 % effluent

Metals criteria may be expressed as a dissolved concentration because local water quality affects toxicity.

Conversion from dissolved criteria to total limits uses ambient total suspended solids (TSS) of the nearest downstream classified segment.

Dissolved fraction = bioavailable fraction.

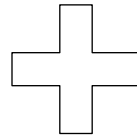
$$\frac{C_d}{C_T} = \frac{1}{1+(K_p \times TSS \times 10^{-6})}$$

$$K_p = 10^b \times (TSS)^m$$

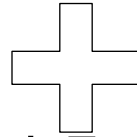


# Putting It All Together

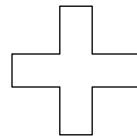
Numerical Criteria



Water Body Quality



Effluent Fraction



Bioavailable Fraction

## Four steps in calculating WQBELs for aquatic life and human health:

Step 1: Calculate **waste load allocation** – WLA

Step 2: Calculate **long-term average** – LTA

Step 3: Calculate **effluent limits**:

- daily average (DLY AVG)
- daily maximum (DLY MAX)

Step 4: Compare WQBELs for aquatic life and human health

# TEXTOX MENU #8 - INTERMITTENT STREAM WITHIN 3 MILES OF A LAKE/RESERVOIR

## PERMIT INFORMATION

Permittee Name: ABC Industry, Inc.  
TPDES Permit No: WQ0005555000  
Outfall No: 001  
Prepared by: Cole Gray  
Date: 10/01/2023

## DISCHARGE INFORMATION

*Intermittent Receiving Waterbody:* ditch  
TSS (mg/L) (Intermittent): 13  
pH (Standard Units) (Intermittent): 7  
Hardness (mg/L as CaCO<sub>3</sub>) (Intermittent): 44  
Chloride (mg/L) (Intermittent): 57  
Effluent Flow for Aquatic Life (MGD) 0.65  
% Effluent for Acute Aquatic Life (Intermittent): 100  
*Lake/Reservoir within 3 miles:* Clean Lake  
Segment No.: 1009  
TSS (mg/L) (Lake/Reservoir): 13  
pH (Standard Units) (Lake/Reservoir): 7  
Hardness (mg/L as CaCO<sub>3</sub>) (Lake/Reservoir): 44  
Chloride (mg/L) (Lake/Reservoir): 57  
% Effluent for Chronic Aquatic Life (Lake/Reservoir): 19  
% Effluent for Acute Aquatic Life (Lake/Reservoir): 74  
Effluent Flow for Human Health (MGD): 0.65  
% Effluent for Human Health (Lake/Reservoir): 9  
Public Water Supply Use? No

Textox Example

# Textox Example (Continued)

CALCULATE DISSOLVED FRACTION (AND ENTER WATER EFFECT RATIO IF APPLICABLE):							
Stream/River Metal	Intercept (b)	Slope (m)	Partition Coefficient (Kp)	Dissolved Fraction (Cd/Ct)	Cd/Ct Source	Water Effect Ratio (WER)	WER Source
Aluminum	N/A	N/A	N/A	1.00	Assumed	1.00	Assumed
Arsenic	5.68	-0.73	73590.43	0.51	-	1.00	Assumed
Cadmium	6.60	-1.13	219403.73	0.26	-	1.00	Assumed
Chromium (Total)	6.52	-0.93	304812.44	0.20	-	1.00	Assumed
Chromium (+3)	6.52	-0.93	304812.44	0.20	-	1.00	Assumed
Chromium (+6)	N/A	N/A	N/A	1.00	Assumed	1.00	Assumed
Copper	6.02	-0.74	156921.31	0.33	-	1.00	Assumed
Lead	6.45	-0.80	362114.00	0.18	-	1.00	Assumed
Mercury	N/A	N/A	N/A	1.00	Assumed	1.00	Assumed
Nickel	5.69	-0.57	113514.75	0.40	-	1.00	Assumed
Selenium	N/A	N/A	N/A	1.00	Assumed	1.00	Assumed
Silver	6.38	-1.03	170859.19	0.31	-	1.00	Assumed
Zinc	6.10	-0.70	209044.94	0.27	-	1.00	Assumed

# Aquatic Life: Calculated Daily Average and Daily Maximum Effluent Limitations

Parameter	FW Acute Criterion (int. stream) (ug/L)	FW Acute Criterion (lake) (ug/L)	FW Chronic Criterion (lake) (ug/L)	WLAa (int. stream)	WLAa (lake)	WLAc (lake)	LTAa (int. stream)	LTAa (lake)	LTAc (lake)	Daily Avg. (ug/L)	Daily Max. (ug/L)
Aldrin	3.0	3.0	N/A	3.00	4.05	N/A	1.72	1.30	N/A	1.91	4.03
Aluminum	991	991	N/A	991	1339	N/A	568	429	N/A	630	1333
Arsenic	340	340	150	665	899	1545	381	288	942	423	895
Cadmium	3.86	3.86	0.14	14.9	27.9	3.92	8.52	8.94	2.39	3.51	7.43
Carbaryl	2.0	2.0	N/A	2.00	2.70	N/A	1.15	0.865	N/A	1.27	2.69
Chlordane	2.4	2.4	0.004	2.40	3.24	0.021	1.38	1.04	0.013	0.019	0.040
Chlorpyrifos	0.083	0.083	0.041	0.083	0.112	0.216	0.048	0.036	0.132	0.053	0.112
Chromium (+3)	290.9	290.9	37.8	1443	5986	3033	827	1915	1850	1216	2572
Chromium (+6)	15.7	15.7	10.6	15.7	21.2	55.8	9.00	6.79	34.0	9.98	21.1
Copper	6.55	6.55	4.69	19.9	41.1	115	11.4	13.2	70.0	16.8	35.5

# Human Health: Calculated Daily Average and Daily Maximum Effluent Limitations

Parameter	Water and Fish Criterion (ug/L)	Fish Only Criterion (ug/L)	WLAh	LTAh	Daily Avg. (ug/L)	Daily Max. (ug/L)
Acrylonitrile	0.80	3.8	42.2	39.3	57.7	122
Aldrin	0.00094	0.0010	0.011	0.010	0.015	0.032
Anthracene	5,569	N/A	N/A	N/A	N/A	N/A
Antimony	6	1,071	11900	11067	16268	34418
Arsenic	10	N/A	N/A	N/A	N/A	N/A
Barium	2,000	N/A	N/A	N/A	N/A	N/A
Benzene	5	513	5700	5301	7792	16486
Benzidine	0.00086	0.0020	0.022	0.021	0.030	0.064
Benzo(a)anthracene	0.68	3.28	36.4	33.9	49.8	105
Benzo(a)pyrene	0.068	0.33	3.67	3.41	5.01	10.6

# Laboratory Analysis Example Worksheet 2.0, Table 2

Pollutant	Sample 1 (µg/L)	Sample 2 (µg/L)	Sample 3 (µg/L)	Sample 4 (µg/L)	Average (µg/L)	MAL (µg/L)
<b>Aluminum</b>	21.9	18.6	28	14	20.625	2.5
<b>Antimony</b>	3.2	3.1	0.717	0.68	1.92425	5
<b>Arsenic</b>	1.2	1.2	1.1	1.1	1.15	0.5
<b>Barium</b>	234.5	230.3	255	233	238.2	3
<b>Beryllium</b>	<0.4	<0.4	<0.1	<0.1	<0.4	0.5
<b>Cadmium</b>	<4	<4	<1	<1	<4	1
<b>Chromium</b>	<0.4	<0.4	5.47	2.12	7.99	3
<b>Chromium (+6)</b>	<1	<1	<0.5	<0.5	<1	3
<b>Chromium (+3)</b>	<1	<1	<1	<1	<1	N/A
<b>Copper</b>	12.7	13.6	10.5	11.9	12.175	2
<b>Cyanide, avail.</b>	<10	<10	<6	<6	<10	2/10
<b>Lead</b>	0.5	<0.4	0.6	0.2	0.375	0.5
<b>Mercury</b>	1.59	1.07	1.03	1.20	1.2226	0.005/0.000 5
<b>Nickel</b>	1.3	1.4	2.3	1.3	1.55	2
<b>Selenium</b>	<0.4	<0.4	0.194	0.20	0.1985	5
<b>Silver</b>	<0.4	<0.4	<0.2	<0.2	<0.4	0.5
<b>Thallium</b>	<0.4	<0.4	<0.2	<0.2	<0.4	0.5
<b>Zinc,</b>	52.6	26.0	14	9	25.4	5.0

# 70% & 85% of Calculated Daily Average Effluent Limits

<b>Aquatic Life</b>		
<b>Parameter</b>	<b>70%</b>	<b>85%</b>
Aluminum	441	535
Arsenic	296	359
Cadmium	2.46	2.99
Chromium (+3)	851	1033
Chromium (+6)	6.99	8.48
Copper	11.7	14.3
Cyanide (free)	20.4	24.7
Lead	26.3	31.9
Mercury	1.07	1.30
Nickel	341	414
Selenium	8.90	10.8
Silver	3.09	3.75
Zinc	128	156

<b>Human Health</b>		
<b>Parameter</b>	<b>70%</b>	<b>85%</b>
Arsenic	N/A	N/A
Barium	N/A	N/A
Cadmium	N/A	N/A
Chromium (+6)	5338	6482
Cyanide (free)	N/A	N/A
Lead	318	387
Mercury	0.130	0.158
Nickel	61202	74317
Selenium	N/A	N/A
Thallium	2.45	2.97



# Compare Pollutant Analysis to TexTox

If the pollutant analysis is above 70% of the calculated daily average

**→ add monitoring requirements.**

If the pollutant analysis is above 85% of the calculated daily average

**→ add permit limits.**

# Compare Pollutant Analysis to TexTox (Cont.)

## Worksheet 2.0, Table 1

Pollutant	Average (µg/L)	MAL (µg/L)
Aluminum	20.6	2.5
Cadmium	<4	1
Copper	12.2	2
Mercury	1.23	0.005

## 70% & 85% of Calculated Daily Average

Aquatic Life		
Parameter	70%	85%
Aluminum	441	535
Cadmium	2.46	2.99
Copper	11.7	14.3
Mercury	1.07	1.30

Human Health		
Parameter	70%	85%
Cadmium	N/A	N/A
Mercury	0.130	0.158

# Existing Permit Limitations

## EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

Outfall Number 001

1. During the period beginning upon the date of permit issuance and lasting through the date of permit expiration, the permittee is authorized to discharge process waste water subject to the following effluent limitations:

The daily average flow of effluent shall not exceed 0.650 million gallons per day (MGD). The daily maximum flow shall not exceed 1.04 MGD.

Effluent Characteristics	Discharge Limitations			Minimum Self-Monitoring Requirements	
	Daily Average mg/L	Daily Maximum mg/L	Single Grab mg/L	Report Daily Average and Daily Maximum Measurement Frequency	Sample Type
Flow	0.650 MGD	1.04 MGD	N/A	Continuous	Totalizing Meter
Total Suspended Solids	N/A	100	100	1/week	Composite
Chemical Oxygen Demand	N/A	200	200	1/week	Composite
Oil and Grease	N/A	15	15	1/week	Composite
Total Aluminum	1.246	2.635	3.738	1/week	Composite
Dissolved Oxygen	5.0, minimum	N/A	5.0, minimum	1/week	Grab

2. The pH must not be less than 6.0 standard units nor greater than 9.0 standard units and must be monitored 1/day<sup>4</sup> by grab sample.
3. There must be no discharge of floating solids or visible foam in other than trace amounts and no discharge of visible oil.
4. Effluent monitoring samples must be taken at the following location: at Outfall 001, prior to commingling with any other waste streams entering into the ditch.

# Draft Permit Limitations

## EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

Outfall Number 001

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Effluent Characteristics	Discharge Limitations			Minimum Self-Monitoring Requirements	
	Daily Average mg/L	Daily Maximum mg/L	Single Grab mg/L	Report Daily Average and Daily Maximum Measurement Frequency	Sample Type
Flow	0.650 MGD	1.04 MGD	N/A	Continuous	Totalizing Meter
Total Suspended Solids	N/A	100	100	1/week	Composite
Chemical Oxygen Demand	N/A	200	200	1/week	Composite
Oil and Grease	N/A	15	15	1/week	Composite
Total Aluminum	0.630	1.333	1.89	1/week	Composite
Total Copper	Report	Report	N/A	2/month	Composite
Total Mercury <sup>1</sup>	Report	Report	N/A	1/week	Composite
Total Mercury <sup>2</sup>	0.000185	0.000392	0.000555	1/week	Composite
Dissolved Oxygen	5.0, minimum	N/A	5.0, minimum	1/week	Grab

2. The pH must not be less than 6.0 standard units nor greater than 9.0 standard units and must be monitored 1/day<sup>1</sup> by grab sample.
3. There must be no discharge of floating solids or visible foam in other than trace amounts and no discharge of visible oil.
4. Effluent monitoring samples must be taken at the following location: at Outfall 001, prior to commingling with any other waste streams entering into the ditch.

<sup>1</sup> The limit is effective from the date of permit issuance and lasting through three years from the date of permit issuance.

<sup>2</sup> The limit is effective from three years from the date of permit issuance and lasting through the date of permit expiration.



My draft permit includes a new or more stringent WQBEL

What can I do?

**Call your permit writer!**





# Why did I receive this limit?

## ◇ New limit

Average concentration from application is  $\geq 85\%$  of calculated daily average WQBEL

## ◇ More stringent limit

Calculated WQBELs are more stringent than existing limits

# Site-Specific Standards

Site-specific Standards –

Adopted in Appendix E of the Standards

- Change in criterion
- Water Effect Ratio
- Site-specific hardness
- Site-specific TSS
- Dissolved fraction available (metals)

# 30 TAC § 307: Appendix E

SEGMENT	TPDES	FACILITY	PARAMETER	SITE-SPECIFIC ADJUSTMENT FACTOR	ADDITIONAL SITE-SPECIFIC CONSIDERATIONS
<b>1412</b>	01768-000	ALON USA	Selenium	Acute Criterion = 219 µg/L Chronic Criterion = 7.5 µg/L	
<b>1201</b>	00007-000	Dow Chemical	Copper <sup>1,3</sup>	1.6	
<b>1013</b>	NA	NA	Copper <sup>1,2</sup>	1.8	
<b>1006</b>	01031-000	NRG Texas Power LLC	Copper <sup>1,3</sup>	2.4	TSS=14.75 mg/L Dissolved Fraction Available = 87%
<b>0604</b>	10447-001	City of Rusk	Copper <sup>1,3</sup>	4.3	Hardness = 40 mg/L

1 Results based on a water-effect ratio study.

2 Site-specific criteria apply to the entire water body.

3 Site-specific criteria may only be used in the evaluation of permit limits for the facility listed under the TPDES and Facility columns.



# Site-Specific Standard Example

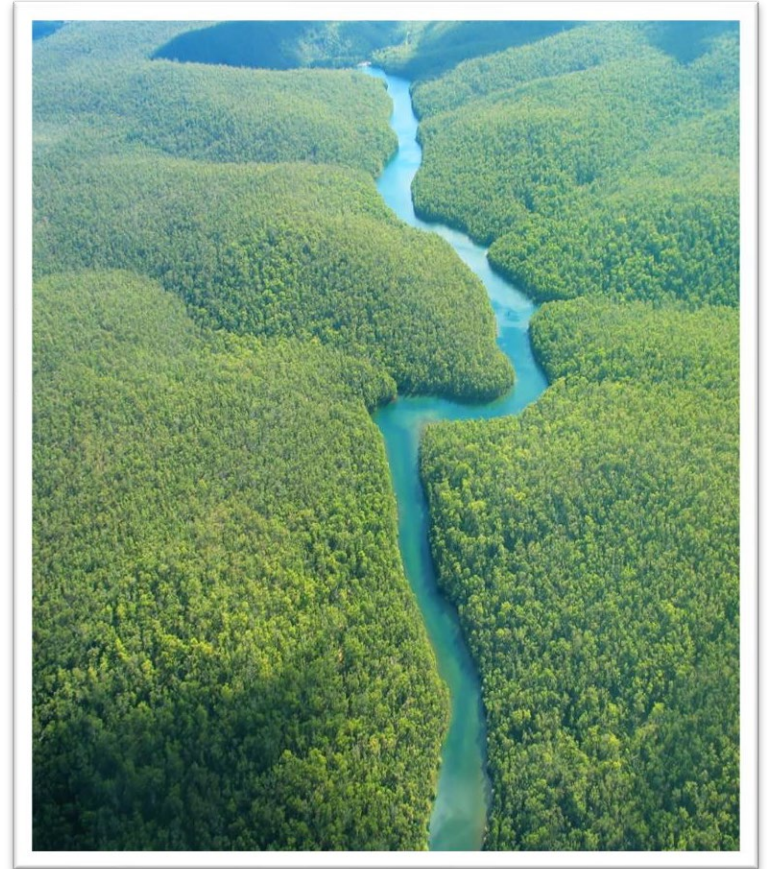
Parameter	FW Acute Criterion (int. stream) (ug/L)	FW Acute Criterion (lake) (ug/L)	FW Chronic Criterion (lake) (ug/L)	WLAa (int. stream)	WLAa (lake)	WLAc (lake)	LTAa (int. stream)	LTAa (lake)	LTAc (lake)	Daily Avg. (ug/L)	Daily Max. (ug/L)
Selenium	20	20	5	20.00	27.03	26.32	11.46	8.65	16.05	12.71	26.90

Parameter	FW Acute Criterion (int. stream) (ug/L)	FW Acute Criterion (lake) (ug/L)	FW Chronic Criterion (lake) (ug/L)	WLAa (int. stream)	WLAa (lake)	WLAc (lake)	LTAa (int. stream)	LTAa (lake)	LTAc (lake)	Daily Avg. (ug/L)	Daily Max. (ug/L)
Selenium	219	219	7.5	219.00	295.95	39.47	125.49	94.70	24.08	35.40	74.89

# Effluent fraction – river or stream:

## ◇ Critical flows

- Stream type – which criteria apply?
  - intermittent – acute (no dilution)
  - perennial – chronic, acute, HH
  - intermittent with perennial pools – chronic (no dilution), acute (no dilution), HH
- Stream flows – 7Q2, HM



# Effluent fraction – lake or bay:

- ◇ Critical mixing conditions
- ◇ Option: Relocate Outfall
  - Narrow arm → smaller mixing zones
    - = larger effluent fractions
    - = more stringent permit limits
  - Wider area → larger mixing zones
    - = smaller effluent fractions
    - = higher permit limits



# Any Questions?

Water Quality Division Mainline  
512-239-4671

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512-239-4736

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