WQBELs Part IV: Calculating Chemical-specific WQBELs

NPDES Permit Writers' Course
Online Training Curriculum

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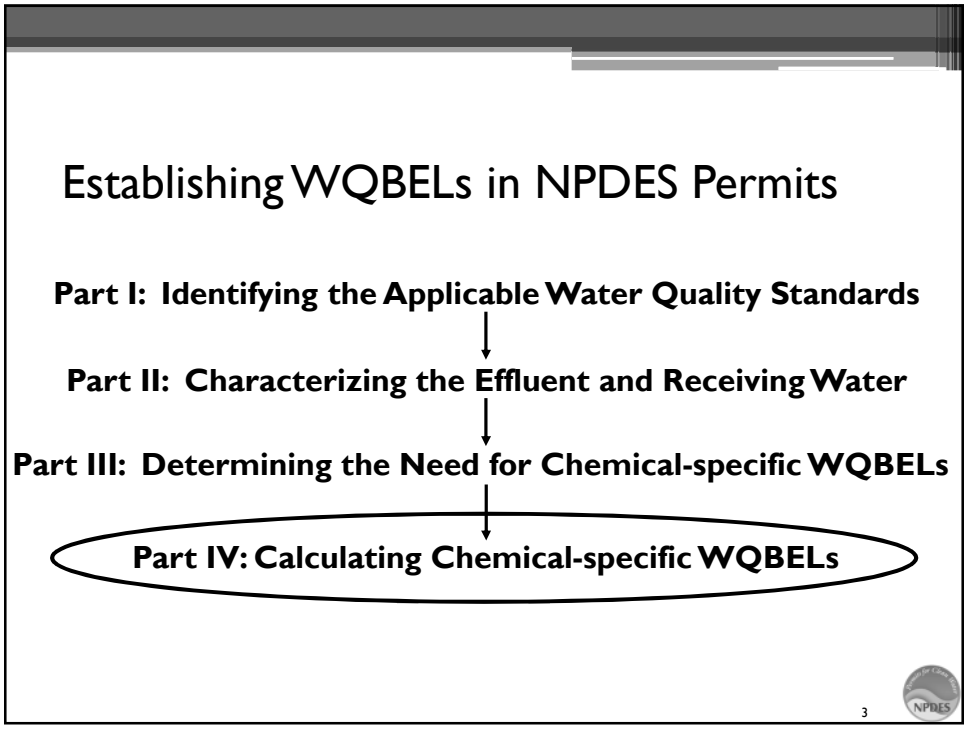
Establishing WQBELs in NPDES Permits
Part I: Identifying the Applicable Water Quality Standards
Part II: Characterizing the Effluent and Receiving Water
Part III: Determining the Need for Chemical-specific WQBELs
Part IV: Calculating Chemical-specific WQBELs
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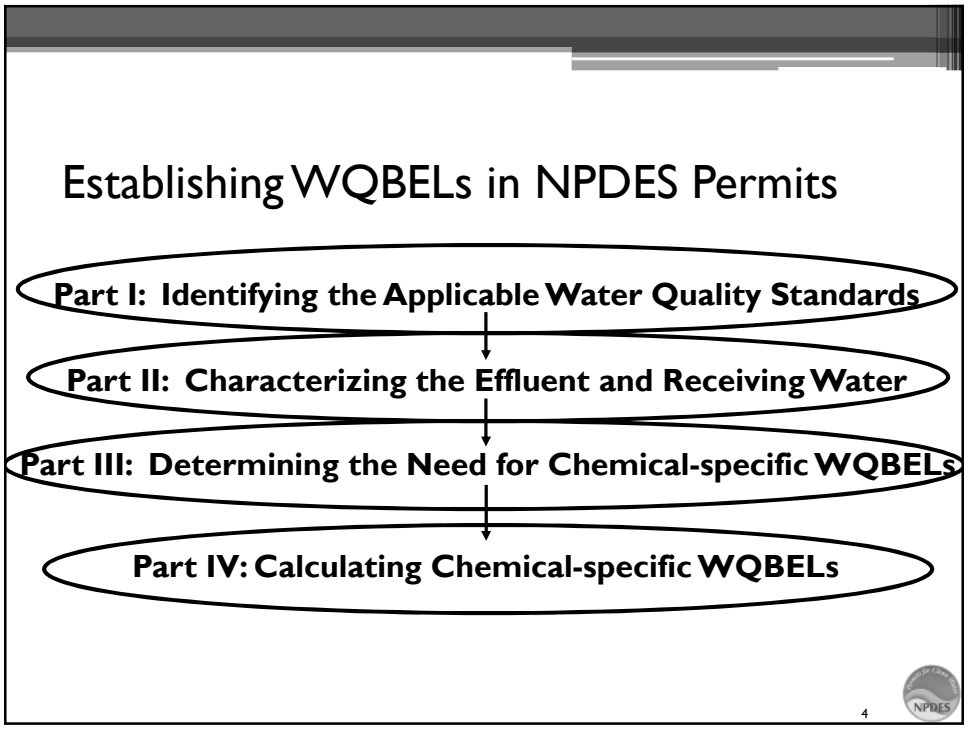
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Developing Chemical-specific WQBELs

Water Quality Criteria
- Magnitude
- Duration
- Frequency

→

Effluent Limitations
- Magnitude
- Averaging period

Permit writers calculate end-of-pipe water quality-based effluent limitations where necessary to ensure that water quality standards are attained in the receiving water.

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Developing Chemical-Specific WQBELs (aquatic life criteria)

Step 1: Determine Acute and Chronic Wasteload Allocations (WLAs) (for Aquatic Life Criteria)

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Step 2: Calculate Long-Term Average (LTA) for Each WLA

↓

Step 3: Select Lowest LTA

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Step 4: Calculate MDL and AML

↓

Step 5: Document Decisions

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Step 1: Determine WLA(s)

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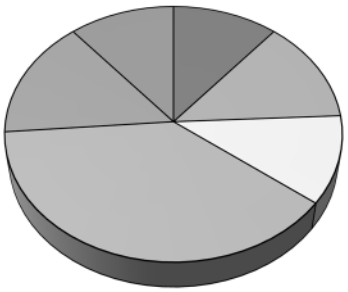
Step 1: Determine WLA(s)—WLA from a TMDL or Watershed Analysis

TMDL for Pristine Creek – Pollutant X



- WLA = portion of the receiving water's total maximum daily load (TMDL) allocated to a specific point source or an allocation to a point source determined from another watershed analysis

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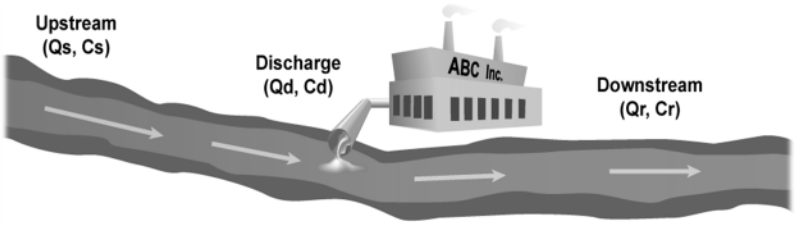
Step 1: Determine WLA(s)—Facility-specific WLA



WLA* = the maximum allowable pollutant concentration in the effluent from ABC, Inc. that, after accounting for available dilution under critical conditions, will meet an applicable water quality criterion

* permitting authorities use various terms for what here is called a WLA

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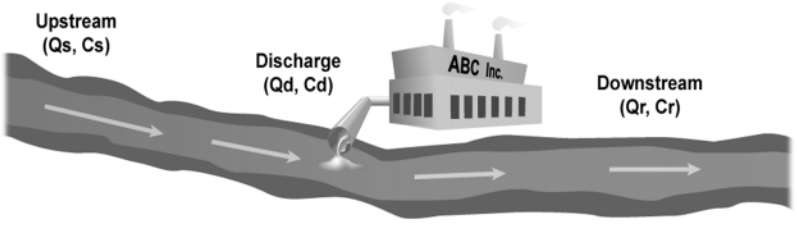
Step 1: Determine WLA(s)—Steady State Analysis Under Critical Conditions



Mass-Balance Equation: $QsCs + QdCd = QrCr$

Determine the allowable discharge concentration (WLA):

$$Cd = \frac{QrCr - QsCs}{Qd}$$

Note that $Qr = Qs + Qd$

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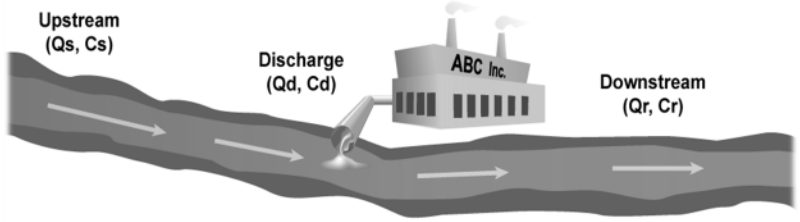
Step 1: Determine WLA(s)—

What is the maximum allowable concentration of Pollutant X in the ABC, Inc. effluent?



Qs = Critical upstream flow (1Q10) = 1.2 cfs
(7Q10) = 2.0 cfs

Qd = Critical discharge flow from ABC Inc. = 0.31 cfs

$$Cd = \frac{QrCr - QsCs}{Qd}$$

Cs = Critical upstream conc. of Pollutant X = 0.80 mg/L

Cr = Water Quality Criteria for Pollutant X
Acute Criterion for Pollutant X = 1.0 mg/L (applied at 1Q10)
Chronic Criterion for Pollutant X = 0.90 mg/L (applied at 7Q10)

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Acute WLA Calculations for Pollutant X

$$Cd(acute) = WLAa = \frac{Cr(Qd + Qs) - CsQs}{Qd}$$

$$Cd(acute) = WLAa = \frac{1.0\ mg/L\ (0.31\ cfs + 1.2\ cfs) - (0.80\ mg/L)(1.2\ cfs)}{0.31\ cfs}$$

WLAa = 1.8 mg/L

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Chronic WLA Calculations for Pollutant X

$$Cd(chronic) = WLAc = \frac{Cr(Qd + Qs) - CsQs}{Qd}$$

$$Cd(chronic) = WLAc = \frac{0.9\ mg/L\ (0.31\ cfs + 2.0\ cfs) - (0.80\ mg/L)(2.0\ cfs)}{0.31\ cfs}$$

WLAc = 1.5 mg/L

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A WLA is Not a WQBEL

- A wasteload allocation (WLA) is not a water quality-based effluent limitation (WQBEL)
  - WLAs
    - derived from water quality criteria through TMDLs, watershed analyses, or facility-specific analyses
    - often have the same duration as criteria (e.g., 1-hour average, 4-day average)
  - WQBELs
    - typically must have daily and monthly (non-POTWs) or weekly and monthly (POTWs) averaging periods [40 CFR 122.45(d)]
    - TSD recommends WQBELs for toxic pollutants should be expressed as MDLs and AMLs for all types of facilities

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Calculating WQBELs from WLAs

- Approaches for developing short- and long-term WQBELs
  - TSD approach establishes a single performance requirement (a long-term average or LTA) used to derive both the MDL and AML
  - State permitting authorities may use alternate procedures; however, these procedures must result in both short- and long-term limits consistent with state water quality standards and § 122.45(d)

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Developing Chemical-Specific WQBELs (aquatic life criteria)

Step 1: Determine Acute and Chronic Wasteload Allocations (WLAs) (for Aquatic Life Criteria)

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Step 2: Calculate Long-Term Average (LTA) for Each WLA

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Step 3: Select Lowest LTA

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Step 4: Calculate MDL and AML

↓

Step 5: Document Decisions

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Step 2: Calculate LTAs

- Wasteload allocation (WLA) is *"never to be exceeded"*
- Assume a *lognormal* effluent distribution
- Characterize never to be exceeded by a *probability basis* (e.g., WLA is the 99th percentile concentration on the lognormal effluent distribution)

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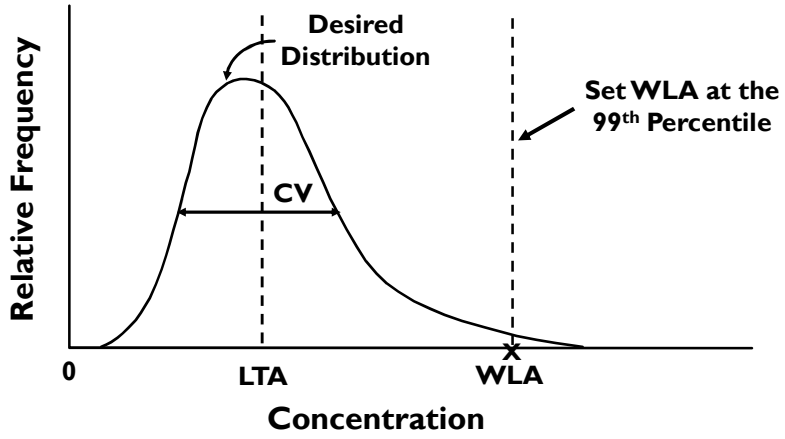
Characterize the Desired Distribution by LTA and CV



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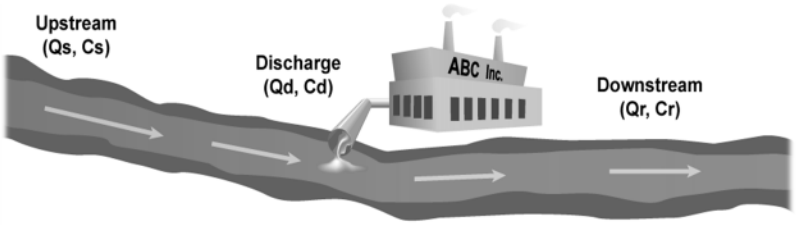
Example: WLAs for Pollutant X for ABC, Inc.



- **Recall that we calculated WLAs for Pollutant X for ABC, Inc. using the simple mass-balance equation:**

$$Cd = WLA = \frac{CrQr - CsQs}{Qd}$$

Cd(acute)	**=**	**1.8 mg/L**
Cd(chronic)	**=**	**1.5 mg/L**

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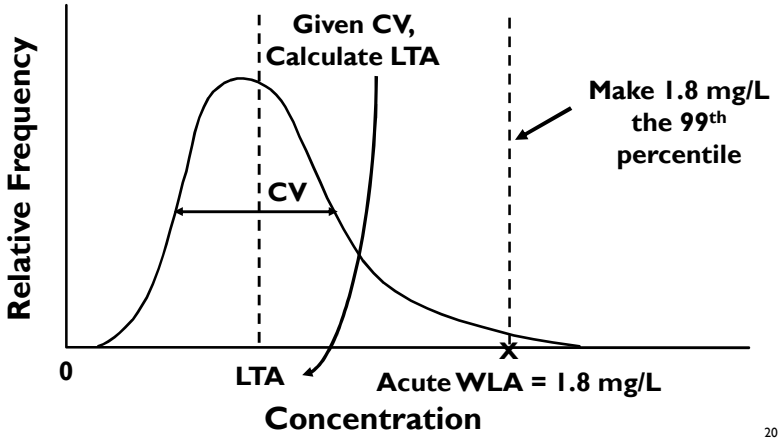
Characterize the Desired Distribution by LTA and CV



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Step 2: Calculate LTAs

CV	WLA multipliers $e^{[0.5\sigma^2 - z\sigma]}$ 95th percentile	99th percentile
0.1	0.853	0.797
0.2	0.736	0.643
0.3	0.644	0.527
0.4	0.571	0.440
0.5	0.514	0.373
→ 0.6	0.468	0.321
0.7	0.432	0.281
0.8	0.403	0.249
0.9	0.379	0.224
1.0	0.360	0.204
1.1	0.344	0.187
1.2	0.330	0.174
1.3	0.319	0.162
1.4	0.310	0.153
1.5	0.302	0.144
1.6	0.296	0.137
1.7	0.290	0.131
1.8	0.285	0.126
1.9	0.281	0.121
2.0	0.277	0.117

Acute

CV = 0.6
WLA(acute) = 1.8 mg/L
= 99th percentile value
LTA(acute) = 1.8 mg/L x 0.321
= 0.58 mg/L

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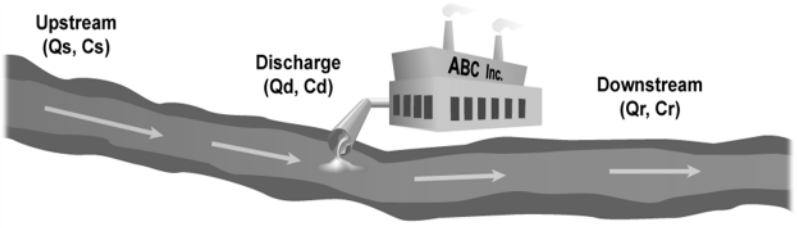
Example: WLAs for Pollutant X for ABC, Inc.



- **Recall that we calculated WLAs for Pollutant X for ABC, Inc. using the simple mass-balance equation:**

$$Cd = WLA = \frac{CrQr - CsQs}{Qd}$$

Cd(acute) = 1.8 mg/L
Cd(chronic) = 1.5 mg/L

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Step 2: Calculate LTAs

CV	WLA multipliers $e^{[0.5\sigma_4^2 - z\sigma_4]}$	
	95th percentile	99th percentile
0.1	0.922	0.891
0.2	0.853	0.797
0.3	0.791	0.715
0.4	0.736	0.643
0.5	0.687	0.581
→ 0.6	0.644	0.527
0.7	0.606	0.481
0.8	0.571	0.440
0.9	0.541	0.404
1.0	0.514	0.373
1.1	0.490	0.345
1.2	0.468	0.321
1.3	0.449	0.300
1.4	0.432	0.281
1.5	0.417	0.264
1.6	0.403	0.249
1.7	0.390	0.236
1.8	0.379	0.224
1.9	0.369	0.214
2.0	0.360	0.204

Chronic

CV = 0.6

WLA(chronic) = 1.5 mg/L
= 99th percentile value

LTA(chronic) = 1.5 mg/L x 0.527

= 0.79 mg/L

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Developing Chemical-Specific WQBELs (aquatic life criteria)

Step 1: Determine Acute and Chronic Wasteload Allocations (WLAs) (for Aquatic Life Criteria)

↓

Step 2: Calculate Long-Term Average (LTA) for Each WLA

↓

Step 3: Select Lowest LTA

↓

Step 4: Calculate MDL and AML

↓

Step 5: Document Decisions

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Step 3: Select Lowest LTA

- Selecting the lowest LTA:
  - assures meeting both WLAs (i.e., attains both acute and chronic criteria)
  - sets one basis for facility performance
- LTA(acute) = 0.58 mg/L
- LTA(chronic) = 0.79 mg/L

Select LTA(acute) = 0.58 mg/L as the basis for WQBELs

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Developing Chemical-Specific WQBELs (aquatic life criteria)

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Step 4: Calculate MDL and AML

- Use the lognormal distribution to calculate the MDL and AML from the lowest LTA
- EPAs TSD procedure:
  - uses upper-bound estimates for both MDL and AML (like effluent guidelines)
    - MDL set at 99th percentile
    - AML set at 95th percentile
  - ties AML to planned monthly monitoring frequency

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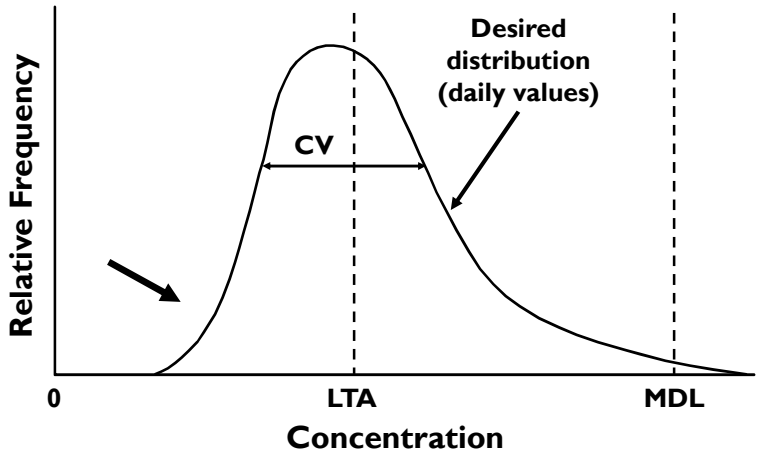
Calculate MDL from the LTA



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Step 4: Calculate **MDL** and AML

CV	LTA multipliers $e^{[z\sigma - 0.5\sigma^2]}$ 95th percentile	99th percentile
0.1	1.17	1.25
0.2	1.36	1.55
0.3	1.55	1.90
0.4	1.75	2.27
0.5	1.95	2.68
→ 0.6	2.13	3.11
0.7	2.31	3.56
0.8	2.48	4.01
0.9	2.64	4.46
1.0	2.78	4.90
1.1	2.91	5.34
1.2	3.03	5.76
1.3	3.13	6.17
1.4	3.23	6.56
1.5	3.31	6.93
1.6	3.38	7.29
1.7	3.45	7.63
1.8	3.51	7.95
1.9	3.56	8.26
2.0	3.60	8.55

MDL

MDL = 99th percentile value

CV = 0.6

MDL = 0.58 mg/L x 3.11

= 1.8 mg/L

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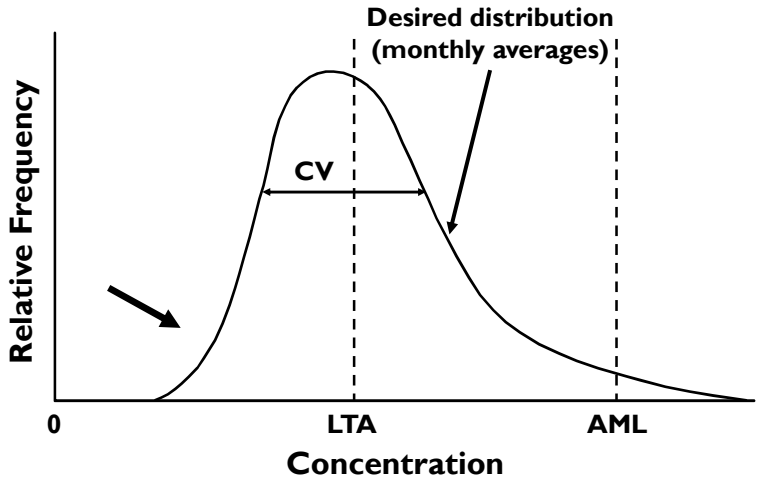
Calculate AML from the LTA



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Step 4: Calculate MDL and **AML**

LTA multipliers

$e^{[z\sigma_n - 0.5\sigma_n^2]}$

CV	95th percentile					99th percentile				
	n=1	n=2	n=4	n=8	n=30	n=1	n=2	n=4	n=8	n=30
0.1	1.17	1.12	1.08	1.06	1.03	1.25	1.18	1.12	1.08	1.04
0.2	1.36	1.25	1.17	1.12	1.06	1.56	1.37	1.25	1.18	1.08
0.3	1.55	1.38	1.26	1.18	1.09	1.90	1.59	1.40	1.27	1.13
0.4	1.75	1.52	1.36	1.25	1.12	2.27	1.83	1.55	1.37	1.18
0.5	1.96	1.66	1.45	1.31	1.16	2.68	2.09	1.72	1.48	1.23
→ 0.6	2.13	1.90	1.55	1.38	1.19	3.11	2.37	1.90	1.59	1.28
0.7	2.31	1.94	1.65	1.45	1.22	3.56	2.66	2.08	1.71	1.33
0.8	2.48	2.07	1.75	1.52	1.26	4.01	2.96	2.27	1.83	1.39
0.9	2.64	2.20	1.85	1.59	1.29	4.46	3.28	2.48	1.96	1.44
1.0	2.78	2.33	1.95	1.66	1.33	4.90	3.59	2.68	2.09	1.50
1.1	2.91	2.45	2.04	1.73	1.36	5.34	3.91	2.90	2.23	1.56
1.2	3.03	2.56	2.13	1.80	1.39	5.76	4.23	3.11	2.37	1.62
1.3	3.13	2.67	2.23	1.87	1.43	6.17	4.55	3.34	2.52	1.68
1.4	3.23	2.77	2.31	1.94	1.47	6.56	4.86	3.56	2.66	1.74
1.5	3.31	2.86	2.40	2.00	1.50	6.93	5.17	3.78	2.81	1.80
1.6	3.38	2.95	2.48	2.07	1.54	7.29	5.47	4.01	2.96	1.87
1.7	3.45	3.03	2.56	2.14	1.57	7.63	5.77	4.23	3.12	1.93
1.8	3.51	3.10	2.64	2.20	1.61	7.95	6.06	4.46	3.28	2.00
1.9	3.56	3.17	2.71	2.27	1.64	8.26	6.34	4.68	3.43	2.07
2.0	3.60	3.23	2.78	2.33	1.68	8.55	6.61	4.90	3.59	2.14

AML

AML Value = 95th percentile

CV = 0.6

Number of Samples (n) = 8 (assume twice-weekly sampling)

AML = 0.58 mg/L x 1.38

= 0.80 mg/L

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Calculated WQBELs

We calculated the following WQBELs for Pollutant X:

MDL = 1.8 mg/L
AML = 0.80 mg/L

Are these the final effluent limitations for Pollutant X?

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Final Check

- Compare:
  - WQBELs based on individual facility WLAs with
  - TBELs or other existing limitations with
  - WQBELs based on a TMDL or other watershed-based requirements
- The most stringent limitations for each parameter are the new, calculated final effluent limitations for that parameter
- Final effluent limitations in the permit must meet antidegradation and anti-backsliding requirements

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Developing Chemical-Specific WQBELs (aquatic life criteria)

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Step 2: Calculate Long-Term Average (LTA) for Each WLA

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Step 3: Select Lowest LTA

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Step 4: Calculate MDL and AML

↓

Step 5: Document Decisions

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Step 5: Document Decisions

- Document in the fact sheet or statement of basis:
  - statutory and regulatory citations
  - the process for determining the applicable wasteload allocations including:
    - selected water quality model
    - critical conditions
    - dilution allowance or mixing zone
  - the process used to calculate water quality-based effluent limitations (including showing calculations)
  - any antidegradation analysis or anti-backsliding analysis conducted and the basis for resulting decisions

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Feedback and Other Presentations

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