Mixing Zones: Wisconsin's Approach

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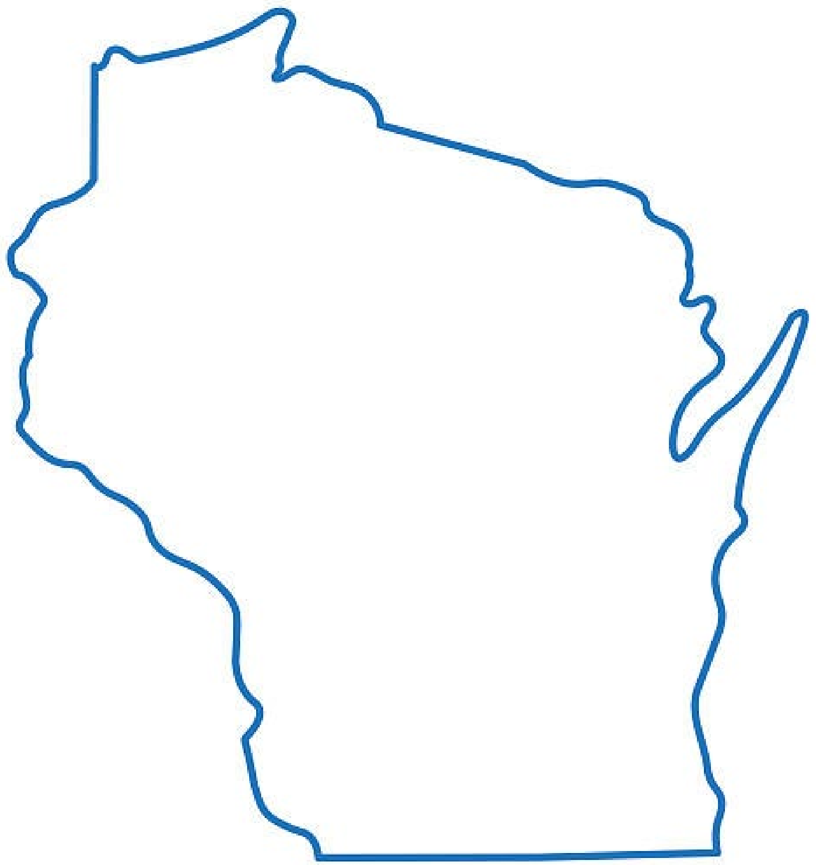
April 7, 2026

Wisconsin Overview

- Individual Permits: ~900
  - ~630 Municipal, 270 Industrial
- Facilities with Mixing Zones ~ 70
  - Mostly industrial
- ~2800 general permits under 21 general permits



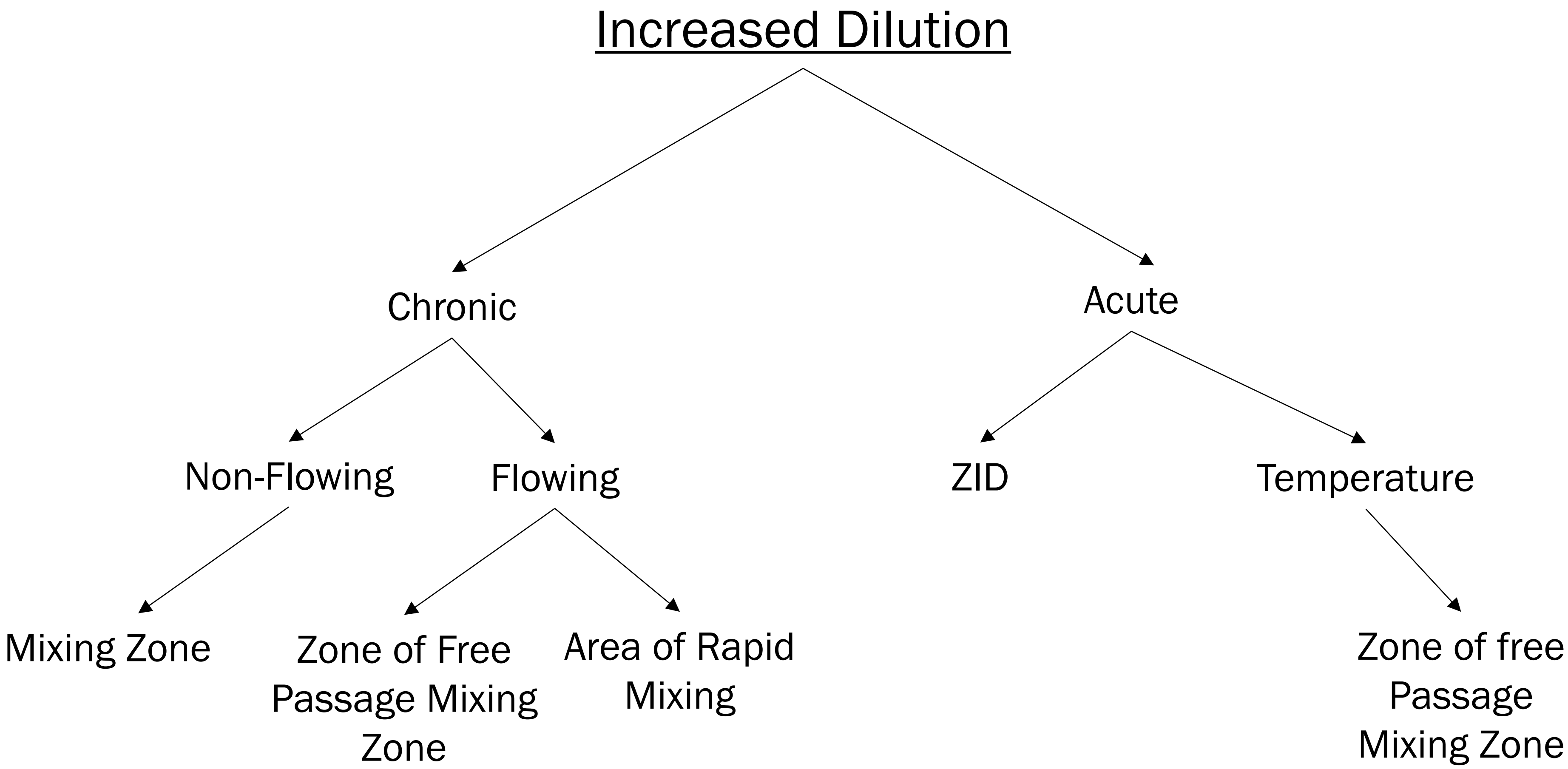
Why Mixing Zones?

Increase dilution available by increasing the stream flow used in calculating WQBELs

$$WQBEL = \left[\frac{(WQC - T_a)(Q_s + (1 - f)Q_e)}{Q_e}\right] + T_a$$

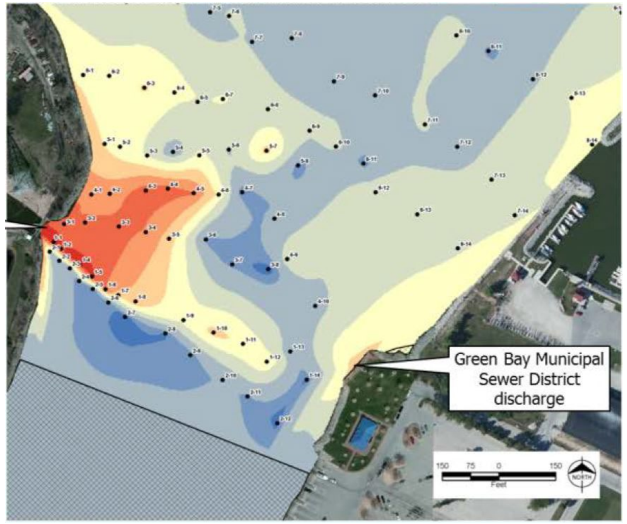
- WQBEL = Water Quality-Based Effluent **Limit**
- WQC = Water Quality **Criteria**
- T_a = Ambient **Temperature**
- Q_s = **Stream Flow** (Usually 25% of 7Q10)
- f = Fraction of water withdrawn from river
- Qe = **Effluent Flow**

Types of Mixing Zones



Types of mixing zone studies we see

- Conductivity studies
- Temperature studies
- Dye Studies
- Plume models



What do we need?
Good Data – or at least the best we can get

In Situ Studies

- Effluent data
- Stream background data
- Multiple transects downstream
  - Working way upstream
- Low stream flow

Plume Models

- Good calibration
- Good inputs
- Low stream flow
- Representative effluent conditions

Dye Studies

Pros

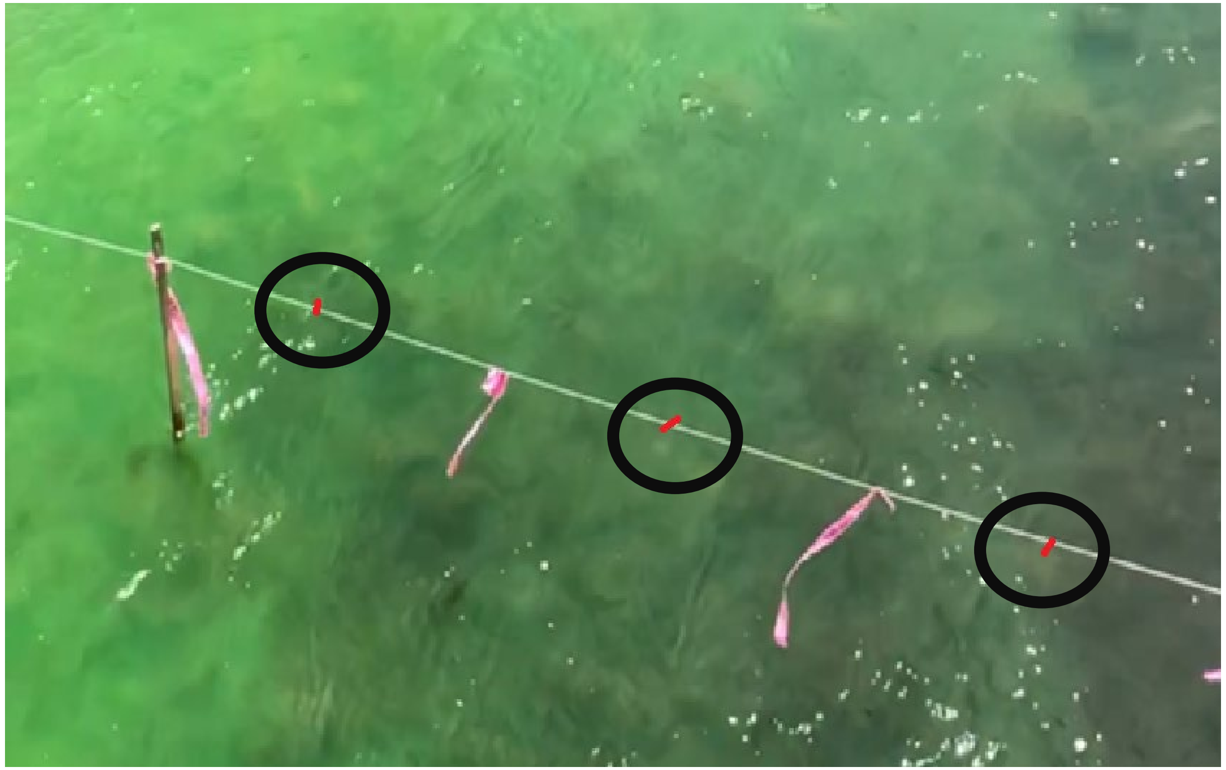
- Good visualization
- Relatively easy to do

Cons

- Imprecise
  - Vertical mixing?
  - Boundaries difficult to determine
- Glare in photos

Dye Study: What we look for

- Percent covered by dye.
- How close is it to the critical conditions?



Conductivity Studies

Pros

- Relatively simple
- Clearer numbers
- More precise
  - Multiple depths
  - Clearer boundaries

Cons

- Capturing low flow conditions
- Instrument sensitivity

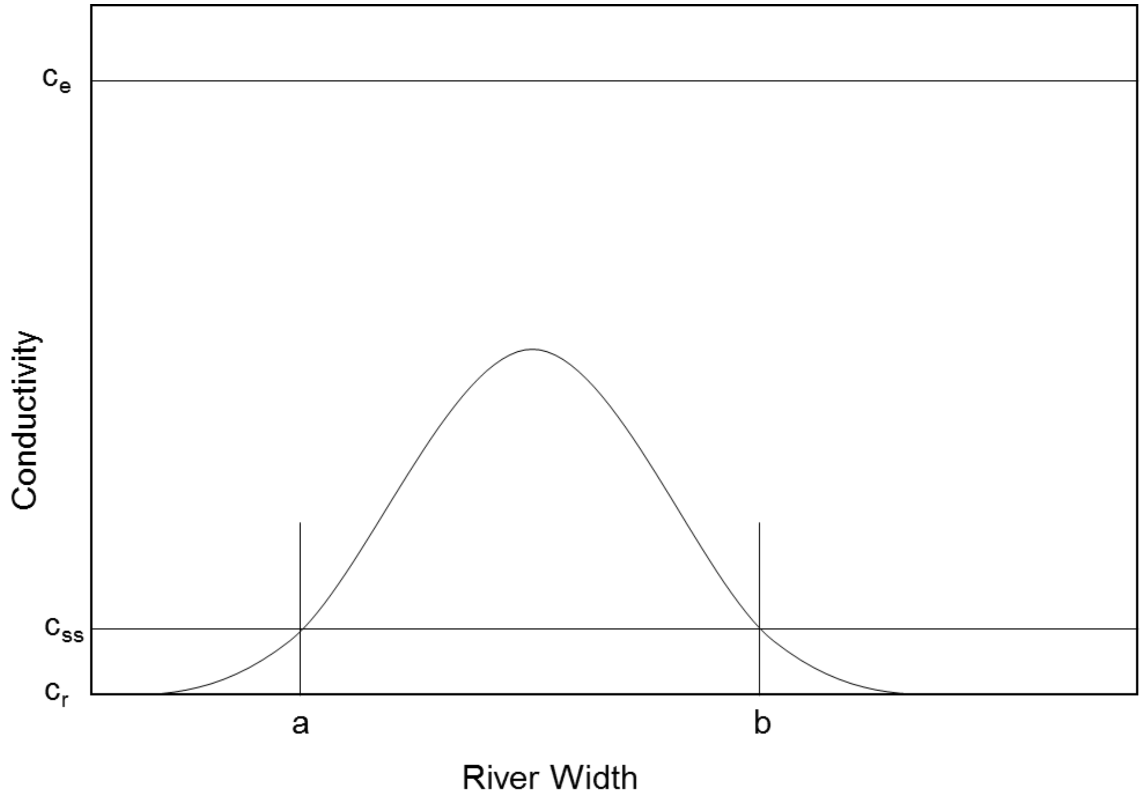
Q_s

		Conductivity (uS/cm)												
Distance f	Transect	26	24	22	20	18	16	14	12	10	8	6	4	2
440	T1			623	622	622	622	623	623	623	623	624	624	625
340	T2	618	618	618	619	619	620	620	621	622	623	623	624	624
300	T3		618	619	619	618	619	620	622	625	625	626	627	628
225	T4		618	619	618	620	621	622	625	627	628	629	630	630
150	T5			614	614	614	616	620	624	624	627	628	629	630
80	T6				613	613	613	613	616	618	622	625	626	623
50	T7	610	610	610	610	611	613	617	625	630	627	625	622	617
25	T8		610	610	610	610	611	633	638	634	627	625	622	617
10	T9		610	610	610	610	610	610	635	760	619	612	611	610
-5	T10	610	610	610	610	610	610	610	610	610	610	610	610	610

Conductivity Continued

Setting the boundaries.

$$c_{ss} = \frac{Q_r c_r + Q_e c_e}{Q_r + Q_e}$$



Where:
c_{ss} = conductivity steady state
c_r = receiving water conductivity
c_e= effluent conductivity
Q_r = receiving water flow
Q_e= effluent flow

Mixing zone is the area between a and b

Conductivity Study: What we look for

c_{ss} = 964 uS/cm

D	0	10	20	30	40	50	60
U	812	812	818	839	912	955	958
L			969	1499	1384	1135	962
E	0	10	20	30	40	50	60
U	808	808	909	947	1019	982	963
L		910	1090	1190	1100	970	968

Percent Mixing = 64%

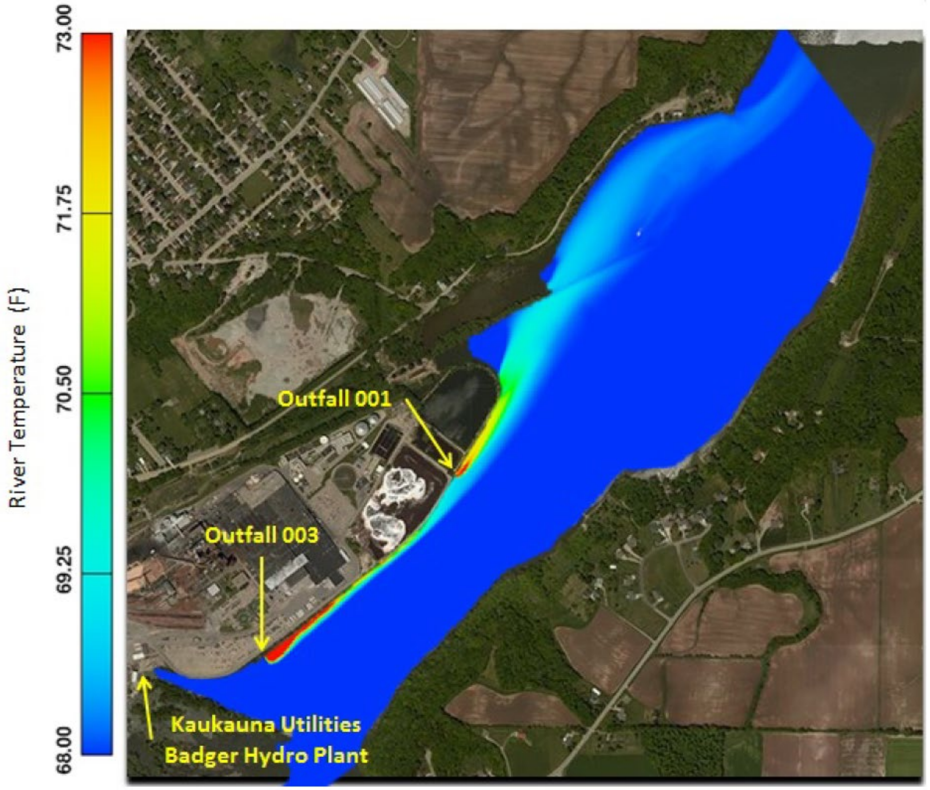
Temperature Study: What we look for

	Transect 1 (-8)									
Depth/wi	2	4	6	8	10	12	14	16	18	20
6	62.24	62.23	62.04	62.19	62	62.35	63.22	63.75	64.1	68.78
12	62.24	62.05	62.04	62	61.99	62.17	62.68	62.13	65.18	
18		62.05	62.04	62	61.99	62.16	62.13	62.13		
24						62.16	62.13			
average	62.64893									

	Transect 2 (20)								
Depth/wi	2	4	6	8	10	12	14	16	18
6	62.1	62.28	62.09	62.09	63.16	62.61	63.69	63.174	63.31
12		62.1	62.09	62.45	63.16	62.79	63.68	62.6	
18		62.1	62.09	62.26	62.62	62.97	62.78		
24			62.09	62.08	62.44	62.43			
average	62.58592								

	Transect 3 (40)								
Depth/wi	2	4	6	8	10	12	14	16	18
6	62.08	62.07	62.61	62.6	63.13	63.12	62.93	62.93	63.28
12	62.08	62.07	62.42	62.6	63.16	62.94	62.93	62.92	62.92
18		62.07	62.6	62.59	62.58	62.76	62.75	62.92	
24		62.07	62.42	62.59	62.58				
average	62.64552								

Plume Models



Pros

- Good for new dischargers
- Good for zone of free passage demonstrations
- Good for non-flowing waters.
- Can capture more conditions

Cons

- Can be expensive
- Complex
- Not all models are created equal

Plume Model: What we look for

- Output is only as good as the input.
  - Correct conditions?
  - Does it make sense?
- Boundary conditions

Table 3: Model Input for Criteria Compliance

Simulation	Point 1 Flow (CFS)	Point 2 Flow (CFS)	Outfall 003 Flow (MGD) / Temp (F)	Outfall 001 (MGD) / Temp (F)	Ambient River Temp (F)
July	0	1234	36.0 / 108.1	18.2 / 92.0	77.0
October	0	1130	36.0 / 99.6	18.2 / 91.0	53.0

Table 4: Water Quality Criteria Compliance

Simulation	Thermal Plume Cross-Sectional Area of Flow (%)	Thermal Plume Width (%)	Ambient River Temp (F)
July	11.1	27.8	77.0
October	16.7	36.1	53.0

Lessons Learned

- Watch compliance dates!
  - Antibacksliding can become an issue
- Review study plans before the study is conducted.

Good Data
leads to
Defensible Determinations!

CONNECT WITH US

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"WILD WISCONSIN: OFF THE RECORD"