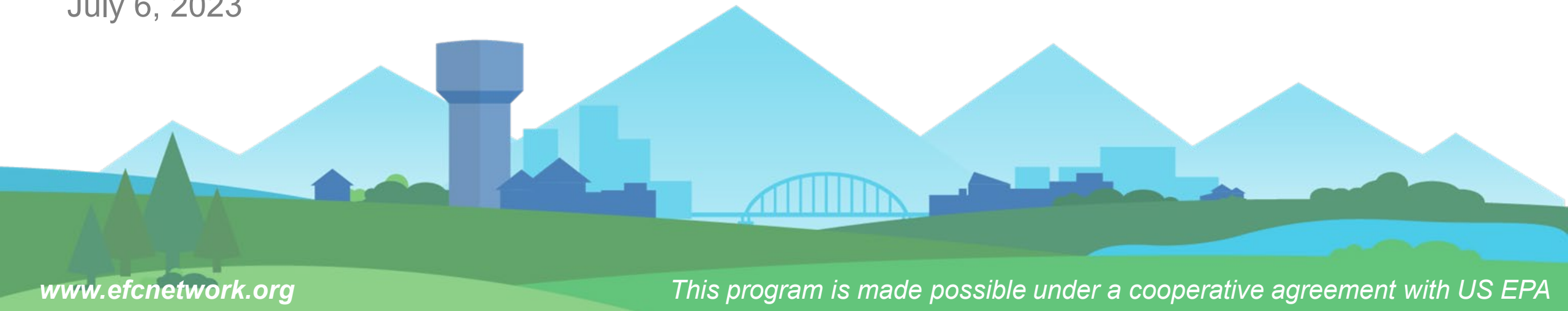
Water Quality Standards:

What You Need (or Ought) to Know

July 6, 2023



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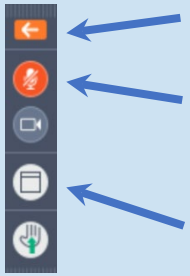

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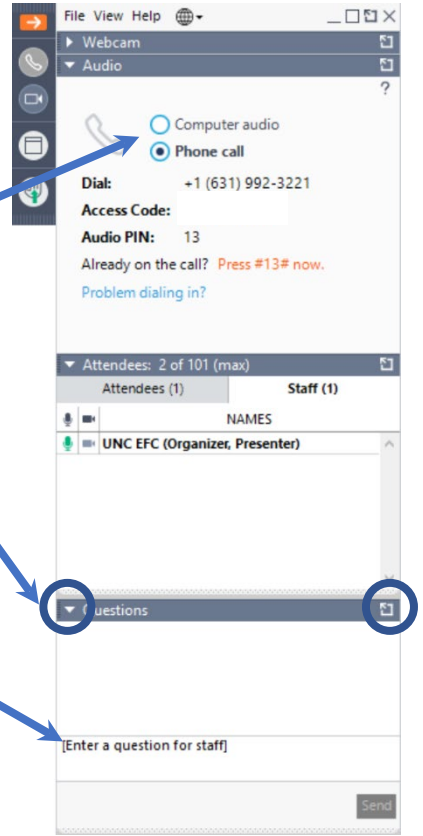

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About Us

The Environmental Finance Center Network (EFCN) is a university- and non-profit-based organization creating innovative solutions to the difficult how-to-pay issues of environmental protection and environmental infrastructure.

The EFCN works collectively and as individual centers to address these issues across the entire U.S, including the 5 territories and the Navajo Nation. The EFCN aims to assist public and private sectors through training, direct professional assistance, production of durable resources, and innovative policy ideas.

EFCN
environmental finance center network

Acronyms

Acronym	Meaning
AD	Antidegradation
CWA	Clean Water Act
DU	Designated Use
IC_{25}	Inhibition Concentration 25 percent
LA	Load Allocation
LC_{50}	Lethal Concentration 50 percent
MOS	Margin of Safety
MZ	Mixing Zone
NPDES	National Pollutant Discharge Elimination System
P-b-P	Pollutant-by-Pollutant
POC	Pollutant(s) of Concern

Acronym	Meaning
TBEL	Technology-Based Effluent Limitation
TSD	Technical Support Document
TMDL	Total Maximum Daily Load
WET	Whole Effluent Toxicity
WLA	Waste Load Allocation
WOTUS	Waters of the United States
WQBEL	Water Quality-Based Effluent Limitation
WQC	Water Quality Criteria/Criterion
WQS	Water Quality Standards
ZID	Zone of Initial Dilution

Overview

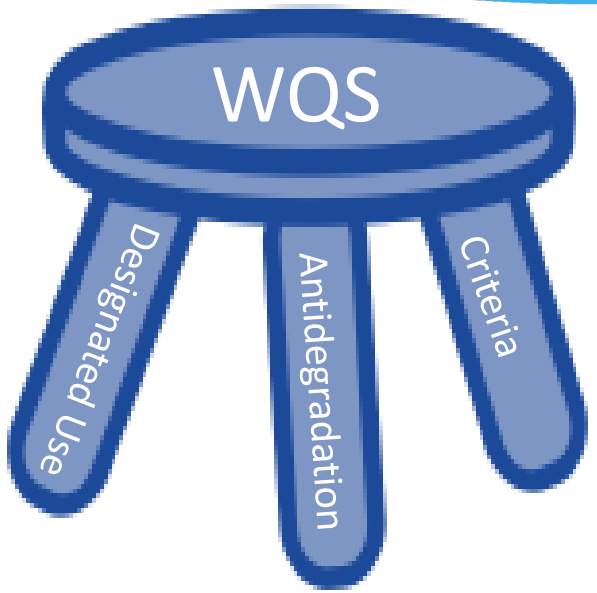
- What Are Water Quality Standards (WQS)?
  - Designated Uses – How you want to use a waterbody
  - Water Quality Criteria – The “number”
  - Antidegradation – minimize impact of discharges
- Key Water Quality Areas That Utilize WQS
  - Monitoring and Assessment
  - Total Maximum Daily Loads (TMDLs)
  - NPDES Permits
- Why You Should Care

What Are Water Quality Standards (WQS)?

- In general terms
  - WQS are a statement of how clean water needs to be to support desired uses
- Support the Clean Water Act (CWA) goal of:
  - "…wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water…"
- Defined by the CWA and Federal Regulation
  - CWA §303
    - States develop and EPA approves state WQS
  - 40 CFR 131
    - Specifies minimum requirements and development of WQS

What Are Water Quality Standards (WQS)?

- *Technically* – WQS composed of
  - Designated Uses (DU) – 40 CFR §131.10
  - Water Quality Criteria (WQC) – 40 CFR §131.11
  - Antidegradation (AD) – 40 CFR §131.12
  - General Policies (*optional*) - 40 CFR §131.13
    - Mixing zones
    - Flows
    - Variances
    - Etc.



States Set Designated Uses

State Develops WQC To Protect Designated Uses

State Develops AD Policy To Protect High Quality Waters

Designated Uses

- Designated Uses (DU) – 40 CFR §131.10
  - Designated Uses describe how states believe waters in their state could be used
    - At a minimum applies to Waters of the US (WOTUS)
  - Examples of Designate Uses include:
    - Aquatic Life Support
    - Recreation
    - Public Water Supply
    - Agriculture - Crop
    - Livestock Watering
    - Industrial
  - Not every water will have every designated use – uses are specific to individual waterbodies
  - Not every water will currently meet the designated use, but could with some intervention
  - If the DU was met on November 28, 1975, it is an existing use and cannot be removed
      - If not an existing use, can be changed or removed with a use attainability analysis for one of 6 reasons

Water Quality Criteria

- Water Quality Criteria (WQC) – 40 CFR §131.11
  - States adopt criteria to protect designated uses – Numeric and Narrative
  - Numeric criteria based on
    - EPA 304(a) Guidance
      - Refers to § 304(a) of the CWA
        - EPA "shall develop and publish, within one year after October 18, 1972 (and from time to time thereafter revise) criteria for water quality accurately reflecting the latest scientific knowledge…"
    - EPA 304(a) Guidance modified based on local conditions
      - For example, may not have certain sensitive species in a waterbody
    - Other scientifically defensible methods
      - What this is can sometimes be a point of contention between a State and EPA
  - Aquatic Life uses generally have *acute* and *chronic* criteria
    - Acute – short term impact, e.g., hourly, daily, etc., that can be lethal
    - Chronic – longer term impact, e.g., weekly, monthly, etc., and impacts sub-lethal (reproductive)

Water Quality Criteria

- Water Quality Criteria (WQC) – 40 CFR §131.11 – contd.
  - Numeric criteria have magnitude, duration and frequency components
    - How much, how long, and how often
    - For example

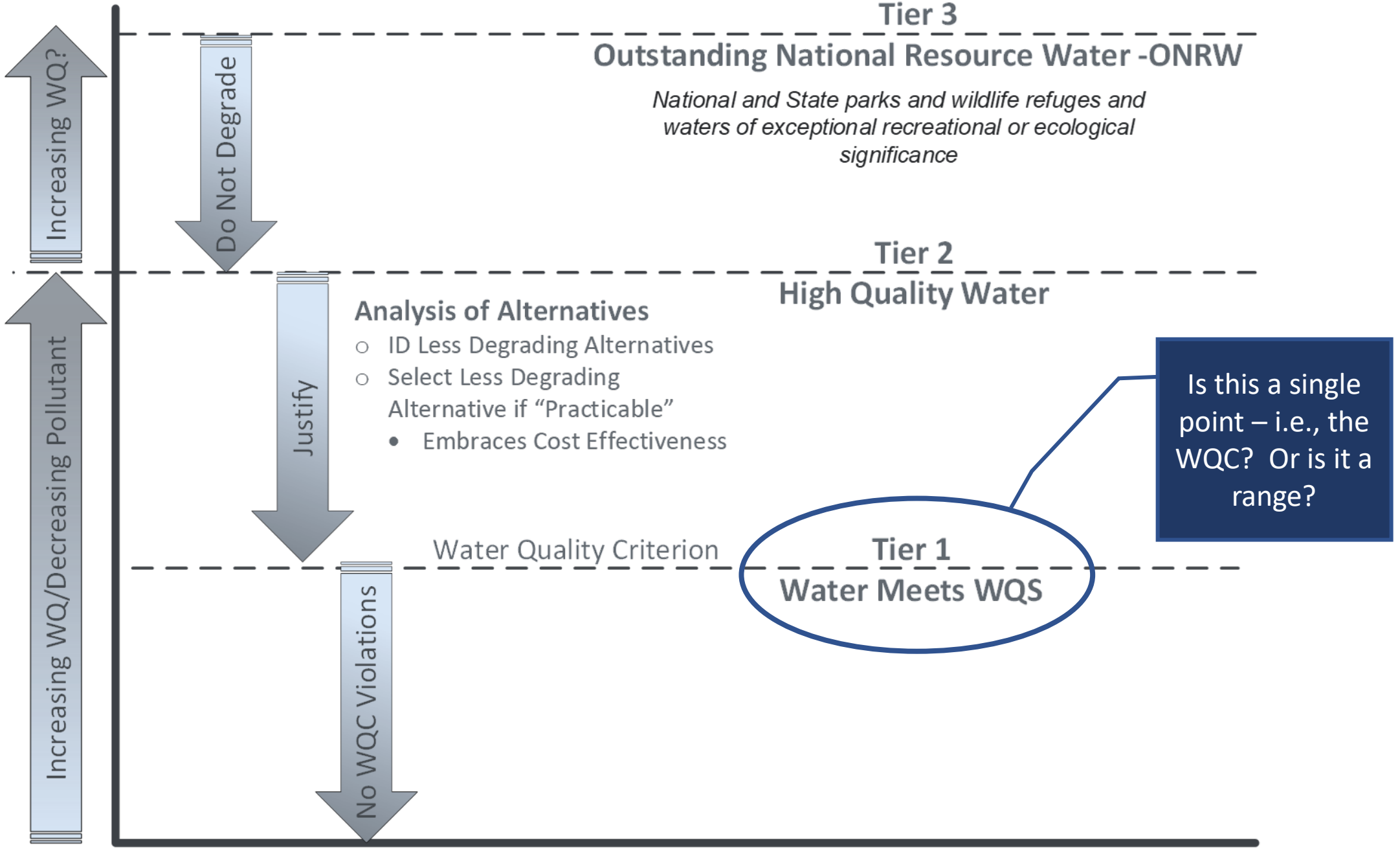
Parameter	Magnitude (How Much)	Duration (How Long)	Frequency (How Often)
$Ammonia_{chronic}$	1.9 mg/L	30-day average	Once in 3 years
$Ammonia_{acute}$	17 mg/L	1-hour average	Once in 3 years
$Nickel_{chronic}$	52 µg/L	4-day average	Once in 3 years
$Nickel_{acute}$	470 µg/L	1-hour average	Once in 3 years

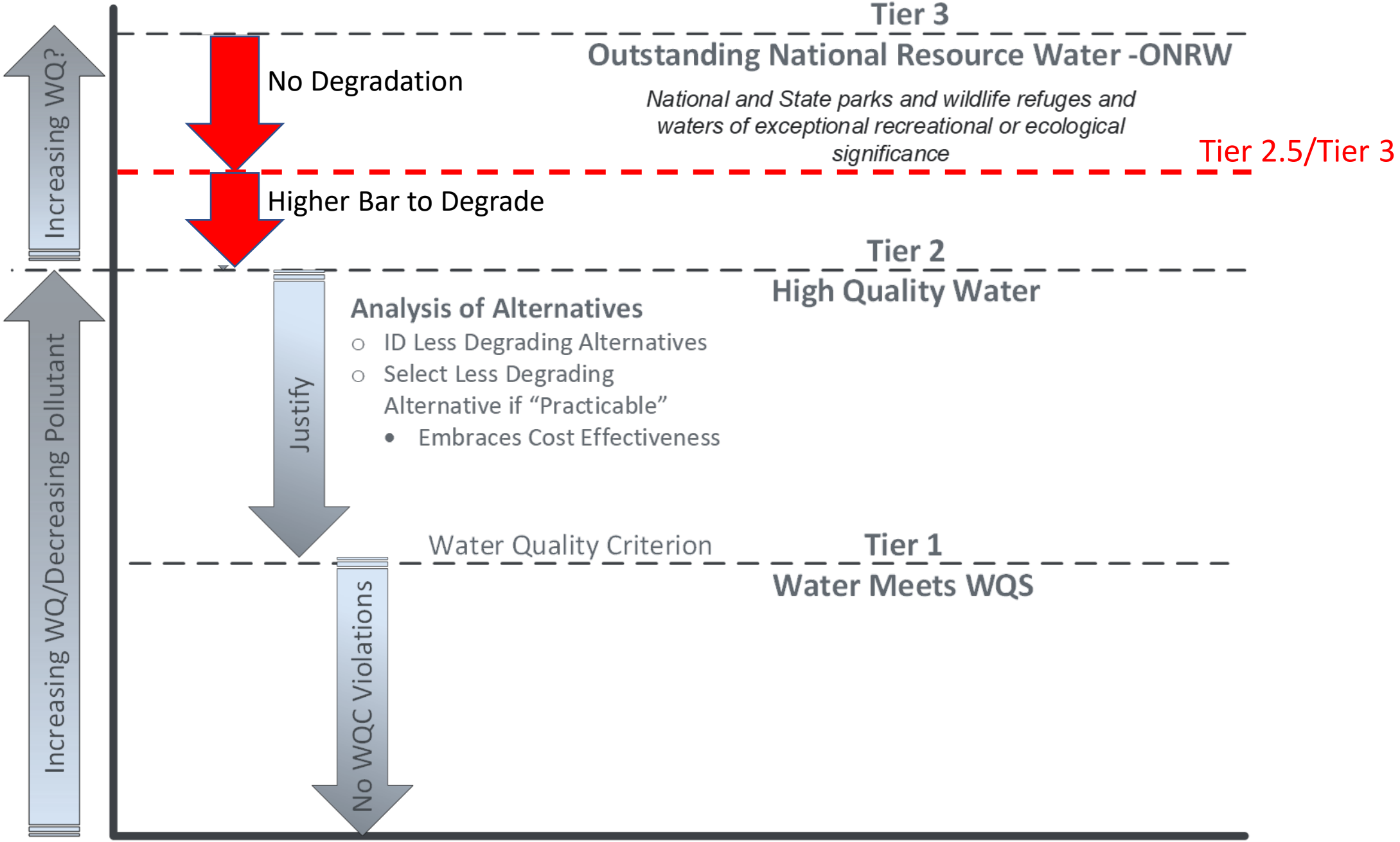
Water Quality Criteria

- Water Quality Criteria (WQC) – 40 CFR §131.11 – contd.
  - Narrative criteria
    - Where numeric criteria cannot be established, or
    - To supplement numeric criteria
  - Narrative Criteria are statements that *describe* desired goals
    - Sometimes referred to as “free froms”
      - Free from oil and grease
      - Free from color
      - Free from excess solids build up
      - Free from excess algae
      - Many, many, more

Antidegradation

- Antidegradation (AD) – 40 CFR §131.12
- What is AD?
  - Framework for maintaining and protecting WQ that has been achieved
    - Policy establishing protection of existing uses and maintaining high quality waters
      - *Generally, applies only to new or expanded discharges*
    - Implementation Procedures for the AD policy that have involved public involvement
  - AD is also the most misunderstood part of water quality standards (IMO)
    - While a WQS, implementation usually associated with NPDES permits
- EPA updated Antidegradation (AD) rules in late 2015
  - Added a couple of key elements
    - Alternatives Analysis
    - Required Implementation Procedures
- By default, 40 CFR §131.12 describes 3 *Tiers* of waters


Tier 3
Outstanding National Resource Water -ONRW
National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance
Increasing WQ?
Do Not Degrade
Tier 2
High Quality Water
Analysis of Alternatives
ID Less Degrading Alternatives
Select Less Degrading Alternative if "Practicable"
Embraces Cost Effectiveness
Justify
Increasing WQ/Decreasing Pollutant
Is this a single point – i.e., the WQC? Or is it a range?
Water Quality Criterion
Tier 1
Water Meets WQS
No WQC Violations


Tier 3
Outstanding National Resource Water -ONRW
National and State parks and wildlife refuges and waters of exceptional recreational or ecological significance
Tier 2.5/Tier 3
No Degradation
Higher Bar to Degrade
Increasing WQ?
Tier 2
High Quality Water
Analysis of Alternatives
ID Less Degrading Alternatives
Select Less Degrading Alternative if "Practicable"
Embraces Cost Effectiveness
Justify
Increasing WQ/Decreasing Pollutant
Water Quality Criterion
Tier 1
Water Meets WQS
No WQC Violations

Antidegradation - Implementation

- The 1995 EPA WQS Economic Guidance may sum up AD best

  Antidegradation is not a "no growth" rule and was never designed nor intended to be one. It is a policy that allows the public to make decisions about important environmental actions. Where the State intends to provide for development, it may decide that some lowering of water quality in "high-quality waters" is necessary to accommodate important economic or social development. Any such reduction in water quality, however, must protect existing uses fully and must satisfy the requirements for intergovernmental coordination and public participation.

Antidegradation - Implementation

- In layman's terms
  - If the current WQ is better than the WQC for the highest use
    - Try to protect that higher quality – don't pollute it right up to the criterion
    - This means the focus is on ≥ Tier 2 waters – defined as "high WQ"
- Which waters are Tier 2?
  - Depends
  - Waterbody-by-Waterbody or Pollutant-by-Pollutant approach?
    - P-b-P means a waterbody can have multiple Tiers based on ambient pollutant amount
    - For example, in the same waterbody
      - If the ambient Zn level just meets the current Zn WQC, it may be Tier 1 for Zn
      - If the ambient NH_3 level is lower than the current NH_3 WQC, it may be Tier 2 for NH_3
  - Identification of pollutants of concern (POC) is important

Antidegradation - Implementation

- The process
  - Determine if new or expanded discharge is *necessary to accommodate important economic or social development*
  - Determine if POCs
    - Will POCs degrade receiving water?
      - If so, look at lesser degrading alternatives
  - Identify "base case" treatment – typically will just meet WQC
  - Determine whether a lesser degrading alternative is "practicable"
    - Is it "technologically possible, able to be put into practice, and economically viable"?
    - If practicable, require a lesser degrading alternative treatment
    - If not practicable, can allow degradation as long as WQC are met
  - Outcome will set NPDES permit limits for POCs
    - Like NPDES permits, AD is subject to public notice and input

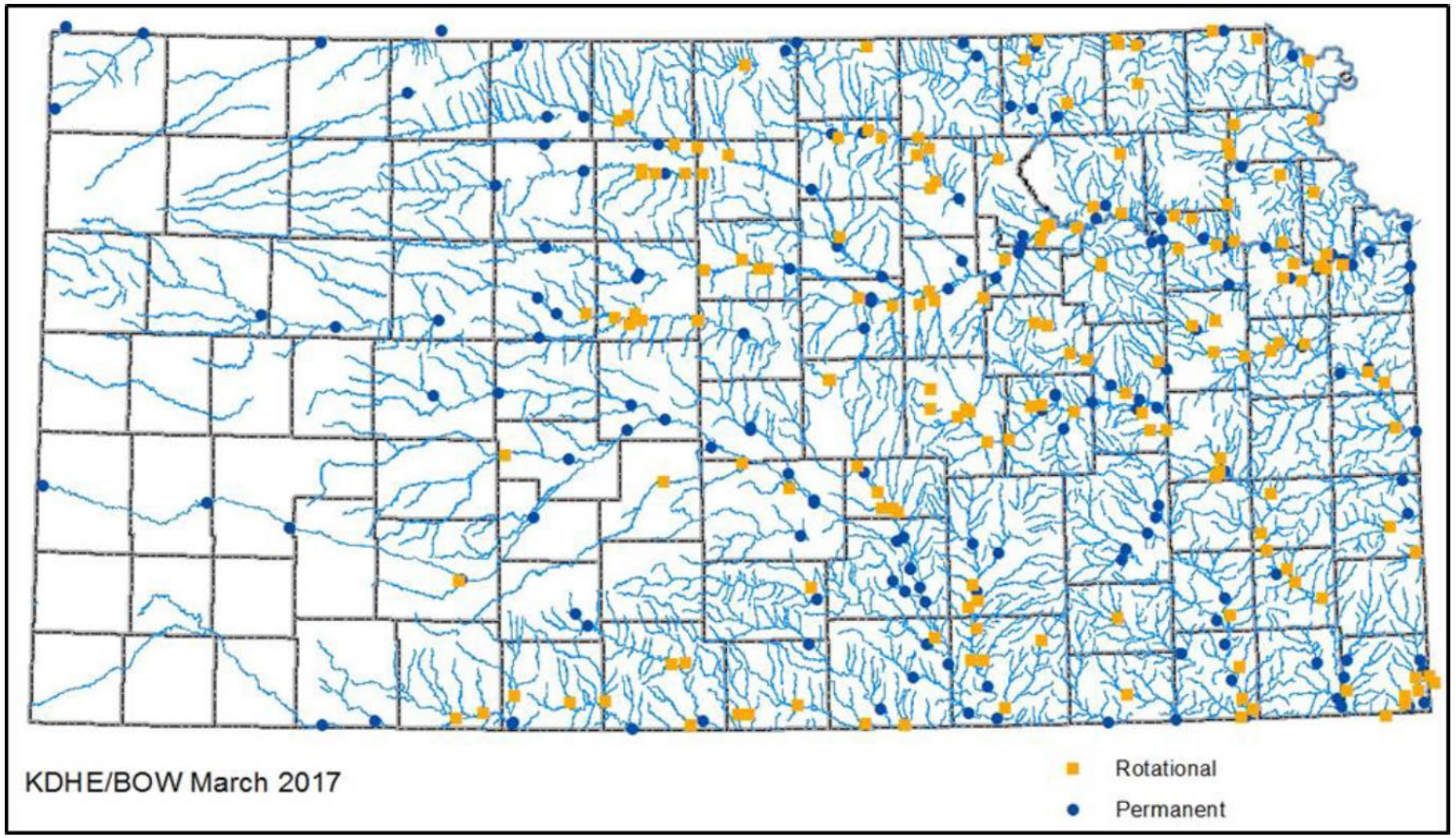
Antidegradation - Implementation

Trust me Bobby, once you deal with Antidegradation, you will wish I was your worst nightmare.

Where And How WQS Are Used - Monitoring

- Monitoring and Assessment
  - Sample and analyze surface water quality
  - Assess whether state waters comply with WQS – can be complicated
    - WQ may vary based on:
      - Flow
      - Seasonality – warm/cold; wet/dry; etc.
    - State must translate WQC to data captured via monitoring and sampling
      - For example
        - How many locations are sampled
        - May collect samples once per month, once per quarter, once per year, …..
        - Some WQC written with a duration of 4-days – how does that work?
          - Statistics 
      - Some state publish how they translate

Where And How WQS Are Used - Monitoring



Kansas Water Quality Monitoring and Assessment Strategy 2019-2028

Kansas Sampling Network

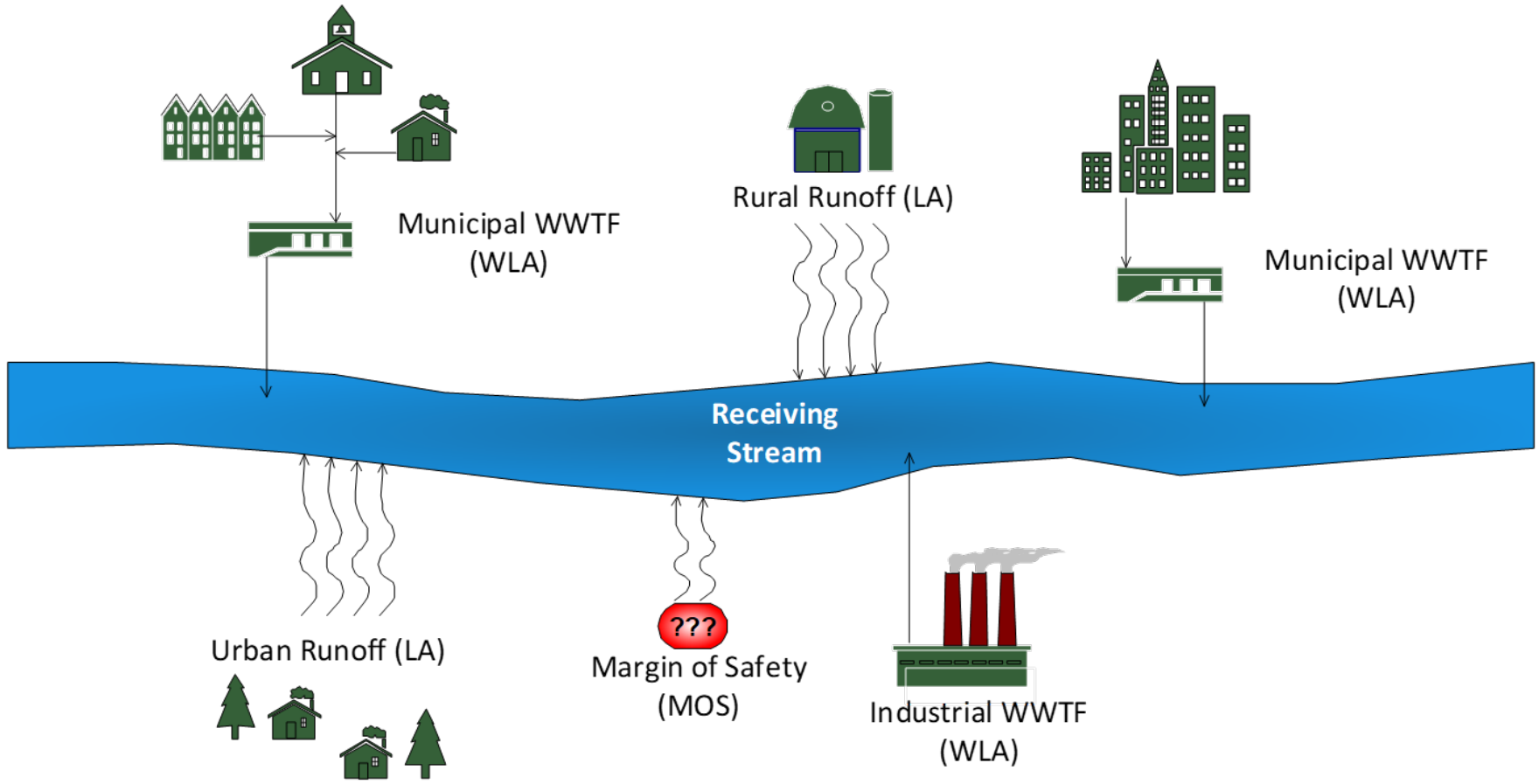
- In operation ~50 yr
- 160 permanent sites
  - Sampled quarterly
- 167 rotational sites
  - 25% sampled each year

Where And How WQS Are Used - TMDLs

- Total Maximum Daily Load (TMDL)
  - States required to develop lists of *impaired waters* under §303(d) of CWA
  - *Impaired Waters*
    - Do not meet WQC states set for them, even after point sources treat effluent
  - On a priority basis, states required to develop TMDLs for those impaired waters
  - TMDLs identify *Wasteload Allocations* (WLAs) for the impairing pollutant
    - WLAs establish levels of pollutants given to point sources
      - May have multiple WLAs - one for each point source
    - Nonpoint sources are given *Load Allocations* (LAs)
    - The TMDL also incorporates a *Margin of Safety* (MOS) because they are based on modeling
    - Theoretically, an impaired waterbody should meet the state WQC for an impairing pollutant if
      - $[WLA_1+WLA_2+....WLA_n] + LA + MOS \leq TMDL$ – Could also throw in some reserve for future

Where And How WQS Are Used - TMDLs

TMDL=Waste Load Allocation (WLA) + Load Allocation (LA) + Margin of Safety (MOS)



Where And How WQS Are Used - TMDLs

Table 21. Phase I WLA Table for the Lower Kansas River TMDL.

KS Permit	Facility	NPDES	TP WLA Conc (mg/L)	Design Flow (cfs)	WLA (lbs/day)
M-KS33-OO01	Lecompton Wastewater Treatment Facility	KS0038644	2.00	0.11	1.19
I-KS31-PO09	Westar Lawrence Energy Center	KS0079821	1.50	1.39	11.27
I-KS31-CO06	Hallmark Cards, Inc.	KS0091481	0.20	0.02	0.02
I-KS31-PO16	Kaw River Water Treatment Plant	KS0088234	0.20	0.66	0.71
M-KS31-IO01	Lawrence Kansas River Wastewater Treatment Facility	KS0038644	1.00	19.34	104.42
I-KS31-PO06	ICL Performance Products LP (fka Astaris)	KS0001511	3.00	0.68	11.03
I-KS31-PO20	Jefferson County RWD No. 13 Wastewater Treatment Facility	KS0096814	0.20	0.01	0.02
I-KS31-PO04	Former Farmland Industries - Lawrence	KS0001601	0.20	0.56	0.60
C-KS31-OO02	KTA - Lawrence Service Area	KS0053694	2.00	0.05	0.50
I-KS31-PO23	Clinton Reservoir Public Water Supply Treatment Plant	KS0099121	0.20	0.97	1.05
M-KS31-OO03	Lawrence Wakarusa River Wastewater Treatment Facility	KS0099031	1.00	10.83	58.48
M-KS17-OO02	Eudora Municipal Wastewater Treatment Facility	KS0094609	1.00	1.39	7.52
M-KS12-OO03	DeSoto Wastewater Treatment Facility	KS0098167	1.00	2.01	10.86

Where And How WQS Are Used – TMDLs

- Once TMDL is set, what if a discharger expands?
  - With TMDL, WLAs are generally set in terms of lb/day
    - If flow increases, concentration must decrease to meet the WLA

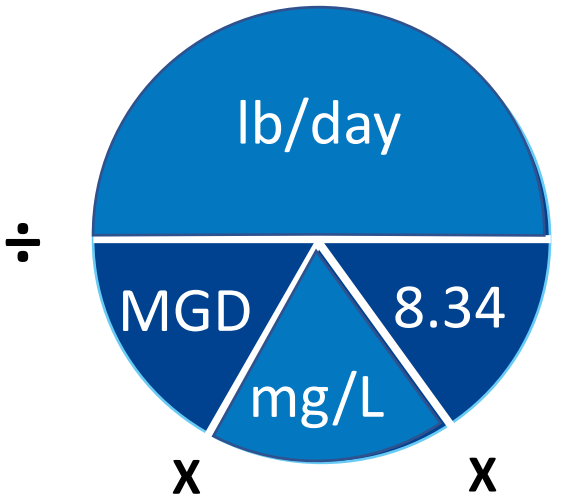
      lb/day = mg/L * Flow (MGD) * 8.34

      Example: TMDL of 11 lb/day for a facility with flow of 1.3 MGD

      11 lb/day = mg/L * 1.3 MGD * 8.34

      11 lb/day ÷ (1.3 MGD*8.34) = 1.0 mg/L

Davidson Pie



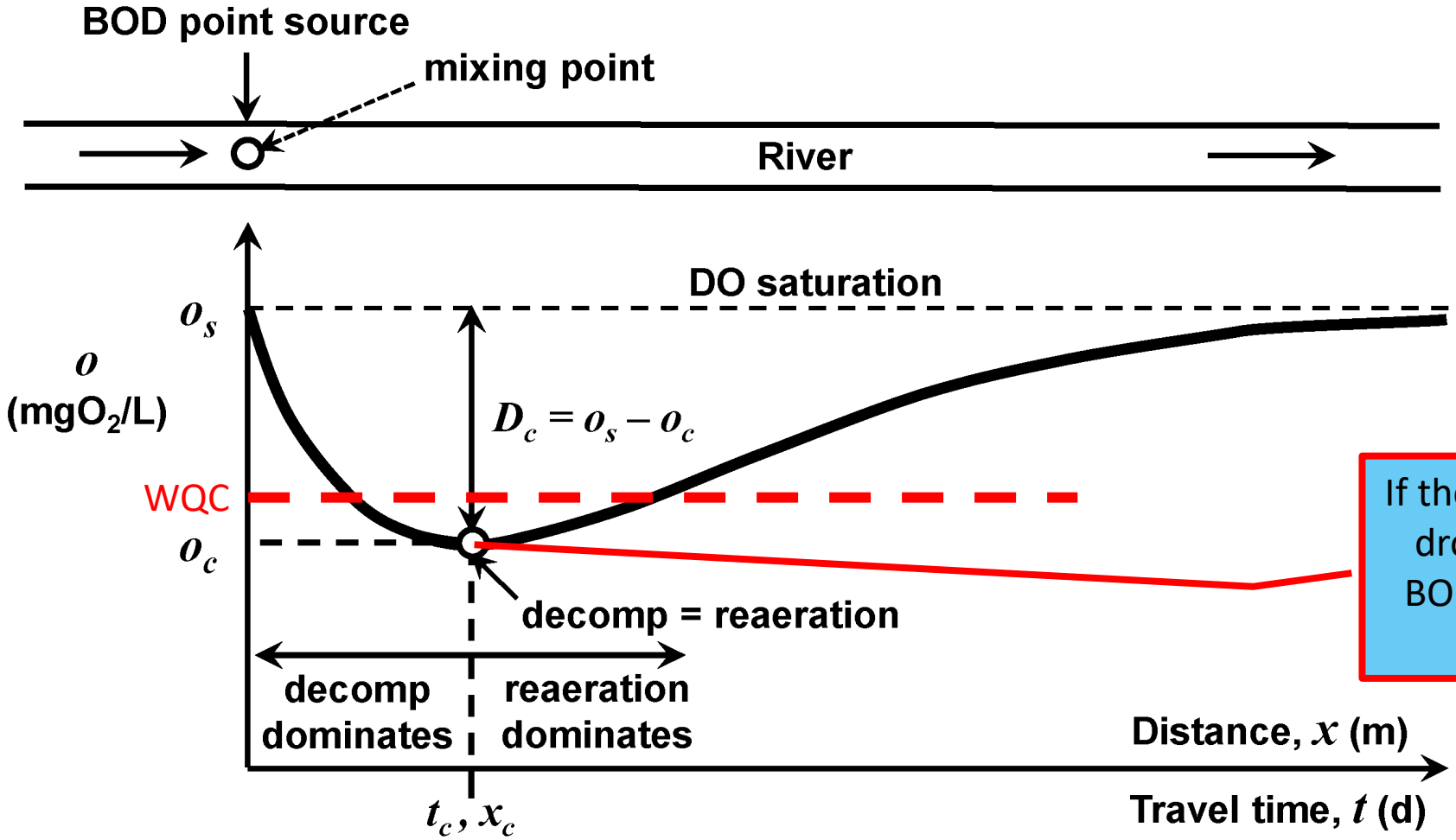
So, if the permittee needed to increase flow to 3.9 MGD (3X), what concentration is required?

11 lb/day ÷ (3.9 MGD*8.34) = 0.33 mg/L

Where And How WQS Are Used – Permit Limits

- NPDES Permit Limits
  - Often the most stringent determinant of NPDES permit limits
- Refresher
  - For the same pollutant we select the most stringent of:
    - Technology-based effluent limits (TBELs)
      - For POTWs – BOD_5/$CBOD_5$, TSS, pH → 30/25 mg/L, 30 mg/L, 6.0 – 9.0, respectively
      - For Industrial dischargers – Effluent Guidelines
    - TMDL-based effluent limits
      - For discharges to impaired waters
    - Water quality-based effluent limits (WQBELs)
      - Based on state WQC
      - Often override TBELs because they are often more stringent
        - Common example is BOD_5

Where And How WQS Are Used – Permit Limits



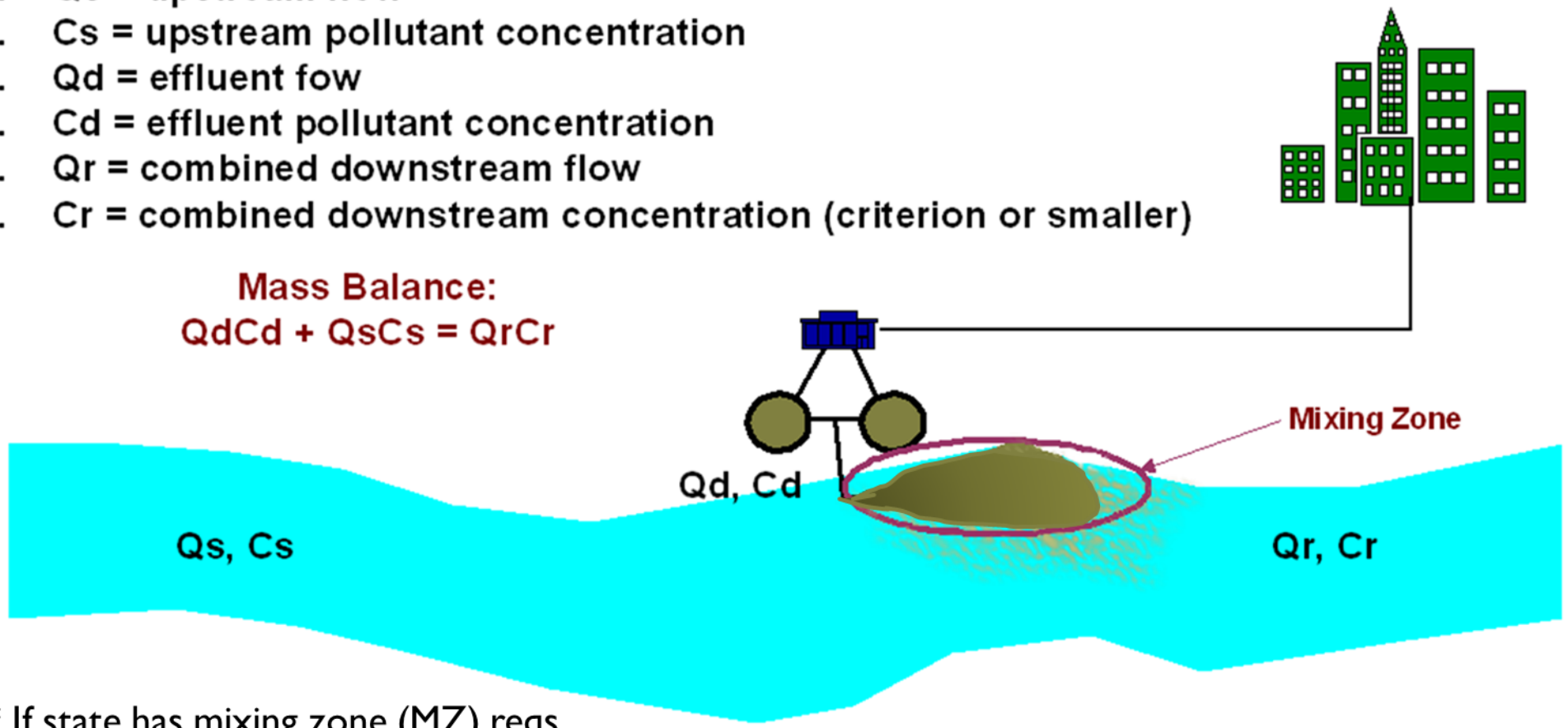
If the minimum dissolved oxygen drops below the stated WQC, BOD5 limit will be set <TBEL of 30 mg/L

Chapra, et al. - https://www.mdpi.com/2073-4441/13/17/2408

Where And How WQS Are Used – Permit Limits

1. Qs = upstream flow
2. Cs = upstream pollutant concentration
3. Qd = effluent fow
4. Cd = effluent pollutant concentration
5. Qr = combined downstream flow
6. Cr = combined downstream concentration (criterion or smaller)

Mass Balance:
QdCd + QsCs = QrCr



* If state has mixing zone (MZ) reqs,
MZ becomes upstream flow

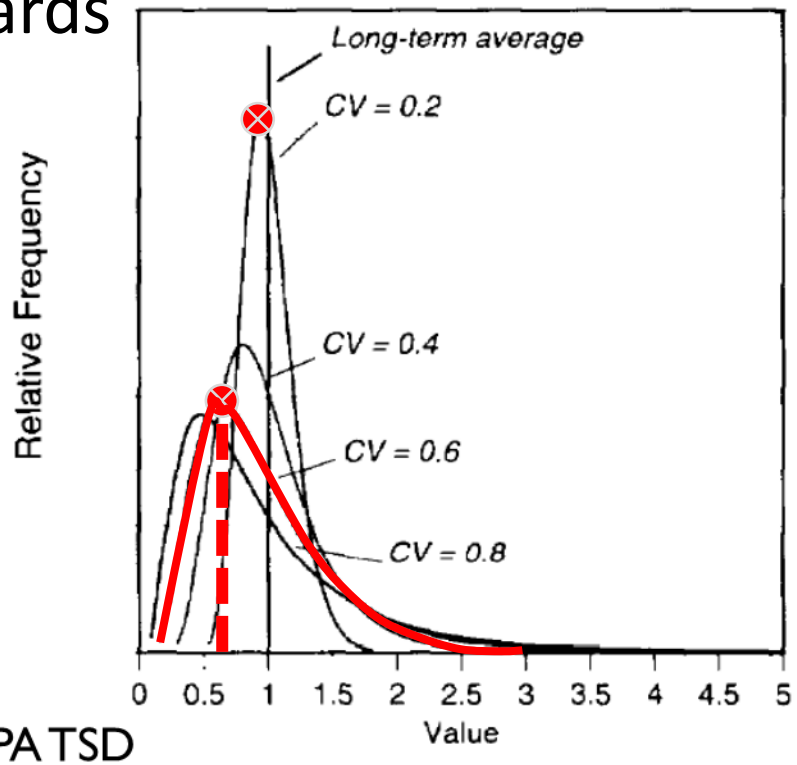
Solve for Cd:
Cd = (QrCr - QsCs) / Qd

Where And How WQS Are Used – Permit Limits

- Critical upstream flow is typically based on a statistically developed low flow
  - 7Q10 – lowest 7-day low flow in a 10-year period (hydrologically-based)
  - 4B3 – 4-day avg flow event occurring on avg once every 3 years (biologically-based)
    - Tries to estimate actual biological exposure of aquatic life
- If mixing zone (MZ), critical upstream flow is multiplied by the MZ fraction
  - Applies to chronic criteria
  - Example - critical upstream flow is 10 cfs and MZ is 25% of stream flow
    - Upstream flow used in calculation 10 cfs X 0.25 or 2.5 cfs
- A fraction of the MZ is called the Zone of Initial Dilution (ZID) – often 10%
  - Applies to acute criteria
- Complete the computation for each WQC to establish WQBELs

Where And How WQS Are Used – Permit Limits

- For toxics, some states and EPA take an extra step detailed in EPA Technical Support Document (TSD) for Water Quality Standards
  - Due to variability of effluent, an average limit will be exceeded at some point
  - TSD procedure tries to minimize excursions
  - Procedure will further reduce the limitation
- TSD also covers Whole Effluent Toxicity (WET)
  - WET looks at potential toxicity entire effluent
  - Acute Toxicity
    - Lethal (kills) test organisms
  - Chronic Toxicity
    - Affects reproduction of test organisms



From EPA TSD

Figure 3-1b. Comparison of Relative Frequencies of Lognormal Distributions with a Mean of 1.0 for Different Coefficients of Variation

Where And How WQS Are Used – Permit Limits

- Whole Effluent Toxicity (WET)
  - Uses live organisms exposed to various concentrations of WWTF effluent
    - Two or Three organisms
      - Daphnia (water flea) - invertebrate
      - Fathead minnow – vertebrate
      - Green Algae
    - Exposure is at controlled temperature, DO, etc.
  - Acute Toxicity – lethality or death
    - Expose organisms to effluent and see if there is more death than a control sample
      - Compute Lethal Concentration of effluent where 50% die (LC_{50})
  - Chronic Toxicity – growth and reproduction
    - Expose organisms to effluent and see if growth or reproduction is affected and how much vs control
      - Compute Inhibition Concentration of effluent with 25% reduction in reproduction or growth (IC_{25})

Where And How WQS Are Used – Permit Limits

- One key take away – WQBELs are based on conservative assumptions
  - Low flow – Often 7Q10 – lowest 7-day avg flow that occurs (on avg) once in 10 years
    - 10% chance in any one year
    - May want to look at seasonal low flows
  - Based on most sensitive species – may not exist in a particular waterbody
    - Generally, up to permittee to request or develop a modified criterion
  - Mixing Zone – criterion can only be exceeded in small fraction of receiving water
  - EPA Technical Support Document for toxics modifications
  - Assumptions that may affect criterion
    - For example:
      - Ammonia based on pH and temperature
      - Many metals based on hardness
      - Copper (biotic ligand model) based on temperature, pH, dissolved organic carbon (DOC), calcium, magnesium, sodium, potassium, sulfate, chloride, and alkalinity
      - WET - temperature

Why Should You Care About WQS?

- Having a basic understanding WQS allows you to:
  - Better understand how your NPDES permit limits were developed
    - Lots of very conservative assumptions go into developing limits
      - Are all the assumptions reasonable?
        - If not, need to comment during public notice period
          - Once a restrictive limit established, *anti-backsliding* makes a future challenge difficult
      - Do you have better data that might help generate a more applicable limit?
    - Better understand when a *variance* may be appropriate
      - Variance possible if one "*can demonstrate that attaining the designated use and criterion is not feasible*"
        - This is no easy task, but it is an option if warranted
  - Better understand how TMDLs are developed – particularly if your WWTF has a WLA
    - Again, lots of assumptions and modeling goes in to crafting TMDL waste load allocations
    - Once TMDL approved, WLA essentially becomes your permit limit
      - Need to make informed comments during public comment period if you think poor assumptions

Want to Know More?

- EPA has a number of resources you may want to explore:
  - ***Water Quality Standards Academy***
    - ***Classroom Academy*** - In-person 5-day course
      - https://www.epa.gov/wqs-tech/water-quality-standards-academy#tab-2
    - ***Online Modules*** - Virtual self-paced course
      - https://www.epa.gov/wqs-tech/water-quality-standards-academy#tab-0
  - ***What are Water Quality Standards?*** – online with links to specific topics
    - https://www.epa.gov/standards-water-body-health/what-are-water-quality-standards
  - ***Water Quality Standards: Regulations and Resources*** - online w/links to topics
    - https://www.epa.gov/wqs-tech

Thank You!

Mike Tate, PE

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Environmental Finance Center

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