Implementation of Water Quality Standards in NPDES Permits

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Learning Objectives

- Discuss the differences and relationships among water quality standards, water quality criteria, and effluent limitations
- Understand the process for translating water quality standards into effluent limitations in NPDES permits
  - Introduce the concepts of dilution and mixing zones
  - Define the terms "TMDL" and "wasteload allocation" and understand their roles in implementation of water quality standards and development of effluent limitations

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Relationship Between WQS and Effluent Limitations

- Water quality standards apply throughout the waterbody (or segment of a waterbody) as defined by the State or Tribe
- Effluent limitations apply at the compliance point established in the permit (generally at the "end of pipe")
- Water quality standards must be translated into water quality-based effluent limitations to be effective in NPDES permits

Components of Water Quality Standards

- **Designated uses** [131.10]
- ***Water quality criteria*** [131.11]
  - Numeric Criteria
  - Narrative Criteria
- **Antidegradation policy** [131.12]

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Translating WQ Criteria into Effluent Limitations

Water Quality Criteria

- Magnitude
- Duration
- Frequency

→

Effluent Limitations

- Magnitude
- Averaging Period

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Translating WQ Criteria into Effluent Limitations

- Methods for translating water quality criteria into effluent limitations are established through water quality standards and their implementing procedures (including NPDES requirements)
  - Dilution considerations
  - Modeling assumptions (i.e., critical conditions)
  - Specific models
  - Etc.

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Applying Numeric Criteria

- Clean Water Act does not require attaining *water quality criteria* at the point of discharge
- States have discretion to allow dilution as *part of their water quality standards* and implementation procedures
- States should specify any conditions on dilution allowances as *part of their water quality standards*
- 40 CFR §122.44(d)(2) states that when establishing WQBELs "shall account for dilution of the effluent in the receiving water (where appropriate)"

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Allowable Dilution

Water Quality Standards often allow dilution …

- *Up to* 100% of critical flow (e.g., 7Q10 low flow) if there is *rapid and complete mixing*
- Within a limited mixing zone at the critical flow if there is *incomplete mixing*

Considering Dilution

Do water quality standards allow consideration of dilution?

No

Criteria apply at end of pipe

Considering Dilution (Continued)

Do water quality standards allow consideration of dilution?

No

Criteria apply at end of pipe

Yes

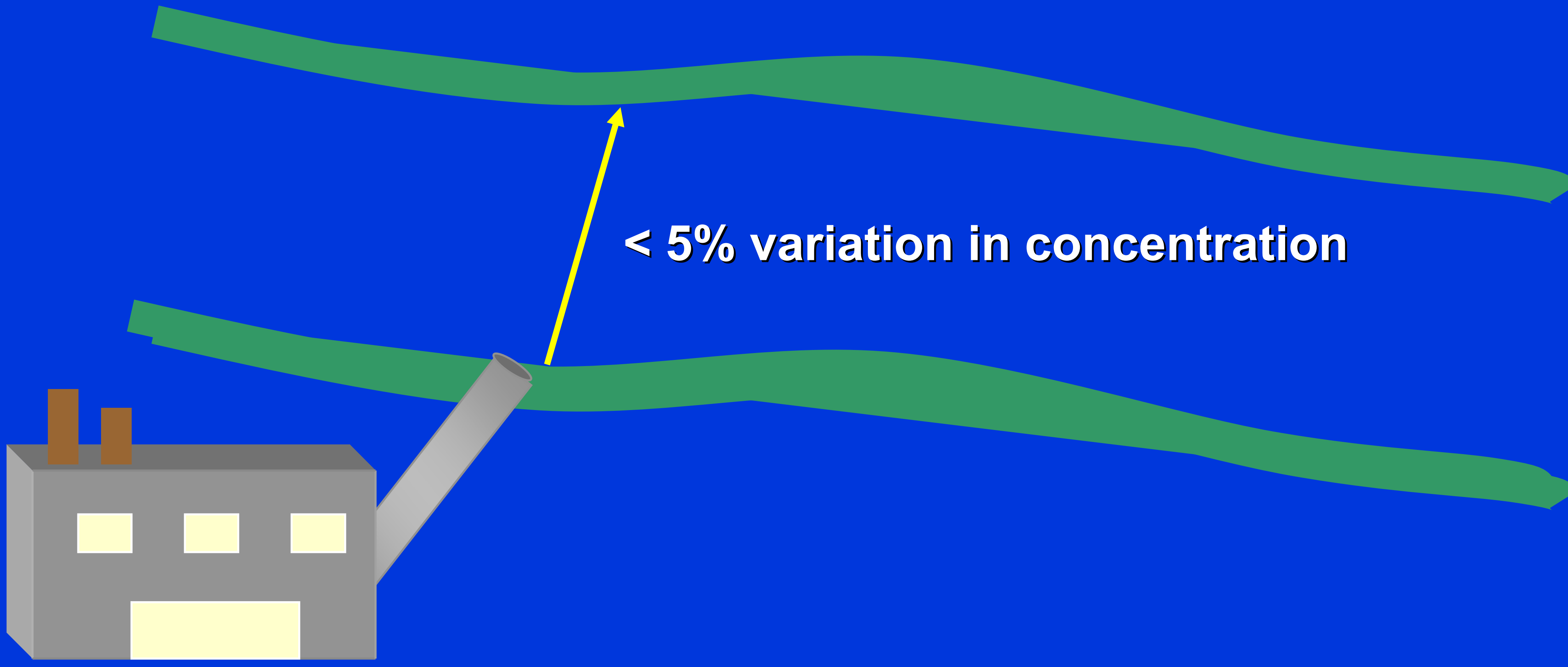
Determine what dilution is allowed by water quality standards

Is there rapid and complete mixing?

What is Rapid and Complete Mixing?

- Rapid and complete mixing occurs when lateral variation in concentration in the direct vicinity of the outfall is small (e.g., less than 5%)
- Potential occurrences include:
  - Effluent dominated systems (effluent flow greater than stream flow)
  - Diffuser located across entire stream width

Rapid and Complete Mixing



Considering Dilution (Continued)

Is there rapid and complete mixing?

Yes

Complete Mix Assessment

(up to the maximum dilution allowed by WQS under complete mix conditions)

Examples of Allowable Dilution in Rapid and Complete Mix Situations

- Where there is rapid and complete mixing, water quality standards may allow permit writers to consider up to a specified percentage of a critical low flow in rivers and streams for dilution when calculating effluent limitations, for example:
  - 100% of 1Q10 or 7Q10 low flow
  - 50% of 1Q10 or 7Q10 low flow (< 100% allowed as a "factor of safety")
  - 25% of 7Q2 low flow

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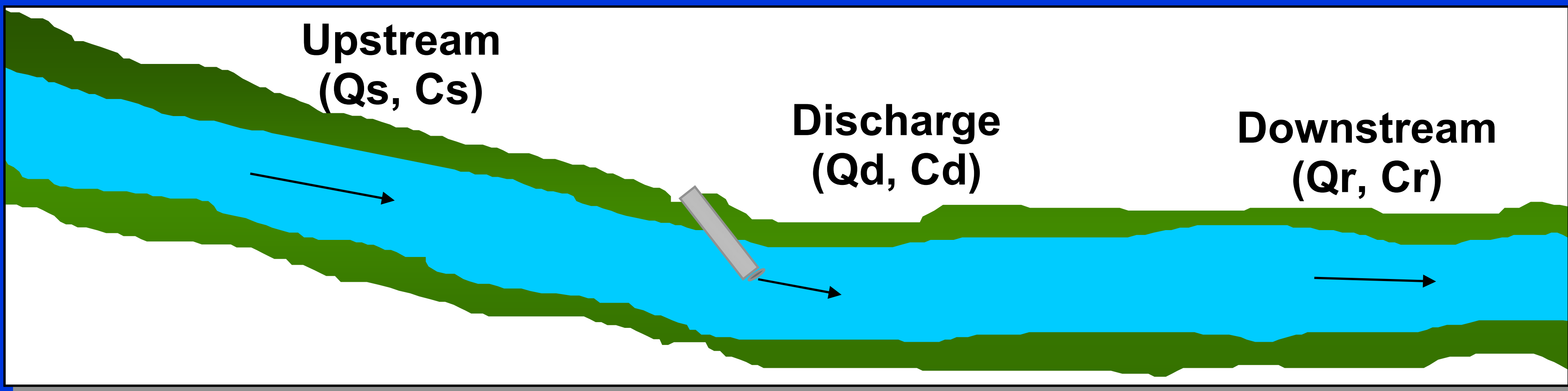
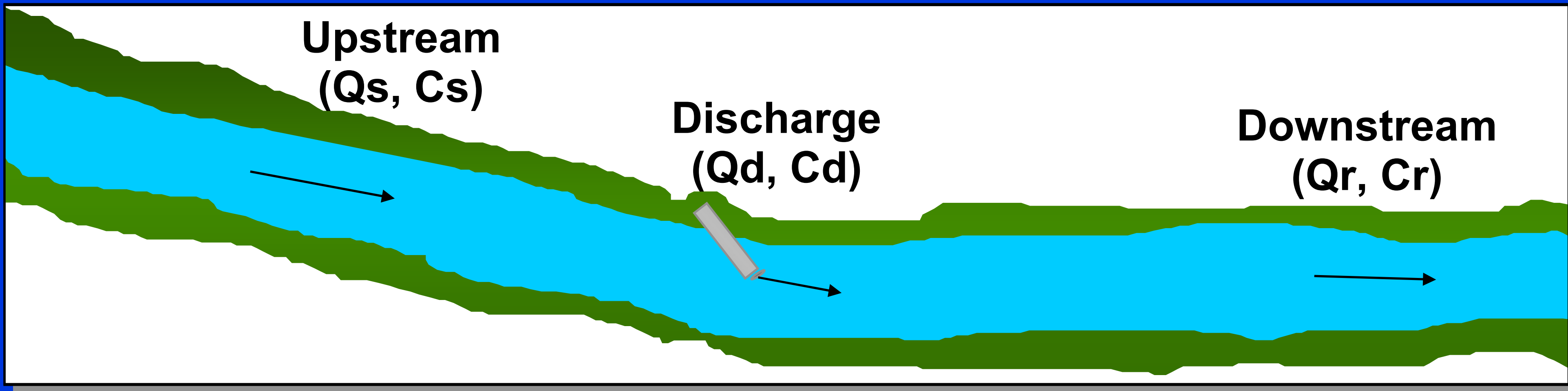
Steady-State Complete Mix Assessment



Mass-Balance Equation: QdCd + QsCs = QrCr

- Q = Flow (mgd or cfs)
- C = Pollutant concentration (mg/l)
- Mass = [Concentration] [Flow]

Steady-State Complete Mix Assessment
QdCd + QsCs = QrCr



- Determine the pollutant concentration in the water body downstream of the discharge:

$$Cr = \frac{QdCd + QsCs}{Qr}$$

- Qs = upstream flow under critical conditions allowed to be considered for dilution as specified in WQS

Note: Qr = Qs + Qd

Considering Dilution (Continued)

Is there rapid and complete mixing?

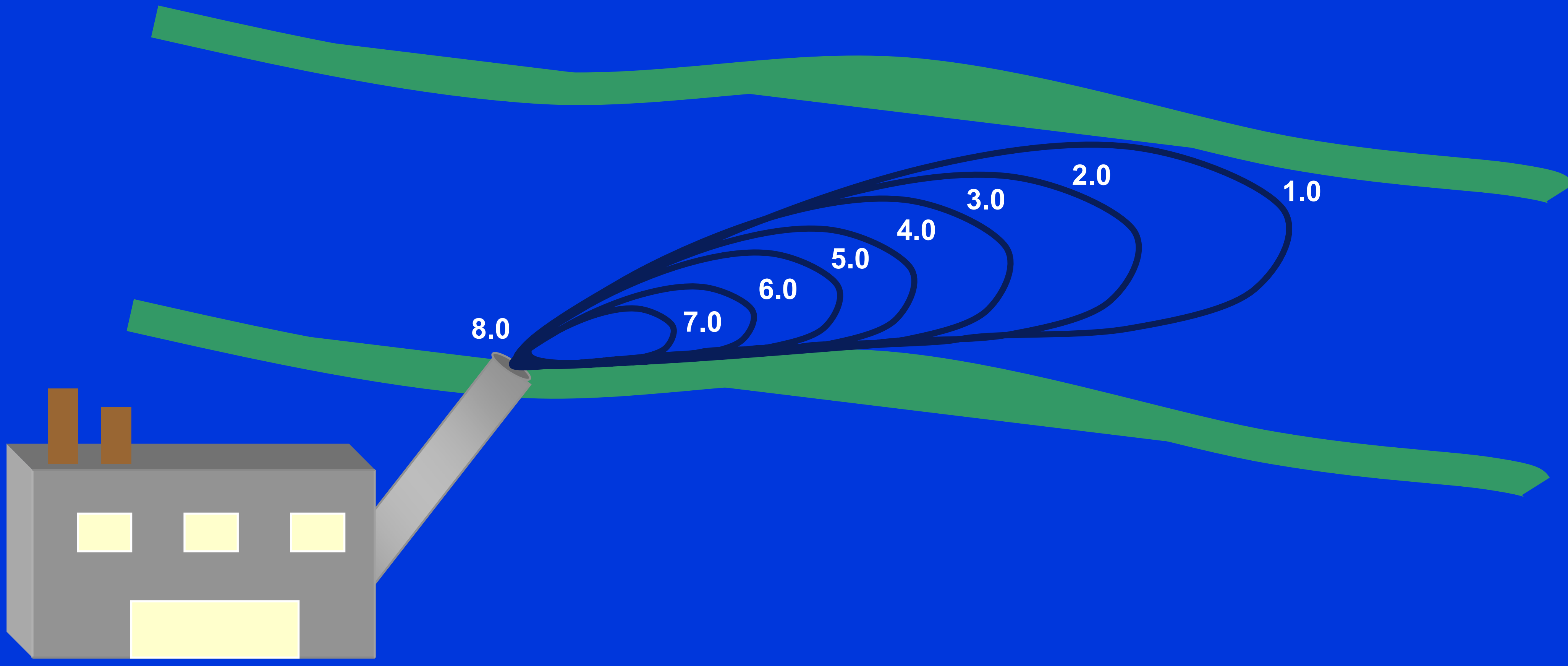
Yes

No

Complete Mix Assessment
(up to the maximum dilution allowed by WQS under complete mix conditions)

Incomplete mix assessment
(up to the maximum dilution provided by WQS regulatory mixing zone)

Incomplete Mixing



Incomplete Mix Assessment

- Field Studies
  - Actual measurement of instream contaminant concentrations
  - Dye studies
- Modeling
  - Calibrated to actual observations
  - Simulate critical conditions

Regulatory Mixing Zones

- Definition
  - A limited area or volume of water where initial dilution of a discharge takes place and where the water quality standards allow water quality criteria to be exceeded
- Common Constraints
  - Cannot impair integrity of the waterbody
  - No significant health risks
  - No lethality to passing organisms

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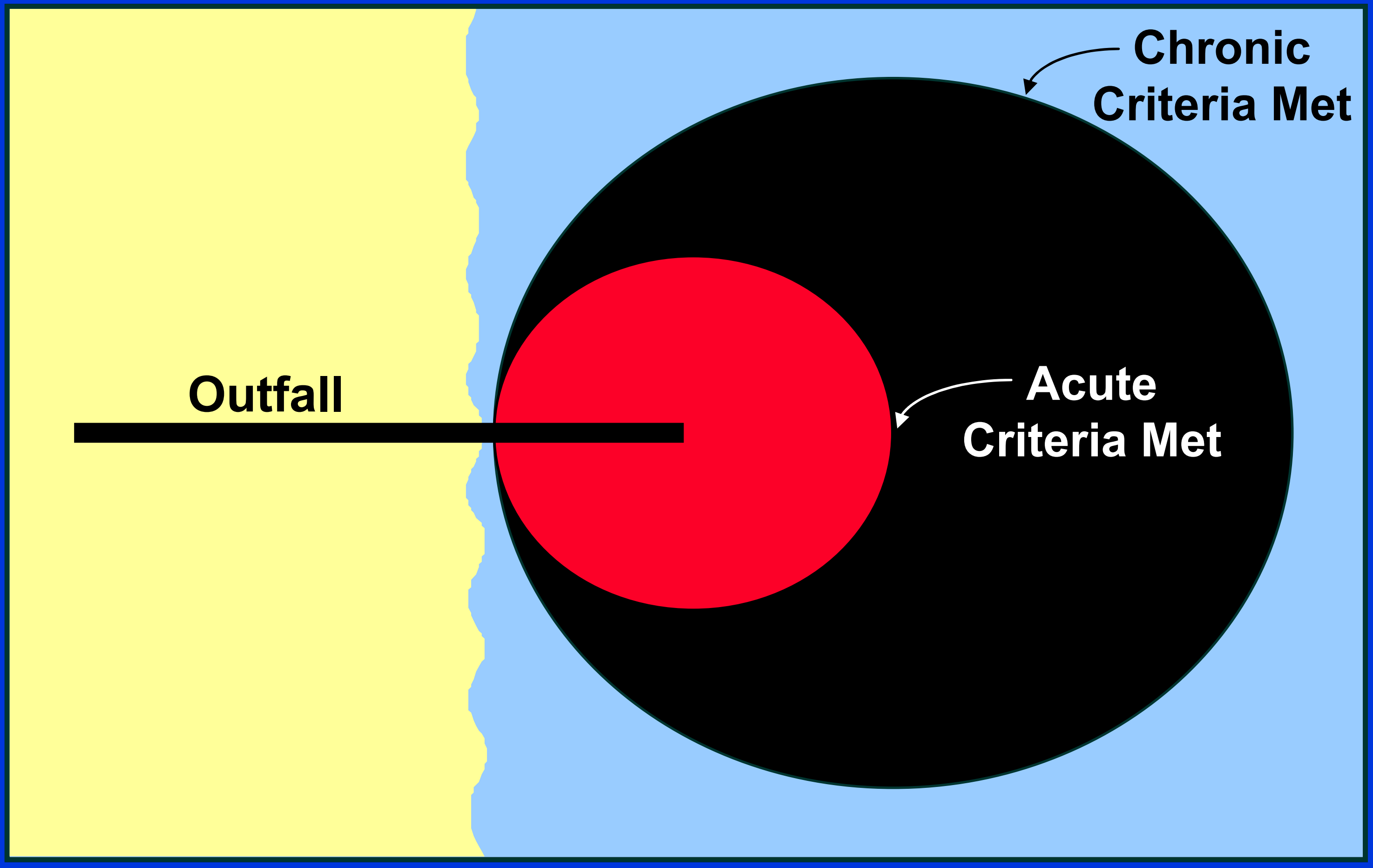
Regulatory Mixing Zones (Continued)



Examples of Regulatory Mixing Zones

- < 1/4 of stream width and 1/4 mile downstream
- <1/2 stream width and longitudinal limit of 5 X stream width
- No more than 5% of the lake surface
- Default of no more than 4:1 dilution for lake discharges

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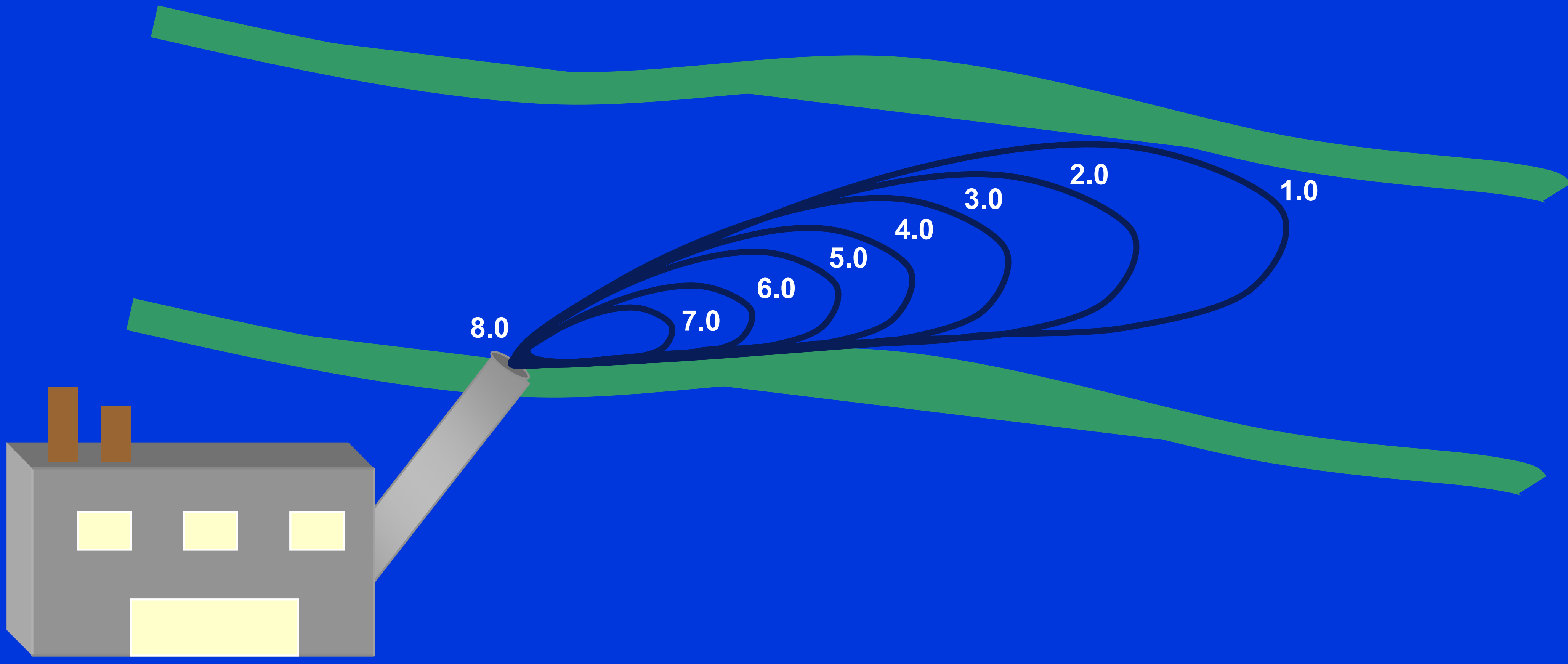
Steady-State Incomplete Mix Assessment

What if the applicable water quality criterion = 4.0 μg/l?



Steady-State Incomplete Mix Assessment (Continued)

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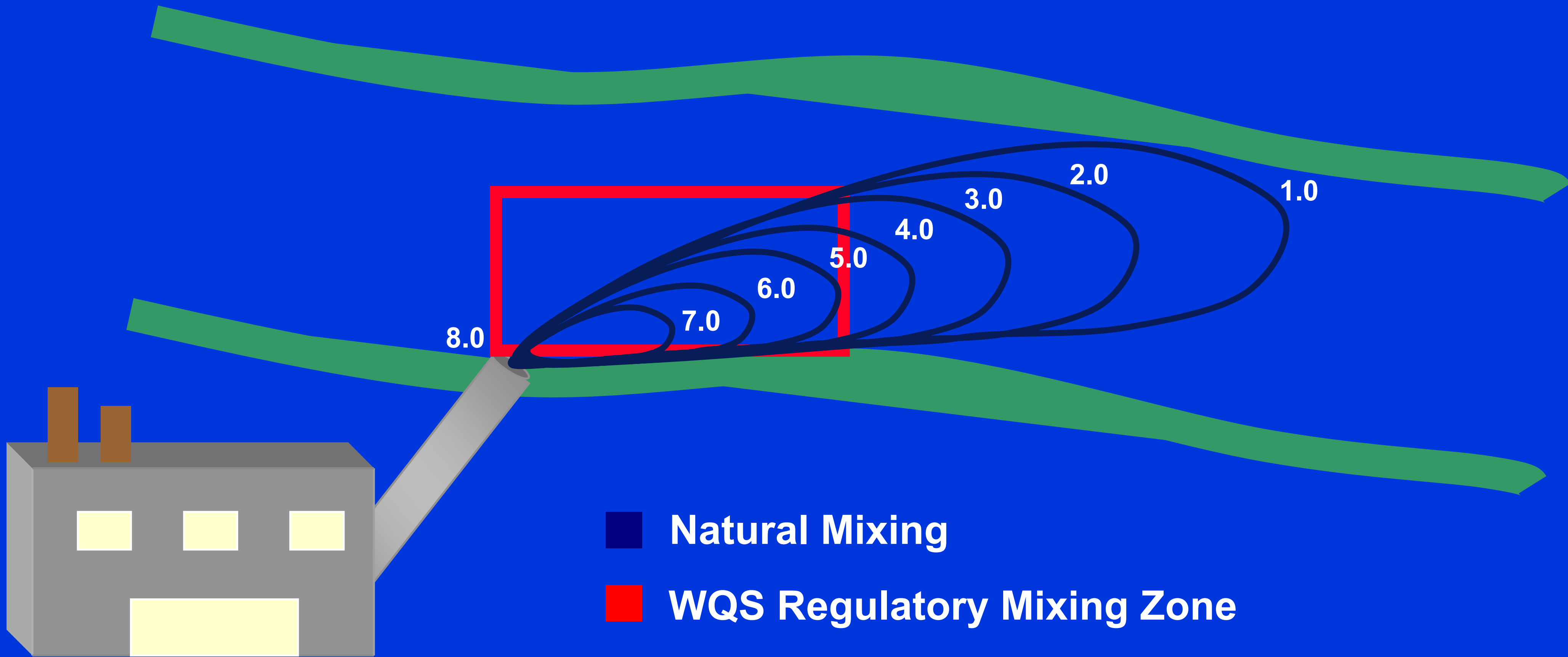

Steady-State Incomplete Mix Assessment (Continued)

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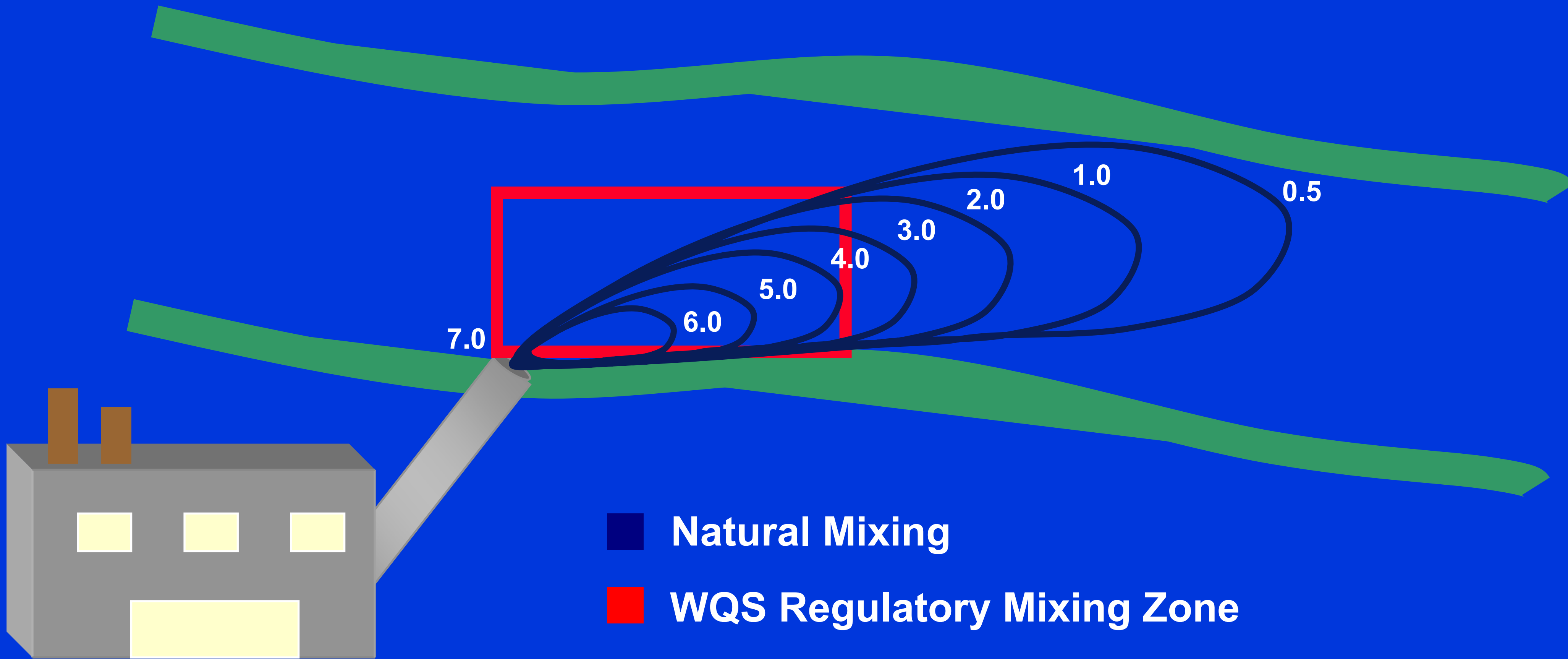

Steady-State Model

- Predicts the magnitude of pollutant concentration for a single set of environmental conditions
- Used when more complete data are not available for dynamic modeling (which accounts for variability in model inputs)
- Assumes “critical conditions” for flow, pollutant concentrations, and environmental effects

Considerations for Steady-State Modeling

- Water quality standards
  - Applicable criteria
  - Critical conditions
  - Allowable dilution
- Discharge characteristics
  - Flow rate
  - Pollutant concentrations

Considerations for Steady-State Modeling (Continued)

- Receiving water characteristics
  - Pollutant concentrations (i.e., background)
  - Stream flow
- Pollutant characteristics
  - Type of pollutant
    - Non-conservative: mitigated by both natural dilution and degradation in the receiving water (e.g., ammonia, bacteria)
    - Conservative: mitigated only by natural dilution (e.g., heavy metals)
  - Reaction rates

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Examples of Steady-State Models

- Heavy metals – Simple Mass Balance Equation
  - Simple mass balance equation considers dilution of effluent discharge by receiving water
- Dissolved oxygen – Streeter-Phelps Equation
  - Mass balance based on removal of oxygen by degradation of organic materials and reaeration by oxygen transfer from the atmosphere

Examples of Steady-State Models (continued)

- Conventional pollutants, DO, nutrients – QUAL2K
  - May be operated either as a steady-state or dynamic model in branching, well-mixed streams and in well-mixed lakes; considers advection, dispersion, dilution, constituent reactions and interactions, sources, and sinks
- Incomplete mix assessment – CORMIX
  - Predicts steady-state mixing behavior of continuous discharges using systems to model submerged single-port and multi-port diffuser discharges and surface discharges; models effluents containing conservative pollutants, non-conservative pollutants, suspended sediments, or a thermal discharge

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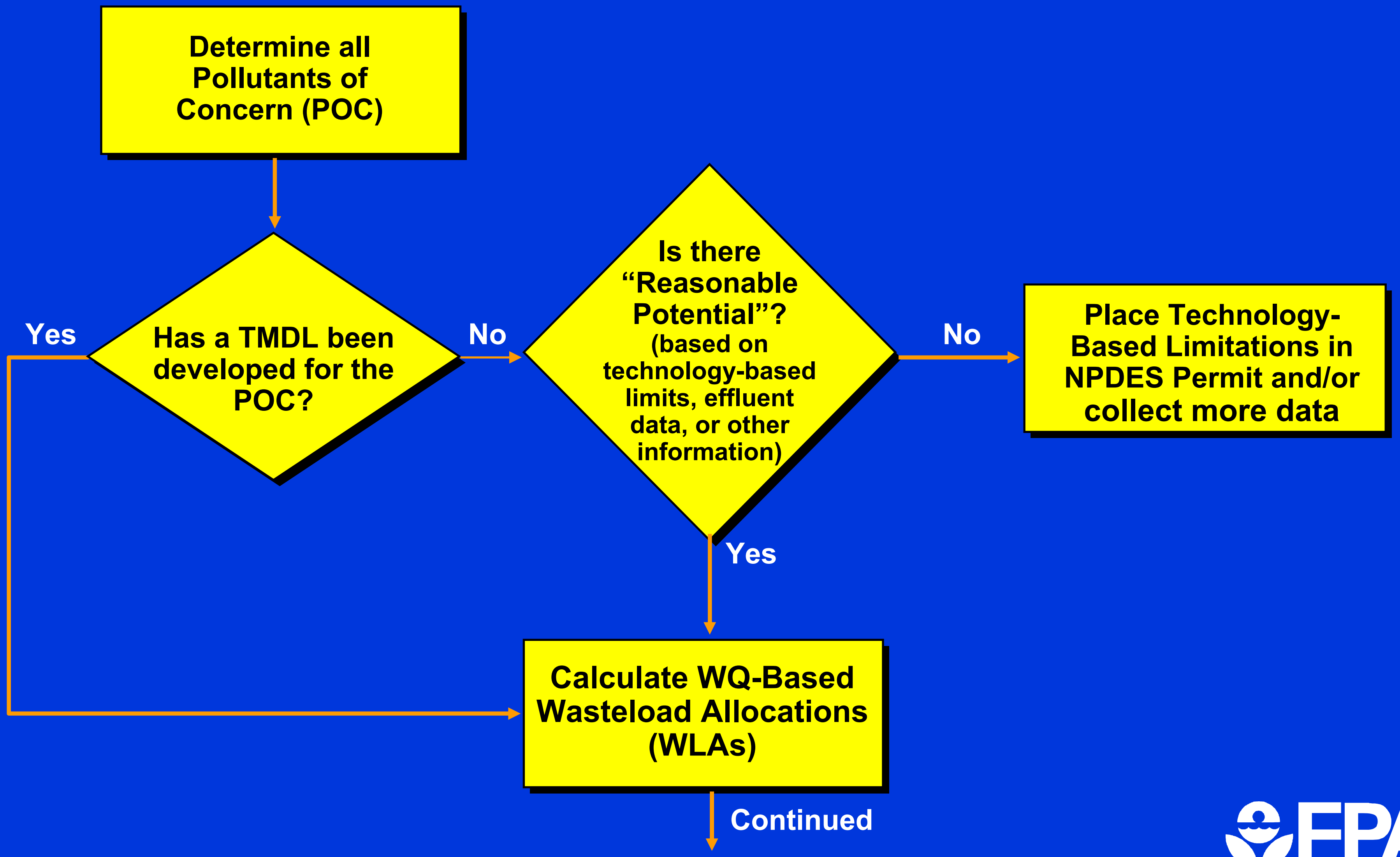
Applying Narrative Criteria

- Narrative criteria are statements that describe the desired water quality goal
- Narrative criteria may be translated into numeric requirements
  - Translation using one of several methods [122.44(d)(vi)]
  - Implemented in same or similar manner as numeric criteria when translated (i.e., must be met in receiving water after any available dilution)
- Some narrative criteria could be *directly* incorporated as permit requirements (e.g., no visible sheen)

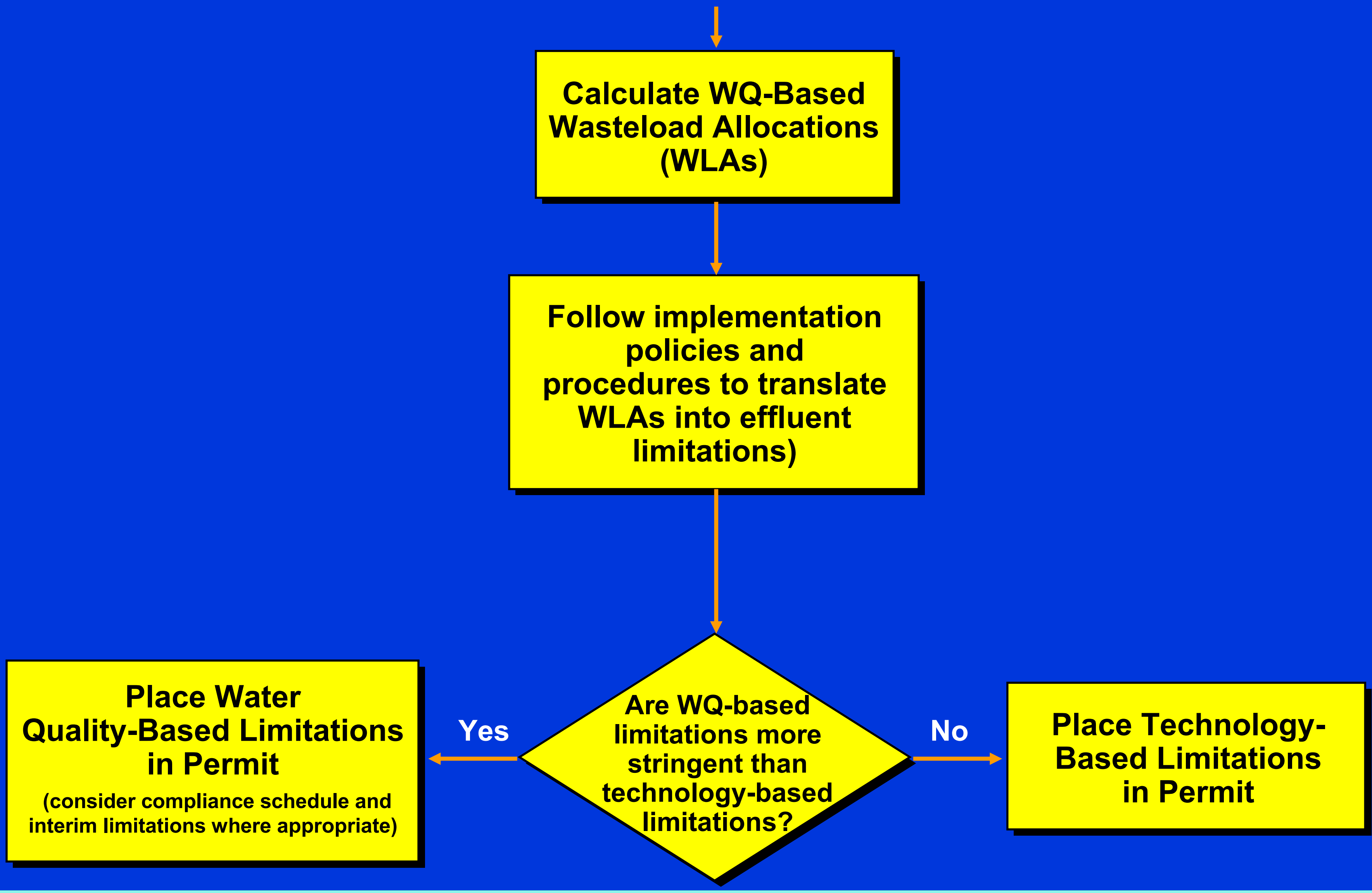
Water Quality-based Effluent Limitations 40 CFR 122.44(d)(1)(i)

- ***When must a permit writer establish effluent limitations using water quality criteria?***
  - **Answer: Limitations must be established in permits to control all pollutants or pollutant parameters that are or may be discharged at a level that will *cause*, have *reasonable potential to cause*, or *contribute* to an excursion above any state water quality standard**

Standards-to-Permits Process



Standards-to-Permits Process
(Continued)



Total Maximum Daily Load (TMDL)

- CWA Section 303(d)(1)
  - Requires States to identify waters that will not achieve water quality standards after implementation of technology-based limitations
  - States rank identified waters based on severity of pollution and uses
  - Requires TMDL for priority waters

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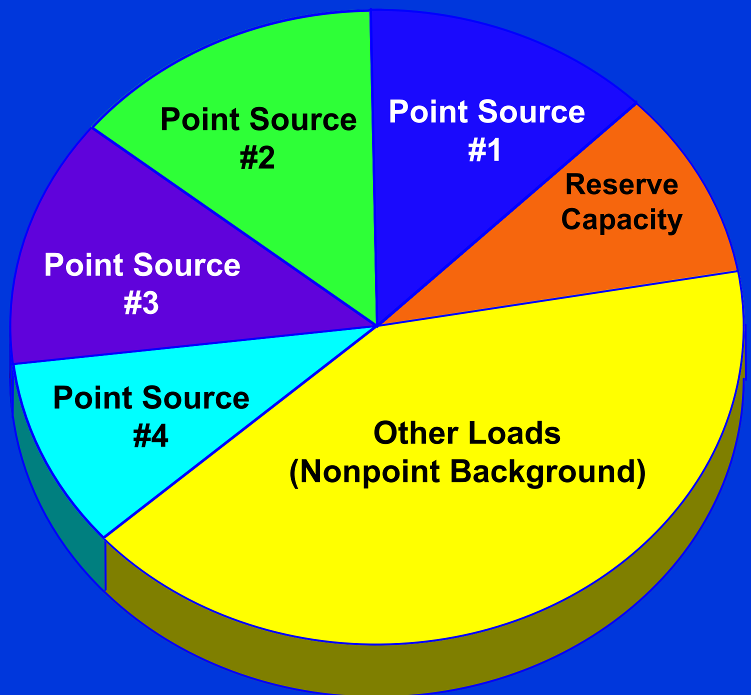
Total Maximum Daily Load (TMDL)
(Continued)

- Defined as the amount of a pollutant that may be discharged into a water body and still meet water quality standards
- Used as a tool for implementing water quality standards

Components of TMDL



- Wasteload allocations (WLAs) are assigned to each point source discharge
- Load allocations (LAs) are assigned to nonpoint sources
- WLAs and LAs are established so that predicted receiving water concentrations do not exceed water quality criteria

Approved TMDLs by Federal Fiscal Year (Through February 2005)

Fiscal Year	Number of TMDLs Approved
1996	143
1997	496
1998	312
1999	449
2000	1515
2001	2178
2002	2904
2003	2688
2004	2667
2005	772

Total Impairments Nationwide = 54,363

http://oaspub.epa.gov/waters/national_rept.control

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TMDLs and NPDES Permits

- If a TMDL has been developed for the waterbody and pollutant of concern:
  - Determine if a WLA has been assigned to the point source being permitted
  - Follow statistical procedures for effluent limitation development
  - Determine whether more stringent requirements are needed based on potential near-field effects

TMDLs and NPDES Permits (continued)

- If a TMDL *has not* been developed for the waterbody and pollutant of concern:
  - Consider whether another waterbody or watershed analysis of the pollutant and multiple sources may be completed
  - In the absence of a waterbody or watershed analysis, conduct a reasonable potential analysis for the individual source

Reasonable Potential Analysis for an Individual Point Source

- Technically defensible analysis to assess potential impact of an individual discharge on the receiving water
- Potential impact on receiving water may be assessed with or without effluent data
- Assessment must consider any technology-based limitations developed for the discharge
- Generally concerned with near-field effects

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Reasonable Potential Analysis Without Effluent Data

- Type of industry or POTW
- History of toxic impacts
- Existing treatment technology
- Species sensitivity
- Available dilution

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Reasonable Potential Analysis with Effluent Data

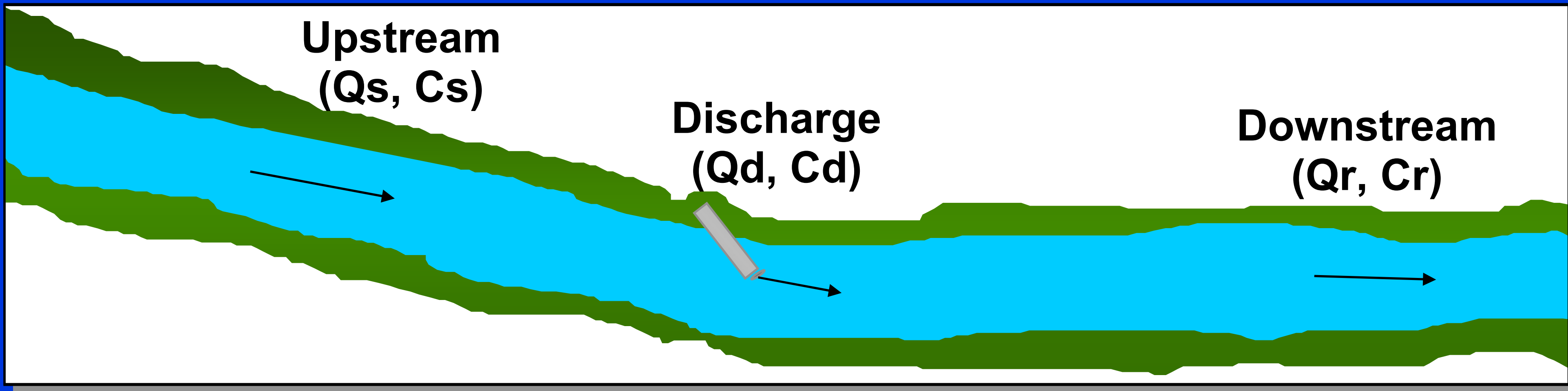
- Model the potential impact of the discharge on the receiving water under foreseeable "critical" conditions
  - Effluent conditions
  - Receiving water conditions
  - Other environmental conditions
- Must consider the "variability" of the pollutant in the effluent [40 CFR 122.44(d)(1)(ii)]

Reasonable Potential Analysis with Effluent Data

Critical Effluent and Receiving Water Conditions → Water Quality Model → Receiving Water Concentration (Cr)

Steady State Complete Mix Assessment

QdCd + QsCs = QrCr



- Determine the pollutant concentration in the waterbody downstream of the discharge:

$$Cr = \frac{QdCd + QsCs}{Qr}$$

- What if Cr > Water Quality Criterion?

Note: Qr = Qs + Qd

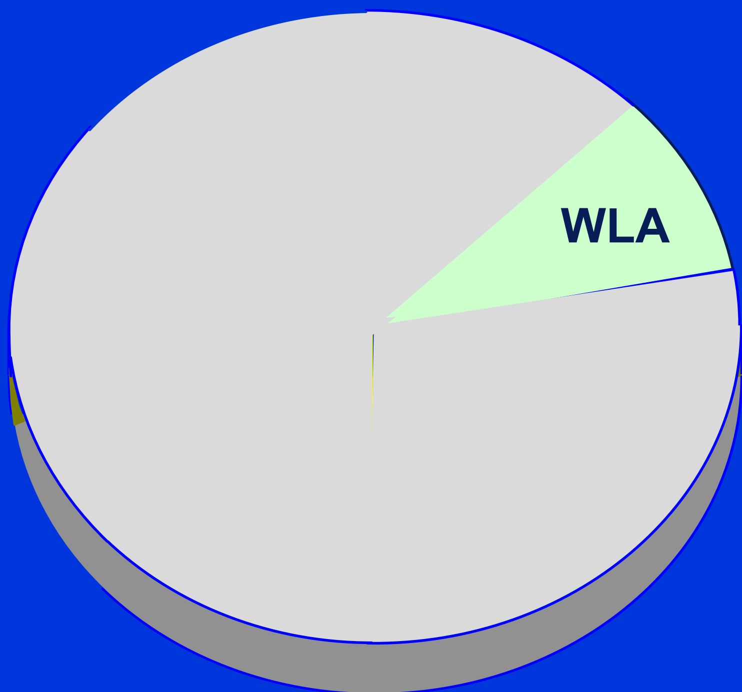
Reasonable Potential Analysis with Effluent Data

- If Cr > State WQ criterion, then <u>must</u> establish a WQ-based limitation.
- If Cr $\leq$ State WQ criterion, then <u>no need</u> to establish a WQ-based limitation.

What if a WQBEL is Needed?

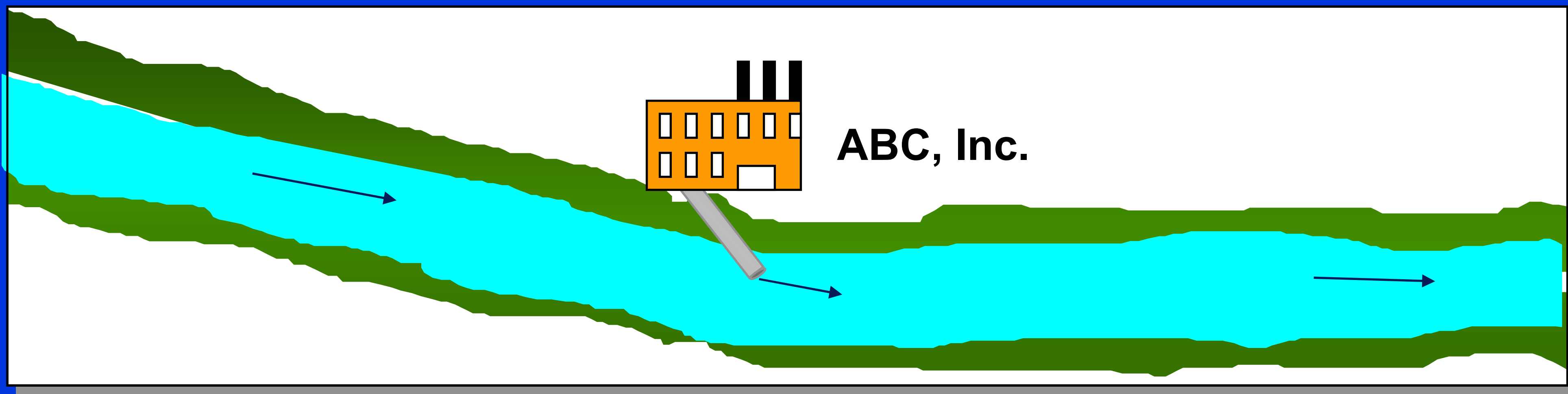
- ***If a water quality-based effluent limitation (WQBEL) is needed, how is it derived?***
  - **Answer: First develop a Wasteload Allocation (WLA), then use statistical procedures to derive effluent limitations (typically maximum daily and average monthly limitations)**

TMDL-Based Wasteload Allocation



WLA = portion of the receiving water's total maximum daily load (TMDL) that is allocated to a specific point source

Facility-Specific Wasteload Allocation

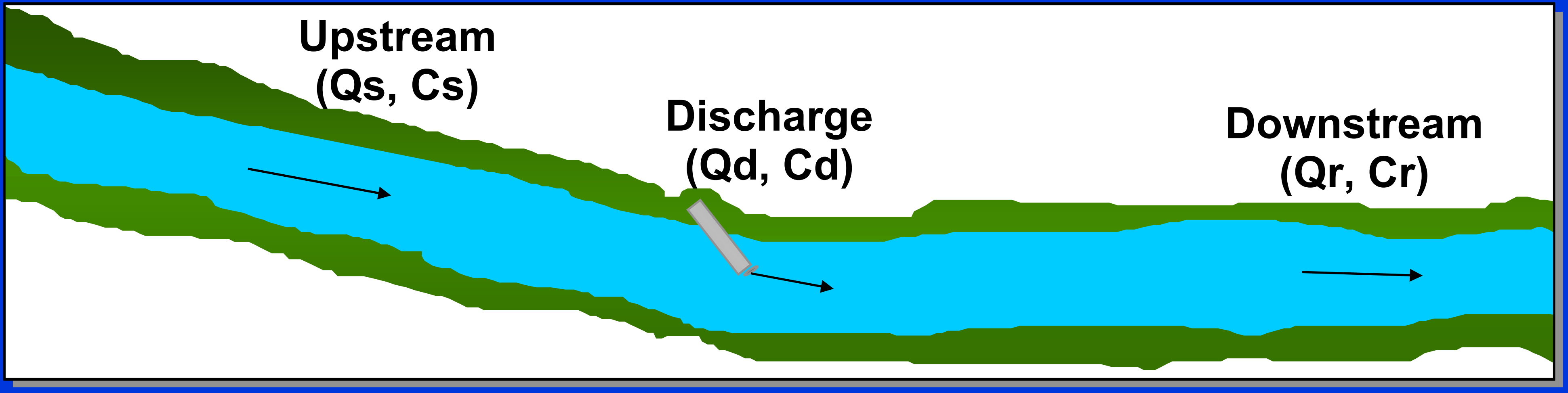


WLA = the maximum allowable pollutant concentration in the effluent from ABC, Inc. that, after accounting for available dilution (following rapid and complete mixing or at the edge of the regulatory mixing zone), will meet an applicable water quality criterion in-stream

Calculating Wasteload Allocations

Critical Conditions and Water Quality Criteria → Water Quality Model → Wasteload Allocation (WLA)

Facility-Specific Wasteload Allocation Using Simple Mass Balance



- Determine wasteload allocation (pollutant concentration in the discharge) that will attain water quality criteria downstream of the discharge:

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

- Cd = wasteload allocation (WLA)

Note: Qr = Qs + Qd

Calculating Effluent Limitations

- Permitting authorities have developed procedures for calculating effluent limitations from WLAs
- Water quality-based effluent limitations for toxic pollutants typically expressed as Average Monthly Limitations (AML) and Maximum Daily Limitations (MDL)
- Other averaging periods used for other parameters where appropriate (e.g., Instantaneous Maximum and Instantaneous Minimum for pH)

Final Check

- Compare:
  - 1) technology-based effluent limitations and
  - 2) water quality-based limitations (based on the most stringent of the TMDL requirements and the requirements of an individual discharge analysis)
- Most stringent limitations for each parameter are new final effluent limitations for that parameter
- Final effluent limitations in the permit must meet antidegradation and antibacksliding requirements

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Antidegradation

- New discharges and expansions of existing discharges generally are required to undergo an antidegradation review
- Antidegradation policies should include implementation procedures for permit writers

Antibacksliding

- Antibacksliding requirements may prohibit less stringent limitations than those in the previous permit
- Permit writers must complete antibacksliding analysis where necessary