Turbidity, Temperature, Toxics

Aspects of the Science for the Non-Scientist

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Topics Covered

- Turbidity
- Temperature
- Reasonable potential analysis for toxics

Approach

- What they are.
- How they are determined.
- Why they are part of regulatory environment.
- Focus is on the biological/ecological context.

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Natural Ecosystems

- Ecosystems are dynamic.
- Rate of change highly variable.
- There is no *proof* for or against data.
- Data quality critical for use in regulatory context.

Turbidity: What It Is

Definition

Turbidity is the physical property of reduced light transmission through water due to absorbence and scattering by solid particles in suspension.

Very fine dissolved solid particles can also contribute to turbidity.

Occurrence

- More in flowing waters than standing waters.
- Naturally present, even in very high amounts.
- Suspended/transported particles settle on bottom when flow velocity decreases.
- Distribution on bottom indicative of average flows.
- Most Oregon streams/rivers clear during low flow periods.

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- Dams and natural lakes slow water, let suspended solids settle on bottom.
- Water more clear down river from impoundments.
- Plankton cause turbidity when flow is low and temperature is high.
- Depth of light penetration less in flowing waters than in still waters.
- Depth of light penetration dependent upon wavelength.

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Occurrence

- Light penetration depends on
  - Surface stillness
  - Angle of incidence
  - Latitude/time of day
  - Riparian vegetation
- Summary: Aquatic biota have evolved adaptations to the natural turbidity in which they live.

Application

- Anthropogenic turbidity can exceed natural levels, timing, locations.
- Laws and regulations based on most sensitive organisms/life stages.
- Given natural occurrence factors, former standard was too high.

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Regulatory Framework

- Attention must be paid to sampling locations and methods.
- Highly site-specific.
- *Draft Implementation Guidelines for Turbidity* OAR 630-041:

"For all sources that have a reasonable potential to cause or contribute to an exceedance of the turbidity criteria, effluent limits must be calculated to meet the applicable turbidity criteria at the edge of the permitted mixing zone. . . . Effluent limits are calculated as an increase above background turbidity using stream background turbidity and dilution data."

Compliance With Criteria

- Many factors affect turbidity and effects on beneficial uses.
- Site-specificity dominates.
- Where/how to collect data critical factor.
- Establish baseline conditions:
  - *Reasonable Potential Analysis* based on Best Professional Judgment.
  - Representative monitoring data or default value.

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Data Collection/Analysis

- No scientific basis for preferring established monitoring sites over project-specific sites.
- Regulations require data from both ambient site and immediately upriver from outfall.
- Time series analysis with seasonal detrending:
  - Requires regular sampling intervals.
  - Provides insight on change over time without seasonal distortions.

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Turbidity Summary

- Natural phenomenon.
- Streams/rivers inherently more turbid than are ponds, lakes, reservoirs
- Temporal and spatial variation very large.
- Affect on light penetration less in flowing waters than standing waters.
- Aquatic biota well adapted to turbidity levels and variability.
- Anthropogenic influences highly dependent on proper collection and analyses.

Temperature: Background

- Stream/river temperatures vary more rapidly than standing water temperatures.
- Range of temperature variation less in flowing waters (lake shallows excepted).
- Summer diel temperature range in small streams as high as $6°C/10.8°F$.
- Maxima occur in late afternoon, minima in early morning.
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Variation Within Basin

- Rivers far from their source have water temperature closely tracking air temperature.
- In winter, ice and snow can form insulating cover so only surface freezes and below it is warmer.
- Therefore, annual range of water temperatures usually less than that of the surrounding landscape.

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Exceptions To Annual Cycle

- Snowmelt runoff in spring keeps water at lower temperature than air.
- Sunshine after heavy rain may raise water temperature because of warm ground.
- Spring-fed streams cooler in summer, warmer in winter than runoff-fed streams.
- Dams and other impoundments alter temperature regimes:
  - Surface standing waters warmer than free-flowing reaches.
  - Bottom dam releases much colder than free-flowing reaches.

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Local Conditions

- Ground water inflow can cool stream reach.
- Aspect (direction of valley) affects temperatures of streams with moderate–high gradients.
- Increased temperature lowers water's viscosity . . .
  - Silt sinks twice as fast at $23^\circ C/73.4^\circ F$ than at $0^\circ C/32^\circ F$.
    - Less turbidity due to small silts in warmer water.
- Warm water flows slightly faster than does cooler water.

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Regulatory Concerns: Biota

- Too much has been written to cover now.
- All aquatic biota affected: distributions, life histories, behaviors.
- Very important relationship between water temperature and dissolved oxygen:
  - The warmer the water, the less oxygen dissolved in it.
- Fish parasitism also increases in warmer waters.
- Humans also affected; warmer waters support pathogenic organisms.

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Measurements

- Most important considerations:
  - Where and how to collect data.
  - How to analyze data and convert it to information.
  - How to interpret information to create knowledge and insight.

Measuring Water Temperatures

- Where along the length of the stream or river?
- Where along the width of the stream or river?
- Where in the water column?
- *Every* situation is different; there is no cookbook solution.

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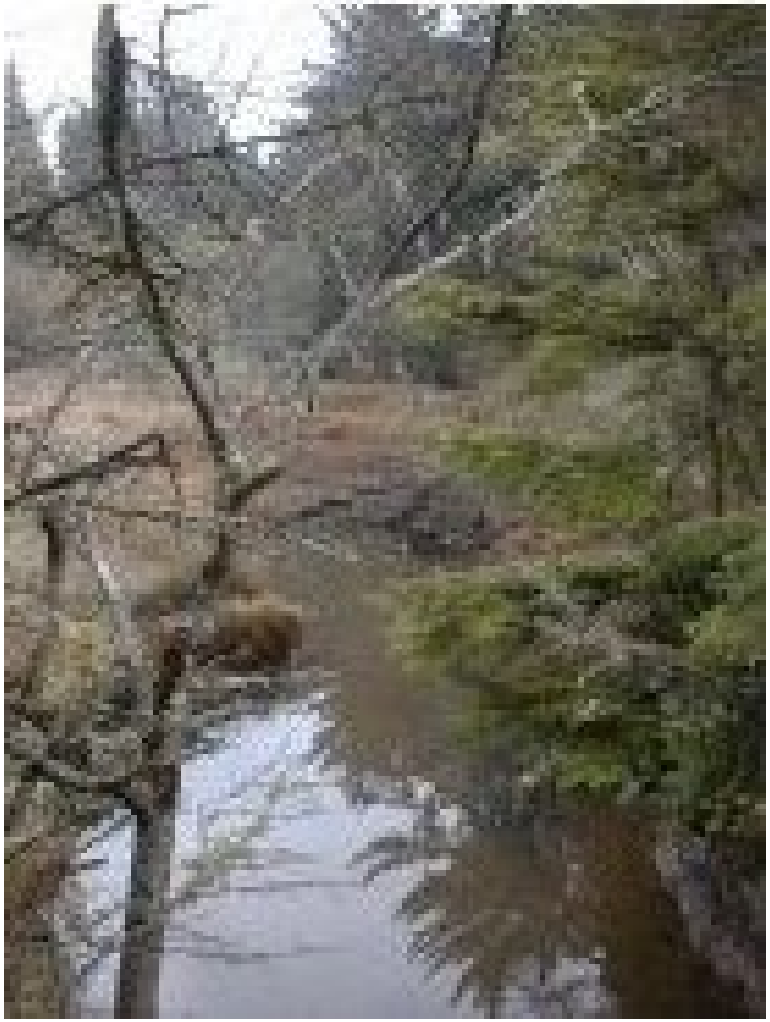
Small Streams



If stream is small, wadeable, uniform in width and depth, straight, then a single measurement at 0.6 depth in the center can be a valid, single-point characterization of water temperature at the time it is taken.

Large Rivers

When the river is too large or fast to wade, there is no single answer to the question of where to measure temperatures. Why the measurements are needed guide the decisions.

Numeric Criteria

- DEQ has established numeric criteria for the most sensitive cold water fish species (OAR 340-041-0028).
- No time to address their validity and appropriateness.

Anthropogenic Increases

- Based on 7-day moving average of *daily maximum* water temperature.
- Limit is $0.3^{\circ}C / 0.5^{\circ}F$ above ambient temperature based on discharged water:
  - Mixing with 25 percent of the stream flow.
  - Or at boundary of temperature mixing zone.

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Affect On Fish

What does this small increase in a 7-day average of maximum daily temperatures mean to a fish?

- **Bull trout:** The $0.3^{\circ}C$ increase over the maximum of $12^{\circ}C$ is a change of 2.5%.
- **Other salmon and trout:** The $0.3^{\circ}C$ increase over the maximum of $20^{\circ}C$ is a change of 1.5%.
- Larger increase on more temperature sensitive species?
- Stream temperatures can vary as much as $6^{\circ}C$ each day. So limit can well be meaningless.

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In Practice

- Most thermometers (analog or digital) are accurate to $\pm 0.5^{\circ} C$; the best data logger is accurate within $\pm 0.2^{\circ} C$. That is 50% of the allowed increase for each reading.
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Temperature Summary

- Regardless of moving 7-day average of maximum daily temperatures by species and life history stage, the allowed anthropogenic increase is biologically and ecologically insignificant.
- Diel variations in water temperature at any specific location may very well exceed the allowed anthropogenic increase.
- Compliance depends upon the most accurate and precise measuring instruments available; those may not be the ones used.
- The precise location of temperature measurements, and certainty that the reading is of that specific location, is critical.

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Temperature Summary

- The scientific support for the temperature criterion is not technically sound.

RPA: Introduction

Reasonable potential analysis for toxic pollutants is an administrative process, not a technical standard or criterion such as those for turbidity and temperature.

Five stages in the analysis:

1. Application completeness review.
2. Antidegradation review.
3. Site-specific receiving water characterization.
4. Effluent characterization.
5. Effluent limit calculations for pollutants with reasonable potential to exceed water quality standards.

Antidegradation Policy Review

- The antidegradation review is core of the analysis.
- This review establishes whether there is a reasonable potential for a discharged toxic pollutant to exceed threshold value.

Decision Points

- *Best professional judgment*; i.e., a subjective decision. But, it should be objective decision based on:
  - Receiving water characteristics.
  - Effluent discharge characteristics.

Receiving Water Characterization

- The quantity and quality of data can benefit from qualified technical input.
- Where, when, and how data are collected and analyzed are important factors.
- Determination of channel characteristics, riparian zone, and land uses affect hydraulics, sediment transport, water quality, and aquatic fauna types and distributions.

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Effluent Characterization

- This must have been done during the antidegradation review.
- Both chemical type (e.g., As-III vs. As-V) and concentrations determined over sufficiently long time.
- Qualified technical assistance can produce maximum information per dollar spent.

Limit Calculations

- Negotiable between the permittee and DEQ.
- Technology may limit what can actually be removed from the waste stream.
- So many variables involved that flexibility is scientifically justified.

RPA Summary

- An administrative process.
- May be highly subjective: *Best Professional Judgment*
- Antidegradation review should include receiving water and effluent characteristics to assess effects on thresholds. This is heart of analysis.
- So many details to be considered that qualified external inputs can expedite the process and help produce results that are more technically sound, legally defensible, timely, and cost effective.

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Overall Summary

- These water quality concerns require attention to:
  - What is measured.
  - How measurements are taken.
  - How data are analyzed and interpreted.

- Not an easy or casual process; careful attention needed so results are technically sound and legally defensible.

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