Monitoring Implications of Using the Copper Biotic Ligand Model (BLM) and EPA's Update of Ambient Water Quality Criteria for Copper

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Acknowledgments

Development of EPA's Update to the Copper Criteria

- EPA OW OST/HECD: Charles Delos, Luis Cruz
- EPA ORD: Cindy Roberts

Development of the Biotic Ligand Model (BLM)

- HydroQual, Inc.: Robert Santore, Paul Paquin

Copper BLM Implementation Working Group

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- EPA Region 6: Melinda Nickason
- EPA Region 8: Dave Moon

State Collaborators

- Colorado, Massachusetts, New Jersey, South Carolina, Virginia, West Virginia, Wisconsin, and more to come …

Presentation Overview

- Background: Water Quality Criteria
- Biotic Ligand Model (BLM)
- Comparison of 1986 and Updated Copper Criteria
- Copper BLM Implementation Project
- Monitoring Implications
- Summary, Conclusions, and Next Steps

Background: Water Quality Criteria

- National Criteria Recommendations: Scientifically defensible guidance developed and published by EPA per Clean Water Act Section 304(a)

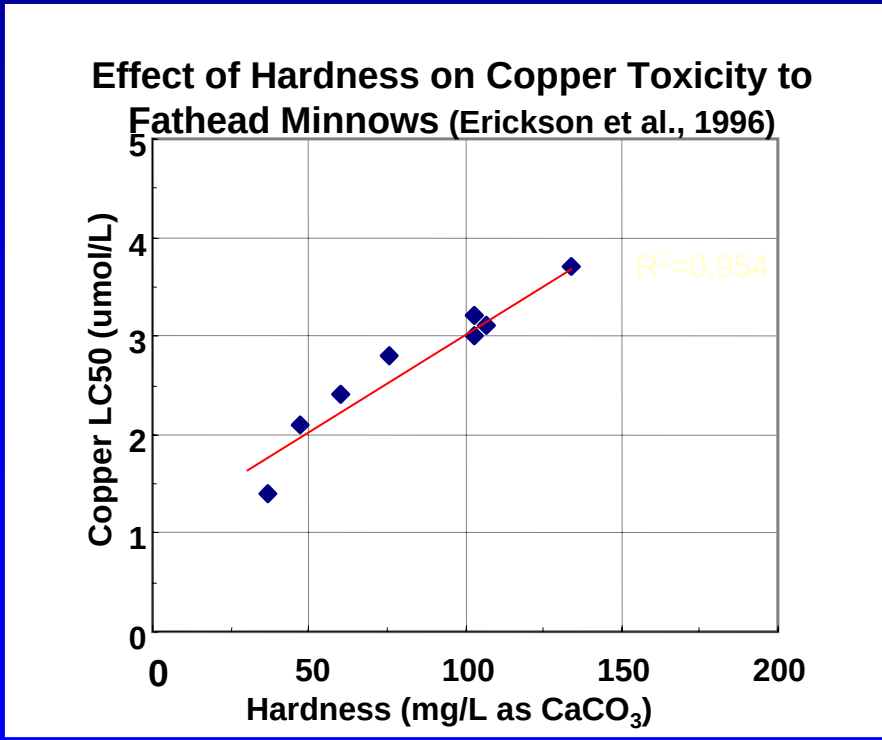
- Criteria: Adopted part of State/Tribal Water Quality Standards under Clean Water Act Section 303(c)

Why Update the AL Copper Criteria?

- There are currently 629 rivers and streams listed as impaired for copper and 5 for contaminated sediments due to copper
- The existing aquatic life criteria for copper are underprotective for some waters and overprotective for others
- The current criteria relies on expensive Water Effects Ratio (WER) testing to develop site specific criteria. A study showed using the Biotic Ligand Model will cost on average 15% of the cost of WER testing
- The updated criteria utilizes the best available science, including the scientifically established relationships between copper toxicity and water chemistry parameters

Background: 1986 Aquatic Life (AL) Copper Criteria

- 1986 Copper Criteria are a function of hardness
  - Acute Copper Criteria: $e^{(0.8545[\ln(\text{hardness})]-1.465)}$
  - Chronic Copper Criteria: $e^{(0.9422[\ln(\text{hardness})]-1.464)}$



Limitations of 1986 AL Copper Criteria

- Potentially under-protective at low pH
- Over-protective at higher dissolved organic carbon (DOC)
- The same copper concentration exerts different degrees of toxicity from time to time and from place to place
- Criteria do not typically reflect the effects of other water chemistry factors that are also known to affect metal toxicity
- Requires site-specific water quality criteria adjustments using Water Effect Ratio (WER) procedure

Update to National Copper Criteria

Draft Update Released December 2003

- Uses the Biotic Ligand Model (BLM) to calculate freshwater criteria on a site-specific basis
- BLM model used as a replacement for the hardness equation
- Predicts acute freshwater water quality criteria using an approach similar to that of predicting organism toxicity; chronic criteria derived from acute using acute to chronic ratio

Final Update Release Expected Nov/Dec 2006

Biotic Ligand Model

The Biotic Ligand Model (BLM) is a bioavailability model that uses receiving water body characteristics and monitoring data to develop site-specific water quality criteria.

Biotic: of or relating to living organisms

Ligand: any molecule that binds to another

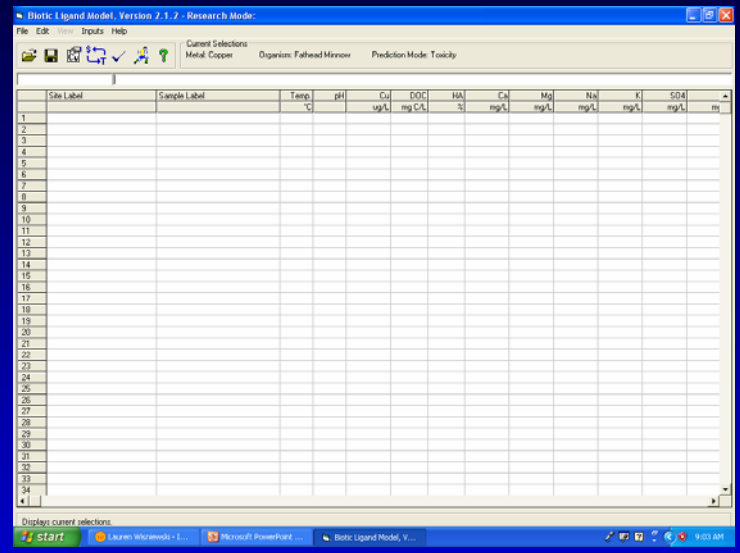
Model Background and Development

- Free Ion Model (1980s): Chemical model
- Gill Model (1996):Toxicological model
- Refinement and incorporation into criterion (2000-2004)

BLM Model Inputs and Outputs

BLM Input Data

- Temperature
- pH
- Dissolved Organic Carbon (DOC)
- Major Cations (Ca, Mg, Na, & K)
- Major Anions (SO_4 & Cl)
- Alkalinity



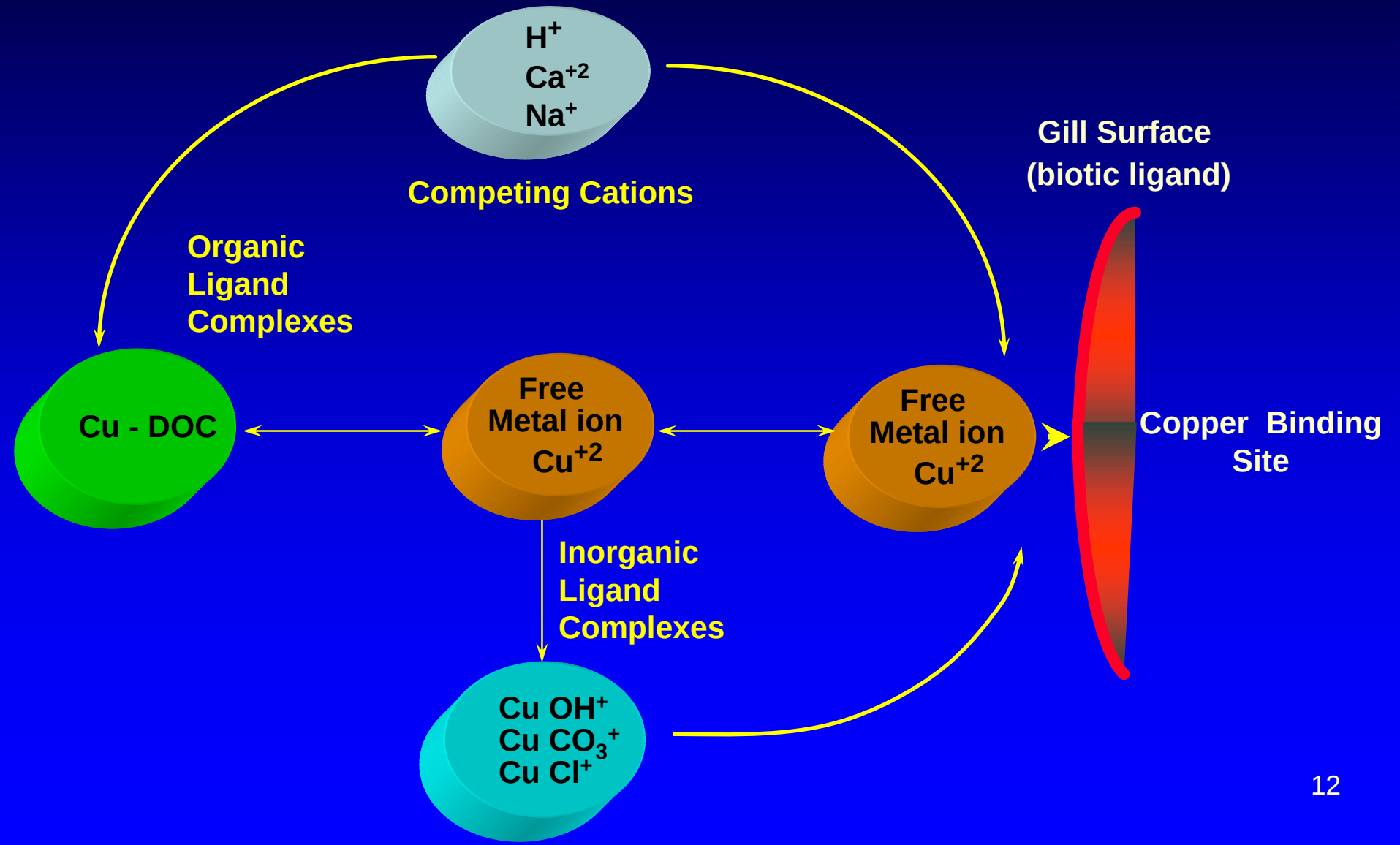
BLM Output Data

- Site-Specific Copper Criteria
- Copper Speciation

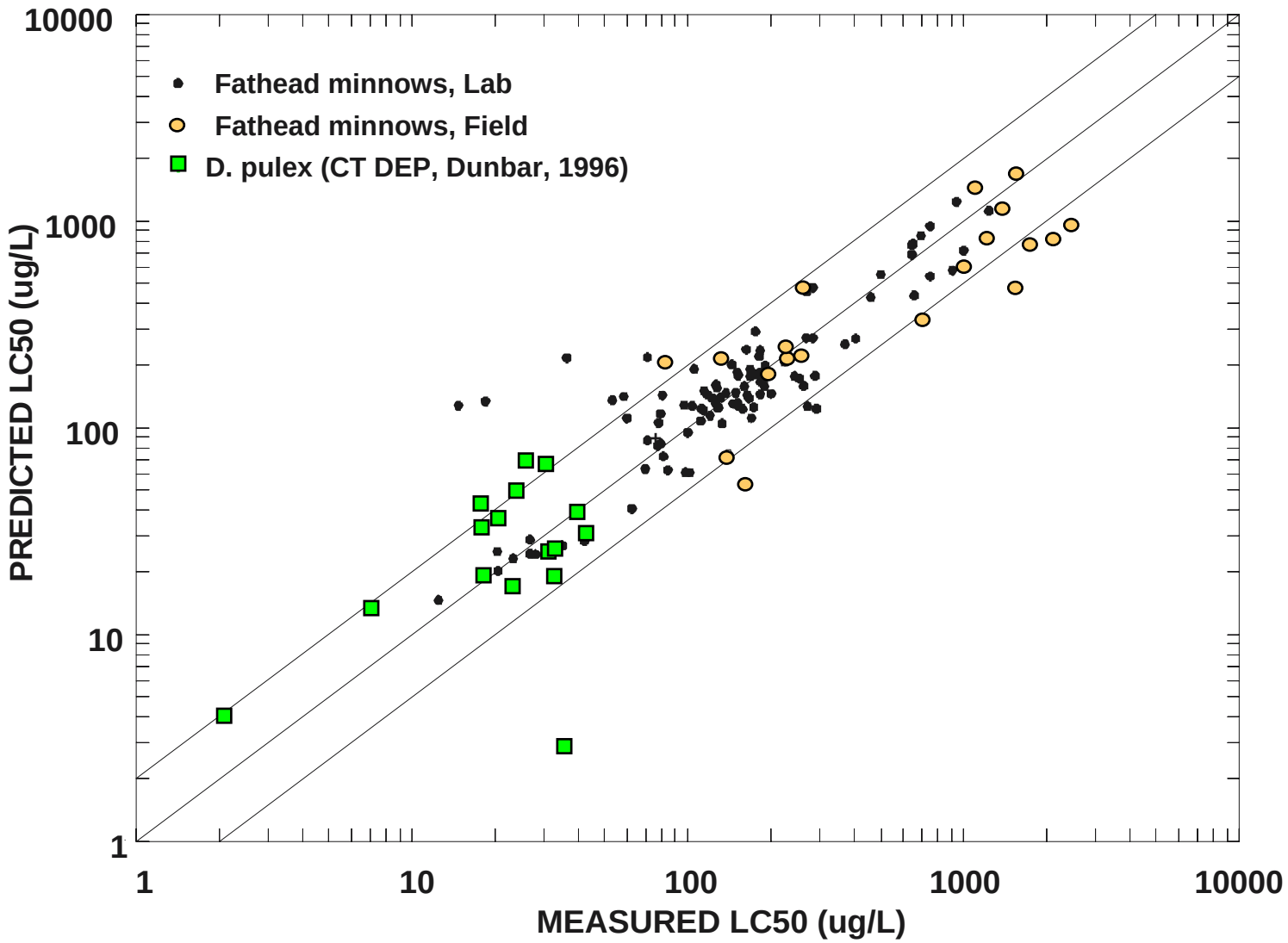
Example of BLM Input Parameter Measurements

- pH 7.8
- DOC 5.0 mg/L
- Ca 11.8 mg/L
- Mg 5.0 mg/L
- Na 1.5 mg/L
- K 0.6 mg/L
- SO_4 3.4 mg/L
- Cl 1.2 mg/L
- Alkalinity 43 mg/L
- Hardness 50 mg/L

Copper BLM Framework



Copper BLM Output vs. Measured Toxicity



Comparison of Criteria Approaches

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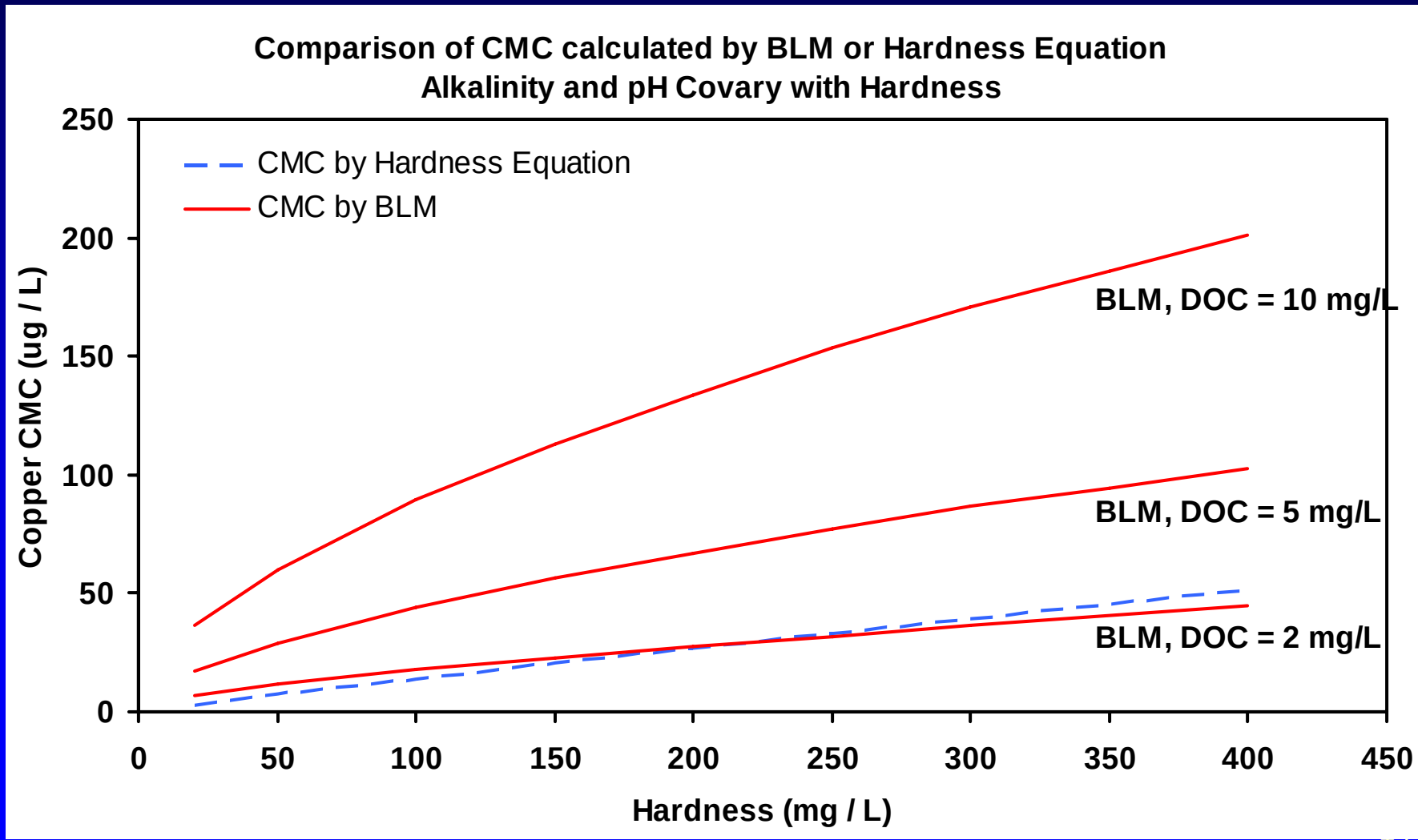

1986 WER-adjusted vs. BLM-derived Criteria

- 1986 Criteria with Water Effects Ratio (WER) Adjustment is comprehensive in scope, but sampling error is high and precision is low
- BLM is limited in model formulation, but sampling error low
- Comparison WER-adjusted and BLM-derived site-specific copper criteria in Colorado and Massachusetts showed the two methodologies resulted in similar values

Advantages and Disadvantage of using the BLM to derive Copper Criteria

Advantages

- BLM-derived criteria utilizes the best available science and will likely result in more appropriate site-specific criteria
- Improves our understanding of how water chemistry affects metal availability and toxicity
- Water chemistry data are cheaper to obtain than site-specific toxicology data
- BLM can be combined with streamlined WER testing

Disadvantages

- The BLM requires more monitoring data and 1-2 days of training and practice before using

Copper BLM Implementation Project

This workgroup-based project that involves EPA Regions and States to meet these goals:

- Implementation Information
  - "Frequently Asked Questions" (FAQs) Document to be released with final update in Nov/Doc 2006
  - Topics: Background on the BLM, Model Applicability, Minimum data requirements for model input, options for state to implement, permitting issues, monitoring and assessment issues
- BLM Training Resources
  - On-site hands-on training, web-based training
- Communications and Stakeholder Outreach
  - State Outreach, Conference Presentations, Fact Sheets, etc.

Implementation Information: FAQs

Office of Science and Technology

DRAFT May 5, 2006

Copper Biotic Ligand Model (BLM) Criteria Implementation Frequently Asked Questions (FAQs) Outline

0.0 Introduction

1.0 Background
- 1.1 What are the new national copper criteria and how are they different than the previous copper criteria?
- 1.2 What is the BLM? Where can I obtain a copy?
- 1.3 What water quality parameters (model inputs) are used in the BLM?
- 1.4 Of these, which are the most critical?

2.0 Model Applicability
- 2.1 Under what conditions can the BLM be used?
- 2.2 Are there any conditions for which the BLM should not be used?
- 2.3 Will new versions of the BLM be released in the future? How will this affect the copper criteria?
- 2.4 Do I have to use the BLM, or can I continue to use the hardness-based criteria?
- 2.5 How does the BLM compare to the WER, particularly in terms of cost?

3.0 Data Requirements
- 3.1 What are the preferred analytical methods to measure the water quality input parameters? How much does it typically cost to measure the 12 water chemistry parameters used in the BLM?
- 3.2 How many observations are adequate to use the BLM?
- 3.3 Should seasonal variability in the parameters be taken into account? If so, how?
- 3.4 How much uncertainty results from various sized data sets for developing a site-specific value for the copper criteria?
  - 3.4.1 Related issues: inter and intra-waterbody variability of individual parameters (distributions of values) and co-variances between different parameters
- 3.5 If there are no data for some parameters, are there default values or estimations that can be used?
  - 3.5.1 Do these defaults need to be defined by eco-region, water body type, and/or other some other factor(s)?
  - 3.5.2 Develop one or more case studies to illustrate

4.0 Implementation Options
- 4.1 How can the output from the BLM be used to select copper criteria (e.g., Monte Carlo simulation, analytical procedure)?
- 4.2 What are the options for states to adopt and implement the national criteria statement?

Handout for the 5th National Monitoring Conference in San Jose, CA, May 7-11, 2006
Concurrent Session I, Evaluating Key Stressors to the Nation's Aquatic Resources

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5.0 Permitting and Monitoring Issues
- 5.1 How do you calculate a permit in terms of total recoverable copper from the dissolved copper criteria value calculated by the BLM?
- 5.2 With regards to permits, will EPA allow variable permit limits, based on the value of the input parameters (e.g., pH, DOC) on any given day?
- 5.3 How do you assess ambient water quality standards monitoring data?
- 5.4 What does the BLM mean for state water quality monitoring efforts? How should my state direct future monitoring efforts? Will we have to conduct different/more expensive monitoring than we do now?

6.0 Training Opportunities
- 6.1 What types of training tools will be available to me?
- 6.2 Will training opportunities be updated to reflect changes to the BLM?

7.0 Questions and Follow-up
- 7.1 Is there a mechanism in place for states to provide feedback on their use of the BLM?
- 7.2 Who may I contact with questions regarding the BLM?

8.0 Legal Issues
- 8.1 If use of the BLM results in different criteria values than what my state currently has, will I need to do a UAA?

For more information, please contact:

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Monitoring Questions

- How will the BLM affect state water quality monitoring programs?
- How could states refine future monitoring efforts to use the BLM?
- How much does it cost to measure the BLM parameters?
  - *approximately $150-$200 for all 10 parameters*
- When and how will the updated copper criteria be implemented?
  - *Some states have already started using a phased approach (CO)*
- Will there be regional defaults or regression equations to fill in data gaps?
- How many data sets are enough to develop site-specific criteria?
- What will be the impact on ambient assessments?
- Can the criteria be developed on a site-specific, seasonal basis?

Environmental Benefits of using the BLM

- Increased precision of the BLM (compared to the hardness-based criteria) will lead to increased efficiency
- BLM-based criteria can be as much as 10 times less stringent than hardness-based criteria in waters with high DOC and neutral pH (which are typical of many water bodies)
- The cost savings of using the BLM instead of WER testing will be considerable for wastewater treatment plants
- Increased monitoring costs will pay greater dividends for environmental protection programs

Summary and Conclusions

- The BLM uses the best available science to develop site-specific criteria that are neither overprotective nor underprotective
- The BLM simulates the interactions between chemical parameters (e.g., pH, DOC) and copper toxicity
- The BLM can be used to calculate site specific copper criteria that agrees remarkably well with bioassay-based WER studies
- BLM may eliminate the need for WER testing

Next Steps

Biotic Ligand Model

- Saltwater BLM is under development
- EPA plans to update the zinc and silver aquatic life criteria using the BLM

Stakeholder Outreach

- EPA is open to hearing the ideas, concerns, and questions of States and other stakeholders.
- States are invited to participate in the next Copper BLM Implementation Working Group Call:

  Thursday May 18th, 1-2 PM ET

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