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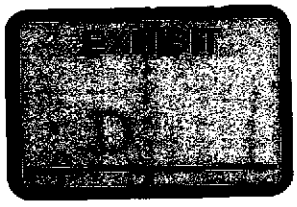
Streamlined Water-Effect Ratio Procedure for Discharges of Copper



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Water-Effect Ratio Procedure
for Discharges of Copper

March 2001

U.S. Environmental Protection Agency
Office of Water
Office of Science and Technology
Washington, D.C.

Notices

This document provides guidance to states and tribes authorized to establish and implement water quality standards under the Clean Water Act (CWA), to protect aquatic life from acute and chronic effects of copper. Under the CWA, states and tribes are to establish water quality criteria to protect designated uses. The CWA and EPA regulations at 40 CFR Part 131 contain legally binding requirements. The statutory provisions and EPA regulations described in this document contain legally binding requirements. This document does not substitute for the CWA or EPA's regulations; nor is it a regulation itself. Thus, it does not impose legally binding requirements on EPA, states, tribes, or the regulated community, and may not apply to a particular situation based upon the circumstances. State and tribal decision makers retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance when appropriate. Therefore, interested parties are free to raise questions and objections about the substance of this guidance and the appropriateness of the application of this guidance to a particular situation. EPA will, and States should, consider whether or not the recommendations or interpretations in the guidance are appropriate in that situation. While this guidance constitutes EPA's scientific recommendations on procedures for obtaining site-specific values for aquatic life criteria for copper, EPA may change this guidance in the future.

This document has been approved for publication by the Office of Science and Technology, Office of Water, U.S. Environmental Protection Agency. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Acknowledgment

This document was prepared by Charles Delos, Health and Ecological Criteria Division, Office of Science and Technology. Appendix A was adapted and modified from the 1994 document *Interim Guidance on the Determination and Use of Water-Effect Ratios for Metals*, which had been prepared by Charles Stephan and others. Appendix B is based primarily on a literature review by Gary Chapman of the Great Lakes Environmental Center.

Peer review of this document was performed by Paul Jiapizian of the Maryland Department of Environment, William Dimond of the Michigan Department of Environmental Quality, and Cindy Roberts of U.S. EPA. This is documented in *Response to Peer Review Comments on Streamlined Water-Effect Ratio for Discharges of Copper*, available in portable document format (pdf) from the contact below.

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Contents

Introduction

This guidance presents a Streamlined Procedure for determining site-specific values for a Water-Effect Ratio (WER), a criteria adjustment factor accounting for the effect of site-specific water characteristics on pollutant bioavailability and toxicity to aquatic life. This guidance is intended to complement the 1994 *Interim Guidance on Determination and Use of Water-Effect Ratios for Metals* (EPA-823-B-94-001).

Whereas the 1994 Interim Procedure applies to essentially all situations for most metals, the Streamlined Procedure is recommended only for situations where copper concentrations are elevated primarily by continuous point source effluents. Because this is a relatively common regulatory situation, a great deal of experience is available to guide the development of a more efficient procedure.

The Streamlined Procedure does not supersede the 1994 Interim Procedure, even for the limited situations to which it applies. Rather, it provides an alternative approach. In these situations the entity conducting the study may choose between using the Interim Procedure or using the Streamlined Procedure.

Synopsis of the Streamlined Procedure

The Streamlined Procedure involves the sampling of two events, spaced at least one month apart. Flow during each event should be stable, and water quality unaffected by recent rainfall runoff events. Samples of effluent and upstream water are to be taken. These are mixed at the design low-flow dilution, to create a simulated downstream sample, to be used as the site-water sample in toxicity tests spiked with various concentrations of soluble copper salts.

In manner similar to the Interim Procedure, the side-by-side, laboratory-water and site-water toxicity tests are run to obtain the 48-hour acute EC50 with either *Ceriodaphnia dubia* or *Daphnia magna*. The result may be expressed as either dissolved or total recoverable copper. After adjusting for any hardness differences, the WER for the sample is the lesser of (a) the site-water EC50 divided by the laboratory-water EC50, or (b) the site-water EC50 divided by the documented Species Mean Acute Value (the mean EC50 from a large number of published toxicity tests with laboratory water). The geometric mean of the two (or more) sampling event WERs is the site WER.

The design of the Streamlined Procedure is intended as a more efficient approach for generating the information needed to make a pollution control decision. The intent is to provide a method that is both easier for the performing organization to carry out, and easier for the regulatory agency to review. The Streamlined Procedure omits laboratory or field measurements that experience with the Interim Procedure has shown to be of little practical value. The design is also intended to be inherently less subject to random sampling variability, thereby allowing a reduction in the number of samples while maintaining reliability.

Table 1 compares the provisions of the Streamlined Procedure with those of the 1994 Interim Procedure.

Table 1. Comparison of Streamlined Procedure and 1994 Interim Procedure

Characteristic	1994 Interim Procedure	Streamlined Procedure
Applicability	Universal	Copper from continuous discharges
Minimum number of sampling events	3	2 with recommended restrictions
Minimum number of WER measurements	4	2
Minimum number of WER measurements considered in obtaining final site WER	3	2
Preparation of constructed downstream water	Mix effluent and upstream samples at the dilution ratio occurring at the time of sampling	Mix effluent and upstream samples at the design low-flow dilution ratio
Calculation of sample WER	Site water LC ÷ Lab water LC	Site water LC ÷ The greater of (a) Lab water LC, or (b) SMAV
Calculation of final site WER	Complicated scheme with six "if...then...else" clauses and 12 possible paths	Geometric mean of the two measurements

Discussion of Technical Approach

The key facets of the procedure are presented below, with an explanation of their purpose. The detailed protocol for collecting samples, obtaining measurements, and conducting tests is presented in Appendix A. An analysis, through Monte Carlo simulation, of the protectiveness of the approach is presented in Appendix C.

1. *Purpose of procedure.* The procedure is for deriving a dissolved and/or total recoverable WER for copper from continuous point source effluents. The results may be used to obtain:
   a. A dissolved WER used to obtain the site-specific value of a dissolved copper criterion.
   b. A total recoverable WER used to obtain either (i) the site-specific value for a total recoverable criterion, or (ii) a total recoverable effluent limit from a dissolved criterion, merging the functions of a dissolved WER and a dissolved-to-total permit translator factor.

Appendix C

Assessment of the Streamlined Water-Effect Ratio Procedure

Abstract

The protectiveness of the Streamlined Procedure for obtaining a copper water-effect ratio (WER) for streams affected by point source discharges has been assessed using Monte Carlo probabilistic modeling.

The Streamlined Procedure uses two WER samples to set the site WER. The probabilistic modeling considered that the two WER samples were collected from a situation where the flow, toxicant concentration, and WER vary over time.

This analysis evaluated the suitability of calculating each site's WER as the geometric mean of the two WER measurements for the site, when the effluent and upstream samples are mixed at the design low-flow dilution. Comparison was made against the predicted unbiased value for the WER: that is, the value that the WER would have if the site-specific criterion were to have the same level of protection as intended for the national criterion.

Overall the results of this work indicated that the Streamlined Procedure tends to yield a site WER slightly more restrictive than the unbiased site WER. In 50 percent of the Monte Carlo trials, the calculated WER was less than 0.84 times the unbiased site WER. Within the range of conditions investigated, the design downstream dilution had no significant effect on the level of protection provided.

In addition, in the Supplement to this Appendix, an estimate was made of the effect, relative to the 1994 Interim Procedure, of having the Streamlined Procedure restrict the lab water EC50 to a value not less than the EPA SMAV. Sixteen lab water EC50s from three WER studies were evaluated. By including the difference in the way the two procedures set the lab water EC50, the Streamlined Procedure and the Interim Procedure could be appropriately compared through the Monte Carlo simulation. Results indicated that the two procedures yielded similar results.

Introduction

The purpose of this assessment is to determine, through modeling, whether the Streamlined Procedure provides the degree of protection intended for aquatic life criteria. The Supplement to this Appendix also deals with the following issues: (a) the purpose of streamlining the copper WER procedure, (b) the reason for preparing samples by mixing at design dilution, (c) the need for the simultaneous laboratory water test, (d) the potential for reducing the number of samples, and (e) a comparison with the 1994 Interim Procedure.

Assessment Strategy

The water-effect ratio (WER) reflects the effect that local site water constituents have on increasing or reducing the pollutant bioavailability and toxicity. The

Results

The results were used to address the question: How much protection is provided if the site WER is set equal to the geometric mean of two sample WERs?

The WER established as such a geometric mean will be here termed the *procedure WER*. Table C-2 shows the ratio of the procedure WER to the unbiased WER for the typical or 50th percentile situation and worst case 95th percentile situation among the 999 final WERs obtained from the Monte Carlo analysis of each of the three dilution scenarios.

The level of protection provided by the Streamlined Procedure does not vary significantly among the dilution scenarios, relative to other uncertainties and random influences. Irrespective of design IWC, the Table C-2 Monte Carlo results indicate that the substantial majority of cases, a streamlined Procedure WER will be below the site's unbiased WER. The probability of obtaining a procedure WER greater than the site's unbiased WER averaged 29% among sites.

Data from Dunbar (1997a, 1997b, 1997c) indicate that over time, the measured WERs at a site are less variable than assumed in this Monte Carlo analysis. Consequently, these results probably represent a conservative worst case portrayal of the performance of the Streamlined Procedure for the type of scenarios considered.

The possibility that a site could be assigned a criterion concentration somewhat greater than ideal is an inherent risk associated with both national and site-specific criteria. If most dischargers are to be assigned a WER not too far below what they deserve, the luck of the draw during sample collection will yield some site WERs somewhat higher. However, for the criterion in question, there is no reason to expect aquatic communities to be sensitive to minor errors or uncertainties in criteria setting. Application of any criterion will always involve some potential for inaccuracy, whether adjusted using the Streamlined Procedure, the 1994 Interim Procedure, the Biotic Ligand Model, an empirical hardness relationship, or whether not adjusted at all for site water quality.

The performance of the Streamlined Procedure was also compared with the 1994 Interim Procedure. This comparison is discussed in the Supplement to Appendix C.

Table C-2. Monte Carlo prediction of relationship between the procedure WER and the unbiased WER.

Design IWC	Ratio of Procedure WER : Unbiased WER		Probability of exceeding the Unbiased WER
	50th Percentile	95th Percentile	
91% Design IWC	0.82	1.49	30%
50% Design IWC	0.81	1.38	25%
33% Design IWC	0.90	1.42	33%
Mean of scenarios	.84	1.43	29%

Conclusion

Analysis of the behavior of the Streamlined Procedure using Monte Carlo modeling techniques has indicated that the procedure provides a level of protection close to that intended for the criteria.

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