Proposed Updated Aquatic Life Criteria for the protection of the Fish and Wildlife Propagation Beneficial Use

Oklahoma Water Resources Board

Staff Report

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Introduction

Water quality standards define the goals for a waterbody and work to safeguard human health and aquatic life by establishing provisions to limit pollution to waterbodies. Standards are comprised of three components 1) a waterbody's beneficial uses, 2) water quality criteria to protect those uses and determine if they are being attained, and 3) antidegradation policies to help protect high quality waters. The Oklahoma Water Resources Board (OWRB) is the state agency responsible for promulgating water quality standards to ensure water quality protection across the state.

Water quality criteria are set to protect beneficial uses and in accordance with section 304(a) of the Clean Water Act (CWA) the Environmental Protection Agency (EPA) develops nationally recommended numeric water quality criteria for the protection of aquatic life. The 304(a) nationally recommend criteria are based upon the latest scientific information and are available to assist States in adopting water quality criteria that protect beneficial uses in accordance with CWA §303(c)(2). Many of Oklahoma's existing aquatic life numeric criteria were adopted as part of Oklahoma's 1988 triennial review of water quality standards. Since 1988, updated toxicological information has resulted in revisions to several of these criteria and OWRB needs to update the state's numeric aquatic life criteria to fully protect the Fish and Wildlife Propagation beneficial use. The numeric aquatic life criteria found in Oklahoma's Water Quality Standards, Appendix G are implemented in key water quality programs across the state. For example, these criteria are used in monitoring programs and water quality assessment programs to evaluate trends in water quality and to determine if beneficial uses are attained or not attained. These criteria also provide the regulatory basis for establishing water quality-based effluent limits in Oklahoma Pollutant Discharge Elimination System (OPDES) permits. Water quality criteria provide the baseline value to determine success in improving or maintaining water quality.

The following chemical parameters are in Oklahoma's Water Quality Standards, Appendix G, but have updated nationally recommended criteria values (Table 1). Staff has reviewed each parameter and calculated updated criterion maximum concentration (CMC) (acute value) and criterion continuous concentration (CCC) (chronic value) values based on the 304(a) nationally recommend criteria. This staff report provides an overview of the criteria derivation method and proposed updated criteria values.

Table 1. List of parameters to be updated

Arsenic 3	Pentachlorophenol
Chromium 3	Dieldrin
Chromium 6	Lindane (Gamma BHC)
Nickel	Cadmium
Zinc	2-4-5 TP Silvex
Endrin	MBAS

Criteria Derivation Method

Aquatic life criteria address the state's goals of providing for the protection and propagation of fish and wildlife. These criteria are based solely on data and toxicological effects of a given parameter on aquatic life. Criteria are developed following the guidance outlined in the EPA *Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses* (1985 Guidelines) (Stephan et al. 1985). Aquatic life criteria for toxic parameters are determined based on the results of toxicity tests with aquatic organisms in which unacceptable effects on growth, reproduction, or survival occurred. Criteria are designed to be protective of the majority of aquatic animal species in an aquatic community (i.e., approximately the 95th percentile of tested aquatic animals representing the aquatic community).

In order to develop aquatic life criteria in accordance with the 1985 Guidelines typically the following information is required.

- Acute toxicity test data for aquatic animals from at least eight diverse taxonomic groups. The diversity of tested species is intended to ensure protection of various components of an aquatic ecosystem. Data from a minimum of eight taxonomic families is required.

  Vertebrates
    - Fish in family salmonidae in the class Actinopterygii
    - Fish from a family other than salmonidae in the class Actinopterygii
    - Third family in the phylum Chordata

Invertebrates

- o Planktonic crustacean
- o Benthic crustacean
- o Insect
- o Family in a phylum other than Chordata or Arthropoda
- o Family in any order of insect or any phylum not represented

- Chronic toxicity test data is needed for at least three species of aquatic animals in three different families.
  - o At least one fish
  - o At least on invertebrate
  - o At least one chronic test being from an acutely sensitive species

- Toxicity data for at least one freshwater alga or vascular plant. If plants are among the most sensitive aquatic organism, toxicity data from a plant in a second phylum is also necessary.

Once all acceptable toxicity data are assembled, a five step calculation process is employed to derive the Final Acute Value (FAV), which is then used to determine the CMC (acute criterion). The calculation steps are listed below.

1. Calculate Species Mean Acute Values (SMAVs) as the geometric mean of all acute toxicity values for a species
2. Calculate Genus Mean Acute Values (GMAVs) as the geometric mean of all SMAVs for a given genus
3. Rank GMAVs from most sensitive to least sensitive
4. Calculate FAV as a least squares regression of the four most sensitive GMAVs (i.e. GMAVs closest to 5^{th} percentile)

$$S^2 = \frac{\sum ((\ln GMAV)^2) - ((\sum \ln GMAV))^2 \ / 4}{\sum (F) - ((\sum (\sqrt{P}))^2/4}$$

$$L = (\sum (\ln GMAV) - S(\sum (\sqrt{P}))) / 4$$

$$A = S(\sqrt{0.05}) + L$$

$$FAV = e^A$$

5. The FAV is divided by two as a margin of safety to arrive at the CMC value. The margin of safety is needed to represent a low level of lethal effect for the fifth percentile genus.

The 1985 Guidelines provide two methods for calculating the CCC (chronic criterion). The first option is to use the same calculations as outlined above when chronic toxicity data are available and all minimum data requirements are met. However, often the chronic toxicity data available are not sufficient to meet the minimum requirements; therefore, the acute-chronic ratio (ACR) approach is often used. The ACR approach utilizes ratios derived from studies in which both acute and chronic toxicity tests were conducted in parallel for the same species. The ACR provides a method of relating the acute and chronic toxicities of a given parameter to aquatic organisms. The CCC is calculated as the FAV divided by the ACR.

Criteria Components

Aquatic life criteria are composed of three components 1) magnitude (CMC or CCC), 2) duration, and 3) frequency. Expressing criteria in this three component format allows the criteria to both protect aquatic life and account for practical realities. This format of expressing criteria provides for variation in flow and pollutant concentrations in both effluent discharges and upstream receiving waters. A very simple criteria format such as, *a magnitude (CMC or CCC) value not to be exceeded,* is very restrictive and does not take into account that aquatic organisms can tolerate higher concentrations of pollutants for short periods of time (EPA Technical Support Document for Water Quality-based Toxics Control, 1991). The magnitude, duration, frequency format establishes aquatic life criteria that are protective without being overprotective.

The CMC and CCC concentrations are the magnitude component of the criteria. The duration is an averaging period and the frequency prescribes how often the criteria may be exceeded. The duration (averaging period) limits the duration of an exceedance above the CMC or CCC concentration while the frequency provides for compensating periods of time during which the concentration is below the CMC or CCC. Consistent with the 1985 Guidelines and the 304(a) nationally recommend criteria the CMC duration and frequency is set as 1-hour average not to be exceeded more than once per three years on the average; the CCC duration and frequency are set as a 4-day average not to be exceeded more than once per three years on the average.

However, for the constituent silver[1] there is a different approach to the duration and frequency component of the criterion. The silver criterion was derived based on the 1980 Guidelines, which had different minimum data requirements and derivation procedures and CMCs were derived as an instantaneous maximum value. Therefore, the criteria were developed with only the magnitude component and do not include the duration and frequency components. In order to apply an averaging period to the silver criterion, EPA recommends dividing the magnitude value by two to obtain a value that is more comparable to a CMC value derived using the 1985 Guidelines.

Consideration of Recalculation Procedure

In addition to the nationally recommended criteria documents, EPA often also publishes various technical support documents and/or guidance documents to assist states in developing water quality criteria. One such document is the *Revised Deletion Process for the Site-Specific Recalculation Procedure for Aquatic Life Criteria* (2013). The Recalculation Procedure is used to edit the taxonomic composition of the toxicity dataset to better match the taxonomic assemblage that resides at a given site. A site can be a large area such as, an entire state. The Recalculation Procedure is intended to provide flexibility to states to derive site-specific criteria that best reflect the species that reside at a particular site. Staff reviewed the national toxicity datasets and applied the Recalculation Procedure to the cadmium acute criterion. This dataset had three salmonidae species among the four most sensitive species and staff wanted to determine if this dataset could be edited. The Recalculation Procedure allows deletion of nonresident species from the dataset if and only if those species are not needed to serve as a surrogate for other resident species, which have not undergone toxicity testing. After applying the Recalculation Procedure, staff found that the salmonidae species could not be removed from the dataset; but were in fact needed to serve as a surrogate for other Oklahoma resident fish species. The only species that could be removed from the dataset was determined to be *Poecilia reticulate* (guppy). Striking this species from the dataset resulted in the criterion being slightly more stringent (1.00 µg/L vs. 1.03 µg/L). While the recalculated value was slightly more stringent it was not more protective of the overall aquatic community. Therefore, recalculation

[1] The proposed revision is to reflect a correction made by EPA to the 1980 304(a) recommended silver criteria document. The hardness equation in the 1980 document had a typo in the intercept value: -6.52 should actually be -6.59. There is not an updated silver criterion based on the 1985 Guidelines.

of the cadmium acute criterion was not pursued and the proposed criterion is consistent with the nationally recommended 304(a) criterion.

Proposed Updated Aquatic Life Criteria

The table below presents the updated aquatic life criteria to be inserted into Appendix G of Oklahoma's Water Quality Standards (Table 2). Pentachlorophenol toxicity is influenced by pH; therefore, the criteria are expressed as a function of site-specific pH. Freshwater aquatic life criteria for certain metals are expressed as a function of hardness because water hardness can affect the toxicity of these metals. Increasing hardness has the effect of decreasing metals toxicity. Thus, the criteria are calculated based on site-specific hardness concentrations in milligrams per liter (mg/L). Attachment A to this report provides the spreadsheets and calculations supporting each proposed criteria.

Table 2. Proposed updated criteria

Parameter	CMC (ug/L)			CCC (ug/L)		
	Magnitude	Duration & Frequency	Criteria Formula	Magnitude	Duration & Frequency	Criteria Formula
Dieldrin	0.24	1-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	N/A	0.056	4-day avg. conc. not to be exceed more than 1 per 3 years on avg.	N/A
Endrin	0.086	1-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	N/A	0.036	4-day avg. conc. not to be exceed more than 1 per 3 years on avg.	N/A
Lindane (Gamma BHC)	0.95	1-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	N/A	N/A	N/A	N/A
Pentacholorphenol*	5.28	1-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	$CMC = e^{1.005(pH) – 4.869}$	4.05	4-day avg. conc. not to be exceed more than 1 per 3 years on avg.	$CCC = e^{1.005(pH) – 5.134}$

Parameter	CMC (ug/L)			CCC (ug/L)		
	Magnitude	Duration & Frequency	Criteria Formula	Magnitude	Duration & Frequency	Criteria Formula
Arsenic 3	340	1-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	N/A	150	4-day avg. conc. not to be exceed more than 1 per 3 years on avg.	N/A
Cadmium**	1.03	24-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	CMC=e^(1.0166[(ln hardness)] -3.924)*[1.136672-0.041838(ln(hardness)]	0.15	4-day avg. conc. not to be exceed more than 1 per 3 years on avg	CCC = e^(0.7409[(ln hardness)] - 4.719)*[1.101672-0.041838(ln(hardness)]
Chromium 3**	1022.1	1-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	CMC = e^(0.819[(ln hardnrss)] + 3.7256)*0.316	48.86	4-day avg. conc. not to be exceed more than 1 per 3 years on avg	CCC = e^(0.819[(ln hardness]) + 0.6848)*0.860
Chromium 6	16	1-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	N/A	11	4-day avg. conc. not to be exceed more than 1 per 3 years on avg	N/A
Nickel**	261.18	1-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	CMC = e^(0.846[ln(hardness)] +2.255)*0.998	29.04	4-day avg. conc. not to be exceed more than 1 per 3 years on avg	CCC = e^(0.8460[ln(hardness)] + 0.0584)*0.997
Silver**	0.98	Shall not be exceeded at any time	CMC = e^(1.72[ln(hardness)] – 6.59)*0.85	N/A	N/A	N/A
Zinc**	66.61	1-hour avg. conc. not to be exceed more than 1 per 3 years on avg.	CMC = e(0.8473[ln(hardness)] + 0.884)*0.978			
*CMC & CCC magnitude calculated at pH 6.5 as an example						
** CMC & CCC values presented for metals were calculated at a hardness of 50 mg/L as an example						

Updated Site-Specific Metals Criteria

The purpose of applying a water effects ratio (WER) to a given statewide metals criteria is to account for any difference that exists between the toxicity of a pollutant in laboratory prepared water and its toxicity in site water. A site-specific WER can be developed and used to modify statewide criteria to account for site-specific conditions. Similarly, a site-specific dissolved translator can be developed to reflect the actual site-specific dissolved to total metals ratio. The dissolved translator is a conversion factor that allows the criteria to be expressed in the dissolved metal form versus the total metal form. Appendix E of the Oklahoma Water Quality Standards contains site-specific criteria for metals based on the application of site-specific WERs and dissolved translators. The site-specific metals criteria need to be updated to reflect the updated statewide criteria. The Table 3 below presents the updated site-specific metals criteria.

Table 3. Updated Site Specific Total Metals Criteria

			Site Specific Total Metals Criteria					
Discharger	**Parameter**	**Hardness (mg/L)**	**Option 1 Acute**	**Option 1 Chronic**	**Option 2 Acute**	**Option 2 Chronic**	**Option 3 Acute**	**Option 3 Chronic**
City of Broken Bow	Zinc	34.9	77.78	N/A	65.32	N/A	86.87	N/A
City of Blackwell	Cadmium	232.5	N/A	5.11	N/A	2.45	N/A	8.45
City of Idabel at Mud Creek	Nickel	88	N/A	41.64	N/A	80.5	N/A	82.69
	Zinc	88	160.14	N/A	169.24	NA	235.78	NA
City of Poteau at Poteau River	Zinc	25.75	93.95	N/A	N/A	N/A	N/A	N/A

Total-to-Dissolved Conversion Factors

In the past metals aquatic life criteria in Table 2 of Appendix G in the Water Quality Standards were presented as the total metal fraction. However, metals criteria values updated as part of this proposed rulemaking are expressed as dissolved metal because dissolved metal more closely approximates the bioavailable fraction of the metal in the water column as compared with total recoverable metal. However, water quality programs such as, Oklahoma Pollutant Discharge Elimination System permits, will often set permit limits based on total recoverable metals in order to account for differences between effluent and receiving water chemistry. Thus, a conversion factor is necessary to translate between the two (dissolved & total) metal fractions. Conversion factors for total-to-dissolved metal fractions are found in Table 3 of Appendix G in Oklahoma's Water Quality Standards.

The proposed update of aquatic life criteria includes new criteria for trivalent chromium and hexavalent chromium. It is necessary to add total-to-dissolved conversion factors for these two metals to Table 3 in Appendix G in order to translate the criteria to the total form, as appropriate. The chromium conversion factors are provided below (Table 4).

Table 4. Chromium total-to-dissolved conversion factors

Metal	Acute Conversion Factor	Chronic Conversation Factor
Trivalent Chromium	0.316	0.860
Hexavalent Chromium	0.982	0.962

Other Changes

Methylene Blue Active Substances

This rulemaking also includes proposed changes to two additional parameters methylene blue active substances (MBAS) and 2-4-5 TP Silvex. Based on EPA's 1972 Blue Book of nationally recommended water quality criteria concentrations of foaming agents in water can be determined by means of their reaction with methylene blue dye and it recommends a limit of 0.5 mg/L to protect public and private water supplies. Oklahoma's Water Quality Standards, Appendix G, Table 2 contains a criterion consistent with this recommendation to protect the Public and Private Water Supply beneficial use. In 2002 an aquatic life criterion for MBAS of 0.001 µg/L to protect Fish and Wildlife Propagation also appeared in Appendix G, Table 2. However, the underlying scientific basis for this criterion is not clear and the 2002 rulemaking documents do not specifically address the addition of a new MBAS criterion for the protection of aquatic life. As part of the 2002 rulemaking, staff reorganized the all of the numeric water quality criteria and created Table 2 in Appendix G and it seems likely that the inclusion of the 0.001 µg/L aquatic life criterion for MBAS was a typo that occurred as part of this major consolidation of numeric criteria into one table. Staff recommends striking the 0.001 µg/L MBAS aquatic life criterion.

2-4-5 TP Silvex

2-4-5 TP Silvex is a historic herbicide and EPA's 1976 Red Book and 1986 Gold Book of nationally recommend water quality criteria provided the value of 10 µg/L in order to protect domestic water supply. In 1982 Oklahoma adopted the value of 10 µg/L for 2-4-5 TP Silvex in two sections of the standards: Section 4.1(a), Toxic Limits for protection of Public and Private Water Supplies and Section 4.3(f), Pesticides for protection of Fish and Wildlife Propagation. Within each of these two sections, the 10 µg/L value for 2-4-5 TP Silvex was simply listed in the table without any acute or chronic notation. The "chronic" notation for 10 µg/L 2-4-5 TP Silvex was added in 1988 when all of the criteria protecting the Fish and Wildlife Propagation beneficial use were moved into a table format with acute and chronic columns. Given the years that have passes since its original adoption, it is unclear why the 10 µg/L 2-4-5 TP Silvex value was included in the 1982 Water Quality Standards to protect the Fish and Wildlife Propagation beneficial use when the criterion's purpose is for domestic water supply protection. The underlying scientific basis for the 2-4-5 TP Silvex criterion to protect Fish and Wildlife Propagation is not clear. Staff recommends striking the 10 ug/L 2-4-5 TP Silvex aquatic life criterion.

References

Stephen, Charles, Mount, Donald, Hansen, David, Gentile, John, Chapman, Gary, Brungs, William. *1985 EPA Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses*. PB85-227049

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Attachment A