

Mercury TMDL for the State of Florida

Appendix M

A Monte Carlo Analysis to Show that the Statewide Mercury TMDL will be Protective of the State Total Mercury Criteria for Ambient Waters

Watershed Evaluation and TMDL Section



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The Department used the following steps to demonstrate that the statewide mercury TMDL will be protective of the total mercury criteria for Florida ambient waters:

The ratio (P) between the ambient methylmercury concentration (C_{Methyl}) and ambient total mercury concentration (C_{THg}) can be represented using Equation 1:

$$P = C_{\text{Methyl}} / C_{\text{THg}} \quad \text{Equation 1}$$

Re-arranging Equation 1, we have:

$$C_{\text{THg}} = C_{\text{Methyl}} / P \quad \text{Equation 2}$$

The ambient methylmercury concentration (C_{Methyl}) can be linked to the fish tissue mercury concentration (C_{FishHg}) using the bioaccumulation factor (BAF):

$$\text{BAF} = C_{\text{FishHg}} / C_{\text{Methyl}} \quad \text{Equation 3}$$

Re-arranging Equation 3, we have:

$$C_{\text{Methyl}} = C_{\text{FishHg}} / \text{BAF} \quad \text{Equation 4}$$

Substituting Equation 4 into Equation 2, we have:

$$C_{\text{THg}} = C_{\text{FishHg}} / \text{BAF} / P \quad \text{Equation 5}$$

Mercury fish tissue concentration data were collected from 264 Florida lakes and streams in the period from September of 2008 through October of 2010. At least 12 largemouth bass were collected from each waterbody by the Florida Fish and Wildlife. In waterbodies where no largemouth were collected or less than 12 largemouth bass were collected, spotted sun fish and/or spotted bass were collected in place of the largemouth bass. Fish tissue mercury concentration was analyzed from these fish samples by the Central Lab of the Department. For each waterbody, individual fish tissue concentrations were then averaged to create a waterbody mean fish tissue mercury concentration. Ambient methylmercury and total mercury concentration data were collected for each sampled waterbody at the same time when fish samples were collected. Using these ambient methylmercury and total mercury data and the waterbody mean fish tissue concentrations, the Department were able to establish distribution curves for both BAF and P (**Table M-1**)

Table M-1 Percentile Distribution of BAF and P Based on Samples Collected from 128 Lakes and 128 Streams in Florida

Percentile	BAF	P
5 percentile	3.77E+05	0.025
10 percentile	6.02E+05	0.037
15 percentile	7.76E+05	0.042
20 percentile	9.25E+05	0.052
25 percentile	1.16E+06	0.061
30 percentile	1.37E+06	0.068

Percentile	BAF	P
35 percentile	1.68E+06	0.076
40 percentile	1.97E+06	0.081
45 percentile	2.31E+06	0.087
50 percentile	2.67E+06	0.093
55 percentile	2.98E+06	0.102
60 percentile	3.27E+06	0.113
65 percentile	3.61E+06	0.127
70 percentile	4.27E+06	0.141
75 percentile	5.18E+06	0.159
80 percentile	6.10E+06	0.172
85 percentile	6.97E+06	0.198
90 percentile	9.41E+06	0.257
95 percentile	1.37E+07	0.364
100 percentile	2.44E+07	0.508

A Monte Carlo analysis was conducted using the Crystal Ball Fusion Edition (Release 11.1) software to examine the distribution of possible ambient total mercury concentrations (C_{THg}) once the fish tissue concentration target is achieved using Equation 5. Basically, the analysis identified the best distribution curves that fit BAF and P distribution. Random BAF and P values were then picked from these distribution curves by the Crystal Ball program and entered into Equation 5 to calculate C_{THg} . At the same time, C_{FishHg} value in Equation 5 was fixed at the 0.3 mg/Kg level to represent the fish tissue target. This process was iterated for 10,000 times. Each time, one possible case of C_{THg} was generated. After the analysis was finished, a cumulative frequency analysis was conducted using the simulated C_{THg} values. **Table M-2** shows the percent distribution of the C_{THg} results from the Monte Carlo analysis.

Percentile Ranking	C_{THg} Concentration (ng/L)
0.0005	0.02
0.01	0.06
0.02	0.09
0.03	0.11
0.04	0.13
0.05	0.15
0.06	0.17
0.07	0.19
0.08	0.21
0.09	0.22
0.1	0.24
0.15	0.33

Percentile Ranking	C _{THg} Concentration (ng/L)
0.2	0.43
0.25	0.53
0.3	0.65
0.35	0.77
0.4	0.91
0.45	1.07
0.5	1.26
0.55	1.50
0.6	1.77
0.65	2.09
0.7	2.49
0.75	3.02
0.8	3.76
0.85	4.87
0.9	6.66
0.91	7.08
0.92	7.72
0.93	8.51
0.94	9.33
0.95	10.55
0.96	12.22
0.97	14.72
0.98	17.88
0.99	25.78
0.991	26.93
0.992	27.94
0.995	34.26
0.9975	44.22
0.998	48.49
0.999	56.03
0.9995	65.85
0.9999	84.42

Based on **Table M-2**, it is obvious that, when the 0.3 mg/Kg fish tissue target was achieved, there is a more than 95% confidence that the ambient total mercury concentration will be lower than the 12 ng/L total mercury criteria for freshwater systems. In addition, there is a confidence level of 98% that the marine ambient total mercury concentration of 25 ng/L is protected.



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