

Mercury TMDL for the State of Florida

Appendix D

**Mercury TMDLs of Other States That Are Waterbody Specific Or Based on
Ambient Water Quality Criteria**

Watershed Evaluation and TMDL Section



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Appendices

Appendix D: Mercury TMDLs of Other States That Are Waterbody Specific Or Based on Ambient Water Quality Criteria

D.1. Lake Mary Regional TMDL for Mercury in Fish Tissue, Arizona

This Total Maximum Daily Load (TMDL) reflects a regional approach to fish tissue mercury contamination. Five lakes within the lower Little Colorado River watershed in northern Arizona was listed as impaired for mercury in fish tissue between 2002 and 2003. Not only are these five lakes within the same water and airsheds, they are also close to the same elevation 6,500-7,000 ft and located within similar surficial volcanic geology and soils. All five TMDL lakes were constructed between 1904 and 1954, display similar water chemistry, contain no known point sources, and share similar historical land uses. Because of these similarities, they have been treated collectively as to mercury contamination. Some differences do exist, however, most notably lake morphology, periodicity of water level (climate and water management), and fish stocking practices.

The fish species which were sampled include walleye, northern pike, largemouth bass, yellow bass, crappie, channel catfish, bluegill and rainbow trout. Many lakes in the Lake Mary region (LMR) are stocked with trout in the summer, however, the lakes are really cool-water rather than cold-water lakes, so trout populations are not likely to survive from year to year. This TMDL addresses mercury levels in all species, with a focus on walleye as the top predator species. There are two critical periods for mercury loading in this region, the monsoon season for intensity of runoff, and the spring snowmelt/runoff season for duration of runoff. The major source of mercury to the lakes in the LMR is atmospheric deposition with some mercury originating from natural geologic materials. As there are no known local atmospheric mercury sources in the LMR, it is not likely that aerial deposition can be significantly reduced in the near future through local efforts. Improvement can be made, however, by reducing soil erosion and transport of organic material from the watersheds. TMDL implementation will focus on decreasing sediment delivery to the lakes, lake level stability and fishery management. Both wet and dry aerial deposition and geologic background mercury concentration were factored into this TMDL. The TMDL model used regional wet and dry air deposition data collected at the Sycamore Canyon Mercury Deposition Network (MDN) station (AZ02). Sediment cores showed pre-impoundment levels of mercury that were later confirmed with watershed soil sampling. Four different types of models were developed and linked for this project: (1) a watershed loading model, (2) a lake hydrologic model, (3) an in-lake mercury cycling model, and (4) mercury bioaccumulation calculations. Site-specific biological accumulation factors (BAFs) were used to link model simulated water column concentrations to fish tissue concentrations. Model predictions of average mercury concentrations in adult walleye were made for various levels of anthropogenic input loads to the lakes.

In order to calculate load reductions on a lake system basis, ADEQ used the trophic level-weighted geometric mean approach described in the Guidance for Implementing the January 2001 Methyl-mercury Water Quality Criterion, (EPA, 2009). Based on trophic-level geometric mean concentrations, the following reductions in mercury loading are necessary to meet the 0.3 mg/kg mercury fish tissue standard. In Upper and Lower Lake Mary, a 25 percent reduction in

methyl-mercury and 32 percent reduction in total mercury. In Soldiers Complex, a 40 percent reduction in methyl-mercury and 46 percent reduction in total mercury.

D.2. Willamette River Basin Mercury TMDL, Oregon

In Oregon's Willamette River Basin (WRB), health advisories currently limit consumption of fish that have accumulated methyl mercury to levels posing a potential health risk for humans. Under the Clean Water Act, these advisories create the requirement for a Total Maximum Daily Load (TMDL) for mercury in the WRB.

Because methyl mercury is known to biomagnify in aquatic food webs, a biomagnification factor can be used, given a protective fish tissue criterion, to estimate total mercury concentrations in surface waters required to lower advisory mercury concentrations currently in fish in the WRB. This TMDL presents a basin-specific aquatic Food Web Biomagnification Model (FWM) that simulates inorganic (Hg[II]) and methyl mercury (MeHg) accumulation in fish tissue and estimates WRB-specific biomagnification factors (BMF_{ME}) for resident fish species of concern to stakeholders. The model was calibrated with WRB-specific fish tissue and surface water data. Probabilistic (Monte Carlo) techniques propagate stochastic variability and uncertainty throughout the model, providing decision makers with credible range information and increased flexibility in establishing a specific mercury target level.

Ambient monitoring data gathered over the course of this study allowed Oregon DEQ to empirically estimate the relative ratio (as a percentage) of dissolved methyl mercury (DMeHg) to total mercury (THg) in the water column of the Willamette River Basin. This DMeHg:THg translator (also known as omega Ω) was used to establish water column guidance values based on units of total mercury, recognizing that it is the methylated form of mercury that is actually prone to bioaccumulation. The estimate of this translator was based on empirical data from the Willamette Basin mercury study.

A fish tissue criterion of 0.30 mg/kg (U.S. EPA methyl mercury tissue criterion), a distribution for the fraction of total mercury that is dissolved MeHg (Ω), a model estimated value for BMF_{ME}, and the following equation were used to estimate total mercury surface water target levels for each fish species.

The target level for total mercury in surface water for each fish species as,

$$TL_n = \left[\frac{TC}{BMF_{ME_n} \cdot \Omega} \right] \cdot CF$$

Where:

BMF_{ME_n} = MeHg biomagnification factor for the nth fish species (L/kg)

TL_n = Total mercury target level for the nth fish species (ng/L)

TC = U.S. EPA fish tissue criterion for MeHg (0.30 mg/kg)

Ω = Ratio of dissolved MeHg to total mercury in surface water (unitless)

CF = Conversion factor (1×10^6 ng/mg)

As a result, the model predicted the probability of tissue mercury concentrations in eight fish species within the range of concentrations actually measured in these species during 25+ years of water quality monitoring.

The estimated mass of total mercury discharged from the Basin as fluvial load was estimated as a function of river flow rate at the confluence (river mile 0) and mercury concentration in unfiltered surface water samples. USGS flow data were available from five gauging stations along the mainstem of the Willamette River (USGS, 2003). An empirical relationship was developed between river flow rate and river mile by pairing measured daily mean flow rates with river mile. This relationship was then used to estimate the daily mean flow rate at sampling locations along the mainstem where daily mean flow rate data were not available for the period between 1997 and 2003. An empirical relationship was then formed between daily mean flow at river mile 0 (RM 0) and the concentration of total mercury in the mainstem. There is a moderate positive correlation between concentration and flow for total mercury; a correlation consistent with the seasonal mobilization of fine-grained particulates in the river sediment and runoff (erosion) with which mercury is associated. The estimated average annual mass load of total (unfiltered) mercury was estimated at the confluence (RM 0) as a function of concentration and flow rate. The annual output from the Basin was thus defined as the mercury discharge rate in units of kg/yr at RM 0. An average of 126.8 kg of total mercury is estimated to be discharged by the Willamette into the Columbia River each year. The estimated inputs of mercury to the Basin (128.6 kg/yr) slightly exceed the mercury mass leaving the Basin as fluvial load, suggesting that a portion of the mercury is deposited in the river bottom.

The loading capacity, presented here in units of total mercury, represents the load of total mercury (in kg/yr) deemed to be protective of the beneficial use of fish consumption. The derivation of this loading capacity relies on both the Basin-Specific Aquatic Food Web Biomagnification Model for Estimation of Mercury Target Levels and the estimate of mercury mass loads discussed above. It is assumed that a given percent reduction in mercury mass loading will result in a linear percent reduction in water column concentrations. The various processes governing mercury speciation and transformation in the Willamette River system are complex rate-dependent processes that are poorly understood and it is difficult to predict with complete certainty how the concentrations of the various species of mercury will change with decreases in total mercury loading. The basic assumption utilized in this mass balance approach, however, is that water column concentrations will decline as source contributions decrease.

The estimated annual mean rate of mercury inputs in the mainstem Willamette River System is approximately 128.5 kg/yr. According to the hypotheses outlined above, it is assumed that a given percent reduction in the mercury mass load will result in a linear percent reduction in water column concentrations. In other words, a 26.4% reduction in the loading of total mercury would eventually lead to a corresponding reduction in water column concentrations. A 26.4% reduction in the average annual load of mercury corresponds to a 33.9 kg/yr reduction in total mercury loading to the Willamette system and a loading capacity of 94.6 kg/yr. This loading capacity represents the maximum amount of total mercury that the Willamette River can absorb on an average annual basis and still meet the beneficial use of fish consumption.



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