Planning Report No. 57

A CHLORIDE IMPACT STUDY FOR SOUTHEASTERN WISCONSIN

Chapter 5

CHLORIDE STANDARDS AND GUIDELINES

This Chapter utilizes information and data from a series of Technical Reports developed by the Southeastern Wisconsin Regional Planning Commission (Commission or SEWRPC) for the Chloride Impact Study (Study). These reports include September 2024 (TR-61); SEWRPC Technical Report No. 62, *Impacts of Chloride on the Natural and Built Environment*, April 2024 (TR-62); SEWRPC Technical Report No. 63, *Chloride Conditions and Trends in Southeastern Wisconsin*, May 2026 (TR-63); and SEWRPC Technical Report No. 67, *Legal and Policy Considerations for the Management of Chloride*, April 2024 (TR-67). Refer to these reports for additional details.

5.1 INTRODUCTION

This Chapter will review current chloride standards and guidelines for groundwater, drinking water, and surface water and discuss whether these standards are protective enough of aquatic life and human health.

5.2 GROUNDWATER AND DRINKING WATER STANDARDS

Wisconsin groundwater standards are set forth in Chapter NR 140, "Groundwater Quality," of the *Wisconsin Administrative Code*. Drinking water quality standards are set forth in Chapter NR 809, "Safe Drinking Water," of the *Wisconsin Administrative Code*.

Wisconsin has issued two groundwater quality standards for chloride: a preventive action limit and an enforcement standard. The preventive action limit sets the concentration at which efforts are required to control contamination in order to minimize the concentrations of chloride in groundwater and prevent

exceedance of the enforcement standard. The preventive action limit also serves as a design standard for several activities that can affect groundwater quality including contaminated site remediation, authorized discharges of liquid and solid wastes, use of approved agricultural chemicals, regulation of landfills, and regulation of beneficial use of industrial byproducts. The preventive action limit for chloride in groundwater in Wisconsin is 125 milligrams per liter (mg/l).

In accordance with the Federal Safe Drinking Water Act (SDWA), Wisconsin has established drinking water quality standards to protect public health, safety, and welfare. These standards apply to public drinking water systems, which are defined as systems that provide water to the public. Any water system that has 15 or more service connections or serves an average of 25 or more people for at least 60 days during the year is considered a public drinking water system.[1]

Drinking water standards include both primary standards and secondary standards. Primary drinking water standards represent minimum standards to protect public health. Secondary drinking water standards are limits on aesthetic parameters that represent public welfare concerns but not public health concerns. Secondary drinking water standards are set for substances that can cause undesirable tastes, odors, or colors in water; damage water equipment; reduce efficiency of treatment for other contaminants; or cause other undesirable effects. Secondary drinking water standards are not Federally enforceable. They serve as guidelines to public water systems for managing drinking water for aesthetic considerations. Standards are expressed in terms of a maximum contaminant level (MCL) that is defined as the maximum permissible level of a contaminant in water that is delivered to a public water supply system. Wisconsin has set an MCL for chloride of 250 mg/l, which is a secondary drinking water standard. There is no primary drinking water standard for chloride in Wisconsin.

Because much of the chloride that is introduced into the environment consists of sodium chloride, concentrations of sodium in drinking water are also of concern. While no drinking water standards have been issued for sodium, the U.S. Environmental Protection Agency (USEPA) has issued two drinking water advisories. These advisories are not regulations. Rather they serve as guidelines to public water supply systems regarding the quality of the water they provide. One advisory is based on the taste that sodium can impart to water and recommends that sodium concentrations in drinking water not exceed 30 to 60 mg/l. The other is a health advisory based on the risks posed by sodium to individuals with salt restricted

[1] *Under the SDWA, "serves" is defined as making water available to people, not that they are known to drink it.*

diets.[2] This advisory recommends that concentrations of sodium in drinking water not exceed 20 mg/l. In addition, water utilities are required to report exceedances of this 20 mg/l level to public health officials so that physicians can advise high-risk patients.

Standard Exceedances and Implications

As documented in Chapter 6 of TR-63, chloride concentrations in shallow groundwater are elevated and increasing across much of southeastern Wisconsin. Table 6.2 in TR-63 indicates for the Study that approximately 19 percent of compiled shallow groundwater chloride samples and 12 percent of the median concentrations at monitored wells exceed the chloride preventive action limit of 125 mg/l. The Study dataset also indicated that approximately 9 percent of samples and 5 percent of median monitored well concentrations exceed the 250 mg/l enforcement limit. These exceedances indicate that shallow groundwater, which is a drinking water source for both municipal and private wells, are becoming contaminated with high salt concentrations. Groundwater chloride conditions and standard exceedances are discussed in greater detail in Chapter 6 of this Planning Report.

5.3 SURFACE WATER STANDARDS

Wisconsin has two surface water quality criteria for chloride. According to the acute criterion for fish and aquatic life the daily maximum concentration of chloride is not to exceed 757 mg/l more than once over a three-year period. Similarly, according to the chronic criterion for fish and aquatic life the four-day average of daily maximum concentrations of chloride is not to exceed 395 mg/l more than once over a three-year period. Waterbodies that exceed either of these criteria are considered to be impaired for chloride under Section 303(d) of the Federal Clean Water Act (CWA) and are entered onto the Impaired Waters List, also known as the 303(d) list, that the State must submit to the USEPA in even-numbered years.

USEPA has issued two aquatic life criteria for chloride. These are not enforceable criteria, but recommendations for surface waters in the United States. The criterion continuous concentration (CCC) is analogous to the chronic toxicity criterion. Under the CCC, the four-day average concentration of chloride is not to exceed 230 mg/l more than once in three years. The criterion maximum concentration (CMC) is analogous to the acute toxicity criterion. Under the CMC, the one-hour average concentration of chloride is not to exceed 860 mg/l more than once in three years. USEPA guidance notes that these criteria were

[2] *U.S. Environmental Protection Agency,* Drinking Water Advisory: Consumer Acceptability and Health Effects Analysis on Sodium*, EPA 822-R-03-006, 2003*.

developed using chloride that is associated with sodium and that they probably will not be adequately protective of aquatic life when chloride is associated with potassium, calcium, or magnesium.[3]

Table 5.1 shows water quality criteria for Canada and three states surrounding Wisconsin. Minnesota has adopted the chloride toxicity criteria recommended by USEPA. Michigan has adopted final chronic and final acute values, which are analogous to acute and chronic toxicity criteria. Illinois has adopted a single water quality criterion for chloride. The Canadian government has also adopted chloride standards for aquatic life related to acute and chronic toxicity.

Protectiveness of Existing Standards

The water quality criteria for chloride described above were developed using data from laboratory toxicity studies on a small number of species.[4] The effects of chloride and chloride salts on biological communities were not considered in developing these standards. Development and application of these criteria assumes that if the criteria are generally protective for the organisms that were tested, they will be protective for the biological communities in which these organisms reside. This assumption may not be valid.

A review of the current literature, as detailed in Chapter 4 of this Planning Report, suggests that chloride and chloride salts affect biological communities in addition to individual organisms and that these impacts occur over a wide range of chloride concentrations. Furthermore, traditional toxicological studies typically measure lethality of older life stages, failing to capture impacts on earlier life stages that may also be contributing to long-term population declines. Such impacts on early life stages, both lethal and sublethal, commonly occur at lower chloride concentrations. Finally, traditional laboratory studies also fail to capture the compounding effects of the multiple ecological stressors that can coincide with rising chloride concentrations. These stressors may be caused by changes in temperature, turbidity, dissolved oxygen, or a variety of other urban pollutants.[5]

Most of the biological thresholds presented in Table 4.1 are lower than Wisconsin's chronic water quality criterion for chloride (395 mg/l) and many are lower than the USEPA recommended criterion continuous

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[3] *U.S. Environmental Protection Agency,* Ambient Water Quality for Chloride—1988, *EPA 440/5-88-01, 1988.*

[4] *For Wisconsin criteria, see: Chapter NR 105, Surface Water Quality Criteria and Secondary Values for Toxic Substances,* Wisconsin Administrative Code. *For USPEA criteria, see: U.S. Environmental Protection Agency 1988* op. cit.

[5] *S.S. Kaishal, G.E. Likens, M.L. Pace, and R.M. Utz, "Freshwater salinization syndrome on a continental scale,"* Proceedings of the National Academy of Sciences of the United States of America, *115 (4): E574-E583, 2018.*

concentration (230 mg/l). This suggests that these water quality criteria may be too high to be fully protective of aquatic communities (see Figures 4.9 and 4.10). It should be noted that these thresholds derive from a small number of studies and may not fully characterize the range of responses aquatic communities might show to chloride levels. A recent study analyzing the impacts of zooplankton and phytoplankton at the current USEPA criterion concentration of 230 mg/l indicates that this criterion does not protect lake food webs.[6] Based on a similar analysis, this study also concluded that the Canadian chronic toxicity standard of 120 mg/l fails to protect lake food webs. The study authors recommended that these criteria be reassessed.[7]

In order to evaluate harmful impacts from chloride on the Region's waterbodies, Commission staff established Commission staff established seven chloride thresholds over a wide range of concentrations as shown in Table 5.2. The lowest threshold (10 mg/l) represents natural background/baseline concentrations that allow for an evaluation of how much our waterbodies have changed or been impacted by chloride. The highest chloride concentration threshold (1400 mg/l) was chosen to represent a severe level of impact as described in TR-62. Other thresholds shown in Table 5.2 include the lowest concentration that negatively affects freshwater organisms (35 mg/l) along with some of the water quality criteria thresholds that are listed in Table 5.1.

As reviewed in Chapters 3, 4, and 5 of TR-63 as well as Chapter 6 of this Planning Report, many lakes and streams across southeastern Wisconsin have chloride concentrations that exceed the lower Study thresholds but are still below the Wisconsin standards for chloride.[8] Based on the thresholds established above, it would be incorrect to assume that waterbodies not listed as impaired for chloride are safe from its harmful impacts. Instead, the numerous exceedances of these thresholds across the Study Area establish that many waterbodies are negatively impacted by chloride across several trophic levels but lack formal recognition of this impact due to the higher concentration state standards. Considering more stringent standards would enable greater recognition of the widespread impacts that chloride already has on waterbodies of Southeastern Wisconsin as many more waterbodies would be designated as impaired waters in the 303(d) list.

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[6] *W.D. Hintz et al., "Current Water Quality Guidelines Across North America and Europe Do Not Protect Lakes from Salinization,"* Proceedings of the National Academy of Sciences*, 119:e2115033119, 2022.*

[7] Ibid.

[8] *See Tables 3.14, 4.13, 4.19, 4.26, 4.33, 4.40, 4.47, 4.54, 4.61, 4.68, 4.75, 4.82, and 5.9 in TR-63.*

Updating the chloride water quality standards would also generate additional targets for policy, programs, and funding to address chloride pollution (see TR-67 for discussion of legal and policy options). Programs such as Total Maximum Daily Loads (TMDLs), adaptive management plans, and water quality trading could facilitate implementation of best management practices that would reduce chloride loading to chloride-impaired waters. Several states, including Illinois, Minnesota, New Hampshire, and Vermont, have previously developed TMDLs to address chloride pollution in impacted waterways and, in the case of Minnesota, these TMDLs were adapted into a statewide chloride management strategy.[9] Both updating the state water quality standards for chloride and developing chloride TMDLs were recommended by the Wisconsin Department of Natural Resources (WDNR) Chlorides Workgroup in their report to the Water Initiatives Steering Committee.[10]

[9] *Minnesota Pollution Control Agency,* Minnesota Statewide Chloride Management Plan, *WQ-S1-94*, *2021*.

[10] *Wisconsin Department of Natural Resources Chlorides Workgroup,* Recommendations on a Statewide Chloride Strategy: Report to Water Initiatives Steering Committee, *2022*. *For more information on this workgroup, see the following link: dnr.wisconsin.gov/topic/Stormwater/learn_more/salt.html (accessed May 2026)*.

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TABLES

Table 5.1
Water Quality Criteria for Chloride for Canada and Three States Surrounding Wisconsin

Jurisdiction	Chronic Toxicity Criterion (mg/l)	Acute Toxicity Criterion (mg/l)	General Chloride Criterion (mg/l)
Canada	120	640	--
Illinois	--	--	500
Michigan	150	640	--
Minnesota	230	860	--
Wisconsin	395	757	--

Source: Environment Canada, Illinois Pollution Control Board, Michigan Department of Environment, Energy, and Great Lakes, Minnesota Pollution Control Agency, and WDNR

Table 5.2
Surface Water Chloride Thresholds for Assessment of Lakes and Streams in the Chloride Impact Study

Threshold Chloride Concentration (mg/l)	Source	Description	Reference
10	Historical/Ambient Background Concentration	This concentration represents a surface water baseline level of chloride from observations in the early 1900s that represent a time period unimpacted by human influences in inland freshwater lakes and streams within the Southeastern Wisconsin regional area. Concentrations below this threshold are considered normal and concentrations above this threshold are considered to begin to have observed negative biological effects.	SEWRPC Technical Report No. 4, 1967; SEWRPC Technical Report No. 17, 1978; E.A. Birge, C. Juday, 1911; and Lillie and Mason 1983.
35	Conservative Lower Impact Concentration	Lowest concentration to negatively affect freshwater aquatic life (lethal and non-lethal impacts) among several trophic levels within aquatic ecosystems. Chloride levels exceeding this concentration have been linked to reduction in fish species diversity, decreased reproduction and increased mortality of several zooplankton (Daphnia) species, substantial changes in the composition of periphytic diatom assemblages, reduced bacteria density in biofilms, reduction in survival of the glochidia life stage of two mussel species (*Lampsilis fasciola* and *Epioblasma torulosa rangiana*), and acute toxicity to the Sida water flea (*Psuedosida ramosa*) and egg life stages of Rohu Carp (*Labeo rohita*). In addition, concentrations between 35 to 120 mg/l are also associated with acute toxicity to wood frog (*Lithobates sylvatica*) tadpoles and reduced photosynthetic production in common waterweed (*Elodea canadensis*), and reductions in wetland plant species richness.	SEWRPC Technical Report No. 62, 2024; Canadian Council of Ministers of the Environment (CCME) 2011; and, Lawson, and Jackson, Ecological Indicators, Volume 168, 2024.
120	Canadian Chronic Toxicity Threshold	Seven-day exposure to fish and invertebrates.	CCME 2011.
230	USEPA Chronic Toxicity Threshold	The four-day average concentration of chloride is not to exceed this value more than once in three years on average.	USEPA 1988.
395	Wisconsin Chronic Toxicity Threshold	The four-day average of the daily maximum concentrations of chloride taken over four consecutive days is not to exceed this value more than once in a three-year period.	NR 102, NR 103, NR 104, NR 105, and NR 207 of the *Wisconsin Administrative Code*.
757	Wisconsin Acute Toxicity Threshold	The daily maximum concentration of chloride is not to exceed this value more than once in a three-year period.	NR 102, NR 103, NR 104, NR 105, and NR 207 of the *Wisconsin Administrative Code*.
1,400	Extreme Impact Level Concentration	This was chosen to represent a chloride concentration associated with a severe level of impacts due to known 0.25-hour through 456-hour EC50 (concentration at which 50 percent of the test organisms showed a toxicity effect) and/or LC50 (concentration that is lethal to 50 percent of the text organisms) for multiple freshwater aquatic organisms. Concentrations exceeding this threshold are considered to also have negative impacts to the composition and structure of freshwater ecological communities, ecological processes such as competition and predation, and/or energy flow within aquatic ecosystems such as inhibition of denitrification, organic matter decomposition, nutrient cycling, and/or primary production.	SEWRPC Technical Report No. 62, 2024.

Source: SEWRPC