Road Salt Report – 2014
Prepared by Rick Wenta and Kirsti Sorsa, Public Health Madison – Dane County
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Overview

The Wisconsin Department of Transportation (DOT) initiated the use of rock salt as a deicer on state highways early in the 1950s. By 1956, the DOT had implemented a "bare pavement" policy for state highways. Madison started salting city streets three years later.

The intensive salting and plowing efforts arising from the bare pavement policy fueled motorists expectations of favorable winter driving conditions, creating a demand for increased road maintenance that persists to this day. Salt use reduction efforts began at both the state and city level in 1973. Yet, despite economic considerations, environmental impacts, and advances in application technology, road salt use continues to increase.

Monitoring of surface and ground water continue to show increasing trends in chloride and sodium levels, although the levels are not yet a human health hazard. Storm water monitoring during snowmelt has identified surges of extremely high levels of chloride. As these surges enter local waterways, they have the potential of harming fish and other aquatic organisms.

Discussion

The History of Road Salt Use

In the early 1940s, state highway maintenance consisted of plowing and application of sand and other abrasives (see Figure 1). Later in the decade, it became common to add rock salt to sand stockpiles to prevent freezing. By the early 1950s, highway deicing with rock salt had begun. Salt soon replaced abrasives as the preferred winter highway treatment. It was cheap, provided better traction, and required one truckload to treat the same stretch of road as eight loads of sand.

A winter driving paradigm was beginning to form, powered in part by Eisenhower's Highway act of 1956 and Ralph Nader's *Unsafe at Any Speed: the Designed-In Dangers of the American Automobile*. The highway act accelerated the construction of a nation-wide highway system. Concurrently, Nader criticized the allocation of 320 million federal dollars for highway beautification, while only 500 thousand was dedicated to highway safety.

Transportation officials throughout the northern United States believed that bare pavement was essential to safeguard the lives of motorists. This led to The Wisconsin Department of Transportation (DOT) adopting a "bare pavement" policy for state highways. However, maintaining bare pavement proved to be an expensive undertaking. It required continuous snow plowing all through a storm and salt application rates averaging 400-1200 pounds per lane mile.

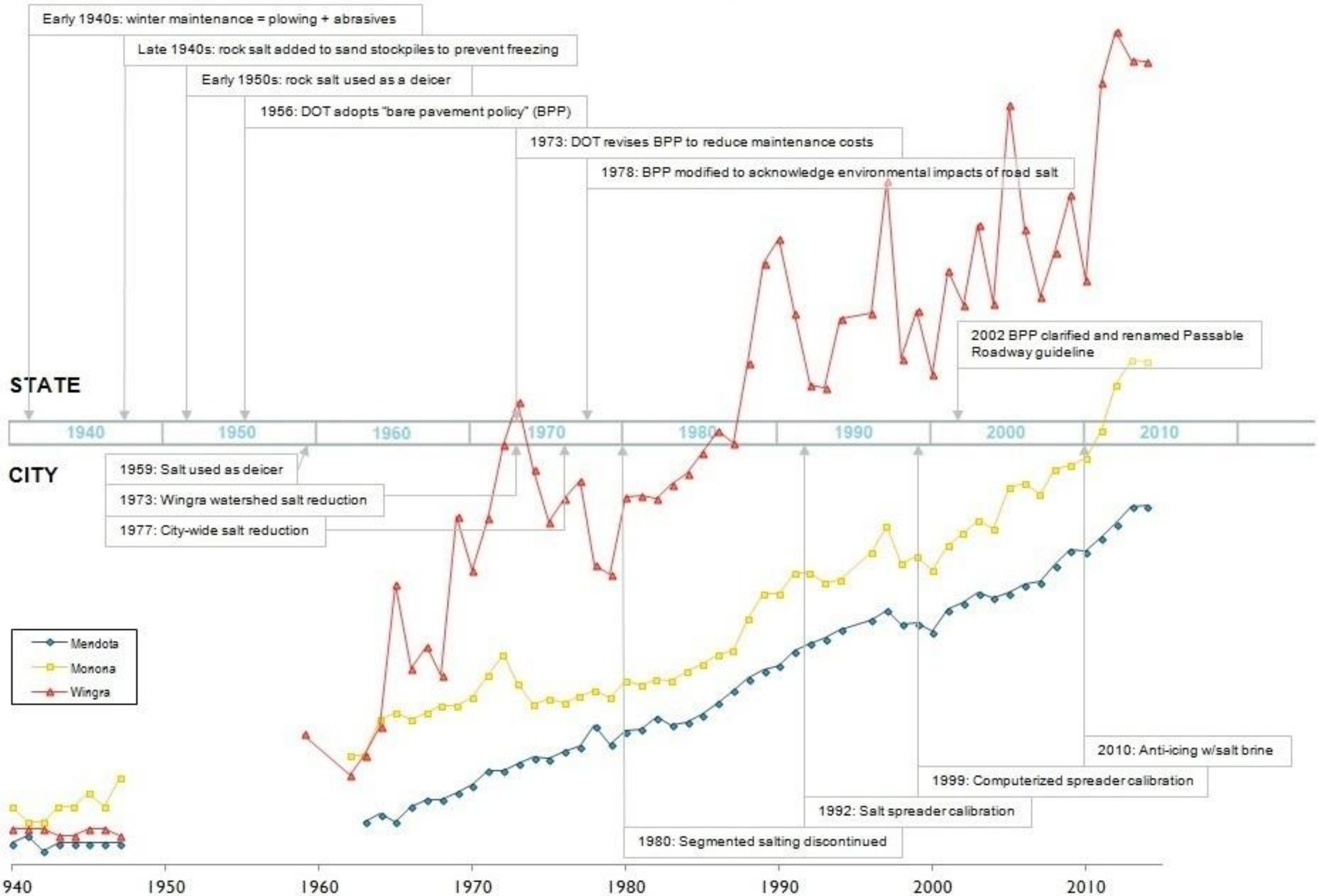
Although awareness of the environmental impacts of road salt was increasing, the first reduction in salting was made to cut costs. Overtime pay and the increased cost of fuel caused by the oil embargo prompted a change in the bare pavement policy in 1973. The DOT reacted by creating three classes of highway with different levels of plowing and deicing.

The DOT officially recognized the environmental hazards of deicing salt in 1978 when it further modified the bare pavement policy. The department would now strive to use deicing chemicals prudently. Snow was to be removed as quickly as possible. Salt use was limited to prevent ice bonding to pavement and to clean-up after a storm. Furthermore, application rates were limited to 300 pounds per lane mile. Handling and storage of deicing materials was also emphasized.

Environmental protection was again addressed in 2002 when the DOT clarified the expectations of the bare pavement policy. The name was also changed to Passable Roadway – During a Winter Storm guideline.

Over this 60-year time span, winter road maintenance in Madison followed a course similar to the DOT's, albeit with a heightened environmental awareness. City salt applications began in 1959. In just three years, concern was voiced

Figure 1 Winter Road Maintenance and Lake Chloride History



over the impacts on the environment. A study conducted by the Rivers and Lakes Commission in 1962 revealed high chloride in roadside ditches following melt water flows, but overall road salt impacts were minimal. Yet chloride levels in Lake Wingra were increasing at an alarming rate, compelling the Rivers and Lakes Commission to request a 50% reduction in road salt use in the Lake Wingra basin for the winter of 1973-74. By 1977, the salt reduction program was extended to the entire city.

Although chloride levels in Lake Wingra were in a steady decline, opposition to the city-wide reduction was strong. By 1980, segmented salting, a major component of reduced salt use, was discontinued. This marked the end of effective means of curtailing the use of road salt. Both the city and state have since tested many methods of reducing salt use, and many effective measures have been adopted. Nevertheless, salt applications continue to rise as maintenance efficiencies stimulate increased public demand for service rather than reduced reliance on salt. Chloride concentrations in surface and groundwater continue to rise as a result.

> Segmented salting reduced salt applications by treating every other block. Traffic was supposed to carry salt residue to the untreated roadway. However, carry-over was minimal and the practice resulted in increased ice formation.

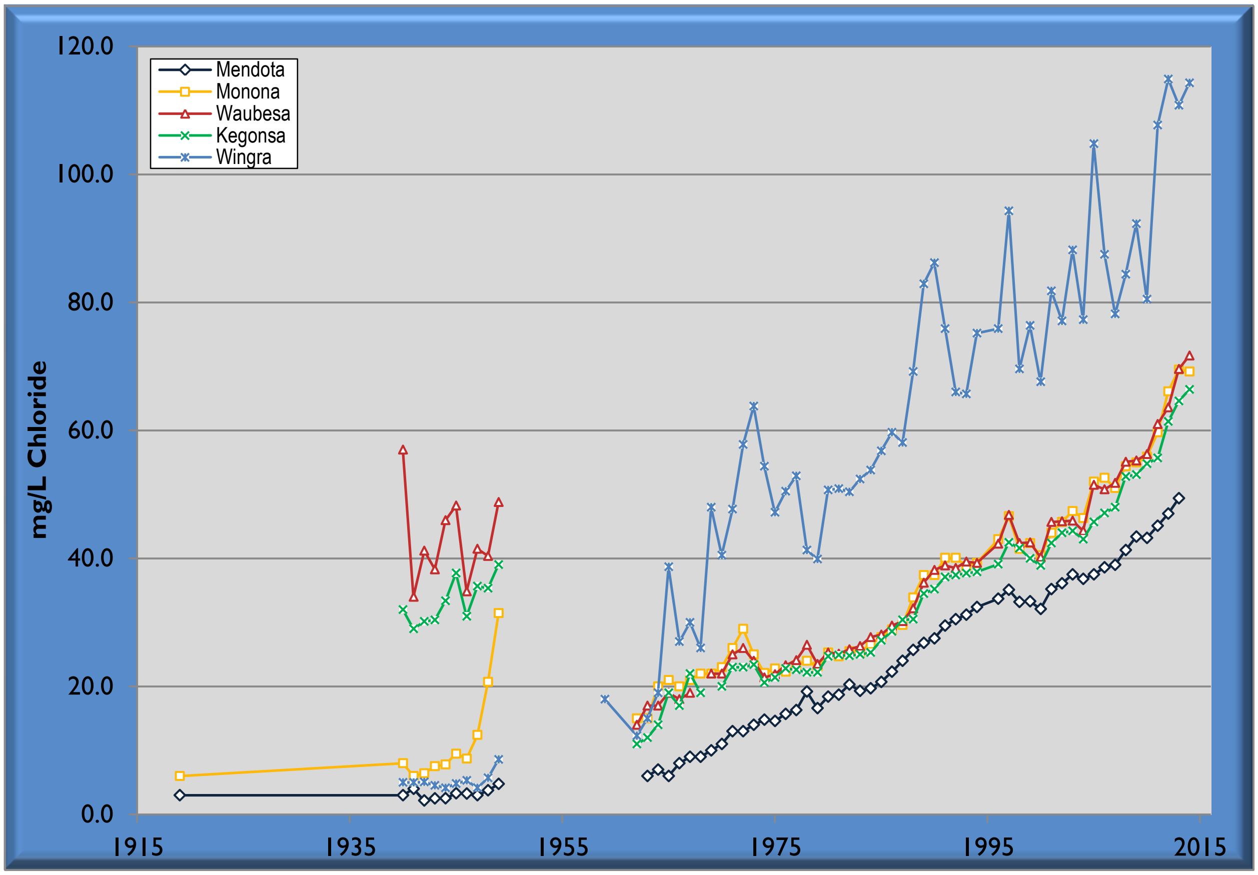
Chloride Trends

Yahara Lakes

Chloride concentrations in 1919 in Lakes Mendota and Monona were 3 and 6 mg/L respectively (see Figure 2). Throughout the 1940s chloride levels in Lakes Mendota and Wingra remained stable in the 3-5 mg/L range while Lake Monona levels were fairly stable around 10 mg/L until it received sewage effluent in 1947-1949. Chloride in Lakes Waubesa and Kegonsa was elevated throughout the decade from effluent discharges from Madison Metropolitan Sewage District.

Chloride levels rose dramatically with the widespread use of deicing salt. In the15 years following the onset of road salt applications, chloride concentration in Lake Wingra more than tripled. Average chloride concentrations in Lake Wingra have been increasing at about 2 mg/L per year since 1962. The rest of the Yahara Lakes have seen average annual chloride increases of about 1 mg/L.

Figure 2: Yahara Lakes Annual Chloride

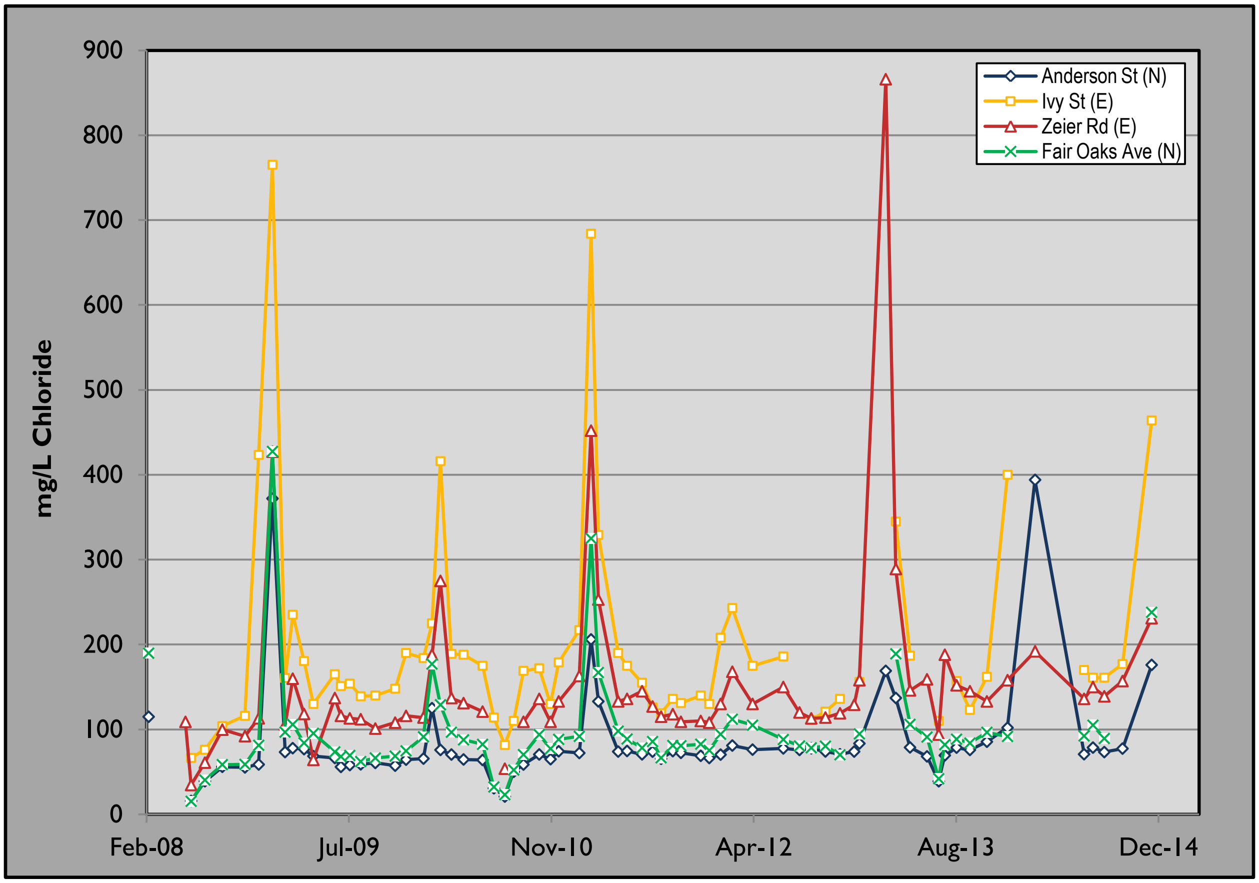


Small Surface Waters

Small surface waters continue to be profoundly impacted by road salt. Public Health Madison and Dane County (PHMDC) chloride monitoring is tailored to capture base-flow conditions rather than the extremes associated with runoff or melt water. Still, seasonal spikes in chloride, above the Chronic Toxicity Criterion (395 mg/L) are commonly observed for Dunn's' Marsh. University Bay Creek (Willow Creek) chloride levels exceed the Acute Toxicity Criterion (757 mg/L) most winters; a concentration of 2160 mg/L was seen in 2007. Magnuson found chloride as high as 755 mg/L in 1918 Marsh (Magnuson, 2014) during the winter of 2012-2013.

Starkweather Creek is also affected by road salt applications. Since 2008, PHMDC has monitored Starkweather Creek water quality at 6 locations. The north branch is sampled at International Lane, Anderson Street, and Fair Oaks Avenue. The east branch is sampled at Zeier Road and Ivy Street. The final sample point is below the confluence of the two branches, at Atwood Avenue. Starkweather Creek monitoring is also designed to obtain information on base-flow conditions. Seasonal chloride impairments are observed regularly.

Figure 3: Monthly chloride concentrations – Starkweather Creek

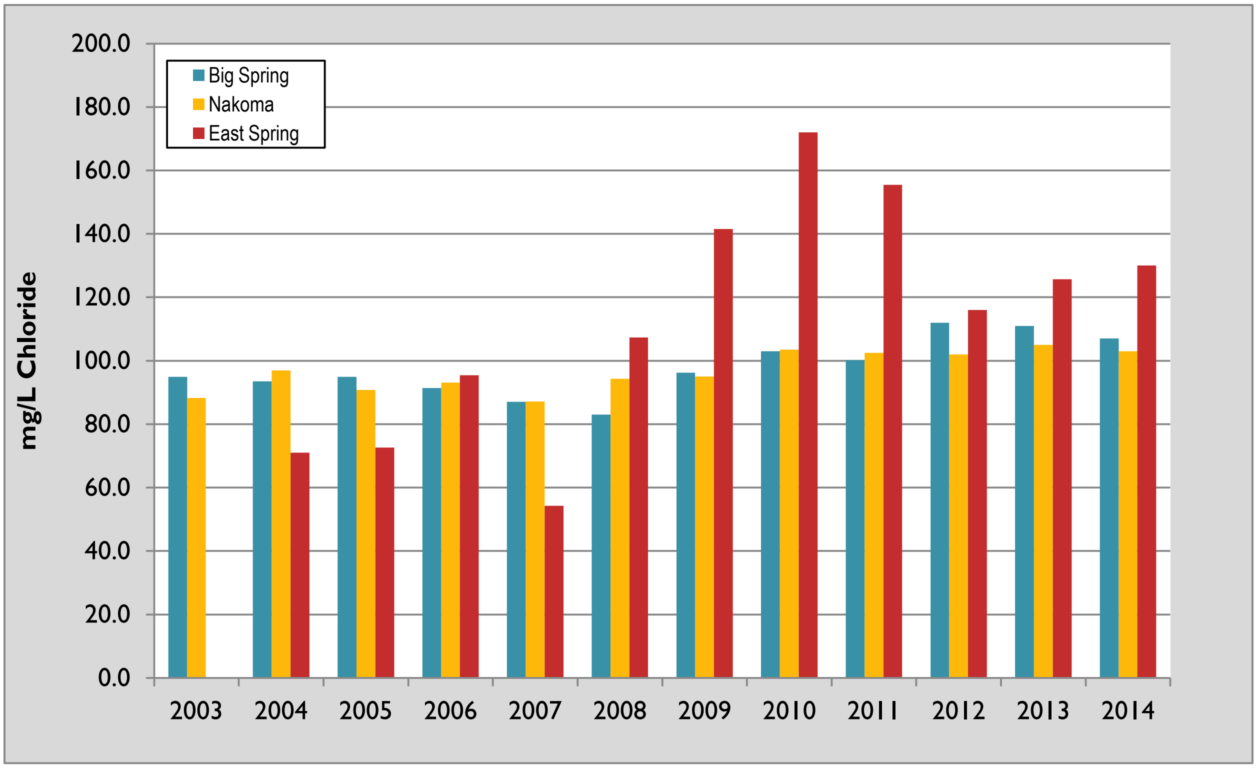


Chloride levels in the two branches reflect the difference in their headwaters. The north branch originates in relatively open space, while the east branch recharge area is heavily urbanized. Exceedences of the chronic toxicity criterion for chloride have occurred predominately in the east branch. Chloride peaks occur in December and February, suggesting melt water as the source.

Groundwater

Biannual monitoring of several springs indicates that chloride levels in shallow groundwater are also increasing, although at a slower rate than surface waters (see Figure 4).The chloride concentration of East Spring, which is the origin of the East Branch of Starkweather Creek, fluctuates widely compared to Big Spring and Nakoma Spring. This variability is likely a function of the urbanized recharge area of East Spring, as it receives a substantial portion of the runoff from the East Towne area. However, chloride has increased in all three springs since monitoring began in 2003.

Figure 4: Chloride trends in area springs.



Road salt applications may also degrade our drinking water. Chloride levels continue to increase in some city wells that draw water from both the upper and lower aquifers near main thoroughfares. Figure 5 compares past chloride concentrations in deeply cased wells, which draw water from the lower aquifer and wells with short casings, which draw water from both the upper and lower aquifers. The bisecting line represents the median concentration. Note the 1995 graphic for deeply cased wells is biased high due to the addition of three new wells in 2006 with very low chloride (see Table 1).

Sodium is also increasing in our drinking water, although at a slower rate than chloride. Average sodium content has risen from 7.0 mg/L to 13.1 mg/L in the past 20 years. Current median and maximum levels are 8.2 mg/L and 40.2 mg/L respectively.

Figure 5: Chloride trends in city wells.

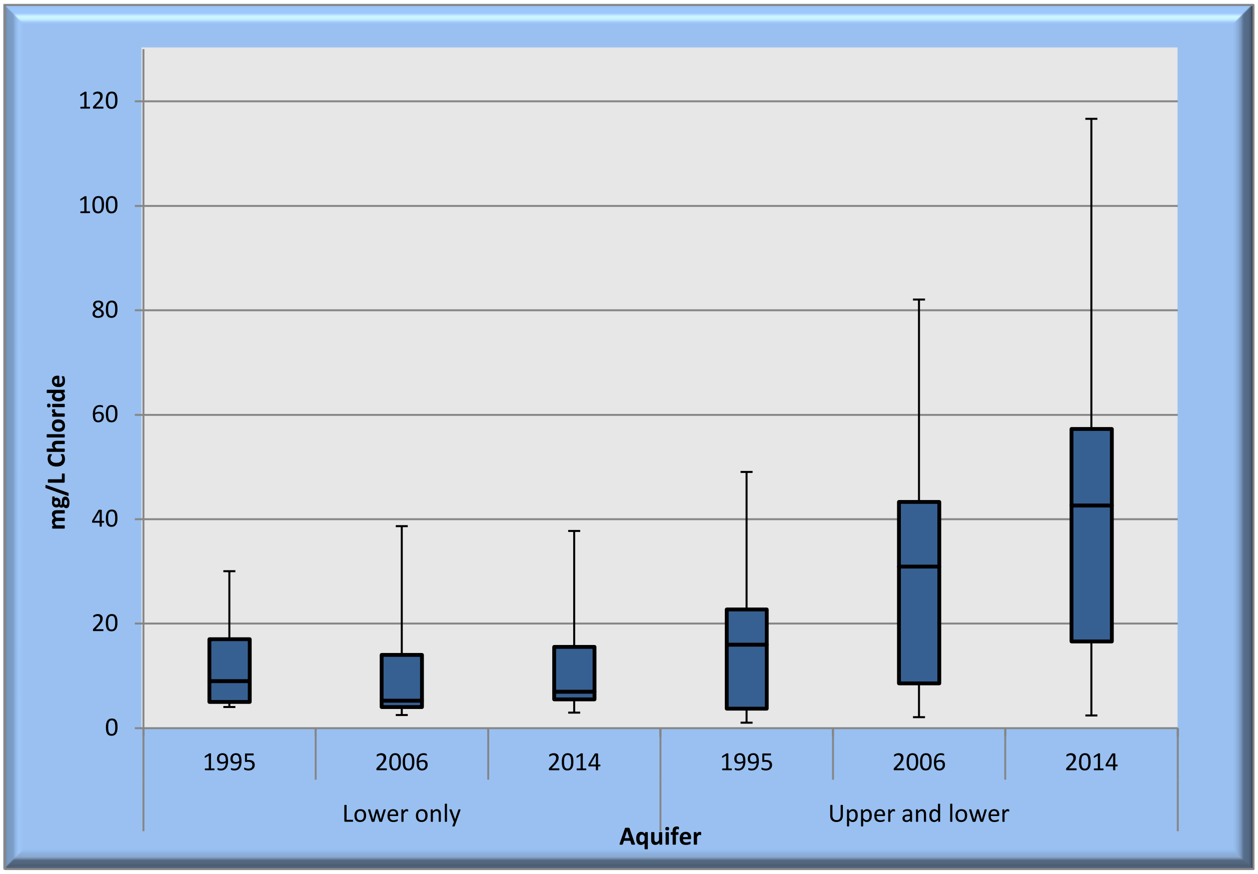


Table 1: Chloride in City wells

lower only								
Year	#7	#8	#19	#24	#27	#28	#29	#30
1995	9.0	17.0	4.0	5.0	30.0			
2006	13.4	16.0	5.4	5.1	38.6	2.5	2.6	4.6
2014	15.1	17.6	7.6	6.3	37.7	2.9	5.3	5.8

upper and lower													
#6	#9	#11	#12	#13	#14	#15	#16	#17	#18	#20	#23	#25	#26
23.0	35.0	18.0	1.0	6.0	41.0	22.0	14.0	21.0	7.0	1.0	49.0	1.0	3.0
28.9	33.0	47.3	2.5	8.3	76.8	41.6	34.2	43.9	9.5	2.1	82.0	2.6	11.4
59.2	45.7	57.1	3.5	39.6	116.6	53.6	57.3	34.9	13.2	2.4	71.7	3.6	26.7

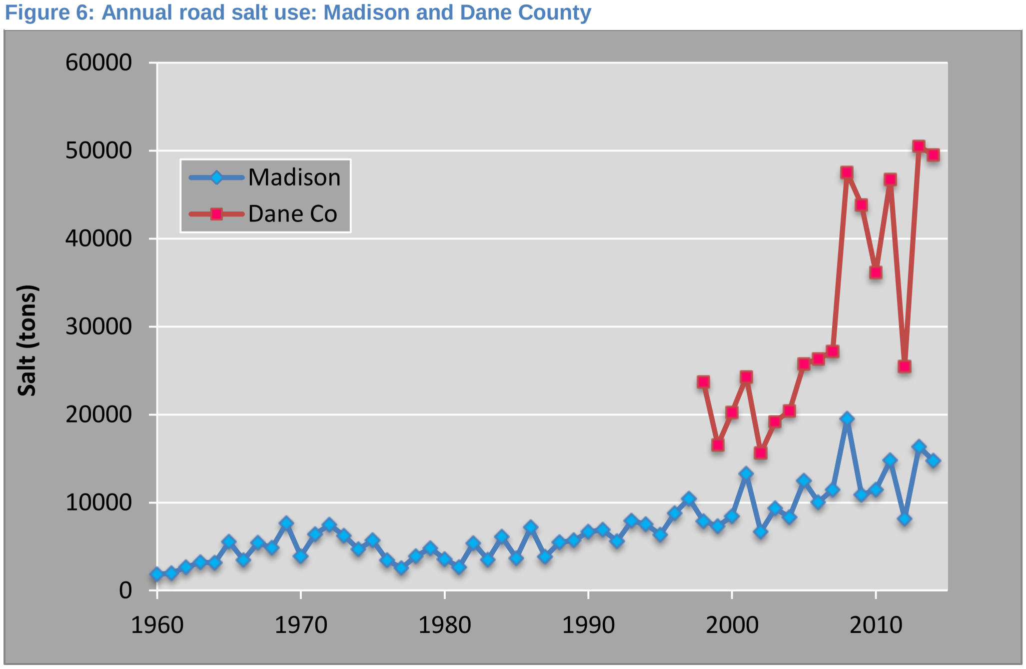
Trends in Salt Use

Assessing trends in City salt applications can be challenging with the vagaries of winter weather and the different metrics used in 75 years of record keeping. Before 2007, data for lane miles of street maintained was unavailable. The unit used, street miles, was the same for a mile of roadway whether it was one or six lanes wide. Yet, Madison only salts a portion of its roads, so lane miles maintained does not directly reflect salt applications either. A better indicator of salt use is tons of salt per lane mile of salted roadway (salt route lane miles). However, this data is only available for three seasons: 1972-73, 2012-13, and 2013-14. The large fluctuations in winter severity common to Wisconsin render this limited data set unusable.

A further consideration is the expansion of services using city salt stockpiles. Increasing use for public sidewalk, city parking lots, and bike paths inflate the salt used on a lane mile of salt route as these alternate uses are not tracked separately. Salt demand for bike path deicing has nearly doubled in the last 5 years and there is considerable public demand for further increases.

Data limitations do not allow a definitive comparison of current deicing efficiency to past practices or to other municipalities. However, examination of the trends in total salt use for Madison and Dane County, the two largest salt users in the Yahara Lakes basin, make it clear that road salt use in the basin is increasing (see Figure 6). Note: Dane County data does not include salt used on county highways.

Figure 6: Annual road salt use: Madison and Dane County



Since technical, procedural, and mechanical efficiencies have been implemented at the county and city, the continuous increase in salt use indicates road building has been increasing faster than salt reduction efforts can offset. Or, the efficiencies in salt reduction realized have been used to increase service rather than reduce salt applications.

Private deicing salt applications also contribute significant levels of chloride to the environment. However, there is insufficient data available to discern any trends in usage. It is likely reliance on salt for clearing parking lots, sidewalks and driveways has increased in concert with roadway maintenance. Plus, there are additional considerations for the private applicator.

Liability for icy walkways is an obvious concern, but many private applications are grossly excessive. If a private applicator applies an insufficient amount of salt, they may have to return to the site to add more. If a surplus of salt is applied, the residual salt may melt away a minor snowfall, saving the applicator the expense of clearing it mechanically. Residual salt will also keep ice from bonding to the pavement before the contractor can remove snow mechanically.

Summary

The golden age of motoring began with the passage of the Highway Act of 1956, promising direct and high-speed travel throughout the nation on an interconnected system of highways. Soon highway maintenance standards rose to provide summer driving conditions in winter and deicing with road salt became the norm.

Although salt reductions efforts were initiated in 1973 and many methods of reduction are in use, substantive decreases in the amount of salt deposited in our environment have not been realized. Current levels of salt applications cannot be sustained without degrading our drinking and surface waters. Motorists' expectations have to change before meaningful reductions will be achieved.

Acknowledgements:
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References

Magnuson, John (2014). Winter in the 1918 Marsh: Ice, Snow and Road Salt. *Preserve!*