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MADISON & DANE COUNTY
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Road Salt Report – 2015

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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.

Surface and ground water monitoring 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. 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.

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 the winter of 1956-57. (The DOT contracts with all 72 counties' highway departments for winter maintenance on state highways and the interstate system). 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 (WI DOT, 2012).

Over this 60-year time span, winter road maintenance in Madison followed a course similar to the DOT's. City salt applications began in 1953. Concern was soon raised 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.

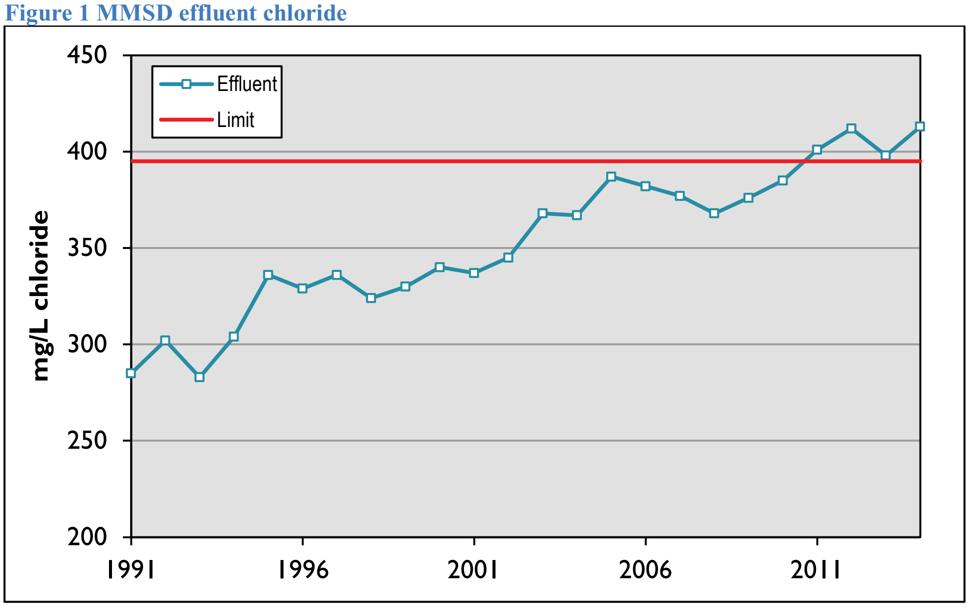
Although chloride levels in Lake Wingra were in a steady decline, opposition to the city-wide reduction was strong. By 1980, the City discontinued segmented salting, a major component of reduced salt use. This marked the end of effective means of curtailing the use of road salt. Both the city and state have since tested many methods of road salt reduction 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. Yet, positive steps toward road salt reduction are occurring.

Reduction Efforts

Perhaps the most promising development in this arena is the formation of the Wisconsin Salt Wise Partnership, a coalition of city and county agencies and the UW with an interest in promoting reduced salt use. The group has addressed the most significant issue in salt use reduction, public demand, with the launching of the website: wisaltwise.com. The site provides relevant information tailored to each user group from policy makers to motorists. Although the partnership is not the first group to promulgate information on the detrimental effects of salt use, the level of interagency collaboration is noteworthy.

Of greater significance, is the compelling factor in formation of the group. The partnership was founded by Madison Metropolitan Sewerage District (MMSD) in response to chloride levels in its treated wastewater effluent, which have been above Clean Water Act limits since 2011 (see figure 1). MMSD has received a variance that allows additional time to meet the required chloride discharge of 395 mg/L. The variance requires MMSD to implement source reduction strategies to reduce the chloride discharged to the plant.

Figure 1 MMSD effluent chloride



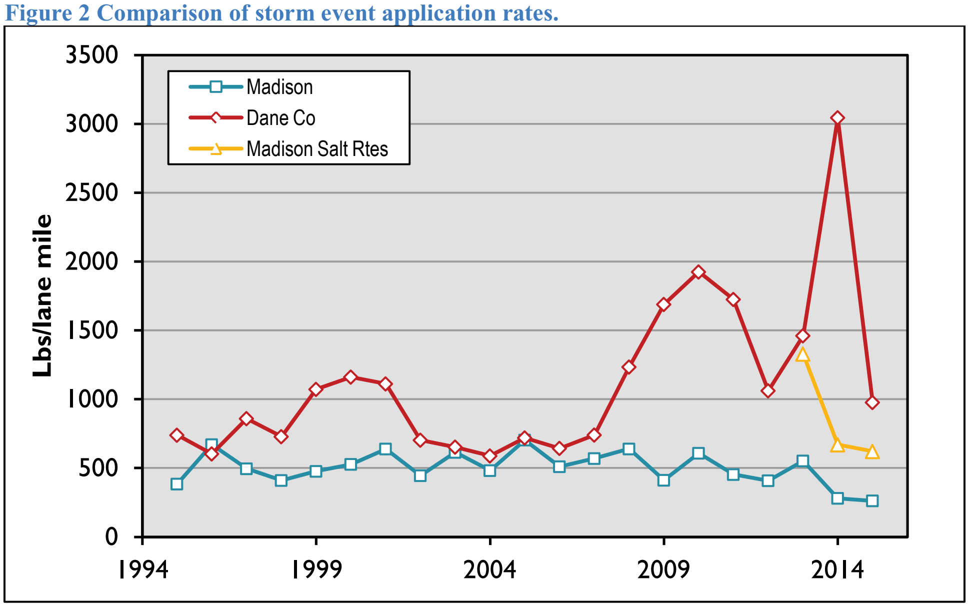
The Wisconsin Salt Wise Partnership is one such reduction strategy with a goal of reducing deicing salt use, which MMSD has identified as a significant chloride source. Salt affects the chloride levels at the treatment plant in two ways. First, parking lot and road salt applications increase the chloride levels in drinking water. (Average annual chloride in all Madison wells has doubled in the last 20 years). Thus, drinking water is an increasing source of chloride to the treatment facility.

The sewer system receives a similar amount of chloride from infiltration. Melt water, laden with chloride from road salt, enters the sewer system through displaced or damaged manhole covers or cracks in manholes and pipes. Based on these two sources MMSD has determined that approximately 15% of its chloride load is attributable to deicing salt applications. Accordingly, changing the paradigm of "more is better" for deicing salt is a sound approach to reducing MMSD's chloride load.

Current Trends in Salt Use

The City of Madison has historically reported winter road maintenance activities in terms of street miles maintained, but has recently started keeping records of lane miles maintained. This allows for a more direct comparison with other agencies as most records are in lane miles. Figure 2 compares the application rates per storm event, for Dane County and the City of Madison. Dane County lane mile data are real. City lane mile data are available for the past eight years. Older Madison lane mile data were estimated by linear regression analysis of the relationship between street miles and lane miles. Lane-mile application rates for city salt routes are shown for the past three seasons. For total salt use by Madison and Dane County, see Figure 7 and Table 2 at the end of this document.

Figure 2 Comparison of storm event application rates.



Madison typically sets its salt spreaders at a rate of 150 pounds per lane mile while the county's spreaders are set at 300 pounds per lane mile. This disparity in application rates may not result in the City applying substantively less salt per lane mile for a storm event. This implies City crews make more salt applications per storm event.

Of particular interest though, is the difference in salt use during the record setting cold of the 2013-2014 season. A direct comparison of Madison salt route application rate to that of Dane County indicates the City applied only about 20% as much salt per storm event, as the County. According to Chris Kelley, superintendant of the Madison Streets Department, they did not apply salt when the temperature was below 15 degrees Fahrenheit. Thus the record setting cold resulted in a substantial reduction in salt use as the city shifted to abrasives when low temperatures rendered salt ineffective.

Data on salt use by commercial applicators is very limited. Chloride levels in meltwater samples taken in February and March of 2010 suggest private application rates are similar to the City's salt use on main arterials (see 2011 Road Salt Report). However, a readers poll of commercial snow removal contractors in the trade e-zine "Snow Magazine" indicates over half of respondents believe 1000-2000 pounds of salt per acre of parking lot (1450-3000 pounds per lane mile) is necessary to achieve acceptable results (Snow Magazine, October 2012). This application rate may reflect a marketing scheme as contractors may sell their services by claiming very high applications rates. Most customers are concerned primarily with slip and fall liability. Thus, a ton of salt per acre becomes the standard that customers believe they need to protect against lawsuits. Nevertheless, commercial applications of deicing salt are a substantive part of the chloride load in the Yahara Lakes basin.

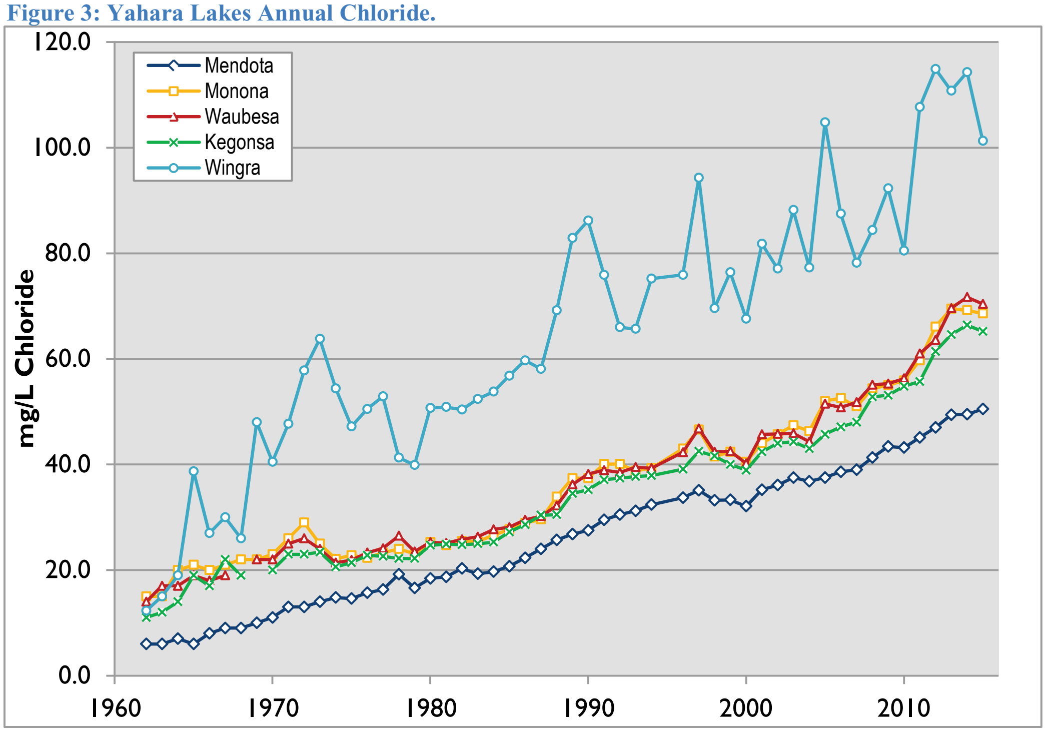
Chloride Trends

Yahara Lakes

Chloride concentrations in 1919 in Lakes Mendota and Monona were 3 and 6 mg/L respectively. 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 Sewerage 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 (see Figure 3). 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 3: Yahara Lakes Annual Chloride.



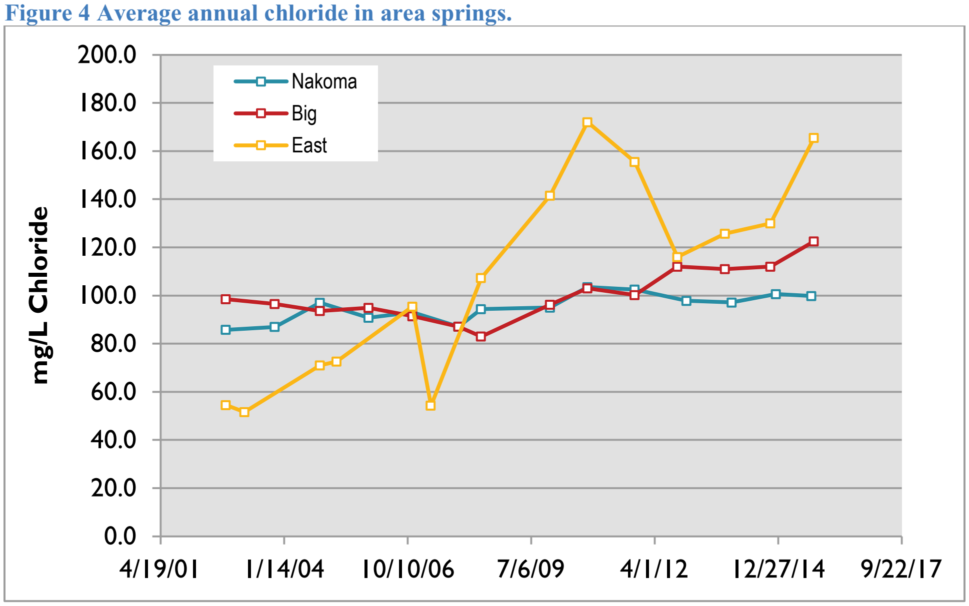
Small Surface Waters

Although Public Health Madison and Dane County (PHMDC) chloride monitoring is designed to capture base-flow conditions rather than the extremes associated with runoff or melt water, 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. Starkweather Creek also experiences regular spikes in chloride above the Chronic Toxicity Criterion. The only toxicity criterion exceedences recorded in the past year occurred in Starkweather Creek at Ivy Street on December 10, 2014 and January 28, 2015, with chloride at 464 mg/L and 440 mg/L, respectively.

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 2002. See Figure 6 at the end of this document for more spring chloride data.

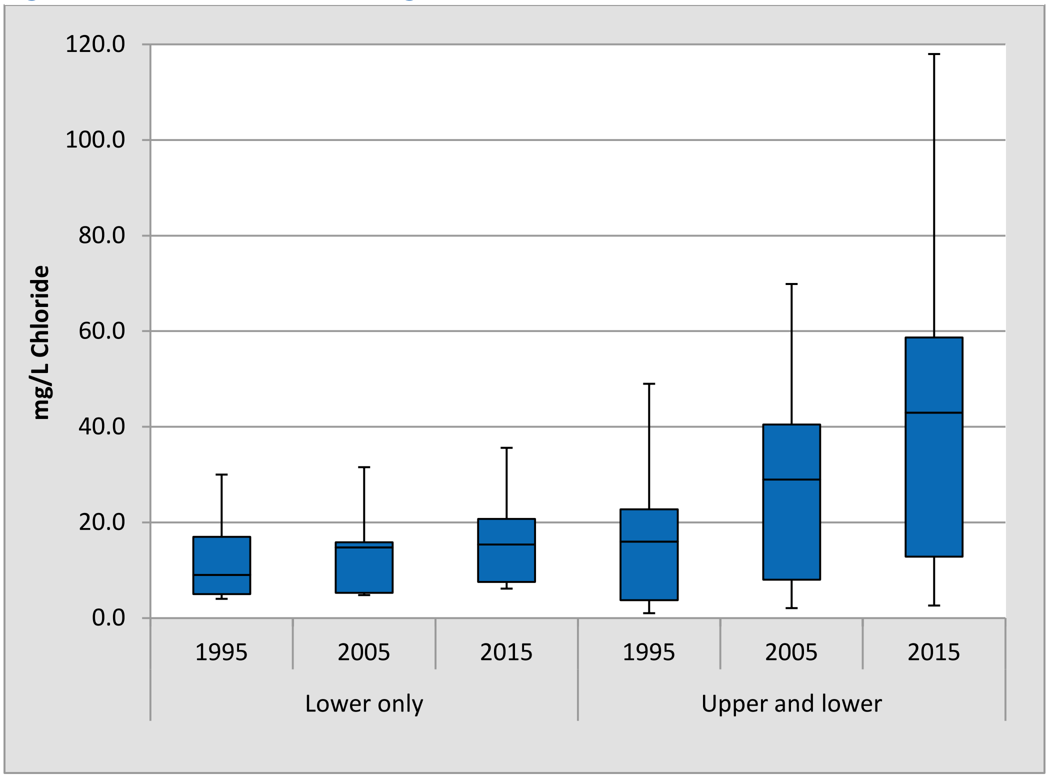
Figure 4 Average annual chloride in area springs.



Road salt applications 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 and the upper and lower edges of the box represent the 75th and 25th percentile, respectively.

Sodium is also increasing in our drinking water, although at a slower rate than chloride. Average sodium content has risen from 6.5 mg/L to 12.0 mg/L in the past 20 years. Current median and maximum levels are 7.9 mg/L and 41.7 mg/L, respectively.

Figure 5: Chloride in Madison Drinking Water.



Summary

Road salt use began in earnest in the 1960s. Within ten years, calls for reducing road salt applications had begun. However the convenience of bare pavement conditions and the increasing efficiencies of road maintenance agencies have fueled motorists' expectations for clear roadways. Although deicing with road salt was seen as a panacea for winter road maintenance for just a few years, the legacy of this belief will be long-lived.

Road salt use has markedly increased chloride levels in area lakes. Local creeks and marshes are strongly affected by seasonal spikes in chloride. Some shallow groundwater has become a chloride sink, slowly releasing elevated chloride to surface waters. Finally, and perhaps most importantly, road salt use has increased sodium and chloride levels in our drinking water.

Current levels of salt use cannot be sustained without degrading our drinking and surface waters. Forty years of salt use reduction efforts have not produced meaningful results, but there are signs of progress. The detrimental effects of road salt are now widely recognized. Practical, user-level information is becoming commonplace. Madison is exploring salt reduction options in well recharge zones, too. Surely, these are positive steps toward reducing the negative impacts of deicing salt.

Acknowledgements:
Kathy Lake, Madison Metropolitan Sewage District
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Joe Grande, Madison Water Utility

References

Wisconsin Department of Transportation, 2012. Highway Maintenance Manual
Snow Magazine, October 2012. Readers Poll

Appendix

Figure 6: Chloride in Dane County springs. Circle diameter increases proportionally to chloride concentration.

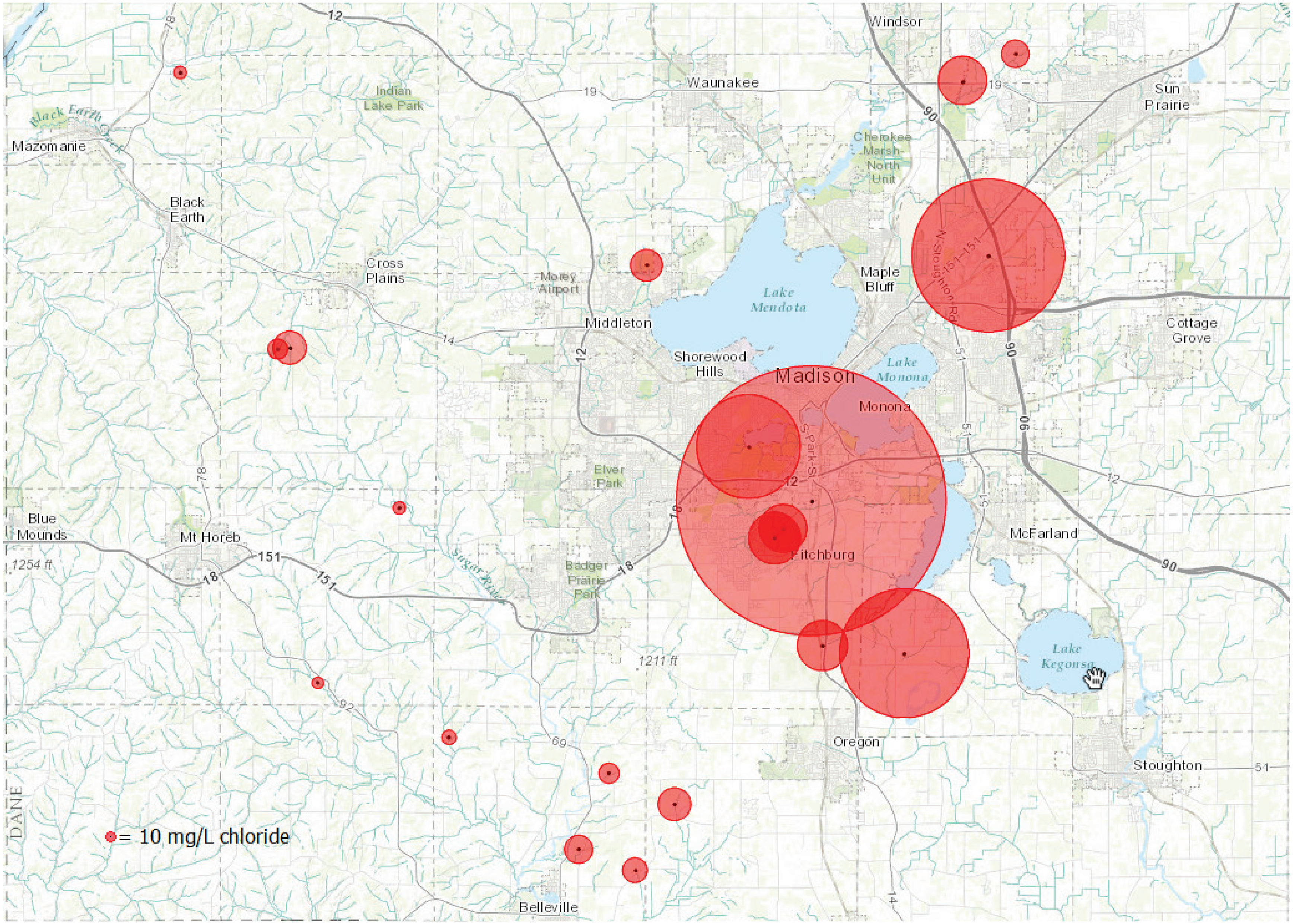

Table 1: Dane County spring chloride levels and geocodes.

Site Description	Date	Cl^- mg/L	Latitude	Longitude
Spring near County Hwy D (Town of Montrose)	8/20/14	25.7	42.87711556520	-89.49040151520
Spring near Remy Rd. (Town of Montrose)	8/20/14	27.7	42.88567516310	-89.52162574440
Spring near Storytown Rd. (Town of Oregon)	8/20/14	32.0	42.90386555610	-89.46884683200
Spring near Vinney St. (Town of Montrose)	8/28/14	18.5	42.91641618620	-89.50506143700
Spring near Fritz Rd. (Town of Montrose)	8/28/14	14.9	42.93085373100	-89.59328482020
Mt. Vernon Creek – Donald Park Big Spring	8/11/14	12.6	42.95288260020	-89.66563564230
Spring near Sand Hill Rd. (Town of Dunn)	9/3/14	143.0	42.96444883090	-89.34235838240
Spring near US Hwy 14 (City of Fitchburg)	9/4/14	56.0	42.96789025670	-89.38724344580
Nine Springs Creek – Big Spring	8/6/14	58.2	43.01127180470	-89.41370995600
Nine Springs Creek – Nursery Spring (channel boil)	8/6/14	51.8	43.01460188150	-89.40872900290
Spring near County Hwy J (Town of Springdale)	8/27/14	13.6	43.02326028850	-89.62071130590
Nine Springs Creek – North Spring	8/7/14	302.0	43.02596263260	-89.39301122000
UW Arboretum – Big Spring	8/7/14	117.0	43.04781804410	-89.42795891950
UW Arboretum – Duck Pond spring	8/7/14	95.5	43.05005205190	-89.43683264150
UW Arboretum – Ho Nee Um Pond spring	8/11/14	104.0	43.05410863660	-89.43177294290
Garfoot Creek spring near Garfoot Rd.	8/14/14	21.2	43.08732633400	-89.68755569050
Garfoot Creek spring near Barlow Rd.	8/14/14	40.1	43.08774374680	-89.68068713450
Pheasant Branch – Frederick Springs (upstream outcropping)	8/11/14	31.3	43.12112237830	-89.48407141440
Spring south of East Springs Dr. (City of Madison)	8/21/14	165.0	43.12474622050	-89.29568756350
Token Creek Recreational Area spring near State Hwy 19	8/13/14	51.8	43.19482087810	-89.30989009390
Spring near Wilkinson Rd. (Town of Mazomanie)	8/27/14	13.4	43.19845438930	-89.74132446980
Token Creek – Culver Springs (north spring left branch)	8/13/14	27.6	43.20609771610	-89.28074545700
Lodi Marsh Wildlife Area spring near Lee Rd.	8/13/14	14.6	43.27379194500	-89.56715174850

Figure 7: Madison/Dane County salt use.

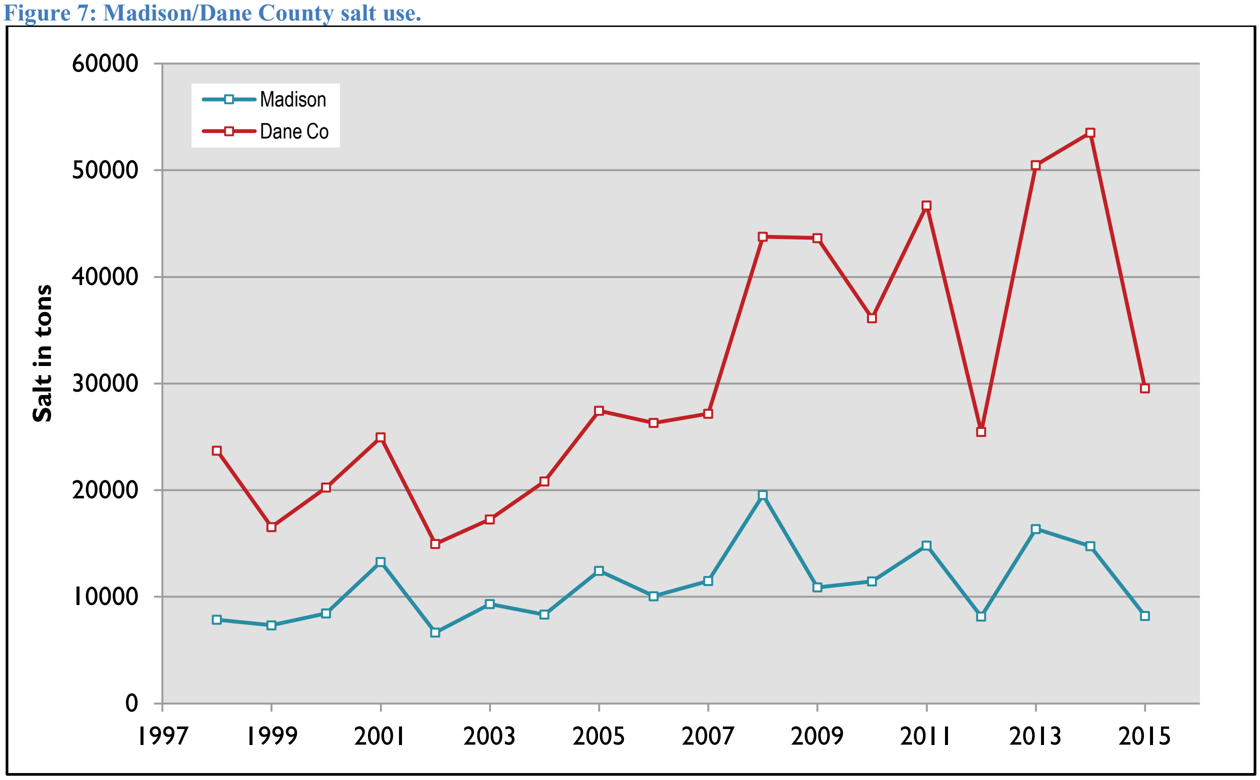

Table 2: Madison/Dane County salt use

Season	Salt in tons	
	Madison	Dane County
1997-1998	7,857	23,709
1998-1999	7,328	16,541
1999-2000	8,448	20,254
2000-2001	13,267	24,964
2001-2002	6,655	14,961
2002-2003	9,326	17,263
2003-2004	8,344	20,824
2004-2005	12,440	27,452
2005-2006	10,057	26,314
2006-2007	11,486	27,171
2007-2008	19,556	43,773
2008-2009	10,889	43,643
2009-2010	11,450	36,131
2010-2011	14,809	46,706
2011-2012	8,156	25,469
2012-2013	16,359	50,488
2013-2014	14,756	53,531
2014-2015	8,209	29,554