

## City of Madison Road Salt Report – 2003–2004

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### Summary

Winter road maintenance in Madison is critical and the application of road salt is an important tool in the maintenance process. However, the overuse of road salt can negatively impact the environment. For this reason, the Madison Common Council implemented a plan to reduce the use of road salt in the City of Madison to 50% of the amount used in the winter of 1972–73. In the winter of 2003–04, there was a 3% decrease in road salt applied over 1972–1973, after correcting for the increase in miles of roads maintained. 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. These surges have the potential of harming fish and other aquatic organisms as they enter local lakes and rivers. Additional efforts to reduce road salt applications are needed if Madison is going to achieve the goals set in the 1970's. It is also important to expand salt reduction efforts to neighboring communities and private properties in order to reduce the sodium and chloride inputs to surface and groundwater resources.

### Historical Background

The City of Madison began recording use of sodium chloride (road salt) as a street deicer in the winter of 1959–60. In 1962, the Madison Common Council requested that the Madison Department of Public Health (MDPH) begin a study of the effects of road salt on surface waters in the Madison area. At that time, the environmental effects of chemical deicers were found to be minimal.

In 1973, the Madison Common Council implemented a plan to reduce the use of road salt in the Lake Wingra watershed to 50% of the amount used in the winter of 1972–73. As part of this plan, the Council renewed MDPH's charge to monitor and analyze the effects of road salt use. In the winter of 1977–78, the 50% salt use reduction objective was extended to include the entire City and MDPH was directed to submit an annual salt report to the Madison Common Council.

### Introduction

Road salt is an important tool for winter road maintenance. Madison Streets Division's winter road maintenance program includes plowing, spreading abrasives

(sand), and spreading deicing chemicals (road salt). Madison uses sodium chloride for deicing because it is readily available, inexpensive, and effective. The primary factors considered by Streets personnel when making decisions about winter road maintenance are ice conditions and traffic safety. In 2003–04, the Streets Division was responsible for maintaining 732 street miles of roads and highways in Madison.

The communities surrounding Madison also apply road salt in the process of winter road maintenance. The Dane County Highway Department maintains County roads and highways and contracts with the Wisconsin Department of Transportation for maintenance of the Beltline and interstate highways. Dane County salts an estimated 2700 lane miles (roughly equivalent to 1000 street miles) of county roads and highways. The salted area covered by private applicators is unknown.

Although road salt plays an important role in assuring transportation safety, it also poses a significant environmental health concern. Water from snow and ice melt carries dissolved road salt into lakes and streams through stormwater runoff and into groundwater through water seepage. Because chloride ions from dissolved road salt are not removed from water by chemical or biological processes, all of the chloride applied as road salt is expected to reach surface water or groundwater. Dissolved sodium also moves easily in the environment although some sodium ions will be adsorbed by the soil. At sufficient concentrations, these chemicals may have toxic effects on plants and fish. If these chemicals seep into our deep groundwater reservoirs, our drinking water quality is also at risk. The following report provides the most recent assessment of Madison's road salt use on the environment.

### Monitoring Results

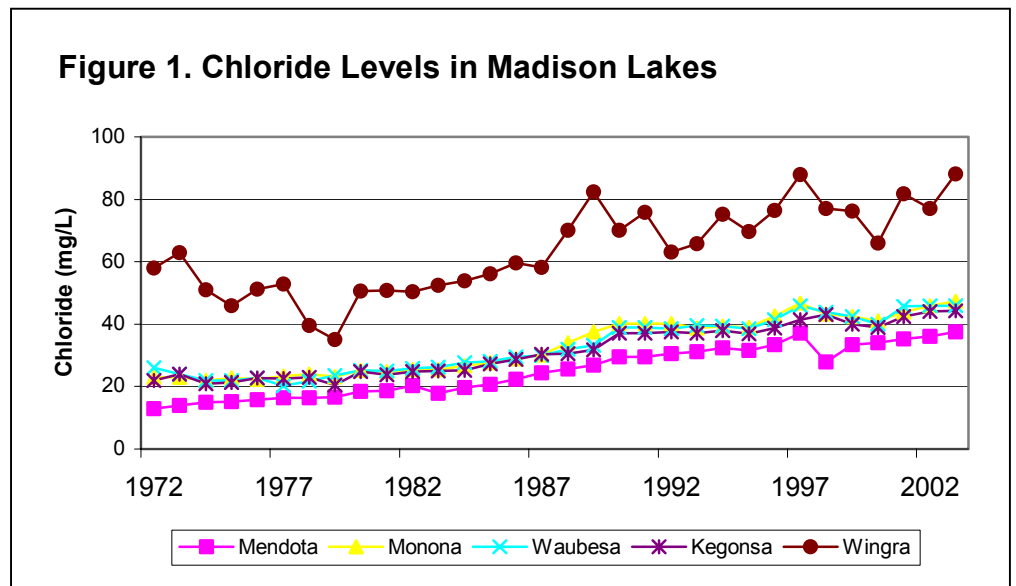
During the winter of 2003–04, 7853 tons of salt and 4909 tons of sand were applied in the process of maintaining 732 miles of Madison streets (Table 1). Because new streets are built every year, measuring progress towards meeting the 50% reduction goal should include the amount of street area maintained. In the winter of 1972–73, 11.1 tons of salt were applied per mile of street maintained. In 2003–04, 10.73 tons of salt per mile of street maintained were applied, representing a 3% decrease. Over the last 10 years, changes in salt application rates have ranged from a 19% reduction in 2001–02 to a 59% increase in 2000–01. The winter of 1984–85 was the last winter that salt use was reduced by 50% or more from 1972–73 rates. The amount of road salt added to the environment by individuals and agencies other than the City of Madison is unknown. Municipalities and agencies in Dane County purchased 36,470 cubic yards (approximately 40,116 tons) of road salt (including the salt portion of sand salt mixtures) for the 2003–04 winter season (Table 2). If all of

this salt were applied during the season, it would be five times the amount applied by the City of Madison. The amount of salt applied to private property, both commercial and residential, may be large. However, Department efforts to collect data on the amount of salt used in these areas have been unsuccessful.

Levels of chloride in Madison’s drinking water are lower than the Wisconsin Department of Natural Resources Preventive Action Limit (PAL) of 125 mg/L (Table 3). With the exception of well 27, the wells listed in Table 3 show small annual increases in sodium and chloride levels. Over time, these small increases have added up to significant increases of these chemicals in drinking water. Between 1975 and 2003, chloride in Well No.6 has increased 235%. Chloride in Well No.10 has increased 340% and Well No.17 shows a 347% increase in chloride levels. Sodium has increased less dramatically over this time period. The average sodium levels in our drinking water range from 2.5 to more than 14 mg/L in active wells. However, levels in excess of 20 mg/L have been detected in well 17. The US EPA has set the health-based drinking water guideline at 20 mg/L to protect individuals on sodium-restricted diets (500 mg sodium/day).

Chloride concentrations in Madison springs, fed by shallow groundwater, are two to four times higher than the concentrations found in impacted drinking water wells, which tap the deep groundwater aquifer (Table 4). These levels are consistent with levels observed in previous studies by Edgewood College students and members of the Friends of Lake Wingra.

The long-term trends in chloride and sodium levels in the local surface waters continue to exhibit gradual

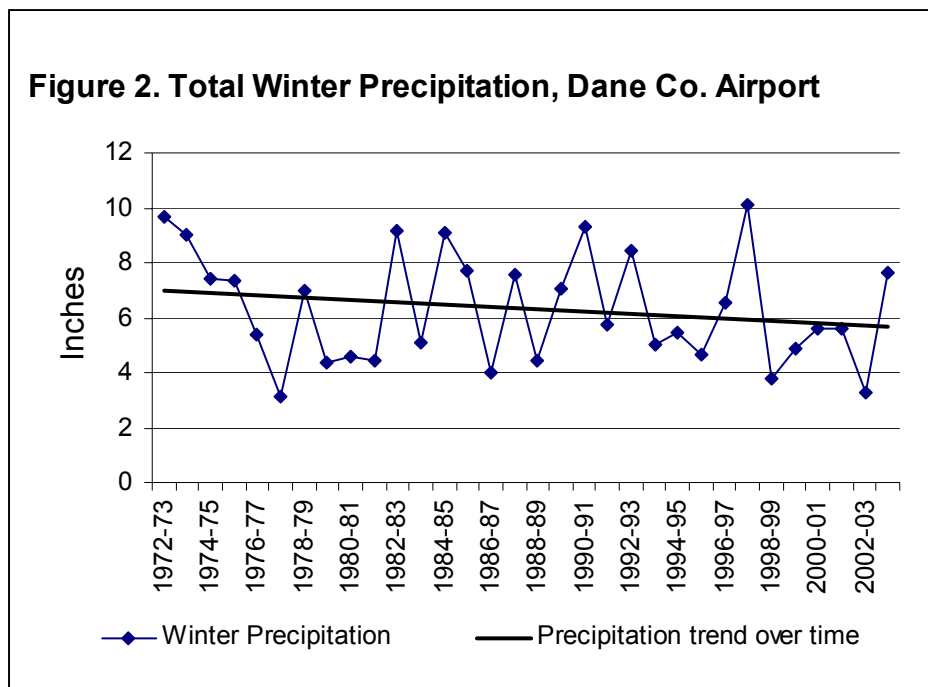


increases. However, these chloride levels have not yet exceeded Wisconsin Department of Natural Resources (WDNR) standards for chronic or acute toxicity, 395 mg/L and 757 mg/L respectively. This suggests that these surface waters, while impacted by past deicing activities, are not yet at toxic levels (Tables 5 and 8 and

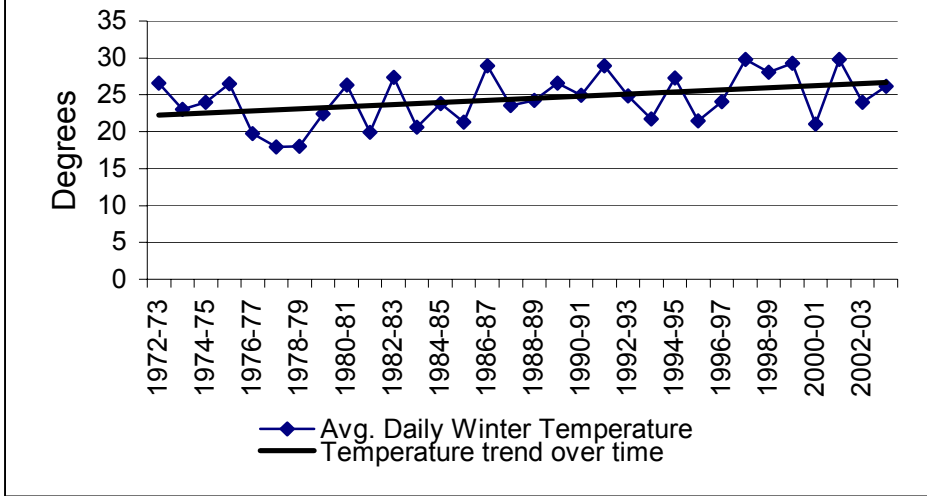
Figure 1). Small water bodies such as Lake Wingra and mid-size lakes such as Lake Monona that drain large urbanized areas are more sensitive to the impacts of road salt than larger Lake Mendota.

Routine monitoring, performed during dry periods, has shown steadily increasing concentrations of these chemicals; however, water analysis of storm water entering the lakes has shown extreme spikes in chloride concentrations. During the winters of 2002–03 and 2003–04, the USGS monitored specific conductance continuously in two locations, the Spring Harbor stormsewer and along Starkweather Creek. In Spring Harbor stormsewer, estimated chloride levels based on specific conductance ranged from 100 to 36,000 mg/L. The estimated total amount of chloride entering the stormsewer at Spring Harbor between January and April was 0.140 metric tons (0.23 tons of salt) in 2003 and 0.190 tons (0.29 tons of salt) in 2004. This stormsewer discharges directly into Lake Mendota. During a snowmelt event in February 2003, estimated chloride concentrations in Spring Harbor near the storm sewer outfall reached 1700 mg/L under the ice and 3300 mg/L near the bottom. With an increasing distance from the outfall, estimated chloride concentrations were diluted to 320 mg/L under ice and 920 mg/L near the bottom (Table 6). Estimated chloride concentrations within the Spring Harbor stormsewer at this time ranged from 19,000 to 20,000 mg/L. Estimated chloride concentrations at the Starkweather Creek monitoring location ranged from about 50 to 1500 mg/L during the winter of 2004 (Table 6).

Data available from the Wisconsin State Climatology Office suggest that winters have become milder since the winter of 1972–1973. The total amount of winter precipitation has decreased during this period; however, none of the recorded totals were significantly different from the mean of



**Figure 3. Average Daily Winter Temperature, Dane Co. Airport**



6.3” of winter precipitation (Figure 2). Winter precipitation is defined as all precipitation received during the months of December through March. Snow and ice are included in this measure after being melted to liquid water. Since 1972-

73, the average daily temperature recorded from December through March has increased although not significantly (Figure 3).

Discussion

Although the total amount of salt applied has increased over time, we have also seen an increase in the miles of streets being maintained. Our current measure to account for the quantity of street maintained, street miles, might overestimate the application rate because it does not take into account the number of lanes each street represents. Because there has been a considerable change in the number of multi-lane streets in Madison, this may be significant. However, the number of lane miles maintained is not available at this time. Using the best measure available, tons of salt applied per street mile, and considering the increasing mildness of winters in Madison, the goal set by the Madison Common Council in 1973 is not being achieved.

In addition to Madison street deicing, Madison’s water resources are impacted by deicing activities that occur in the communities surrounding the City as well as on private property within the City. Only 30% of the of the total area drained by the Yahara River north of Lake Waubesa lies within the City of Madison. However, efforts to quantify the amount of salt applied in these areas have been mostly unsuccessful. Table 2 shows that agencies maintaining streets and highways around Madison purchased over five times the salt that was applied in Madison. However, there is no information on how much of this road salt was applied during the winter. In the case of private property, there is no data on the amount of deicing salt applied to driveways, sidewalks, and parking lots. Due to the large size and increasing development of

parking lots associated with shopping centers, road salt applications on parking lots may be a significant portion of the total application of road salt in Madison.

Levels of chloride and sodium in Madison groundwater and surface water continue to be within the regulatory limits and are not a human health hazard at this time. The only exception to this statement is the sodium level found in drinking water well #17. As shown in Table 3, the water from this well has exceeded the US EPA guidance value (non-enforceable) for sodium in the past. While the presence of elevated sodium in this well was higher than desired, it is not considered to be a human health hazard and the last two years has shown acceptable levels of sodium in this well.

A pilot study conducted by the USGS and MDPH has measured specific conductance and subsequently estimated chloride concentrations as high as 36,000 mg/L in stormwater runoff discharging directly into Lake Mendota. This translates to 59,000 mg/L of salt, which is 69% higher than the concentration of salt in seawater (Table 7). The receiving water in Lake Mendota as well as Starkweather Creek also exhibited high chloride concentrations during a snowmelt event, exceeding the chronic and acute toxicity levels set by the Wisconsin DNR for chloride. These extreme levels of chloride in storm runoff may exert severe short-term adverse effects on aquatic organisms and biological diversity, particularly in low-dilution aquatic systems. Canadian researchers have estimated that 5 percent of aquatic species would be affected at chloride concentrations of about 210 mg/L, and 10 percent of species would be affected at chloride concentrations of about 240 mg/L. Sensitive algal species are affected at concentrations as low as 10 to 20 mg/L of chloride (Environment Canada, 1999).

High levels of chloride, due to dissolved road salt, in snow and ice melt is toxic to a variety of grasses, flowering plants and trees (terrestrial plants). For this reason, the Salt Institute cautions against the overuse of salt for deicing on sidewalks and driveways. Studies have shown that vegetation along heavily salted roads is negatively impacted by dissolved road salt when it seeps into soils or is splashed directly onto the plant. While these effects are known, the Madison Department of Public Health has not received complaints from owners or managers of properties where grass, flowering plants or trees have been damaged by excessive salt applications. The Department's monitoring effort does not include the measurement of dissolved road salt in soils or on vegetation near streets receiving road salt. Without complaints or monitoring data, this report is unable to assess the impact of road salt on terrestrial plants in Madison.

## Conclusions

The data presented in this report suggest that additional efforts are needed if the City expects to achieve the road salt use goals set in the 1970's. As recently as the winter of 2001-02, the City realized an 18.6% reduction in salt use, which indicates that increased efforts may not need to be dramatic. However, an increased effort is necessary due to the fact that surface water and groundwater monitoring shows increasing levels of chloride and sodium in Madison's drinking water, lakes, and rivers. While levels do not yet pose a human health hazard, salt concentrations in storm water are high enough to potentially cause changes in the aquatic and terrestrial biota favoring halophilic species. In addition to reducing salt use on Madison streets, additional actions to consider include:

- Quantify the street lane miles salted within the City using existing geographic information system (GIS) data and aerial photography. This would be especially useful if the lane miles maintained in 1972-73 could also be estimated.
- Continue to evaluate deicing alternatives.
- Work with communities surrounding Madison to adopt salt reduction plans.
- Provide educational information to private property owners, especially businesses with large parking lots.
- Work to better estimate the total salt used on all property in the City of Madison and other communities in the Yahara River watershed.

## References:

Environment Canada, 1999. Priority Substances List Assessment Report. Road Salts  
Canadian Environmental Protection Agency.

## Acknowledgements:

Abdiel Galindo, Madison Department of Public Health, was instrumental in compiling the road salt application and water monitoring data presented in this report. He has also performed a significant amount of the research that laid the foundation of this report.

The following individuals and agencies provided the data presented in this report:

Lyle Anderson, WI State Climatology Office  
Alan Schumacher, Madison Streets Division  
Dane County Public Works  
Steve Corsi, The US Geological Survey

**Table 1. Madison Street Division Salt/Sand Usage 1972-73 Season to 2003-04**

Year	# Salt Applications	Salt Applied (tons)	Sand Applied (tons)	Streets Maintained (miles)	Salt Applied per Street Mile (tons/mile)	Change from Winter 1972-73			
						Total Salt Applied		Salt Applied per Street Mile	
						(tons)	(%)	(tons)	(%)
1972-73	21	5690	2990	512	11.12	--	--	--	--
1973-74	29	3760	5220	517	7.26	-1930	-34%	-3.86	-35%
1974-75	34	4850	4630	517	9.38	-840	-15%	-1.74	-16%
<b>1975-76</b>	<b>27</b>	<b>2490</b>	<b>5140</b>	<b>525</b>	4.73	<b>-3210</b>	<b>-56%</b>	-6.39	-57%
<b>1976-77</b>	<b>24</b>	<b>1520</b>	<b>5700</b>	<b>529</b>	2.87	<b>-4170</b>	<b>-73%</b>	-8.25	-74%
<b>1977-78</b>	<b>20</b>	<b>2280</b>	<b>8930</b>	<b>538</b>	4.23	<b>-3420</b>	<b>-60%</b>	-6.89	-62%
1978-79	27	3280	8460	548	5.99	-2410	-42%	-5.12	-46%
<b>1979-80</b>	<b>21</b>	<b>2680</b>	<b>4940</b>	<b>558</b>	4.81	<b>-3010</b>	<b>-53%</b>	-6.31	-57%
<b>1980-81</b>	<b>20</b>	<b>1620</b>	<b>5800</b>	<b>563</b>	2.88	<b>-4070</b>	<b>-72%</b>	-8.24	-74%
1981-82	24	4010	7540	565	7.09	-1680	-30%	-4.03	-36%
1982-83	23	2890	3480	568	5.09	-2800	-49%	-6.03	-54%
1983-84	23	4980	6180	552	9.02	-710	-13%	-2.10	-19%
<b>1984-85</b>	<b>20</b>	<b>2900</b>	<b>4260</b>	<b>568</b>	<b>5.10</b>	<b>-2790</b>	<b>-49%</b>	<b>-6.02</b>	<b>-54%</b>
1985-86	30	5570	8730	561	9.93	-120	-2%	-1.18	-11%
1986-87	16	3270	3010	564	5.80	-2420	-42%	-5.32	-48%
1987-88	23	4490	5370	571	7.87	-1200	-21%	-3.25	-29%
1988-89	23	4390	7060	580	7.57	-1300	-23%	-3.54	-32%
1989-90	23	5600	5800	587	9.54	-90	-2%	-1.58	-14%
1990-91	24	5840	5730	587	9.94	150	3%	-1.18	-11%
1991-92	20	4950	3750	591	8.37	-740	-13%	-2.74	-25%
1992-93	31	7150	4120	595	12.01	1460	26%	0.89	8%
1993-94	27	6820	3950	621	10.99	1130	20%	-0.13	-1%
1994-95	28	5910	4200	628	9.41	220	4%	-1.70	-15%
1995-96	22	8090	7030	632	12.81	2400	42%	1.69	15%
1996-97	35	9860	6120	636	15.51	4170	73%	4.39	39%
1997-98	31	7450	4060	643	11.59	1760	31%	0.47	4%
1998-99	24	6640	6840	655	10.14	950	17%	-0.97	-9%
1999-00	25	7980	4700	655	12.18	2290	40%	1.06	10%
2000-01	28	12485	7818	707	17.66	6796	119%	6.54	59%
2001-02	20	6423	2320	710	9.05	733	13%	-2.07	-19%
2002-03	20	9010	3163	731	12.33	3320	58%	1.21	11%
2003-04	22	7853	4909	732	10.73	2163	38%	-0.39	-3%



**Table 2. Dane County Highway Department & WI DOT Salt Purchases  
for the 2003-04 Winter Season**

<b>Towns</b>	<b>Salt cu. yd.</b>	<b>Salt-Sand Mix cu. yd.</b>
Berry	374.44	0
Black Earth	99	0
Blooming Grove	142	0
Blue Mounds	76	0
Bristol	164.81	0
Burke	689.57	0
Christiana	123.55	0
Cross Plains	408.43	0
Dane	108	0
Dunkirk	77	0
Madison	286.09	0
Mazomanie	32	0
Montrose	184	0
Perry	57.5	0
Pleasant Springs	211.42	0
Primrose	44	0
Roxbury	472.02	0
Rutland	135.5	0
Springdale	155	0
Springfield	330.05	0
Vermont	72	0
Windsor	502.94	0
<b>Cities</b>		
Monona	232	0
Stoughton	721.5	0
<b>Villages</b>		
Black Earth	43	0
Blue Mounds	78.25	0
Cottage Grove	167.5	0
Cross Plains	100	0
Dane	27	0
Maple Bluff	70	0
Mazomanie	17	0
McFarland	558	1
Shorewood Hills	69	5
<b>Agency</b>	<b>Salt cu. yd.</b>	<b>Salt-Sand Mix cu. yd.</b>
Federal agencies	38.5	0
State-various	206	0
UW	572.5	0
Mad Metro Sewer Distr	24	2
Wis Heights School Distr	4.5	0
Stoughton School Distr	38	2
Other County Depts.	355.55	6.5
WisDOT Usage	18,581.50	18
County Highway Usage	9,809.50	11
<b>TOTALS</b>	<b>36,458.62 (40,104 tons)</b>	<b>45.5 (50 tons)</b>

- Treated sand is mixed at a 3:1 ratio, 3 parts sand to 1 part salt.
- One Cubic Yard of Road Salt equals approx 1.1 tons.
- WI Dept. of Transportation maintains interstate and state trunk highways.
- County Highway maintains county trunk highways.
  - Salt usage by municipalities does not reflect their quantity on hand when the season started, purchases from other sources or their season ending inventory, if any (Dawn S. Erickson, Dane Co. Public Works).

**Table 3. Sodium and Chloride History, Selected Madison Water Utility Deep Wells 1975-2003**

	UW 4		UW 6		UW 10		UW 17		UW 26		UW 27	
Year Drilled	1930		1937		1953		1966		1986		1989	
Well Depth (ft)	737		750		1005		800		1175		744 (replaced UW 4)	
Year	Na	Cl	Na	Cl	Na	Cl	Na	Cl	Na	Cl	Na	Cl
1975	28	52	4.6	8.2	2.6	1.0	9.0	13.0				
1976			4.8	9.0	2.3	<1.0	9.2	13.1				
1977			5.0	8.4	2.4	<1.0	11.9	16.7				
1978			5.3	9.5	2.5	1.6	10.0	15.1				
1979			5.0	12.0	2.3	1.4	10.0	18.0				
1980	27.0		5.7	13.7	2.3	1.0	16.1	33.5				
1981	27.0		6.0	14.0	2.4	<1.0	14.0	23.8				
1982	46.0	150.0	6.5	16.0	4.0	<1.0	12.4	22.9				
1983	48.0	115.0	6.8	17.1	2.4	<1.0	14.2	24.8				
1984	46.0	118.0	7.9	18.2	2.6	1.0	13.8	23.6				
1985	45.0	114.0	7.0	13.0	2.8	1.0	14.0	24.0				
1986	45.4	121.0			2.6	1.6	11.9	20.5				
1987	37.3	101.0	6.2	23.8	2.5	3.6	8.6	17.0				
1988	41.9	108.0	8.0	22.4	2.5	2.4	12.9	27.7	1.9	1.1		
1989	46.0	114.0			2.6	3.0	10.7	11.6	1.8	1.0		
1990	44.4	114.0	7.3		2.4	1.1	13.0	28.2	1.9	<0.5		
1991	46.8	96.0	6.8	19.0	2.6	1.6	20.0	46.6	2.1	1.5		
1992	47.7	115.9	6.8	21.5	2.5	1.8	15.3	36.0	2.3	1.6		
1993			7.2	23.0	2.4	3.0	20.1	49.0	2.3	3.0		
1994			7.6	21.9	2.5	1.5	12.8	26.3	2.4	2.1	13.6	33.0
1995			8.0	23.0	2.0	3.0	11.0	21.0	2.0	3.0	12.0	30.0
1996			7.8	24.6	2.5	3.6	21.0	52.8	2.6	3.5	11.0	25.9
1997			7.7	22.7	2.5	2.3	22.0	54.4	2.8	3.7	11.0	24.8
1998			9.4	23.7	2.7	2.2	ND	25.9	3.7	3.8	11.0	23.4
1999			8.0	25.1	2.5	3.8	20.0	49.6	2.9	4.5	10.0	23.1
2000			8.9	25.9	2.5	2.9	23.0	53.5	3.2	4.7	9.6	19.4
2001			9.1	26.3	2.7	4.3	12.0	23.5	3.4	5.5	11.0	22.6
2002			9.4	26.2	2.7	4.4	11.8	23.5	3.7	6.1	11.0	21.8
2003			9.5	27.5	2.8	4.4	25.2	58.1	4.0	6.8	11.7	24.4
<b>Average</b>	<b>41.2</b>	<b>109.9</b>	<b>7.12</b>	<b>19.07</b>	<b>2.56</b>	<b>2.17</b>	<b>14.00</b>	<b>29.44</b>	<b>2.69</b>	<b>3.26</b>	<b>11.19</b>	<b>24.84</b>
<b>Annual change</b>			<b>0.18</b>	<b>0.69</b>	<b>0.01</b>	<b>0.17</b>	<b>0.58</b>	<b>1.61</b>	<b>0.14</b>	<b>0.38</b>	<b>-0.21</b>	<b>0.87</b>

**Table 4. Chloride Levels (mg/L) in Natural Springs**

Sample Site	Arboretum Spring	Monroe Street Spring	East Towne Spring
2001	97	83.75	60.35
2002	98.55	85.75	54.55
2003	96.42	86.96	51.57
<b>Average</b>	<b>97.32</b>	<b>85.49</b>	<b>55.49</b>

**Table 5. Yearly Chloride Values (mg/L) - Madison Area Lakes**

Year	Mendota		Monona		Waubesa		Kegonsa		Wingra	
	Na	Cl	Na	Cl	Na	Cl	Na	Cl	Na	Cl
1972	NA	13	NA	23	NA	26	NA	22	NA	58
1973	NA	14	NA	23	NA	24	NA	24	NA	63
1974	NA	15	NA	22	NA	22	NA	21	NA	51
1975	8.0	15.2	12.8	22.8	12.4	21.9	11.9	21.4	23.5	45.9
1976	7.5	15.7	12.7	22.3	12.9	22.7	12.1	22.8	25.2	51.3
1977	8.9	16.3	13.5	23.3	13.1	20.2	12.8	22.6	25.2	52.9
1978	8.8	16.3	13.3	24.0	12.4	21.8	11.4	22.9	19.5	39.6
1979	8.4	16.6	11.8	23.1	12.4	23.5	11.4	20.5	19.9	35
1980	9.0	18.4	13.6	25.3	12.3	25.3	12.7	24.7	23.9	50.7
1981	9.1	18.7	13.0	24.7	12.8	25.1	12.5	23.7	23.6	50.9
1982	10.1	20.3	13.7	25.5	13.4	25.8	12.4	24.8	24	50.4
1983	9.9	17.8	13.8	25.4	13.8	26.3	12.7	25.0	24.4	52.4
1984	10.0	19.7	14.8	26.6	14.7	27.7	13.1	25.3	25.8	53.8
1985	11.3	20.7	15.7	27.7	15	28.1	14.3	27.2	29.6	56.2
1986	10.8	22.3	15.1	28.9	14.8	29.5	14.3	28.6	27.5	59.7
1987	9.7	24.3	12.9	30.1	12.9	29.9	12.4	30.4	22.7	58.1
1988	11.1	25.7	15.6	34	14.6	32	13.1	30.5	29.8	70.1
1989	11.7	26.8	17.4	37.4	16.9	33.1	15.4	31.7	38.2	82.3
1990	12.7	29.5	18.8	40.1	17.9	38.9	16.5	37.1	31.2	70.1
1991	12.7	29.5	18.8	40.1	18.1	38.9	16.7	37.1	31.2	75.9
1992	12.1	30.5	19.2	40.1	18.8	38.5	17.3	37.4	31.1	63.2
1993	13.5	31.2	19.0	38.8	19.4	39.5	18.1	37.0	31.3	65.7
1994	12.9	32.4	16.9	39.3	17.1	39.3	16.2	37.9	31.4	75.2
1995	13.4	31.5	17.8	39	17.3	38.6	16.3	36.9	31.5	69.7
1996	14.1	33.4	18.8	42.7	18.8	41.4	17.5	38.8	33.9	76.5
1997	15.6	37.0	21.2	46.7	19.9	46.0	17.9	41.3	41.3	87.9
1998	15.9	33.4	22.7	43.3	23.1	43.9	21.8	43.1	39.6	77.0
1999	22.7	33.3	23.0	42.5	23.9	42.5	22.5	40.0	36.4	76.2
2000	15.0	34.0	20.0	41.0	20.0	40.0	19.0	39.0	31.0	66.0
2001	15.9	35.2	22.2	43.9	22.4	45.7	20.4	42.4	39.2	81.8
2002	16.0	36.0	22.0	46.0	22.0	46.0	21.0	44.0	37.0	77.0
2003	16.7	37.5	23.4	47.4	22.6	45.9	21.1	44.3	41.5	88.2

NA = Data not available

**Table 6. Summary of Continuous Monitoring from Spring Harbor and Starkweather Creek**

	Spring Harbor Stormsewer		Starkweather Creek
	Maximum Concentration	Total Amount in Stormsewer	Maximum Concentration
		January - April	
	mg/L Chloride	tons Chloride	mg/L Chloride
2003	26,000	0.14	
2004	36,000	0.18	1500
<b>Chloride in Lake Mendota at Spring Harbor February 1 &amp; 2, 2003</b>			
	Spring Harbor	Acute toxicity*	Chronic Toxicity*
	mg/L Chloride		
Under Ice	320 - 1700	757	395
Near Bottom	920 - 3300		

\* = WI Admin. Code NR 105 Water Quality Criteria

**Table 7. Varied Source Comparisons of Salt Concentrations**

Sources of Water	Salt Concentrations mg/L.
Distilled	0
Rain	10
Pyramid Lake (saline lake, Nevada)	5,200
Ocean	35,000
Brine Well	125,000
Dead Sea	250,000

**Table 8. Chloride Concentration Increases (mg/L) Madison Area Lakes from Salt Reduction Base Year 1972 to 2003**

Area Lake	1972-73 Cl (mg/L)	2003 Cl (mg/L)	% Increase
Mendota	14	37.5	<b>168</b>
Monona	23	47.4	<b>106</b>
Waubesa	24	45.9	<b>91</b>
Kegonsa	24	44.3	<b>85</b>
<b>Average of Yahara Lakes</b>	<b>21</b>	<b>43.8</b>	<b>109</b>
Wingra	63	88.2	<b>40</b>