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Inventory of Road Salt Use in the Minneapolis/St.Paul Metropolitan Area

by

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Abstract

In the northern regions of the U.S. and in Canada a water contaminant of increasing concern is chloride. The source of chloride contamination is mostly sodium chloride (NaCl) which is used in large quantities for road de-icing and for water softening. Chloride enters into the environment easily in snowmelt runoff and in wastewater treatment plant discharges. Because it is a fairly conservative material it can travel long distances without assimilation. It affects the quality of aquatic ecosystems. Because of its adverse effects on plants and aquatic animals, MPCA standards of 230mg/L and 800 mg/L have been set for chronic and acute exposure.

The Twin Cities Metropolitan Area (TCMA) is one of the regions where salt is used for winter road maintenance and for water softening. The TCMA is an urbanized area with a population of about 2.7 million people. It is located at about 45^{o}N latitude and has a reputation of cold and long winters. The TCMA is traversed by the Mississippi River and several of its tributaries, and claims to have 949 lakes within its seven counties and over 186 cities and townships. There are over 26,000 lane miles of roadways with impervious surfaces in the TCMA.

In this report an inventory of the amount of road salt (NaCl) applied in the TCMA each year is given. This study was not aimed at evaluating the effectiveness, suitability or cost of using NaCl as a de-icer. In addition to the total amounts of salt used, it is of interest to identify and quantify the metrics that determine the rates of road salt application. The spatial and temporal scales will be large enough so that the results of this study can be compared to other regions in northern climates.

Many sources of information regarding the use of road salt in the TCMA and the state of Minnesota were consulted. In the TCMA, most municipalities and counties purchase salt through contracts offered by the Material Management Division (MMD) of the state of Minnesota. The average amount of reported salt use per winter season (2001 to 2006) was 236,800 tons per year and varied between 243,000 and 274,000 tons per year. Relative to the sum of the contract amounts, the actual reported use was on average 93% for the TCMA.

Not all municipalities participate in the MMD contract or keep track of the actual road salt applications. The amount of road salt used by municipalities without information was estimated based on a per capita road salt use rate of 0.045 tons per season per person. The rate was determined from the reported road salt use in the TCMA covering about 90% of the population.

Application of road salt (NaCl) by public agencies (state, county, municipal) is just one portion of the total salt use for winter road maintenance. Commercial contractors are responsible for the de-icing of school and private parking lots and driveways, shopping mall and other commercial areas, and in some cases, township road maintenance. The number of commercial contractors and their road salt use in the TCMA could not be easily identified. To estimate the commercial salt use in the TCMA, market share amounts were used. The market share is the percentage of road salt

production and sale to the commercial sector. Since the TCMA matches national trends with regard to population growth and salt purchases, average market share values of 13% and 20% were assessed using values by the U.S. Geological Survey and the Salt Institute, respectively. The U.S. Geological Survey (USGS) publishes a yearly minerals report, which contains this information. The Salt Institute (SI), an organization comprised of salt distributors, also publishes a national market share estimate annually. The Salt Institute value of 20% was used to determine the commercial use of road salt in the TCMA. The resulting amount of salt use was approximately 66,000 tons per year.

The total amount of NaCl applied to roads in the TCMA per season is estimated at 349,000 tons per year. The breakdown is: cities at 33%, Mn/DOT at 23%, counties at 21%, commercial outfits (bulk) at 16%, and others at 5%.

Other metrics besides population that correlate with the amount of road salt use on long timescales include road miles and climate. At short timescales salt application is related to the number of days with snowfall, i.e. weather. Trends in the use of road salt were found to have a strong correlation with population, and length of roads in the region. These two parameters are useful to estimate the spatial distribution of road salt use. On a long timescale (decades), population is the main indicator of road salt use. The per capita use in the TCMA in the last decade has been on the order of 0.045 tons per person per season.

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1. Introduction

Natural sources of salt (NaCl) in the environment include bedrock weathering and atmospheric additions. The latter is attributed to sea spray and can be disregarded for a mid-continent location. Along with the natural addition of NaCl through the hydrologic cycle, anthropogenic sources of salt (NaCl) in the environment include road salt, household uses (water softening), industrial and agricultural uses. Anthropogenic sources have been identified to have a high or dominant influence on chloride loadings in lakes where these activities take place within the watershed (Evans, M. and C. Frick. 2002).

Salt has been widely used for ice and snow control on roads in the US, Canada and other parts of the world affected by adverse winter driving conditions. The primary product used in North America for deicing is sodium chloride (NaCl), a readily available and inexpensive product that provides adequate treatment to roadways under winter conditions. In the spring, road salt dissolved in the runoff from roadways and parking lots and enters ditches, streams or storm sewers. In metropolitan areas a large portion of the storm sewers drain into streams, rivers, lakes and detention ponds.

One goal of this study was to determine the annual amount of road salt currently imported and used in the Minneapolis/St.Paul Twin Cities Metropolitan Area (TCMA). Another goal was to determine the variables and the relationships that this use depends on.

2. Study Area

The Twin Cities Metropolitan Area in Minnesota (Figure 2.1) is home to 2.7 million people in 186 cities and townships. There are 949 lakes and 49 regional parks within the region. The Metro area encompasses the seven counties of Anoka, Carver, Dakota, Hennepin, Ramsey, Scott and Washington (Met Council). There are over 26,000 lane miles of roadways with impervious surfaces in the area, maintained by state, counties and municipalities (Mn/DOT - TIS). Interstate routes I35 and I94 pass through the area and are used extensively for the transport of goods and by daily commuters living or working in outer ring communities. Since the TCMA lies within the snow belt of North America, winter travel is a safety and economic concern for citizens and government officials. Nearly 12 million dollars are spent on road deicing products, mostly NaCl, by public agencies in Minnesota every year. This does not include any costs associated with equipment, maintenance or personnel.

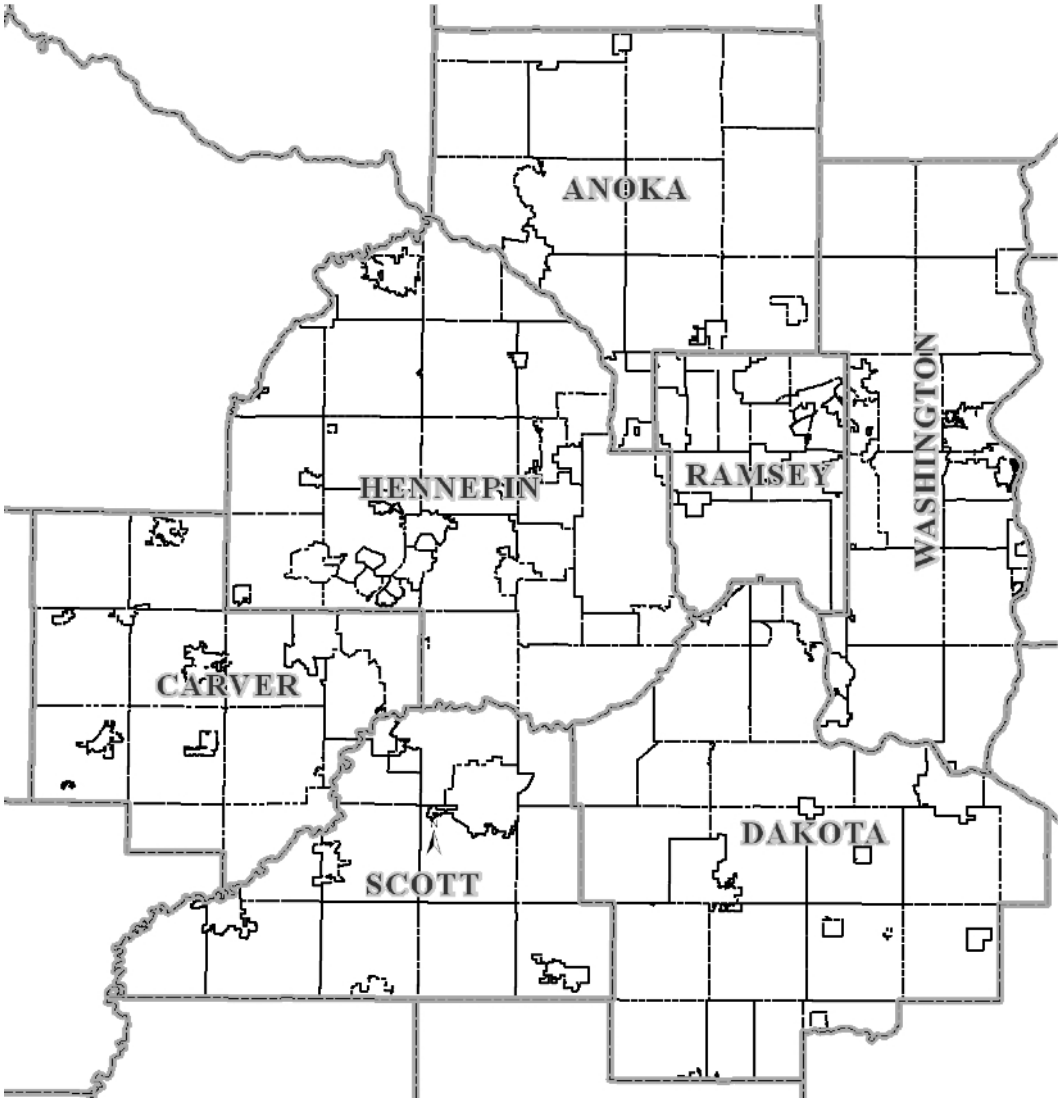

Figure 2.1 Map of the Twin Cities Metropolitan Area. (Metropolitan Council)

The salt that is applied to roadways can be transported to three final destinations: atmosphere, surface water bodies such as lakes and wetlands, and groundwater. The residuals that enter the atmosphere are believed to be very small as the method of transport by air is less dominant than that by water. Also once dissolved in water the chloride will remain there and not diffuse into the air due to its non volatile nature. Runoff entering ditches enters the soil through infiltration or is carried through the drainage system if there is a sufficient amount of runoff. Runoff that is carried through storm sewers or ditches is routed to detention ponds, wetlands, lakes and rivers. In urban areas, the amount of runoff that is routed through storm sewers is increased dramatically by impervious areas. In the TCMA, there are many natural lakes, creeks and two main rivers that receive not only overland flow, but stormwater flow as well. The Mississippi River is the largest and final waterway that transports surface and groundwater from the metro area.

We will show that in the TCMA, approximately 265,000 tons of road salt (NaCl) are applied by publicly funded agencies this is broken down to state, county and municipal use as shown in Figure 7.1. This number has increased over the last half century as population has increased. The amount of rock salt (primarily for deicing) brought into the state matches well with the national road salt use as reported by the USGS. Variance between the two can most likely be attributed to regional versus national weather conditions.

3. Methodology

Winter road safety is a major concern for agencies that maintain the road system. In the TCMA, road salt is used by transportation departments representing state, county and municipal agencies. In the state of Minnesota, the state DOT, Mn/DOT, purchases salt through a state bidding program managed by the Materials Management Division (MMD). Other agencies take advantage of the state's program including counties and municipalities. Not all cities and counties partake in the MMD bid system and seek bids from salt distributors directly. Since the bid amounts represent the estimated usage by each agency, these amounts were a starting point for determining the total NaCl use in the TCMA.

To supplement the MMD bid amount information, agencies that use the program were contacted to retrieve the actual amounts of salt applied. Agencies that do not use the program were also contacted to determine their usage. The information from agencies that had contracts through the MMD and could provide actual amounts used proved to be very useful. An annual percent of contract amounts used was determined, linking the contract amounts to the actual usage by these agencies. These calculated values of usage were then correlated with weather in the TCMA. A flow chart of the data collection and use is shown in Figure 3.1.

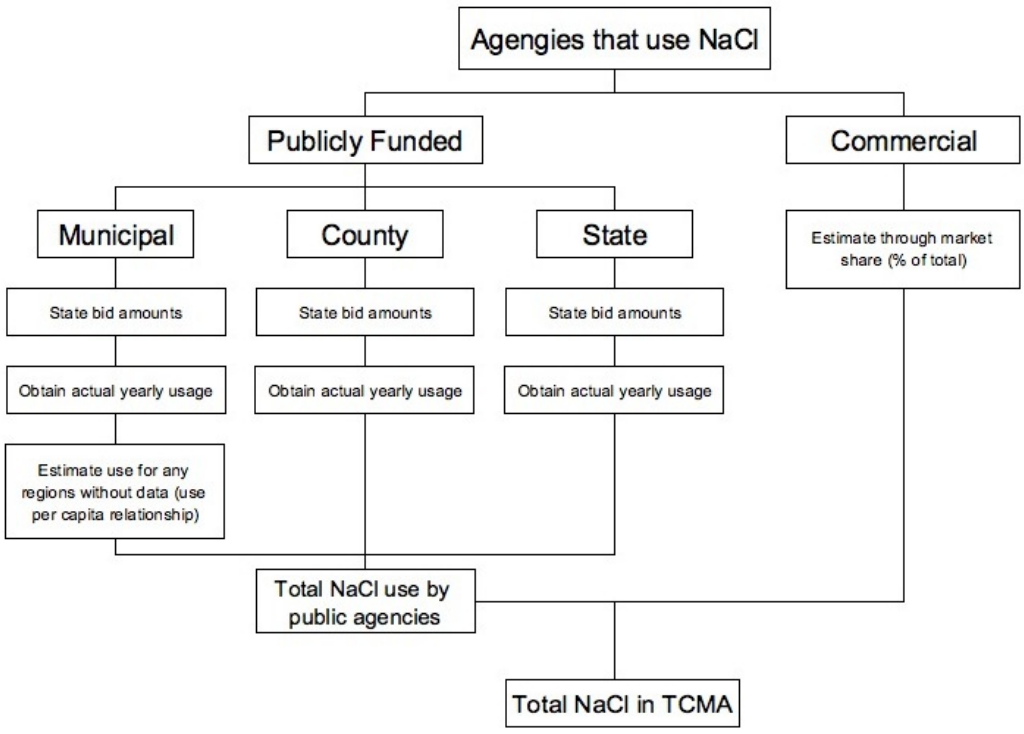

Figure 3.1 Flow chart for data assembly collection and assembly.

Since information could not be obtained from all agencies in the entire TCMA, an estimate for salt usage based on some measurable variable was needed for the missing areas, representing approximately 10% of the population. The variables considered were population and length of road miles. These are convenient parameters since the information on these two parameters is readily available from census and GIS information databases for the entire TCMA (U.S. Census Bureau, MnDNR, Mn/DOT). The per capita rate of road salt use was previously applied in a study for Environment Canada (D. Morin, M. Perchanok, 2000) as well as an indicator of road salt use reduction for the town of Caledon Ontario (Muntz, 2004). The road salt use per road mile relationship is useful to determine usage within a region not defined by political boundaries.

The commercial portion of road salt use in the TCMA was estimated using market share values from industry sources and the U.S. Geological Survey (USGS). This relationship is based on national data, but there are several indicators, discussed later in the trend analysis section, that show the applicability to the TCMA.

The trends in salt use in the TCMA were used to establish a national/regional correlation as well as a baseline trend of the variables that affect the use of road salt and the use of road salt itself. National and regional data used in this study include national population, road salt use, regional population, and rock salt imported into Minnesota. Weather parameters specific to winter road maintenance include the number of declared snow emergencies, snowfall depth, and number of days with snowfall per year.

Data Collection

To obtain the total amount of road salt applied within the geographical region of this study, information was gathered from the agencies that use road salt. These included seven counties (Ramsey, Scott, Anoka, Hennepin, Washington, Dakota, and Carver), the Minnesota Department of Transportation (Mn/DOT) Metro division and municipalities within the area. The contract amounts for these agencies established through the Minnesota Materials Management Division (MMD) were also obtained. For the purpose of this document the terms “public” and “government” are synonymous and refer to all state, county and municipally structured organizations in the TCMA.

In addition, information on commercial salt use was gathered from other studies, contractors that apply deicing products, the Minnesota Pollution Control Agency (MPCA), the United States Geological Survey (USGS) and the Salt Institute (SI). The amount of road salt that is applied each season by each agency has a high variability due to the number of factors affecting winter road safety measures.

A table of agencies and cities contacted is given in the Appendices A through C.

4. NaCl Budget Components for TCMA

4.1 Road Salt Use by Public Agencies

4.1.1 Road Salt Contracted

The MMD provided the annual amount of NaCl contracted for purchase by government agencies in the state of Minnesota. The state (MMD) handles salt contracts separately for Mn/DOT and for the Cooperative Purchasing Venture (CPV). The contracts enable public agencies to obtain the road salt required at a set rate through the state's bidding process. The amounts compiled do not include agencies that purchase salt directly from distributors. All agencies that participate are required to purchase a minimum of 80% of the contracted amounts, and suppliers are required to be able to deliver up to 120% of the contracted amounts. The contract amounts are established at the beginning of the winter season, and represent the estimated amount of salt that an agency expects to use during that season. Contract quantities for each agency vary from year to year, as the amount of salt needed per year depends upon:

- Public safety concerns
- Service expectations
- Anticipated snowfall amounts
- Number of anticipated snowfall events
- Impervious road surface increases (lane mile increases)
- Amount of salt in the stockpile from the previous season

The total amounts of salt that were contracted through MMD from 2001 through 2006 for the TCMA are summarized in Table 4.1. It is important to note that years in Table 4.1 represent the winter season starting in the listed year, i.e. 2000 represents the 2000 to 2001 winter season.

Table 4.1 Contract amounts of road salt for the TCMA

Year	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Tons of Salt	244,440	252,700	245,255	274,393	269,490	243,195

The Minnesota Department of Transportation is the largest user of road salt in Minnesota as their area of responsibility encompasses the entire state. Mn/DOT purchases approximately 40% of the road salt contract amounts in the Metro area as well as statewide. The total amounts from state, county and city contracts for the entire state based on the information from MMD are shown in FIGURE 4.1. This plot also indicates the total contract amounts for the TCMA and the corresponding amounts purchased by Mn/DOT.

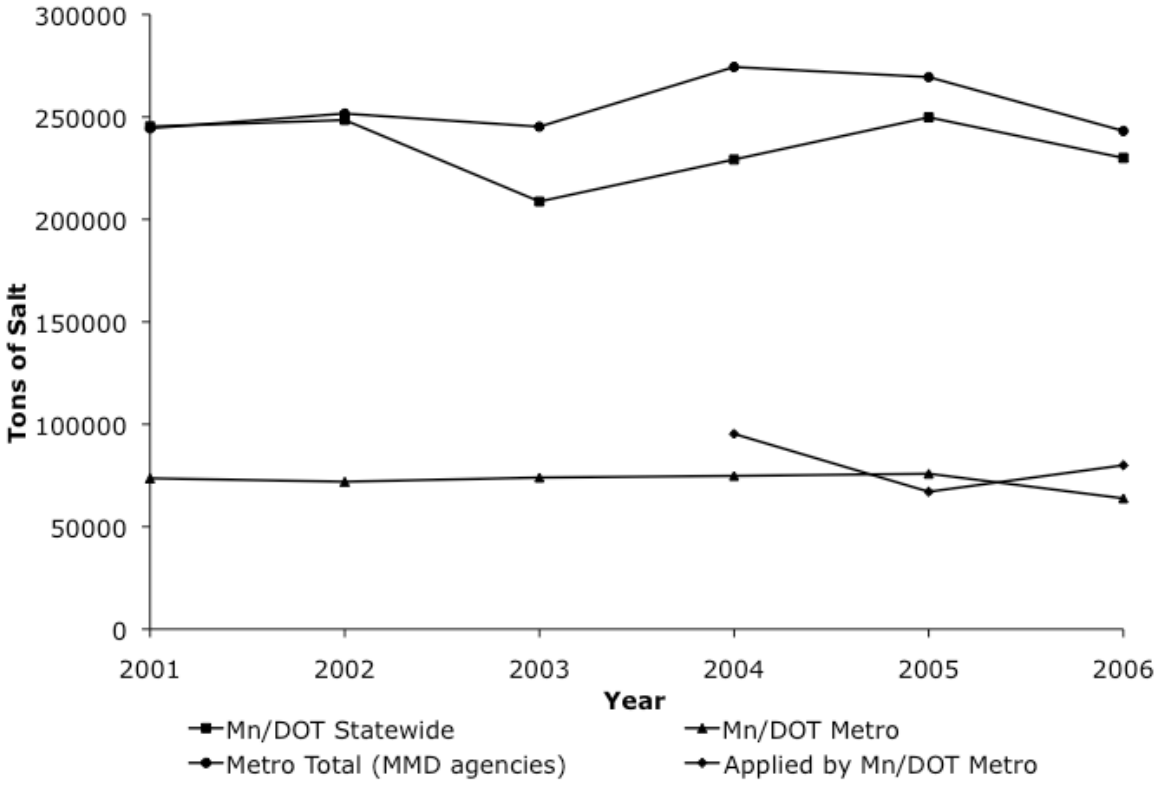

Figure 4.1 MMD road salt contract amounts (tons per year) for the TCMA

4.1.2 Road Salt Applied

The amount of road salt actually applied for each snowfall event depends on (MPCA, TAC):

- Classification of precipitation (snow, freezing rain, etc.)
- Temperature of road surface
- Time of day
- Traffic demands

Cities, counties and Mn/DOT were surveyed to determine the actual usage of salt in each season (Appendices B and C). This included cities that are part of the CPV and cities that do not participate in the program. Most agencies were able to provide information on the actual salt use from 2000 through 2006; a few were able to provide information as far back as 1988. The salt application tracking is variable; some agencies were able to provide per lane mile application data for each route in their region. The majority of agencies were able to provide the amount of salt that was actually used. Because the length of time for which the records are kept differs from agency to agency, it was difficult to get a complete historical account of salt usage from all of the agencies. Records were also incomplete in some cases. The missing data were left blank and not replaced by estimates because interpolation would depend on too many factors. Samples of the data are shown in Table 4.2 and in Figure 4.2. More detailed data are given in Appendices B and C.

Table 4.2 Tons of road salt used per year by cities (sample)

Agency	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Newport	125	125	125	125	125	125	125	125	125	125	125	125
St. Paul Park		125	125	125	125	125	125	125	125	125	150	175
Orono							200	200	200	200	200	200
St. Anthony							220	200	300	280	345	205
New Brighton							500	500	300	400	250	350
Eden Prairie	1411	1493	1250	895	902	1285	940	736	624	542		
Roseville	463	500	465	465	449	644	525	495	422	638	827	703
Fridley							750	750	750	750	750	750
Hopkins										800	750	850
Eagan	1626	2616	1796	1247	798	1492	1125	826	1264	1149	2761	2100
Bloomington	2298	2192	1827	1822	1212	1665	996	1402	1403	1630	992	1235
Edina										1850	2450	1900
Oakdale	760	800				1320	1759	1900	2208	2250	2812	2288

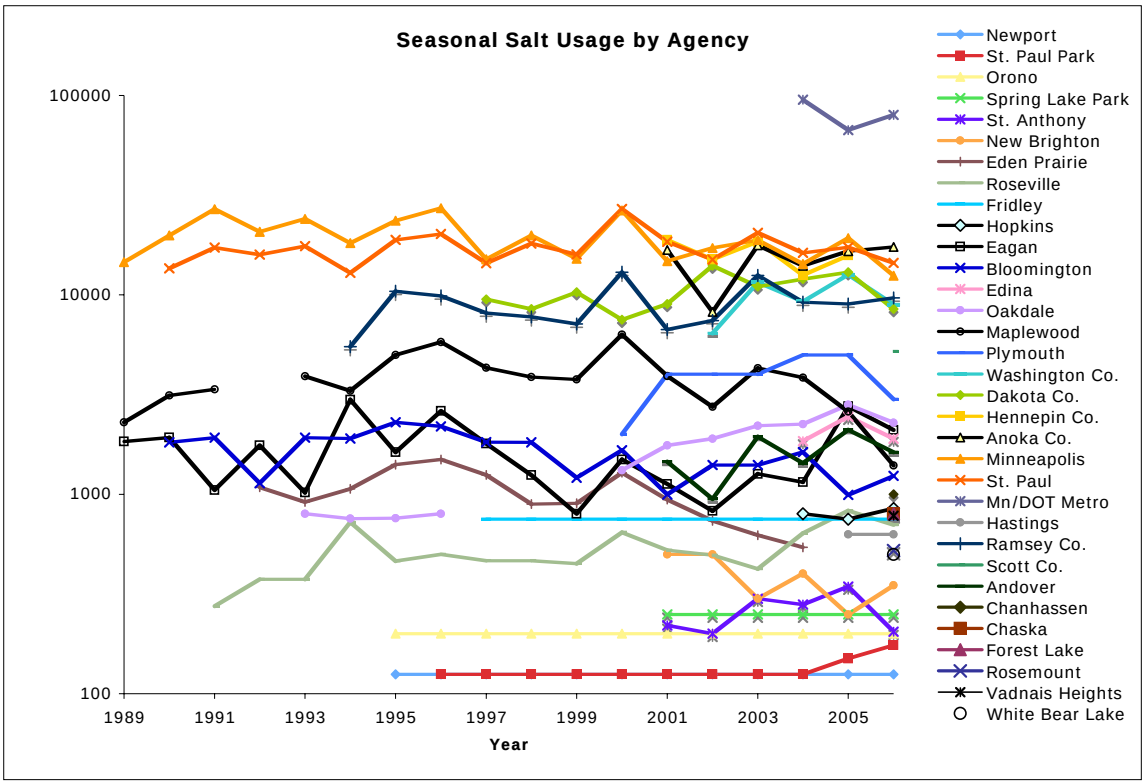

Figure 4.2 Road salt usage (tons per year) by cities and counties in the TCMA from 1989 to 2006

Many cities and counties have chosen not to use a salt/sand mixture, but rather straight salt instead to reduce the need for spring street sweeping. Mixtures of salt and sand are still used when temperatures make the use of straight salt an ineffective road safety measure. Salt amounts tend to remain consistent through the transition from salt/sand application to that of just straight salt. The same amount of salt is used, but with fewer loads required, reducing the amount of equipment and time required to handle a snow event.

4.1.3 Relationship between Road Salt Contract Amounts and Use

The data from agencies that provided good records were compared to their respective contract amounts from the MMD to determine an average percent usage of the contract amounts. This percentage accounts for variability in the seasons and any remaining salt in storage. The MMD data varied by year, due to storage, lane mile increases etc. The percent usage of the contract amounts was applied to the contract amounts to obtain the public salt use component amount for the TCMA. The results are shown in Table 4.3.

Table 4.3 Percentage of MMD contract amounts used and calculated used amounts.

	2001	*2002*	*2003*	*2004*	*2005*	*2006*	*Average*
Average Percent of Contract Amounts Used	92%	92%	103%	86%	99%	87%	93%
Contract Amounts [tons]	244440	252700	245255	274393	269490	243195	254912
Adjusted Usage [tons]	224880	232823	252526	237002	267559	212365	237859

4.2 Commercial and Private Road Salt Use

In the previous section we presented data from government agencies that carry out deicing activities in the TCMA. The amount of road salt applied by the public sector for deicing activities has to be augmented by the use of road salt that is categorized as commercial and private. This market sector includes:

Bulk and Pre-packaged deicers for:

- Homeowners (single family)
- Multi family dwellings
- Government offices
- Private roads and parking lots
- School Districts
- Airports
- Colleges
- Businesses

The amount of NaCl that is used by commercial snow removing companies and homeowners has been estimated in the past with great variability in values. Determining the amount of salt that is applied by this sector is a challenge due to the large number of stakeholders. Also, private contractors do not have an obligation to release any information of their road salt applications. The amount of salt applied by this market segment was determined by gathering data from contractors, from previous studies, the Minnesota Pollution Control Agency (MPCA) and the Salt Institute. The amount of salt used by private applicators was determined as a percentage of market.

Market share values:

- 5%-10% road salt - commercial and industrial (Cheminfo Services Inc.)
- 20% bulk road salt - non-governmental (Salt Institute)
- 13% Ice control salt – commercial use / other (USGS)

Cheminfo Services Inc., an environmental consulting firm in Canada has estimated the market share for commercial and industrial users at a national level as 5%-10% (Cheminfo Services Inc., 1999). Their estimate in the Socio-Economic Background and Options Study on the Canadian Salt Industry was part of a Government of Canada report focusing on the environmental toxicity of road salt. The estimate for commercial and industrial uses is based on an estimate from industry interviews. Locally, the mean of the range, 7.5% has been used in the Shingle Creek Watershed TMDL study (MPCA, 2006)

The Salt Institute (SI) is a North American-based non-profit salt industry trade association comprised of salt producers worldwide. Members represented here in the U.S. include: Cargill, Compass, Morton, Lyons, Detroit, United and Exportadora de Sal (Mexico). The SI has compiled statistical data on the salt industry as part of confidential information available to its members. The information is analyzed by an independent auditing firm and given to its members. Part of the SI activities is coordinating with various agencies to make more effective use of road salt (TAC, 2003). The SI was able to provide information from their reports for the years 2005 and 2006. The data provide information for the entire U.S., and are not broken down into smaller regions. A summary can be found in Table 4.4.

Table 4.4 Bulk versus packaged salt use and government versus non-government salt use in the U.S.

2005	*2006*
91- 97% of deicing salt sales are bulk salt • 596,000 tons is packaged; 19.9 million tons (97%) is bulk • $51.7 million in packaged product revenues; $492 million (91%) for bulk	**93-95% of deicing salt sales are bulk salt** • 251,000 tons is packaged; 11.9 million tons (95%) is bulk • $21.6 million in packaged product revenues; $286 million (93%) for bulk
82% of bulk deicing salt is purchased by governments* • Of bulk deicing salt tonnage, 16.4 million tons were purchased by governments • Of bulk deicing salt revenues, $404 million came from governments	**80% of bulk deicing salt is purchased by governments*** • Of bulk deicing salt tonnage, 9.5 million tons were purchased by governments • Of bulk deicing salt revenues, $231 million came from governments
Virtually all (99.2%) of packaged deicing salt is purchased by non-government customers • Of the packaged salt tonnage, 4.8 tons were purchased by governments • Of the packaged salt revenues, $382,000 came from governments	**Virtually all (98.6%) of packaged deicing salt is purchased by non-government customers** • Of the packaged salt tonnage, 3.6 tons were purchased by governments • Of the packaged salt revenues, $310,000 came from governments

* Governments include public universities

The USGS Mineral Information office publishes a Mineral Yearbook annually. This document reviews the mineral and material industries of the United States. The mineral report on salt breaks down the use of salt for ice control and stabilization. From the amounts of salt in each sector, a percentage used by commercial users is determined. A summary is given in Table 4.5. The data from this report are based on a survey of 27 salt companies in the United States. Natural Resources Canada has indicated that the USGS values on consumption could be used to estimate the corresponding consumption in Canada. (Natural Resources Canada-Materials Yearbook, Salt, 2005)

Table 4.5 Government and commercial use of road salt (metric tons per season) (from USGS)

Year	Government (Federal, State, Local)	Commercial	Total	Percent Commercial
1993	12,700,000	896,000	13,596,000	7
1994	15,000,000	1,430,000	16,430,000	9
1995	11,800,000	1,030,000	12,830,000	8
1996	15,300,000	2,400,000	17,700,000	14
1997	13,100,000	1,900,000	15,000,000	13
1998	8,690,000	794,000	9,484,000	8
1999	13,500,000	1,820,000	15,320,000	12
2000	17,400,000	2,370,000	19,770,000	12
2001	14,800,000	2,030,000	16,830,000	12
2002	11,600,000	1,730,000	13,330,000	13
2003	16,200,000	2,320,000	18,520,000	13
2004	15,600,000	2,380,000	17,980,000	13
2005	18,200,000	2,740,000	20,940,000	13

The estimates from the three sources vary considerably. The Cheminfo estimate in the 1999 report is most likely based on the 1998 values. If this is the case, then it is in a good agreement with the data from the USGS. The SI estimate is based on information provided only by its members, while the USGS data include all distributors of domestic and imported salt. The USGS data also incorporated salt used for road stabilization, which is primarily used by governments. This difference might also be caused by the following factors:

- Year of study
- Cheminfo value is based on Canadian sales, SI on US sales
- Population / population density differences between Canada and the US
- Number of sources (Cheminfo -1, SI -7)
- Cheminfo value based on an estimate, SI based on sales data

5. Trends in road salt use

The amount of road salt being applied to the road in the Twin Cities Metro area can be influenced by a number of factors. Long-term trends can be correlated with population or road mile increased as well as follow national trends in usage. Short-term changes could follow weather patterns in terms of how much snow or how many days of snowfall occur in a season.

Nationally, the use of salt for road deicing has risen considerably since the 1940s. The increase has been at a much faster rate than the growth of the US population (Figure 5.1). Minnesota has experienced this trend as well as shown by the amount of rock salt that is imported into the state and used primarily for winter road maintenance (Note the logarithmic scales present in order to display the local and national data for comparison). There is a sharp increase in the amount of salt brought into the state from 1940 to 1970. The relationship between the national and Minnesota road salt use is shown in Figure 5.2.

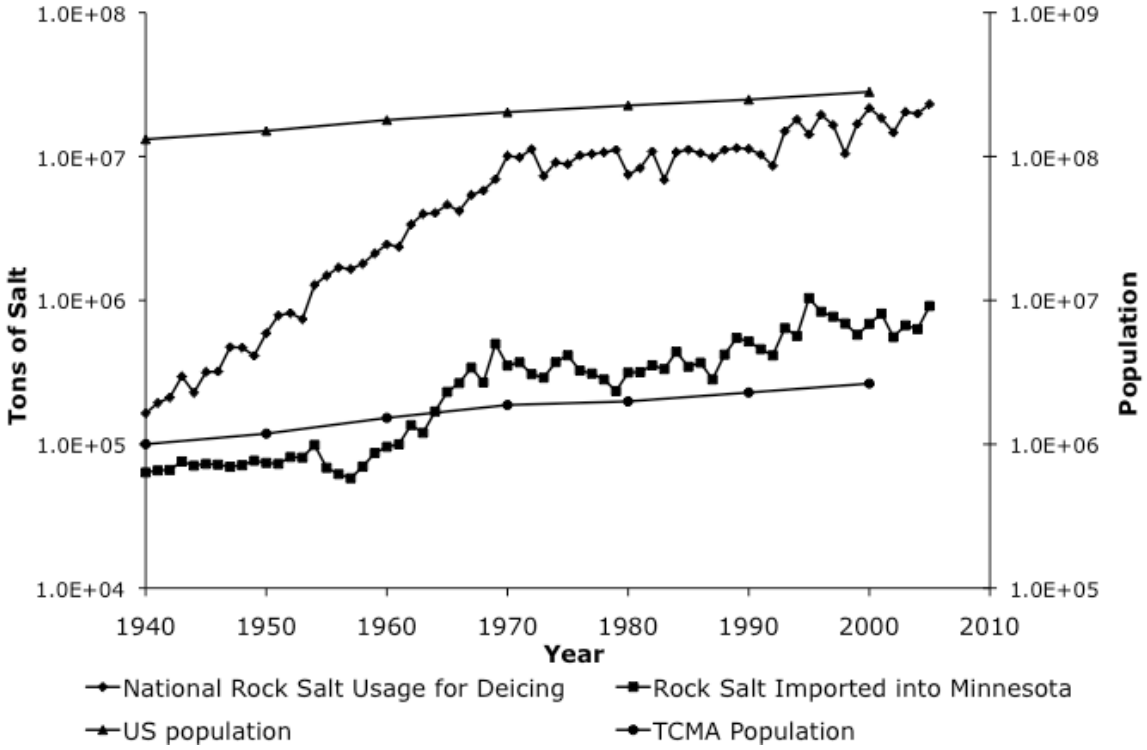

Figure 5.1 National road salt use and rock salt imported into Minnesota (tons per year) and the national and TCMA population growth.

The data provided by the public agencies were used to determine a trend in salt usage in the TCMA based on average usage (Figure 5.3). In this plot, yearly salt use was compared to an average use by each agency. These values were then averaged to obtain the values in the chart. According to Figure 5.3 the amount of salt used each year by the public sector has risen only slightly over the last decade and a half.

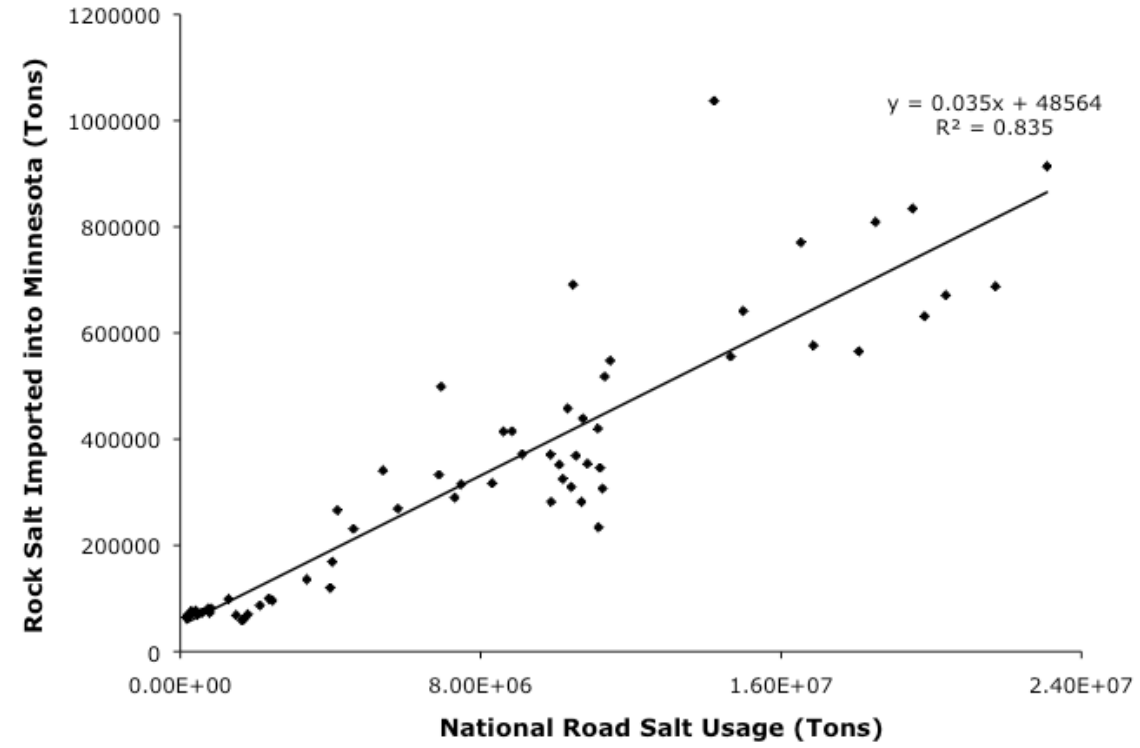

Figure 5.2 Correlation between national road salt use and rock salt imported into Minnesota (tons per year)

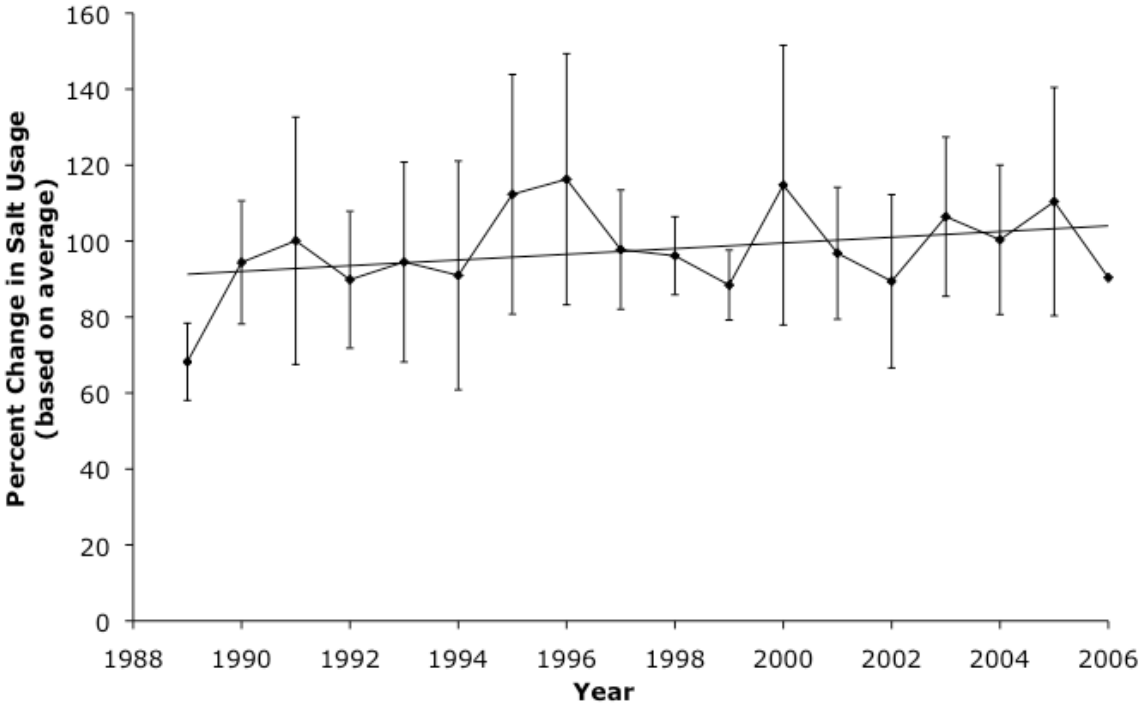

Figure 5.3 Annual road salt use as a percentage of the long-term (1989-2006) average.

6. Correlation of road salt use with snowfall, population and road lengths

6.1 Correlation of road salt use with snowfall amounts and snowfall emergencies

Road salt use records from a few agencies were compared to two factors that impact salt application: seasonal snowfall and number of snow emergencies in a winter season. Figures 6.1 and 6.2 show that both snow parameters affect the use of road salt. The data were provided by the City of Minneapolis and were recorded as part of their snow and ice control program. Adjacent cities and counties show similar relationships.

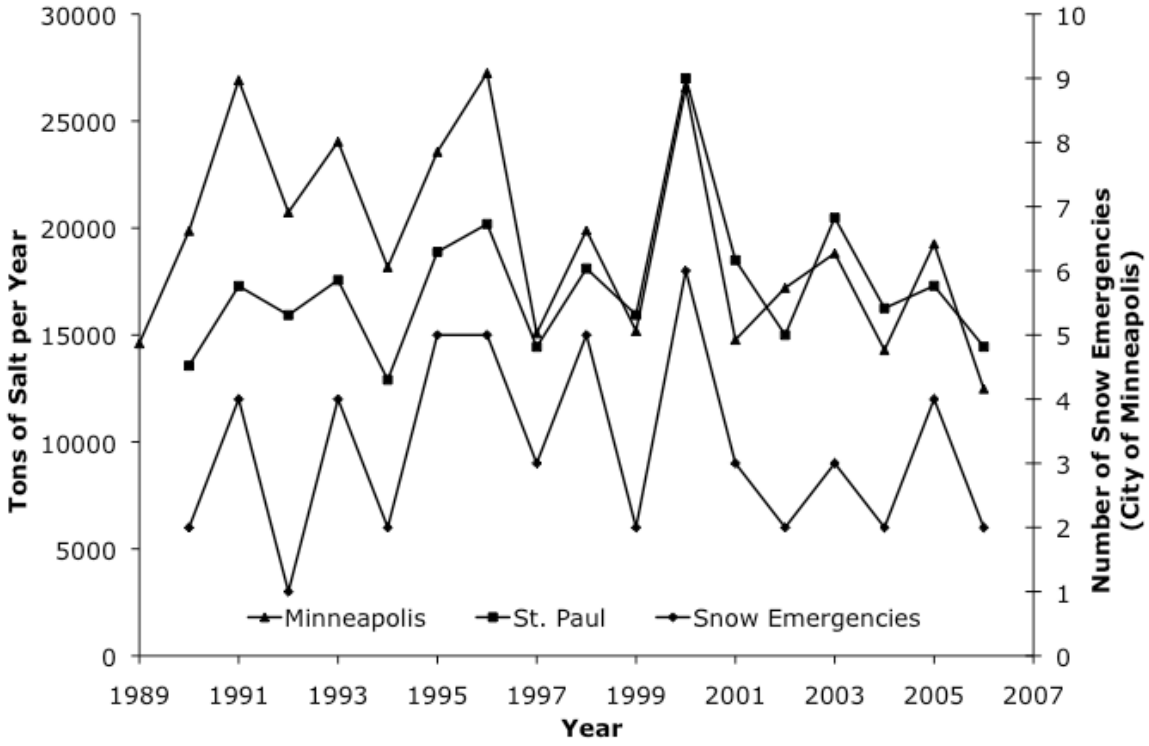

Figure 6.6.1 Seasonal road salt use (tons per season) and declared snow emergencies in Minneapolis and St. Paul.

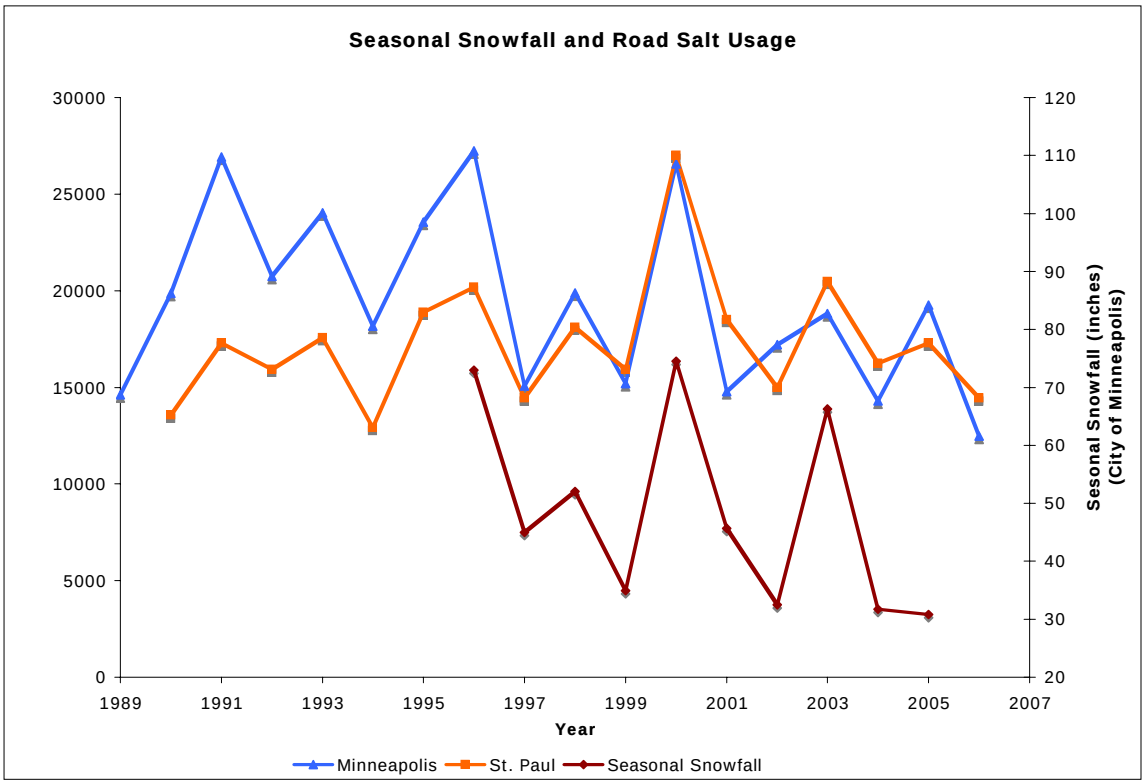

Figure 6.6.2 Seasonal road salt use (tons per season) and snowfall amounts in Minneapolis and St. Paul.

6.2 Correlation of road salt use with snowfall events

Weather data collected by the National Weather Service (NWS) were used to determine the number of days with snowfall in each year. Data were gathered for 12 locations described by the following township, range, and section designations within the TCMA.

29N 22W S18	30N 23W S26	28N 21W S7	117N 22W S1
29N 22W S18	118N 21W S9	115N 19W S14	28N 22W S27
30N 23W S26	27N 24W S10	117N 22W S17	28N 22W S27

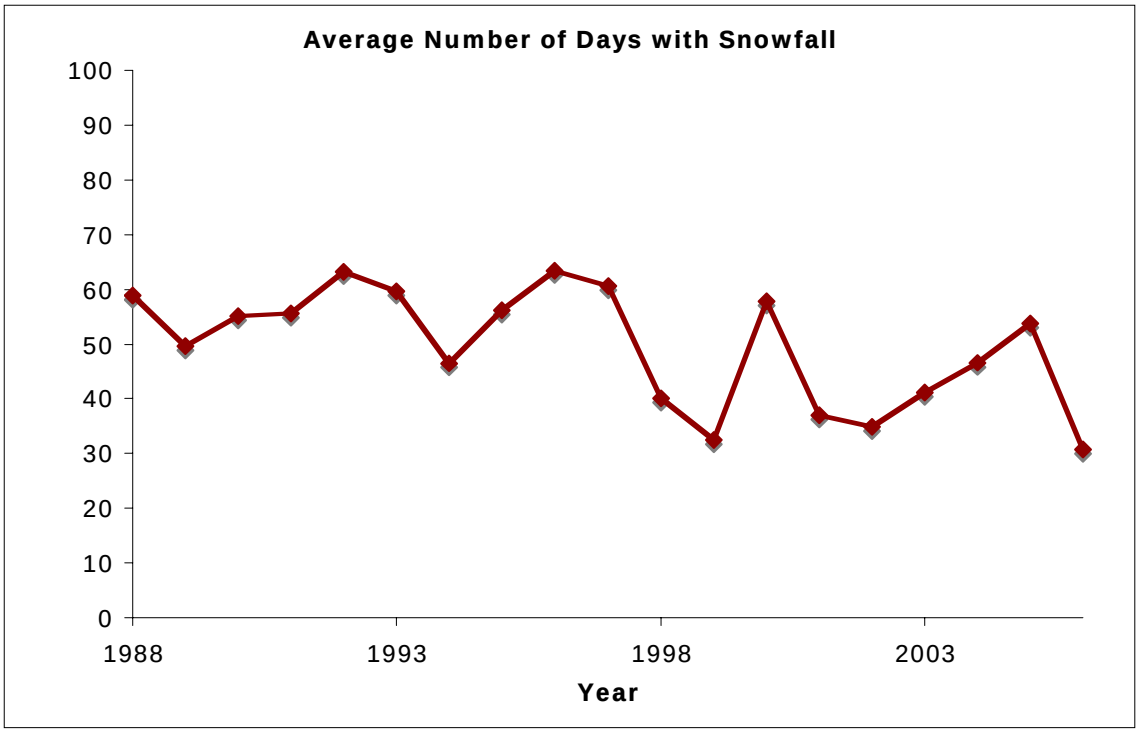

Figure 6.6.3 Average number of days with snowfall in the TCMA.

The data shown in Figure 6.3, gave an overall average of 50 days with snowfall per year. When the calculated annual road salt amounts (Table 4.3) were plotted against the average number of days with snowfall, a strong correlation was found (Figure 6.4). This shows that the method of correcting the actual usage from the state contract amounts is valid as it reflects the severity of the various winter seasons.

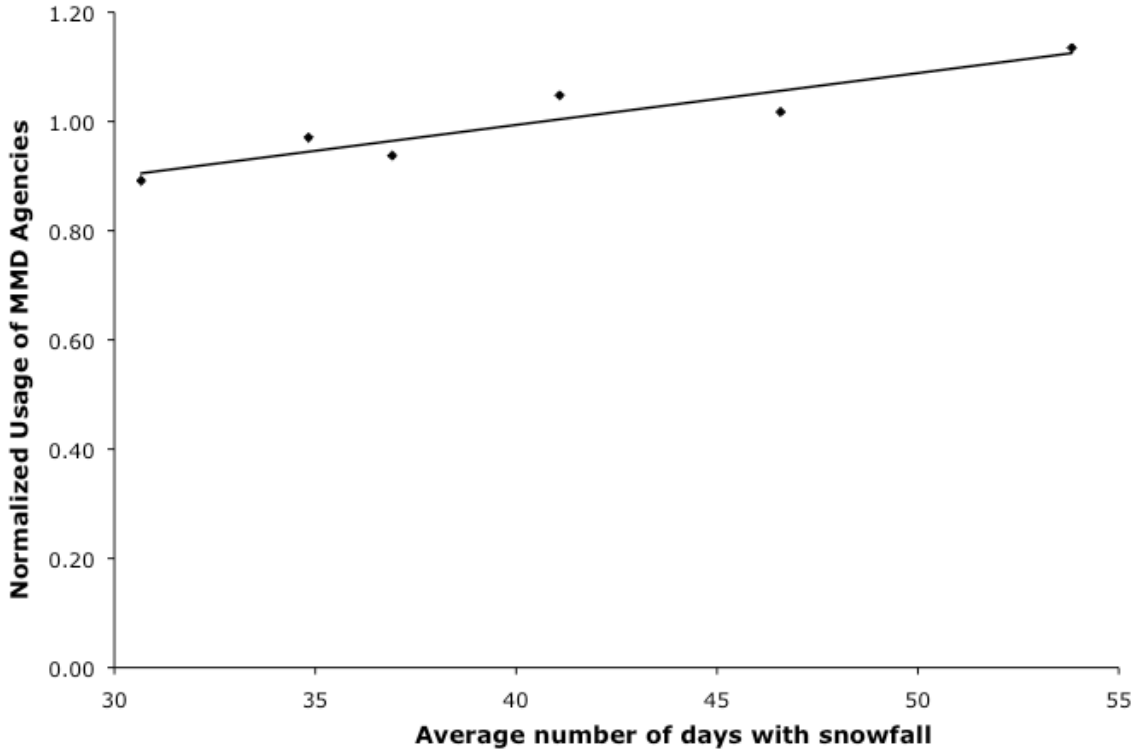

Figure 6.6.4 Annual road salt use from MMD participants (tons per year) in the TCMA vs. annual average number of days with snowfall

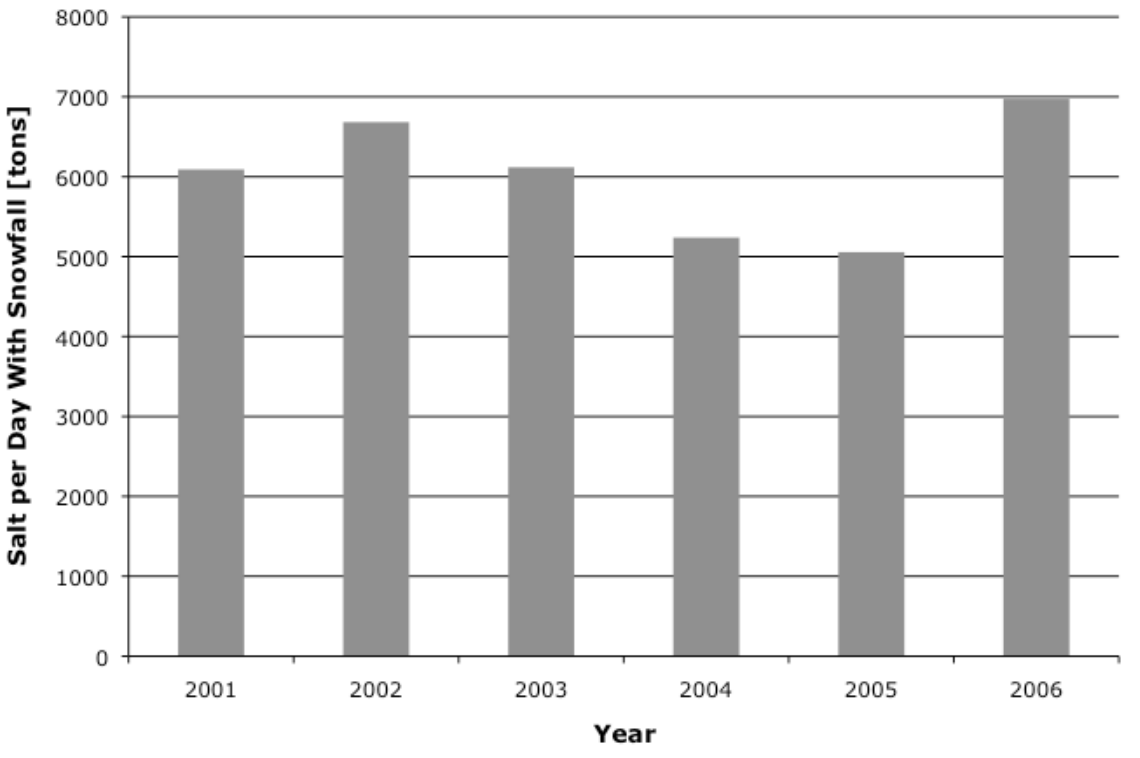

Figure 6.6.5 Salt use (tons) per day with snowfall

The calculated road salt use by the MMD contract participants was divided by the average number of days with snowfall and the results are shown in Figure 6.5.

6.3 Correlation of road salt use with population

Trends that are seen on the national level are also seen in Minnesota. The TCMA population shows a good correlation with the amount of rock salt imported into the state (Figure 6.6). This shows that the population of the TCMA is a forcing parameter for road salt used in the state. Data for individual cities in the TCMA are given in Appendix C.

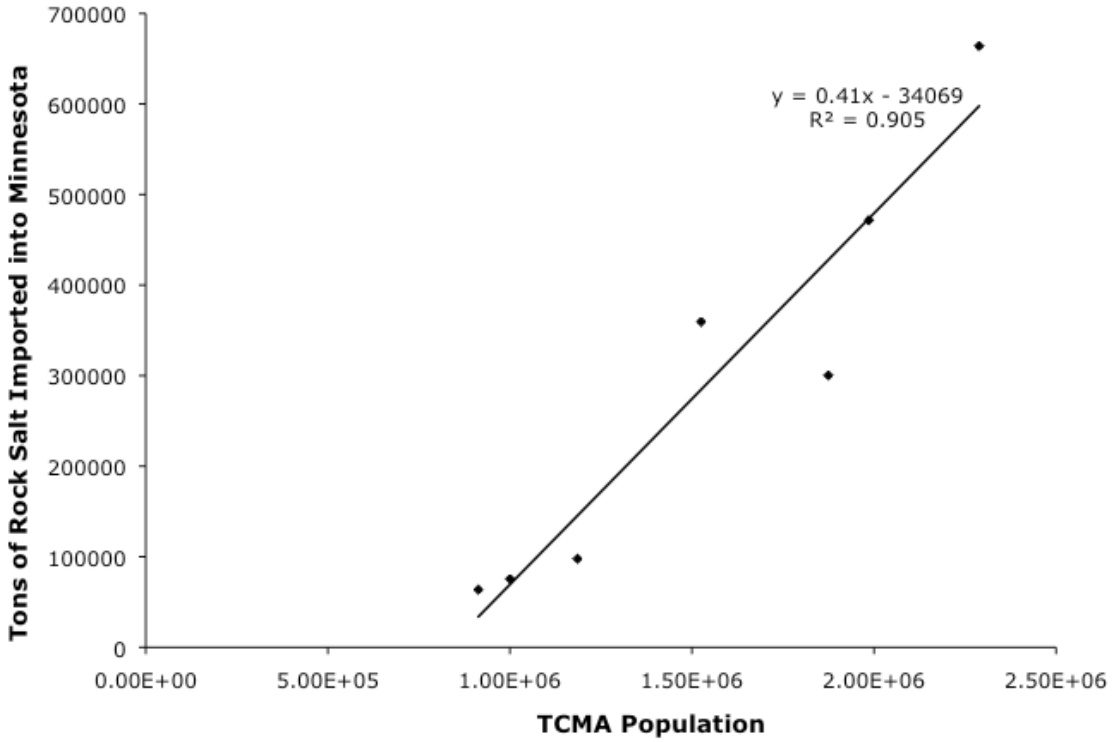

Figure 6.6.6 Rock salt imported into Minnesota (tons per year) vs. TCMA population.

The MMD and the public agencies that provided data for salt usage serve about 90% of the TCMA population. A relationship between salt usage and population was determined to be useful for estimating the salt use by cities in the TCMA that did not provide salt use data. Other relationships considered were:

- Salt per household
- Salt per population density
- Salt per land surface area
- Salt per road mile
- Salt per household density

The above base data is available through the Metropolitan Council and the state's GIS database. Due to the large amount of agencies involved, obtaining the amount of lane miles in each region would not be feasible.

The reported amounts of salt used or 93% of contract amounts were plotted vs. the populations served. Figure 6.7 shows the per capita road salt use. A larger population includes more roadway users and the possibility of more accidents. The per capita relationship agrees well with the relationship between road salt imported into Minnesota and the population of the TCMA (Figure 5.3).

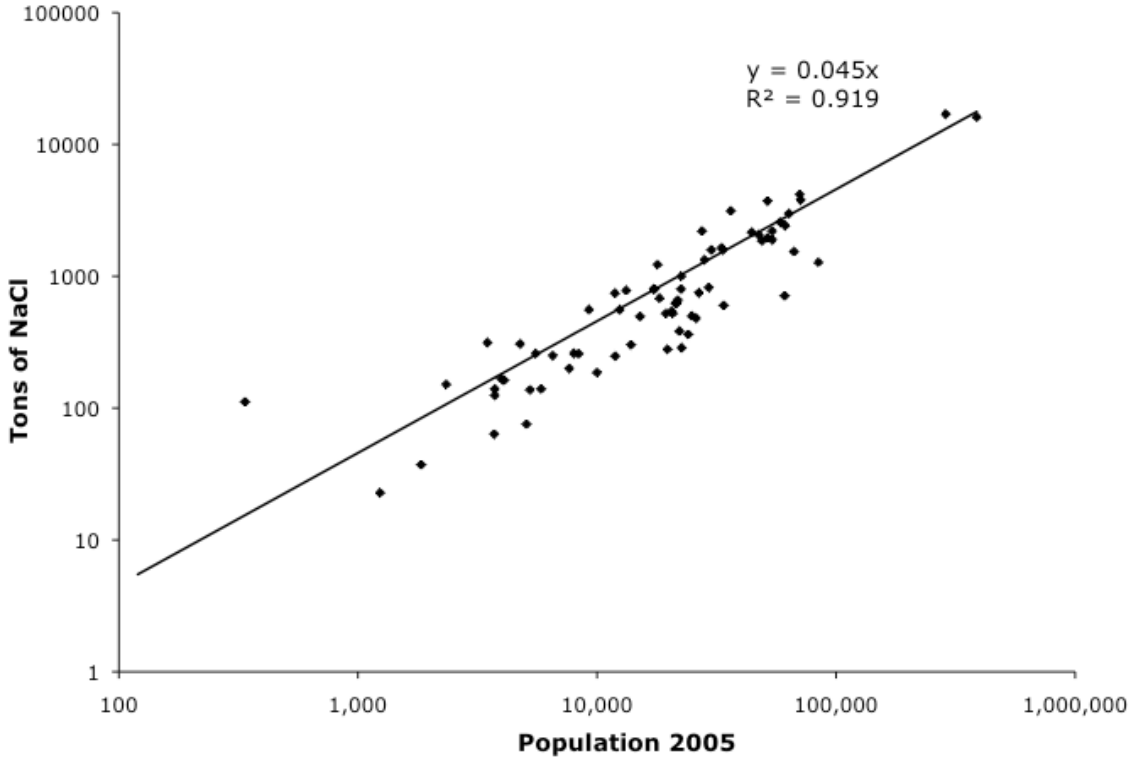

Figure 6.7 Per capita road salt use (tons per season) in cities and counties of the TCMA.

6.4 Correlation of road salt use with road length

The approach used with population was also used to establish a relationship between road miles and salt use. The data from MMD and the agencies were plotted against the road km for each agency from the current GIS data. Figure 6.8 shows the relationship between road length and yearly road salt use for cities in the TCMA, while Figure 6.9 is based on county use. It is worthwhile to note that the number of road miles in a city is equivalent to twice the number of lane miles.

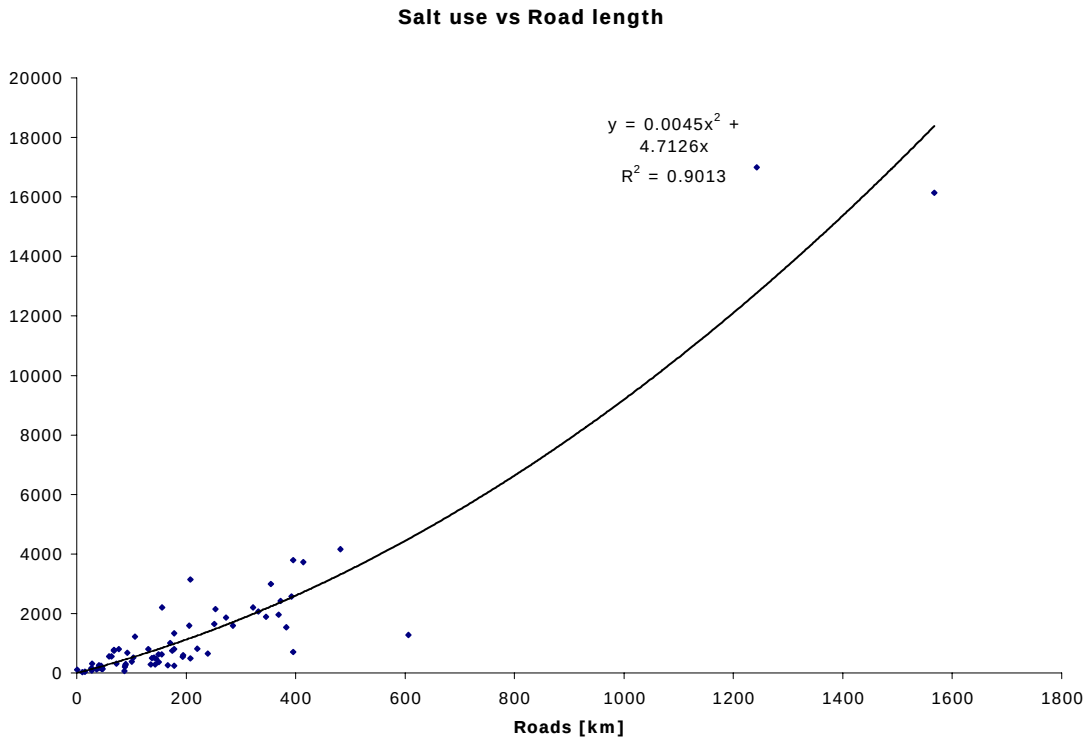

Figure 6.8 Annual road salt use (tons per year) by cities in the TCMA vs. road length

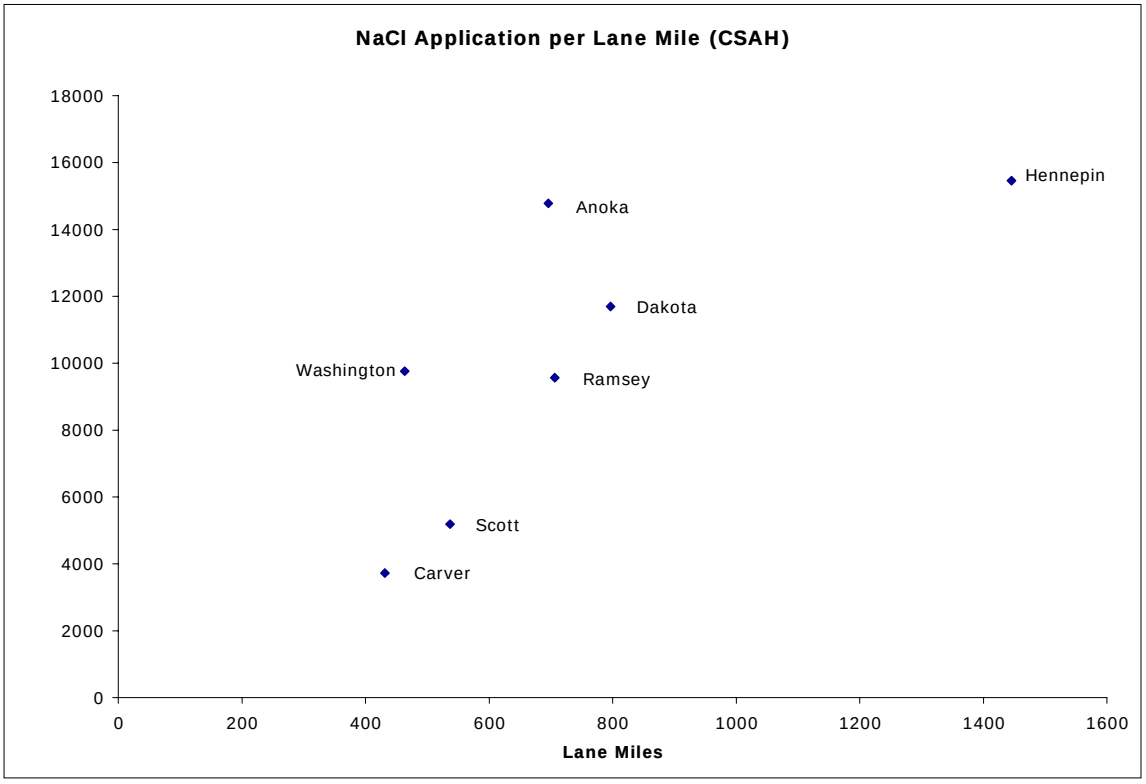

Figure 6.9 Annual road salt use (tons per year) by counties in the TCMA vs. road length

Figure 6.9 displays the salt used by a county and the amount of County State Aid Highways (CSAH) that are the respective maintenance divisions. Figure 6.10 shows the application rate based on the counties use. Note that not all county roads are paved with concrete or asphalt and therefore do not receive road salt in the winter. The application rates amongst the counties in the TCMA vary substantially.

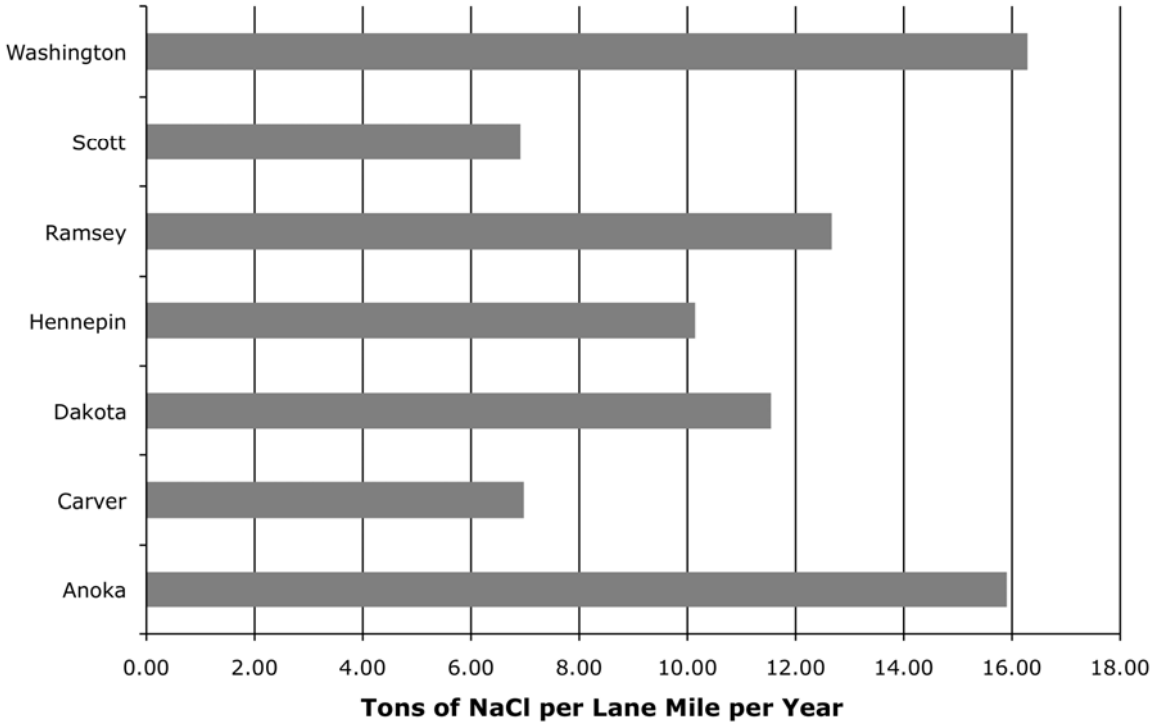

Figure 6.10 Annual road salt use per lane mile per year (tons per mile per year) by counties in the TCMA.

There is a relationship with the population and the number of roads in a city. This is a result of higher traffic flow, service demand and urbanization. The TCMA demonstrates quite well this trend over 2001-2006 as shown in Figure 6.11. The number of impervious lane miles has increased as a result of a growing population. This correlation is important as it ties the two parameters used for determining the spatial application of road salt together.

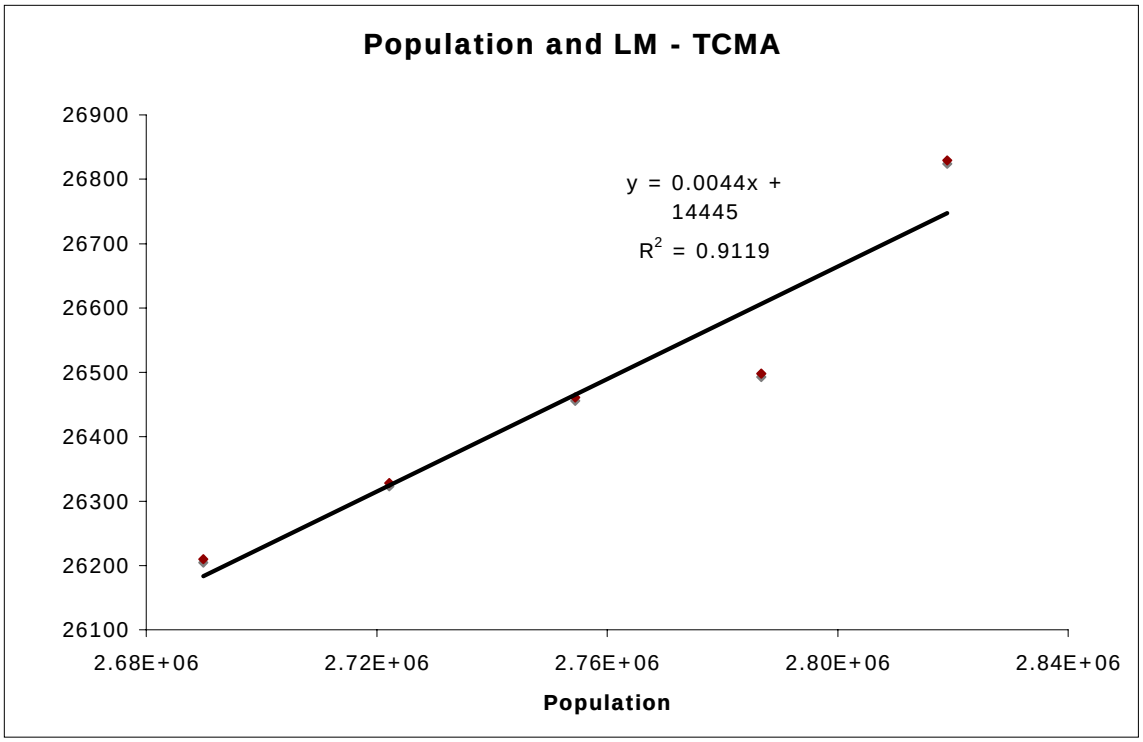

Figure 6.11 Lane miles vs. population in the TCMA

7. Total Road Salt Application in the TCMA

To calculate a total road salt application value for the TCMA, the reported amounts of salt use and the amounts from the MMD contracts were used as a starting point. These amounts represent the usage from 90% of the TCMA population. The remaining 10% of the TCMA population for which no information was provided, was estimated using the per capita relationship.

Source of Data	**Amount**
Reported applied tons or 93% of MMD contracts (90% of TCMA population)	100,274 tons
Estimated (Remaining Population x 0.045 tons/person)	14,041 tons
Total tons of salt from cities	**114,314 tons**

The total amount of road salt applied by public agencies within the TCMA is then:

Agency	**Amount**
Mn/DOT	80,797 tons
Counties	70,284 tons
Cities	114,314 tons
Total road salt by public agencies in the TCMA	**265,395 tons**

If the market share values are used to determine the portion of bulk road salt from commercial applications, the following is found. Since the information provided by the SI is based on national data, it was necessary to see if it was representative of the state of Minnesota. Figure 5.2 shows the national historical use of road salt and the increase of rock salt imported into Minnesota. Since the national and local data match favorably, the SI data should be an accurate representation of the salt uses in Minnesota and the TCMA. Outliers in the plot can be attributed to seasonal fluctuations in Minnesota and other parts of the country. The percent of the market looked at for determining commercial usage of NaCl is shown in Table 7.1. This also compares the total amount of bulk NaCl based on the governments use and the commercial market share. The 7.5% from the Cheminfo study was not used in the final estimate, because the number is not as current as the data obtained from the USGS and the SI. The SI data had the benefit of having a break down of what is sold in packaged deicing products. Since the SI report indicated that the bulk road salt contributes 93%-95% of the deicing salt total, the remaining amount is packaged for home and commercial use. This breakdown is shown in Table 7.2.

Table 7.1 Partitioning between public and private bulk road salt use (tons per year)

Percent of Market	*Public Use*	*Private Use*	**Total**
7.5%	265,395	21,518	286,913
20%	265,395	66,349	331,744
13%	265,395	39,657	305,052

Table 7.2 Partitioning between bulk and packaged deicing products in the TCMA (tons per year)

Bulk	*Packaged*	**Total**
331,744	17,460	349,204

Using the SI information, the total road salt use in the Twin Cities Metropolitan Area can be estimated and is summarized in Figure 7.1. The amount of road salt that is applied by state, county and municipal agencies in the TCMA is on the order of 265,400 tons per season. This is approximately 2.8% of the total bulk deicing salt used by government agencies nationally (Salt Institute). The amount of bulk deicing salt applied by commercial snow and ice control companies is estimated to be on the order of 66000 tons per season. Packaged deicer for home and commercial use is estimated at 17,460 tons per season, bringing the estimated total loading of deicing products to 349,000 tons per season.

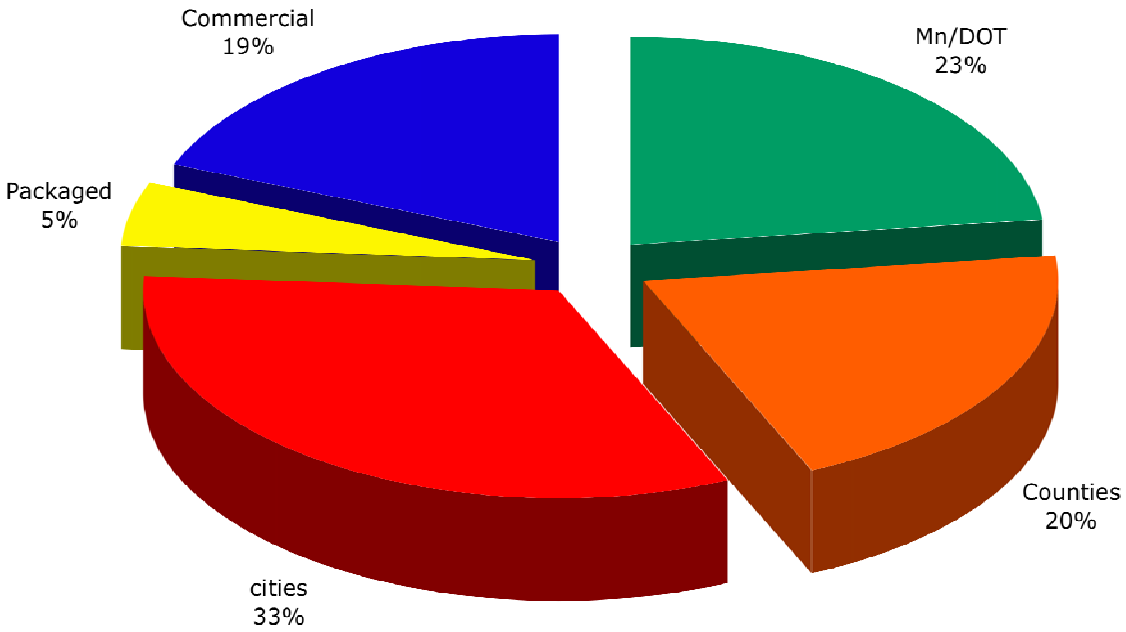

Figure 7.1 Total road salt use in the TCMA (tons per season)

8. Summary and Conclusions

The goal of this study was to determine the amount of road salt (NaCl) applied in the TCMA each year. This study was not aimed at evaluating the effectiveness, suitability or cost of using NaCl as a deicer. In addition to the total amounts of salt used, it is of interest to identify and quantify the metrics that determine the rates of road salt applications. This information was generated at large enough spatial and temporal scales so that the results of this study can be compared to other regions in northern climates. This is already evident with the similarity in the per capita salt use used in Environment Canada's road salt loading assessment.

Trends in the use of road salt were found to have a strong correlation with population, and length of roads in the region. These two parameters are useful in analyzing the spatial distribution of road salt. On a long timescales (decades), population is the main indicator of road salt use. The per capita use in the last decade has been on the order of 0.045 tons per person per season. It is expected that better control of application practices can decrease this rate. Year to year variances of salt use can be attributed to weather variations, including the total snowfall received and the total number of days with snowfall. Other metrics besides population, that correlate with the amount of road salt use on larger time scales include road miles and climate. At shorter timescales salt application is related to the amount of snowfall, and the number of days with snowfall.

The method of determining the amount of road salt applied in the TCMA involved many sources of information, as there are many stakeholders in the use of road salt. In the TCMA, most municipalities and counties purchase salt through contracts offered by the Material Management Division (MMD) of the state of Minnesota. The amount ordered by each municipality or county is representative of the expected salt use in the next winter season, a number which remains fairly constant from year to year. The total amount of reported salt use per winter season (2001 to 2006) was 236,800 tons per year and varied between 243,000 and 274,000 tons per year. Relative to the sum of the contract amounts the actual reported use was on average 93% for the TCMA.

Not all municipalities participate in the MMD contract or keep track of the actual road salt applications. In these cases individual agencies were contacted to obtain usage information. The amount of road salt used by municipalities from which information was not available was estimated based on a per capita road salt use rate of 0.045 tons per season per person. This is appropriate because population is an independent driving parameter for road salt use on the city, state and national scale as use is impacted by traffic, population, and service needs. The rate was determined from the reported road salt use in the TCMA covering about 90% of the population. The extrapolation was made for the remaining 10%, and amounted to about 14,000 tons per year.

Application of salt (NaCl) by public agencies (state, county, municipal) is just one portion of the total salt use for winter road maintenance. Commercial contractors are responsible for areas such as commercial, school and private parking lots and driveways, and in some cases, township road maintenance. The number of commercial contractors and their road salt use in the TCMA could not be easily identified. To estimate the commercial salt use in the TCMA, market share amounts were used. The market share is

the percentage of road salt production and sale to the commercial sector. The U.S. Geological Survey (USGS) publishes a yearly minerals report, which contains this information. The Salt Institute (SI), an organization comprised of salt distributors, also publishes a national market share estimate annually. Since the TCMA matches national trends with regard to population growth and salt purchases, the average market share values of 13% and 20% from the USGS and the SI were evaluated. The Salt Institute value of 20% was used to determine the commercial bulk use of road salt in the TCMA, as additional information provided by the SI also gave indication to what amount of salt is sold as packaged deicer. The resulting amount of salt use was approximately 66,000 tons per year.

The amount of road salt that is applied by state, county and municipal agencies in the TCMA watershed is on the order of 265,400 tons per winter season. This is approximately 2.8% of the total deicing salt used by government agencies nationally (Salt Institute). The amount of NaCl deicing salt applied by commercial snow and ice control companies was estimated to be on the order of 66,349 tons per season. Packaged NaCl for home and commercial use was estimated at 17,460 tons per season. The total amount of NaCl applied to roads in the TCMA per season is estimated at 349,000 tons per year. The breakdown of users is as follows: cities – 33%, Mn/DOT – 23%, counties – 20%, commercial outfits (bulk) – 19%, packaged – 5%.

Acknowledgements

This technical report provides results of a study funded by the Local Roads Research Board (LRRB / Mn/DOT) and guided by a Technical Advisory Panel (TAP). The members of the TAP are Connie Fortin (Fortin Consulting), Tom Struve (City of Eagan), Andrew Kubista (Mn/DOT), Norm Ashcroft (Mn/DOT), Wayne Sandberg (Washington County), Greg Felt (Scott County), Biz Colburn (CTS), Ann Mclellan (Mn/DOT), Kathleen Schaefer (Mn/DOT), Jeff Goetzman (St. Louis County), Eric Macbeth (City of Eagan). These TAP members represent a wide range of agencies within the TCMA with an interest in winter road maintenance and environmental protection.

The completion of this project was made possible by many individuals and organizations that contributed information and their expertise. Many people from the state, county and municipal levels gave their time to provide information for this report. Appendix A is a list of agency contacts that provided salt usage data for their respective agencies. These are mostly winter maintenance supervisors and superintendents that have a great deal of first hand knowledge and experience dealing with the use of road salt in the TCMA.

Jackie Finger and Aric Wilson at the MMD provided a great deal of help regarding state contracts and bid information. Mark Filipi at the Metropolitan Council along with Gene Hicks and Matthew Koukol at Mn/DOT provided information on road systems within the study region. Dennis Kostick at the USGS and Dick Hanneman at the Salt Institute provided information and insight on the use of road salt in different sectors. Valerie Hourdebaigt, with the Chemicals Sector at Environment Canada provided supporting documents for the Environment Canada's assessment of road salt.

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Evans, M. and C. Frick. 2002. The effects of road salts on aquatic ecosystems. Environment Canada, National Water Research Institute, Burlington/Saskatoon, NWRI Contribution No. 02-308.

Appendix A. Agency Contacts

Name	*Agency*
Al Bauer	City of New Brighton
Jim Weber	University of Minnesota Facilities Management
Dennis Kostick	U.S. Geological Survey
Richard Hanneman	Salt Institute
Aric Wilson	Minnesota Materials Management Division
Bob Egan	Dakota County
Bob Paschke	City of St. Anthony
Brian Langseth	Hennepin County
Bryan Nagel	City of Maplewood
Chuck Bradley	City of Blaine
Dave Randt	Carver County
Dave Ricker	City of Crystal
David Rutt	City of Shakopee
Don DeBaere	City of Orono
Doug Hartman	City of Burnsville
Doug Johnson	Washington County
Gary Smith	City of Plymouth
Gene Busacker	Scott County
Gerald Auge	Ramsey County
Greg Lee	City of Mounds View
Jackie Finger	Minnesota Materials Management Division
Jeff Dubay	City of Minnetonka
Jeff Jensen	City of Fridley
Jim Christenson	Anoka County
Jim Eiler	City of Bloomington
Jim Perron	City of Arden Hills
Jim Romanik	City of Oakdale
John Neska	City of Newport
Jon Holmes	City of Anoka
Lee Flandrich	City of St. Paul Park
Mark Peine	City of Hastings

Mike Kennedy	City of Minneapolis
Neil Miller	City of Inver Grove Heights
Norm Ashfeld	Minnesota Department of Transportation (Mn/DOT)
Ray Vogtman	City of Hopkins
Richard A. LaValle	Chisago County
Robin Bowman	City of Minnetrista
Rod Keller	City of Maple Grove
Steve Collin	City of Minneapolis
Steve Johnson	City of Edina
Steve Zweber	City of Roseville
Terry Randall	City of Spring Lake Park
Tom Olund	City of Mendota Heights
Tom Reiner	City of Ham Lake
Tom Scaramuzzo	City of St. Paul
Tom Struve	City of Eagan
Tom Tesch	City of Eden Prairie
Troy Grossman	City of Lakeville

Appendix B. Amounts of NaCl ordered through MMD

Agency Purchasing Through M.M.D.	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*
Anoka County		17000	18000	10000	22000	13600	13300
Anoka Mn/DOT	3650	4200	4200	4200	4200	4200	3700
Arden Hills Mn/DOT	7000	7000	7000	7000	5500	5500	4500
Camden Mn/DOT	8000	7000	7000	7000	7000	7000	4000
Cedar Mn/DOT		1450	1450	1000	500	1500	1500
Chisago County		3640	5000	5000	7000	7000	8000
City of Apple Valley		2000	2200	2200	2000	1800	1800
City of Birchwood Village							
City of Blaine		2000	2200	2200	2000	2800	3000
City of Bloomington			1400	1400	2000	2000	1200
City of Brooklyn Center	900	1500	1400	1500	1500	1500	1200
City of Brooklyn Park		4000	5000	5000	5000	3000	2500
City of Burnsville		1600	2100	2650	2785	4000	2500
City of Champlin			300	500	500	350	300
City of Circle Pines				100	50	75	100
City of City of Anoka		1400	1400	900	1500	1500	1200
City of Columbia Heights		800	800	700	700	700	700
City of Coon Rapids		2600	1500	2200	4000	5000	4000
City of Cottage Grove	1600	1700	1800	1500	1800	1800	2000
City of Crystal		250	250	280	330	340	400
City of Deephaven	100	150	150	150	150	150	
City of Dellwood							
City of Eagan		1700	700	1700	2200	2000	2400
City of East Bethel		250	250	250	250	250	350
City of Eden Prairie		1300	1150	1300	1300	1300	1400
City of Edina		2600	2650	2200	2850	3000	3000
City of Fridley	700	700	700	700	700	700	800
City of Golden Valley	600	700	600	600	600	700	300
City of Ham Lake		400	500	400	500	600	800
City of Hastings		500	500	500	350	350	300
City of Hopkins	400	450	450	400	600	750	1000
City of Independence					50	75	80
City of Inver Grove Heights							
City of Lakeville		1600	1920	1920	2253	2470	2470
City of Lauderdale							
City of Lilydale							
City of Lino Lakes		300	300	300	300	300	300
City of Little Canada		200	200				
City of Long Lake							40
City of Mahtomedi							

City of Maple Grove		2400	3000	3000	3000	2600	2600
City of Maplewood		1000	1000	750	1000	880	1000
City of Medina			300	250	350	450	300
City of Minneapolis		20000	20000	18000	20000	20000	20000
City of Minnetonka		2000	4000	5000	5000	4000	4000
City of Minnetrista		200	225	300	300	300	350
City of Mounds View			700	700	500	500	
City of New Brighton							400
City of New Hope	600	720	600	400	800	350	500
City of Newport							
City of North Branch		600	600	600	800	1000	1200
City of North Oaks							
City of North St. Paul		800	800	800	800	800	800
City of Oak Grove		100		300	250	300	450
City of Oakdale		1500	1500	1500	2200	3300	3300
City of Orono	200	250	250	250	250	250	250
City of Pine Springs							
City of Plymouth		4000	4000	4000	5000	5000	5000
City of Prior Lake					600	700	700
City of Ramsey		500	800	500	700	850	900
City of Richfield		1750	1700	1700	1700	1700	1700
City of Robbinsdale	300	350	300	300	300	350	350
City of Rockford					120	120	
City of Rosemount		600	700	750	950	1000	1500
City of Roseville		650	650	700	700	750	600
City of Shakopee		600	700	600	1000	1400	1000
City of Shoreview		350	350	350	350	900	800
City of South St. Paul							
City of St. Anthony							
City of St. Louis Park	1700	2000	2200	2200	2500	2500	2500
City of St. Paul		21150	21125	21125	21125	21125	21125
City of St. Paul Park							200
City of Vadnais Heights							
City of Wayzata	160	180	180	180	180	180	180
City of West St. Paul							
City of White Bear Lake							
City of Willernie							
City of Woodbury	1600	1300	2000	2000	2200	2200	2500
Dakota County		10000	10000	12500	12500	13000	11500
Eden Prairie Mn/DOT	5200	5200	5200	5200	5200	5200	4200
Forest Lake Mn/DOT	5000	6000	6000	2500	5000	5000	4000
Golden Valley Mn/DOT	3500	4000	4000	4000	4000	4000	300
Hampton Mn/DOT	1250	1750	1750	1750	1750	1750	750
Hastings Mn/DOT	3700	3700	3700	4000	4000	4000	3500
Hastings School District					40	50	50
Hennepin County		14500	14500	20000	20000	20000	13300

Jordan Mn/DOT	3450	3500	3500	3500	3900	3500	3500
Lakeville Mn/DOT	1000	1000	1000	1000	1000	1000	1000
Maple Grove Mn/DOT	5700	5000	5500	5500	5500	5500	5000
Maryland Ave. Mn/DOT	8500	7000	7000	7000	7000	7000	6000
Mendota Mn/DOT	7800	7500	7500	7000	7000	7000	6000
Metro Transit		600	600	600	800	800	750
MNSCU - Century College					160	175	
North Branch Mn/DOT	3550	4000	4500	4500	4500	4500	4000
Oakdale Mn/DOT	3500	3500	3500	2500	5000	5000	4000
Plymouth Mn/DOT	7700	7000	3500	2500	2500	2500	1500
Ramsey County		5500	10000	10000	10000	10000	10000
Ramsey County Mn/DOT		3500					
Savage Mn/DOT	500	500	500	1500	1200	1500	800
Shakopee Mn/DOT	3500	3700	3700	3700	3700	3700	4200
Spring Lake Park Mn/DOT	3500	5500	5500	5500	5500	5500	5000
Taylor Falls Mn/DOT	1000	1500	1500	1500	2000	2000	1500
Washington County		8000	9000	7000	7000	7000	9000
Totals		244440	252700	245255	274393	269490	243195
80% of Totals		195552	202160	196204	219514.4	215592	194556

Mn/DOT salt facilities within the TC Metro area

Appendix C. City data: populations, road lengths and road salt data for cities in the TCMA

City in TCMA	Population 2005	Roads in the TCMA (km)	Roads in TCMA watershed (km)	Percent of roads in watershed	Salt applied[1)] (tons/year)	Population with no data
Afton	2,919	81	1	1	128	2919
Andover	30,080	285	177	62	1585	0
Anoka	17,899	107	47	44	1225	0
Apple Valley	48,988	273	14	5	1860	0
Arden Hills	9,787	53	53	100	431	9787
Bayport	3,171	20		0	140	3171
Belle Plaine	6,037	57		0	266	6037
Bethel	509	4		0	22	509
Birchwood Village	943	7	7	100	41	943
Blaine	54,020	322	322	100	2201	0
Bloomington	84,347	606	606	100	1277	0
Brooklyn Center	28,137	179	179	100	1333	0
Brooklyn Park	71,048	396	396	100	3798	0
Burnsville	61,262	372	290	78	2423	0
Carver	2,339	27	27	100	151	0
Centerville	3,848	23	23	100	169	3848
Champlin	24,071	150	135	90	363	0
Chanhassen	22,518	171	171	100	1000	0
Chaska	22,467	131	131	100	800	0
Circle Pines	5,072	28	28	100	76	0
Coates	162	3		0	7	162
Cologne	1,237	10	9	91	23	0
Columbia Heights	18,261	93	93	100	682	0
Columbus	4,062	110	72	66	179	4062
Coon Rapids	63,480	355	355	100	2992	0
Corcoran	5,884	103	96	93	259	5884
Cottage Grove	33,179	251	249	99	1643	0
Crystal	22,595	143	143	100	287	0
Dayton	5,007	71	50	71	220	5007
Deephaven	3,737	46	46	100	140	0
Dellwood	1,103	20	20	100	49	1103
Eagan	66,709	383	383	100	1538	0
East Bethel	11,917	178	44	25	248	0
Eden Prairie	60,955	395	395	100	711	0
Edina	47,448	332	332	100	2067	0
Elko	1,321	13	0	1	58	1321
Excelsior	2,380	16	16	100	105	2380
Falcon Heights	5,679	37	37	100	250	5679
Farmington	18,023	116		0	793	18023
Forest Lake	17,385	178	60	34	800	0
Fort Snelling (unorg.)	262	5	5	100	12	262
Fridley	26,679	175	175	100	750	0
Gem Lake	468	1	1	100	21	468
Golden Valley	20,510	194	194	100	543	0
Grant	4,218	104	21	21	186	4218
Greenfield	2,847	64	3	5	125	2847

Greenwood	759	8	8	100	33	759
Ham Lake	15,136	208	199	96	496	0
Hamburg	566	4		0	25	566
Hampton	751	5		0	33	751
Hanover	507	6		0	22	507
Hastings	21,486	149	8	6	630	0
Hilltop	792	1	1	100	35	792
Hopkins	17,263	77	77	100	800	0
Hugo	9,440	121	104	86	415	9440
Independence	3,714	87	8	9	64	0
Inver Grove Heights	33,195	233	173	74	1461	33195
Jordan	5,048	37	33	91	222	5048
Lake Elmo	7,966	99		0	351	7966
Lake St. Croix Beach	1,145	18		0	50	1145
Lakeland	1,891	26		0	83	1891
Lakeland Shores	364	5		0	16	364
Lakeville	51,722	369	45	12	1958	0
Landfall	734	3	3	100	32	734
Lauderdale	2,329	7	7	100	102	2329
Lexington	2,114	14	14	100	93	2114
Lilydale	809	0	0	100	36	809
Lino Lakes	19,698	135	135	100	279	0
Little Canada	9,996	46	46	100	186	0
Long Lake	1,839	15	15	100	37	0
Loretto	637	5		0	28	637
Mahtomedi	7,941	64	46	72	349	7941
Maple Grove	58,420	393	393	100	2573	0
Maple Plain	1,982	13	5	39	87	1982
Maplewood	36,279	207	206	99	3135	0
Marine on St. Croix	669	15		0	29	669
Mayer	1,290	11		0	57	1290
Medicine Lake	359	2	2	100	16	359
Medina	4,770	73	60	82	307	0
Mendota	182	4	4	100	8	182
Mendota Heights	11,582	105	105	100	510	11582
Minneapolis	387,711	1567	1567	100	16139	0
Minnetonka	51,657	414	414	100	3720	0
Minnetonka Beach	625	8	8	100	28	625
Minnetrista	5,542	89	73	82	260	0
Mound	9,838	67	67	100	433	9838
Mounds View	12,442	63	63	100	558	0
New Brighton	22,113	101	101	100	383	0
New Germany	330	3		0	15	330
New Hope	20,747	103	103	100	522	0
New Market	1,490	14	4	26	66	1490
New Prague	4,049	29	29	100	178	4049
New Trier	120	1		0	5	120
Newport	3,738	36	36	100	125	0
North Oaks	4,502	73	73	100	198	4502
North St. Paul	11,885	68	66	98	744	0
Northfield	874	5		0	38	874
Norwood Young America	3,479	28		0	314	0
Oak Grove	7,997	166		0	260	0
Oak Park Heights	4,664	34		0	205	4664
Oakdale	27,492	156	71	45	2203	0
Orono	7,653	88	88	100	200	0

Osseo	2,492	21	21	100	110	2492
Pine Springs	395	7		0	17	395
Plymouth	70,455	482	482	100	4167	0
Prior Lake	21,395	155	155	100	620	0
Ramsey	21,749	240		0	659	0
Randolph	365	3		0	16	365
Richfield	33,667	205	205	100	1589	0
Robbinsdale	13,873	89	89	100	302	0
Rockford	337	1		0	112	0
Rogers	6,716	62	16	25	296	6716
Rosemount	19,418	141	26	18	522	0
Roseville	33,882	194	194	100	602	0
Savage	24,662	172	172	100	1085	24662
Shakopee	29,335	220	220	100	822	0
Shoreview	25,964	145	145	100	481	0
Shorewood	7,551	80	80	100	332	7551
South St. Paul	20,078	115	115	100	883	20078
Spring Lake Park	6,527	45	45	100	250	0
Spring Park	1,705	4	4	100	75	1705
St. Anthony	8,376	41	41	100	258	0
St. Bonifacius	2,377	16	16	100	105	2377
St. Francis	7,163	61		0	315	7163
St. Louis Park	44,380	254	254	100	2155	0
St. Marys Point	420	8		0	18	420
St. Paul	287,385	1243	1243	100	16996	0
St. Paul Park	5,246	46	46	100	138	0
Stillwater	17,429	134		0	767	17429
Sunfish Lake	543	10	9	85	24	543
Tonka Bay	1,545	16	16	100	68	1545
Vadnais Heights	13,241	68	68	100	780	0
Vermillion	455	4		0	20	455
Victoria	5,837	47	47	100	140	0
Waconia	9,250	59	59	100	558	0
Watertown	4,088	27		0	163	0
Wayzata	3,973	40	40	100	167	0
West St. Paul	18,849	93	93	100	829	18849
White Bear Lake	24,927	138	131	95	500	0
Willernie	566	6	6	100	25	566
Woodbury	54,091	346	193	56	1891	0
Woodland	528	8	8	100	23	528

[1)] **Amount of salt applied was estimated using 0.045 t/yr/capita if no data were available**

City in TCMA	Applied or 93% of contract Amount (tons/yr)	Road length with no data	Estimated based on RM	Road salt amount applied in 2001-2006 (tons/yr)	Road salt contract amount in 2001-2006 (tons/yr)
Afton		1	3		
Andover	1586	0	0	1585.80	
Anoka	1225	0	0		1316.67
Apple Valley	1860	0	0		2000.00
Arden Hills		53	263		
Bayport		0	0		
Belle Plaine		0	0		
Bethel		0	0		
Birchwood Village		7	33		
Blaine	2201	0	0		2366.67
Bloomington	1277	0	0	1276.88	1600.00
Brooklyn Center	1333	0	0		1433.33
Brooklyn Park	3798	0	0		4083.33
Burnsville	2423	0	0		2605.83
Carver	151	0	0		162.50
Centerville		23	110		
Champlin	363	0	0		390.00
Chanhassen	1000	0	0	1000.00	
Chaska	800	0	0	800.00	
Circle Pines	76	0	0		81.25
Coates		0	0		
Cologne	23	0	0		24.50
Columbia Heights	682	0	0		733.33
Columbus		72	364		
Coon Rapids	2992	0	0		3216.67
Corcoran		96	493		
Cottage Grove	1643	0	0		1766.67
Crystal	287	0	0		308.33
Dayton		50	249		
Deephaven	140	0	0		150.00
Dellwood		20	98		
Eagan	1538	0	0	1537.77	1783.33
East Bethel	248	0	0		266.67
Eden Prairie	711	0	0	710.50	1291.67
Edina	2067	0	0	2066.67	2716.67
Elko		0	1		
Excelsior		16	77		
Falcon Heights		37	182		
Farmington		0	0		
Forest Lake	800	0	0	800.00	
Fort Snelling (unorg.)		5	23		
Fridley	750	0	0	750.00	716.67
Gem Lake		1	6		
Golden Valley	543	0	0		583.33
Grant		21	103		
Greenfield		3	16		
Greenwood		8	40		
Ham Lake	496	0	0		533.33
Hamburg		0	0		
Hampton		0	0		

Hanover		0	0		
Hastings	630	0	0	630.00	416.67
Hilltop		1	5		
Hopkins	800	0	0	800.00	608.33
Hugo		104	538		
Independence	64	0	0		68.33
Inver Grove Heights		173	951		
Jordan		33	162		
Lake Elmo		0	0		
Lake St. Croix Beach		0	0		
Lakeland		0	0		
Lakeland Shores		0	0		
Lakeville	1958	0	0		2105.50
Landfall		3	16		
Lauderdale		7	35		
Lexington		14	66		
Lilydale		0	2		
Lino Lakes	279	0	0		300.00
Little Canada	186	0	0		200.00
Long Lake	37	0	0		40.00
Loretto		0	0		
Mahtomedi		46	228		
Maple Grove	2573	0	0		2766.67
Maple Plain		5	24		
Maplewood	3135	0	0	3134.67	938.33
Marine on St. Croix		0	0		
Mayer		0	0		
Medicine Lake		2	12		
Medina	307	0	0		330.00
Mendota		4	17		
Mendota Heights		105	547		
Minneapolis	16139	0	0	16138.67	19666.67
Minnetonka	3720	0	0		4000.00
Minnetonka Beach		8	40		
Minnetrista	260	0	0		279.17
Mound		67	336		
Mounds View	558	0	0		600.00
New Brighton	383	0	0	383.33	400.00
New Germany		0	0		
New Hope	522	0	0		561.67
New Market		4	18		
New Prague		29	142		
New Trier		0	0		
Newport	125	0	0	125.00	
North Oaks		73	368		
North St. Paul	744	0	0		800.00
Northfield		0	0		
Norwood Young America	314	0	0		337.50
Oak Grove	260	0	0		280.00
Oak Park Heights		0	0		
Oakdale	2203	0	0	2202.83	2216.67
Orono	200	0	0	200.00	250.00
Osseo		21	100		
Pine Springs		0	0		
Plymouth	4167	0	0	4166.67	4500.00
Prior Lake	620	0	0		666.67
Ramsey	659	0	0		708.33

Randolph		0	0		
Richfield	1589	0	0		1708.33
Robbinsdale	302	0	0		325.00
Rockford	112	0	0		120.00
Rogers		16	74		
Rosemount	522	0	0	522.00	916.67
Roseville	602	0	0	601.67	675.00
Savage		172	942		
Shakopee	822	0	0		883.33
Shoreview	481	0	0		516.67
Shorewood		80	404		
South St. Paul		115	600		
Spring Lake Park	250	0	0	250.00	
Spring Park		4	20		
St. Anthony	258	0	0	258.33	
St. Bonifacius		16	77		
St. Francis		0	0		
St. Louis Park	2155	0	0		2316.67
St. Marys Point		0	0		
St. Paul	16996	0	0	16996.17	21129.17
St. Paul Park	138	0	0	137.50	200.00
Stillwater		0	0		
Sunfish Lake		9	40		
Tonka Bay		16	75		
Vadnais Heights	780	0	0	780.00	
Vermillion		0	0		
Victoria	140	0	0		150.00
Waconia	558	0	0		600.00
Watertown	163	0	0		175.00
Wayzata	167	0	0		180.00
West St. Paul		93	478		
White Bear Lake	500	0	0	500.00	
Willernie		6	27		
Woodbury	1891	0	0		2033.33
Woodland		8	36		