
Shingle Creek Watershed Management Commission Shingle Creek Chloride TMDL *Five Year Review December 2014*



Watershed Management Commission

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This report is a review of progress toward meeting the load reductions identified in the Shingle Creek Chloride TMDL. It includes an assessment of actions that have been implemented and the water quality trends that have been observed. Finally, this report describes the actions planned for the next 5 years of the implementation plan and sets forth how progress toward the TMDL will be measured.

Shingle Creek was formally designated an Impaired Water for chloride in 1998. A major tributary, Bass Creek, was designated as impaired in 2002. A TMDL and Implementation Plan were approved in 2007. The TMDL determined that the likeliest source of chloride to the Creek was road salt – sodium chloride – applied to the highways, roads, parking lots, and other surfaces in the watershed. Groundwater also contributes a small but potentially significant load to the stream. A 71% load reduction across the watershed is necessary to be sure the concentration is not exceeded for any flow regime.

The Implementation Plan identified a number of Best Management Practices (BMPs) that the nine cities in the watershed, Hennepin County, and MnDOT could undertake to reduce road salt application while still being protective of public safety. Most of these BMPs focused on: methods of optimizing the amount of road salt use; improving equipment operator and public education and awareness; and keeping abreast of and implementing new technologies and products such as salt alternatives.

The Commission and its monitoring partner the USGS have been measuring conductivity and chloride in Shingle Creek since the impairment was determined. As part of developing and then implementing the TMDL, the road authorities have been reporting their road salt application data to the Commission since 2005. The data were analyzed to identify trends in road salt application and trends in in-stream chloride concentrations. This analysis is difficult as road salting operations can vary widely event to event and even city to city depending on temperature and precipitation. This leads to extreme variability in the data year to year and even day to day, complicating efforts to identify trends.

There does appear to be a downward trend in the rate of road salt application for some road authorities that have fully implemented pre-wetting technology on their trucks. However, given the annual variability it will likely take several more years of data before any trends become clear. There does not appear to be a trend, either for better or worse, in stream chloride concentrations. Again, it may take a number of years before any effect is apparent in the data.

The cities, Hennepin County, and MnDOT will continue to implement the BMPs identified in the TMDL implementation plan with two additional actions: 1) identify the critical areas within the watershed that are most likely to deliver the highest loads to the stream, and focus load reduction efforts in those areas; and 2) consider a paired subwatershed study to evaluate pollutant loading and cost effectiveness of using traditional sodium chloride road salt compared to alternate de-icing products.

As a part of this Five Year Review, the stakeholders have established interim goals to measure progress toward meeting the state water quality standard: 1) all road authorities in the watershed implement all the BMPs identified in the TMDL; 2) eliminate all exceedances of the acute standard of 860 mg/L of one-hour exposure; and 3) reduce by 20% the number of days the stream exceeds the 230 mg/L four-day average exposure chronic standard, from the 10-year average of 140 days to 112 days.

2.1 BACKGROUND

The Shingle Creek Chloride Total Maximum Daily Load (TMDL) addresses the chloride impairment in Shingle Creek, located in Hennepin County, Minnesota (see Figure 2.2). Shingle Creek is tributary to the Mississippi River. The chloride impairment in Shingle Creek, Hennepin County, Minnesota was detected in water quality monitoring performed by the USGS as part of its ongoing National Water Quality Assessment (NAWQA) Program. The chloride impairment in Shingle Creek was first designated in 1998. A major tributary, Bass Creek, was designated as impaired in 2002. The Shingle Creek Watershed Management Commission (SCWMC) in cooperation with the Minnesota Pollution Control Agency (MPCA) completed a Total Maximum Daily Load (TMDL) analysis and implementation plan to quantify the chloride reductions needed to meet State water quality standards for nutrients in Shingle Creek (HUC 07010206-506). The TMDL and Implementation Plan were approved in 2007. In 2008 the American Public Works Association recognized the partnership that completed the Implementation Plan with an Excellence in Snow and Ice Control Award.

The TMDL determined that the likeliest source of chloride to the Creek was road salt – sodium chloride – applied to the highways, roads, parking lots, and other surfaces in the watershed. Groundwater also contributes a small but potentially significant load to the stream. A 71% load reduction is necessary to ensure the concentration is not exceeded for any flow regime.

The chloride TMDL for Shingle Creek is in the form of a winter load duration curve. On Figure 2.1 below, that is represented by the red curve. At very high flows, which occur up to 10% of the time, the stream can assimilate a higher daily load of chloride because of the increased volume being conveyed. At lower flows a lower daily load is necessary. The blue symbols indicate actual data points collected in 2002 and 2003, prior to TMDL implementation. A stream meeting state standards would have nearly all those values at or below the red line. The black line is the necessary load reduction.

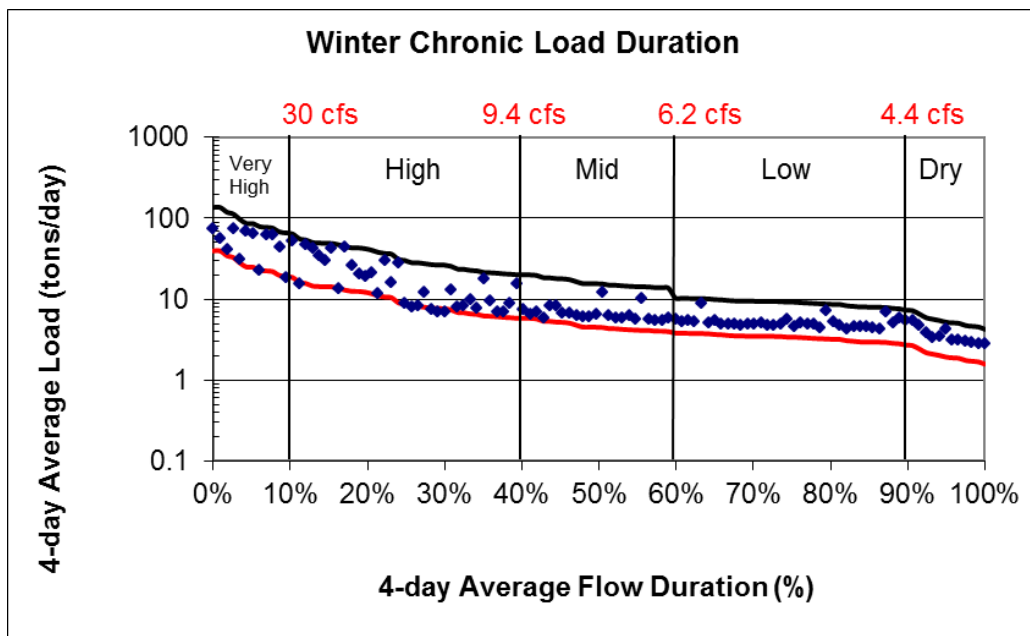


Figure 2.1. Shingle Creek Chloride TMDL load duration curve and 2002-2003 data.

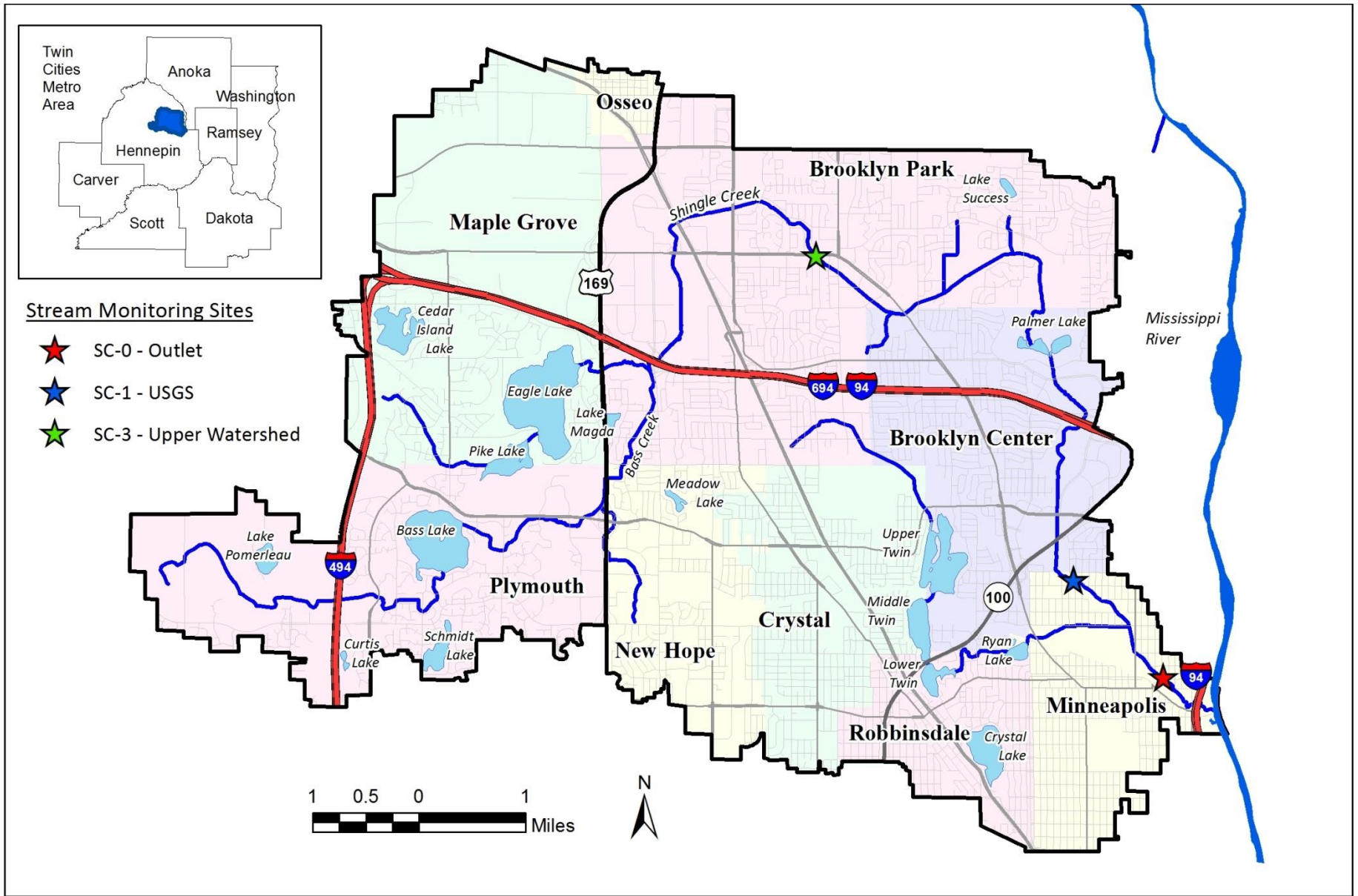


Figure 2.2. Shingle Creek watershed monitoring sites.

2.2 IMPLEMENTATION PLAN BACKGROUND

2.2.1 Approach

The activities and BMPs identified in the implementation plan are the result of a series of stakeholder working meetings facilitated by the Commission. Representatives from cities, MnDOT, Hennepin County and regulatory agencies discussed the TMDL requirements, BMPs and technologies available to address chloride, public safety, and the feasibility of implementing the activities.

The first task in developing the implementation plan was determining the allocation of load reductions to the users in the watershed. The stakeholders - member cities, Hennepin County, and MnDOT - agreed to work collectively towards a 71% reduction in chloride use, understanding that each stakeholder was working under unique financial, public safety and perception, and feasibility limitations. This collective approach allows for greater reductions for agencies with more capability and lesser for those with more constraints.

As the second step in the process, member cities, MnDOT, and Hennepin County agreed to identify and implement BMPs to reduce chloride use. Stakeholder meetings focused on current activities and identification of activities that could be considered to address the needed load reductions. The topics discussed included:

1. Product application equipment and decisions
2. Product stockpiles
3. Product type and quality
4. Operator training
5. Clean-up and snow stockpiling
6. Ongoing research into salt alternatives

2.2.2 Principles

Through the discussion of policies and practices, current activities, and ongoing research, the stakeholders developed five principles to guide development and implementation of the load reduction plan. These included:

1. Utilize appropriate snow plow techniques
2. Select, store, and apply materials appropriately to balance public safety and environmental risks
3. Encourage communication between applicators
4. Foster stewardship through improved applicator awareness
5. Communicate with the public

2.3 IMPLEMENTATION PLAN ACTIONS

2.3.1 Commission Actions

The Commission agreed to take the lead on general coordination, education, and ongoing monitoring. This information is incorporated into the Commission's annual Water Quality Report.

- Coordination
 - Complete an annual report on monitoring and activities
 - Provide assistance as necessary to develop city Salt Management Plans
 - Integrate chloride reductions into permit requirements
- Education
 - Promote private applicator education
 - Conduct public education and outreach
 - Provide information to public officials
 - Sponsor an annual applicator workshop
- Monitoring
 - Conduct annual in-stream monitoring
 - Collect and analyze road salt application data
 - Track BMP implementation

2.3.2 Stakeholder Actions

Although the SCWMC took the lead in developing the Chloride TMDL and Implementation Plan, individual stakeholders are ultimately responsible for implementing the identified BMPs, and each is in a unique position to implement the BMPs. For example, BMPs requiring new equipment or accessories depends upon the individual stakeholder’s ongoing equipment replacement schedule. Other activities must be integrated into other street and highway maintenance responsibilities. The following are the general BMP implementation areas agreed to by the stakeholders.

- Product Application Equipment and Decisions
 - Calibrate spreaders at least annually
 - Use the Road Weather Information Service (RWIS) and other sensors such as truck mounted or hand held sensors to improve application decisions
 - Evaluate new technologies such as pre-wetting and anti-icing as equipment is replaced
 - Investigate and adopt new products (such as Clear Lane, a commercially available pretreated salt) where feasible and cost effective
- Deicer Stockpiles
 - Cover all product stockpiles and store them on impervious surfaces
 - Practice general housekeeping policies for handling road salt
- Operator Training
 - Train supervisors and operators to determine the least amount of product necessary to maintain public safety
- Cleanup and Snow Stockpiling
 - Stockpile snow away from sensitive areas
 - Sweep streets as soon as possible in late winter
- Ongoing Research into Salt Alternatives
 - Evaluate new technologies
 - Implement the most appropriate technologies where feasible.
- Tracking and Reporting
 - Report BMP implementation

3.1 IMPLEMENTATION ACTIONS

3.1.1 Commission Actions

The Commission has focused on monitoring and collecting information, and on providing training and education opportunities.

- Chloride and conductivity monitoring is routinely completed on Shingle Creek year-round, with both continuous conductivity and winter/spring snowmelt grab sampling. Summer and winter/spring snowmelt grab samples are taken on Bass Creek. The results and trends are summarized in the Commission's annual Water Quality Report.
- Every year the Commission collects and analyzes road salt application data from the road authorities in the watershed.
- The Commission surveyed road authorities to obtain BMP implementation information.
- The Commission sponsored 11 workshops for public and private salt applicators.
- The Commission's Education and Public Outreach Committee developed a "Low Salt Diet for Shingle Creek" brochure aimed at single-family property owners, and several of the cities distributed them to all residents or excerpted the brochure in their city newsletters and websites.
- The Education and Public Outreach Committee developed a "Maintain Your Property the Watershed-Friendly Way" booklet aimed at managers of commercial and multi-family property owners. The booklet included tips for hiring winter maintenance contractors and specifying how that work should be done to minimize salt application.

The Commission received two significant grants to assist in the implementation of this TMDL.

- In 2006 the Commission received a \$238,500 Clean Water Legacy grant to assist Hennepin County, Brooklyn Park, and Plymouth with implementing pre-wetting on their trucks used in the watershed. Maple Grove also participated and purchased an EPOKE brand bulk spreader for precision salt application, with computer control of the spreaders to alter the spread pattern. This spreader is used in the dense Arbor Lakes commercial area.
- In 2010 the Commission received a \$281,992 EPA/MPCA Section 319 grant to partner with the City of Robbinsdale to undertake a research project called the Paired Intersection Study. Two intersections in Robbinsdale were reconstructed using porous asphalt pavement, with adjacent intersections constructed using traditional asphalt pavement as controls. The traditional pavement received typical plowing and salting, while the porous pavement was plowed but was not salted. The resulting ice control performance was monitored to determine if porous pavement could be an effective substitute for road salt. The results show that porous pavement has some promise under the right conditions, but at this time is a very expensive BMP for the benefit received. The full results were published in a final report in January 2014.

3.1.2 Stakeholder Actions

The road authorities in the watershed have been undertaking BMPs to reduce and more effectively use road salt for snow and ice control. Eight of the nine member cities as well as Hennepin County and MnDOT completed a survey reporting the status of those BMPs (Appendix D).

- All the respondents practice good housekeeping, including calibrating spreaders annually or more frequently, storing salt stockpiles indoors on hard surfaces and promptly cleaning up spillage, and providing annual or as needed training. Many send their operators to the annual Road Salt Symposium, and several have ensured that all or most of their operators achieve the MPCA salt applicator certification.
- Nine of the ten respondents use sensors to measure road temperature and base salt application rates on road temperature.
- Eight of the ten respondents have used some type of alternate de-icer. Most find the alternate products useful in certain situations or when it is too cold for sodium chloride to work.
- Six of the ten respondents use pre-wetting on all their trucks, and another three are outfitting their trucks as the equipment is replaced. Salt brine is applied to road salt as it is being discharged from the truck. This pre-wetting makes the crystals sticky and less likely to bounce and roll off the road, so less can be applied. It also activates salt's ice-control properties faster. Most of the respondents report that pre-wetting has reduced salt application.
- Several respondents also practice anti-icing, mostly on pavements prone to icing such as bridge decks, and on hills and sharp curves.
- Supervisors are tracking application data and providing feedback and coaching to operators who appear to be applying at rates outside what was recommended for an event.

City/County comments regarding the use of weather forecasting systems:

- "We handle each snow event on a case by case basis looking at high and low temps for the 24-hour period and determine if pre-wetting before the snow would be cost effective."
- "Will monitor MnDOT RWIS sites. One of our weather forecasting service providers includes response and application recommendations as part of service."

City/County comments regarding experiences using pre-wetting:

- "Reduction of salt usage by about 30%. No operational issues of consequence."
- "Pre-wetting activates salt quicker reducing need for second applications. Application rate settings have been reduced. No operational issues, partner with another city to supply brine."
- "At first there was reluctance on the part of the operators (just more work) once they started to catch on we have had a lot of positive comments from the operators. We believe that salt usage has gone down. We purchase brine from another agency and need to run transports to supply outlying shops. This can cause issues during busy times."
- "Approximate 30% reduction in salt."

Other City/County comments:

- (Training) "We provide annual training to our employees on proper application of materials when-where and how to apply to reduce over application and placing in the right place to be most effective. We discuss environmental issues and good housekeeping."
- (Alternate Products) "We purchase treated salt off of the State contract. Our experience has been positive. At colder temperatures the treated salt can be applied at a lower rate."
- (Housekeeping) "Sweep salt loading area after salt deliveries and after loading trucks; sweep excess salt spills on roadways. Do not overload trucks to prevent spillage."

3.2 WATER QUALITY TRENDS

3.2.1 In-Stream Chloride Trends

The Commission monitors continuous conductivity at two locations in the watershed (SC-0 and SC-3 on Figure 2.2), and the USGS monitors continuous conductivity at the Queen Avenue bridge in Minneapolis. Conductivity is much less expensive and is easier to monitor than chloride. A good chloride-conductivity relationship was developed for each site in the TMDL (see Appendix A), and chloride samples continue to be periodically taken to refine that regression relationship. The USGS site in Minneapolis has the longest, most complete data set, and the figures shown below use data from that site. Similar figures for the outlet site, SC-0 (in Webber Park in Minneapolis) and the upper watershed site SC-3 at Brooklyn Boulevard in Brooklyn Park are shown in Appendix B.

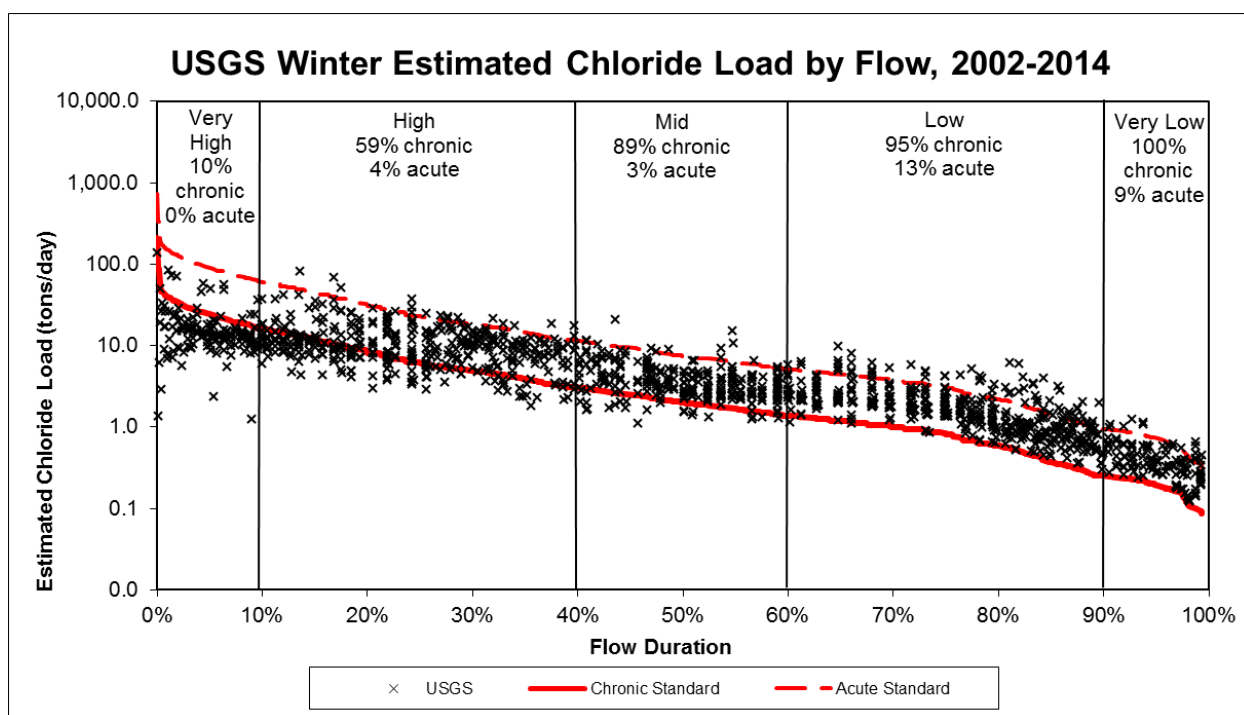


Figure 3.1. TMDL load duration curve and 2002-2014 winter data.

Figure 3.1 shows the TMDL load duration curves for the critical winter monitoring season (December – April), compared to the loads estimated from conductivity and flow at the USGS site. A load duration curve shows the relationship between streamflow and loading capacity. At the very highest streamflows - those that occur less than 10% of the time - the stream can carry a much higher load of chloride because of the effects of dilution. At lower flows – those that occur 90% or more of the time, there is not as much dilution, and the load that can be carried without exceeding the state standard concentration is much lower. On Figure 3.1, the solid red line indicates the load at the chronic standard, and the dashed red line is the load at the acute standard. A stream meeting the state chloride standard would have all or nearly all estimated load values below the solid red line, and there would be no values above the dashed red line. Most of the acute exceedances appear to occur at low or very low flows, which are small, mid-winter snowmelt events. During the highest winter flows, which are large spring snowmelt events, the load conveyed to the stream is high, but so is the volume, which dilutes the load enough to stay at or below the state standard concentration.

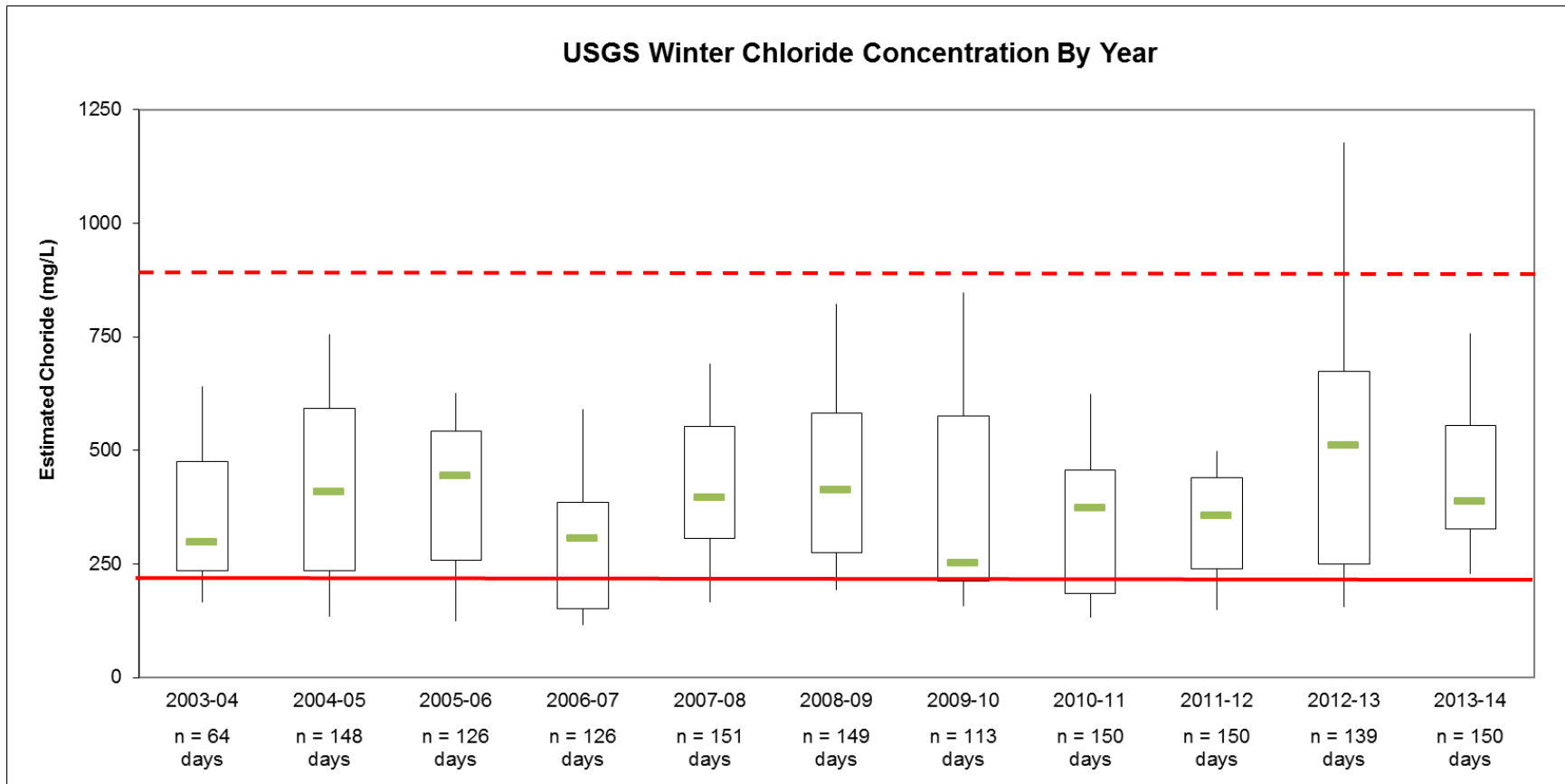


Figure 3.2. Winter estimated chloride concentration at the USGS monitoring site.

Note: the solid red line is the chloride chronic standard and the dashed red line the acute standard. The green bars are the median of the concentration data for that winter season. The boxes show the 25% - 75% range and the whiskers the 10% - 90% range.

Table 3.1. Monthly climate data at the New Hope, MN weather station.

Year	2003/4	2004/5	2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	2011/12	2012/13	2013/14
Dec-Feb Snowfall (in)	29	15	28	30	29	38	40	62	19	37	43
Dec-Feb Avg (HDD)	45	43	37	41	46	44	40	45	32	44	55

HDD = Heating Degree Days = 65°F – daily average temperature. The higher the number, the colder the temperature.

Figure 3.2 shows the estimated concentration at the USGS site compared to the chronic and acute water quality standards. There is no clear trend in concentration and no apparent relationship between concentration and the general winter precipitation and temperature data. In other words, in general, the range of chloride concentrations does not appear to correlate to whether the winter was snowier or less snowy, or colder or less cold than normal. Figure 3.3 shows the estimated chloride load in Shingle Creek over the winter monitoring period at the USGS site. It is difficult to see a trend in the total load carried by the stream, and again, no apparent trend compared to general winter conditions.

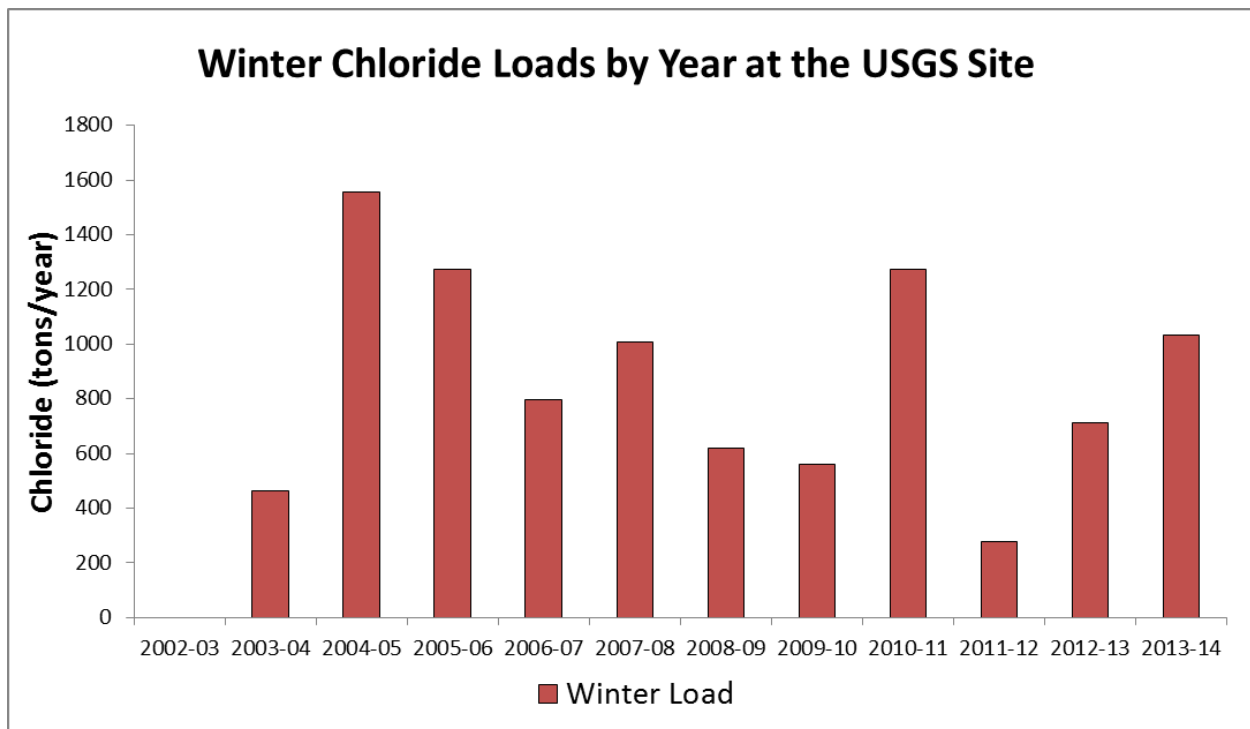


Figure 3.3. Estimated winter chloride load at the USGS site by year.

Annual variability in average concentration and total load appears to be largely driven by unique weather factors and events. For example, in February 2011, there was a series of 40+ degree days and almost a foot of snowpack melted in a few days. This washed a tremendous amount of load into the Creek. However, because the volume of snowmelt was also high, the concentration was diluted. A few days later the temperature dropped and it snowed 11 inches, requiring more road salt to be applied to replace the residual that had been washed off. Thus we see 2010-2011 winter load was higher than in previous or subsequent years, driven mainly by those two February events.

Conversely, January and February 2013 were characterized by many small melt and refreeze events and swings in temperature. With each melt event, low volumes of snowmelt were discharged into the Creek. Because the volume of runoff was low, it was not diluted. The actual winter load was low compared to other years, but the concentrations were high. Loads and concentrations seem to be most influenced by the timing and duration of snowmelt events.

3.2.2 Salt Application

As part of the TMDL Implementation Plan, the member cities, MnDOT, and Hennepin County for several years tracked the application of road salt in the watershed. Three cities and Hennepin County had the

most complete data sets, and that application data was compiled and evaluated to see whether there were any trends in application rates.

Appendix A includes a number of figures showing estimated road salt application per event and per lane mile. For this purpose, an event was defined as any time plow trucks were called out, regardless of the extent of work being completed – whether they were responding to a large storm event or just salting the main road corridors or intersections. This data is also shown by lane mile. Lane miles are defined as the total number of land miles under that road authority’s jurisdiction, whether or not they were actually treated with road salt.

While the road authorities that have implemented prewetting report anecdotally that they are applying less salt than they used to, it is difficult to see a significant downward trend in the data. The median (the green bar on the box-and-whisker figures in Appendix A) does fluctuate, but the range of the 25%-75% interval represented by the boxes on the box-and-whiskers figures for Hennepin County and Brooklyn Park appear to be tightening and getting lower. Both these authorities implemented pre-wetting with the assistance of the 2006 Clean Water Legacy grant noted above. There does not appear to be a downward trend yet for Crystal, which also has outfitted all its trucks with pre-wetting equipment, and for Brooklyn Center, which has only some of its trucks outfitted.

Because the amount of road salt applied depends on local weather conditions and also on a particular road authority’s salt application policies, it is difficult to draw conclusions about changes in salt application. The best data may simply be observational. Street superintendents and operators have stated that they are purchasing and using less salt, in some cases significantly less, than they would have in the past when responding to similar types of events.

3.2.3 Base Flow

As the chloride load from the watershed is decreased over time, it may take a number of years to flush residual chloride from the ponds, wetlands, and channels and streams. Elevated chloride concentrations during summer base flows suggest that local groundwater is also a contributor to in-stream concentration. The MPCA (2013) has found that thirty percent of its monitoring wells installed in the sand and gravel aquifers in the Metro Area had chloride concentrations greater than the chronic water-quality standard of 230 mg/L.

The USGS completed National Water Quality Assessment (NAWQA) studies in the 1990s on Shingle Creek and Nine Mile Creek. Those studies ultimately led to those streams’ chloride impairment listings. The USGS staff noticed that chloride concentrations in Shingle Creek remained relatively high during non-chloride application open-water months, which they hypothesized was due to previous years’ loading into the surficial aquifer that later discharged into Shingle Creek. They observed this effect greater in the relatively permeable sandy-outwash geologic setting of Shingle Creek than in the relatively less permeable and higher relief geologic setting of Nine Mile Creek. They also saw greater chloride concentrations in urban-land use wells located in older development than in more recently developed areas (James Fallon, pers. comm.). The MPCA groundwater study showed that groundwater chloride concentrations in the Metro Area are increasing over time. This may help explain why application mass has decreased 2003-2014, but chloride concentrations have not necessarily in a corresponding way

The monitoring data show that while the peaks in chloride concentration come in the early spring with snowmelt, the average summer concentration is climbing as well. Other streams with chloride impairments also show elevated base flow concentrations (Table 3.2). The increased concentrations of chloride in groundwater may be contributing to the impairment in Shingle Creek and other streams.

Table 3.2. Summer chloride concentration in various Metro streams.

Stream	Years Sampled	May-November Chloride Concentration	
		# Samples	Average (mg/L)
Bassett Cr	2001-2013	111	128
Nine Mile Cr	2001-2013	121	91
Minnehaha Cr	2000-2013	160	72
Coon Creek	2005-2012	54	56
Rice Creek	2008-2011	17	85
Shingle Creek (SC-0)	2002-2013	115	125
Shingle Creek (USGS)	1996-2010	113	117

Source: MPCA EQulS.

3.2.4 Exceedances of the State Standards

Minnesota’s chloride standard includes both a chronic exposure component and an acute exposure component. The chronic exposure standard is considered violated if the average chloride concentration over any four day period exceeds 230 mg/L. The acute exposure standard is considered violated if the average chloride concentration over any one hour period exceeds 860 mg/L. If over a three year period a stream experiences more than two violations of the chronic standard or one or more violations of the acute standard, it is considered an Impaired Water. Figure 3.4 below shows the number of days that Shingle Creek exceeded the chronic and acute standard at the USGS monitoring site.

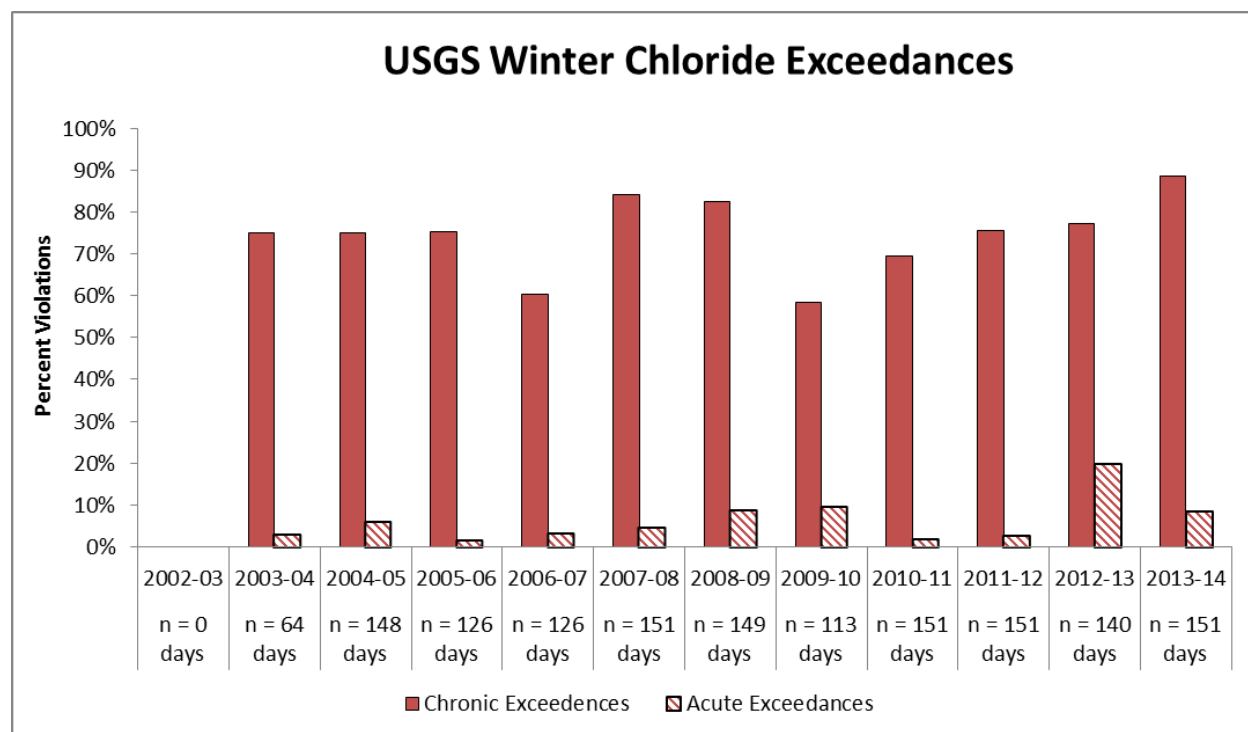


Figure 3.4. Number of days the USGS site exceeded state chloride concentration standards.

As with the concentration and seasonal load data, there does not appear to be a trend of improvement, but this may be masked by the extreme variability. Since the monitoring program became more intensive in 2004-2005, the number of times the average stream concentration exceeded the chronic standard ranged from 65 in the best year to 135 times in 2013-2014. As noted above, the impairment threshold is more than two exceedances over three years. The number of times the acute standard was exceeded ranged from twice in the best year to 28 times in 2012-2013.

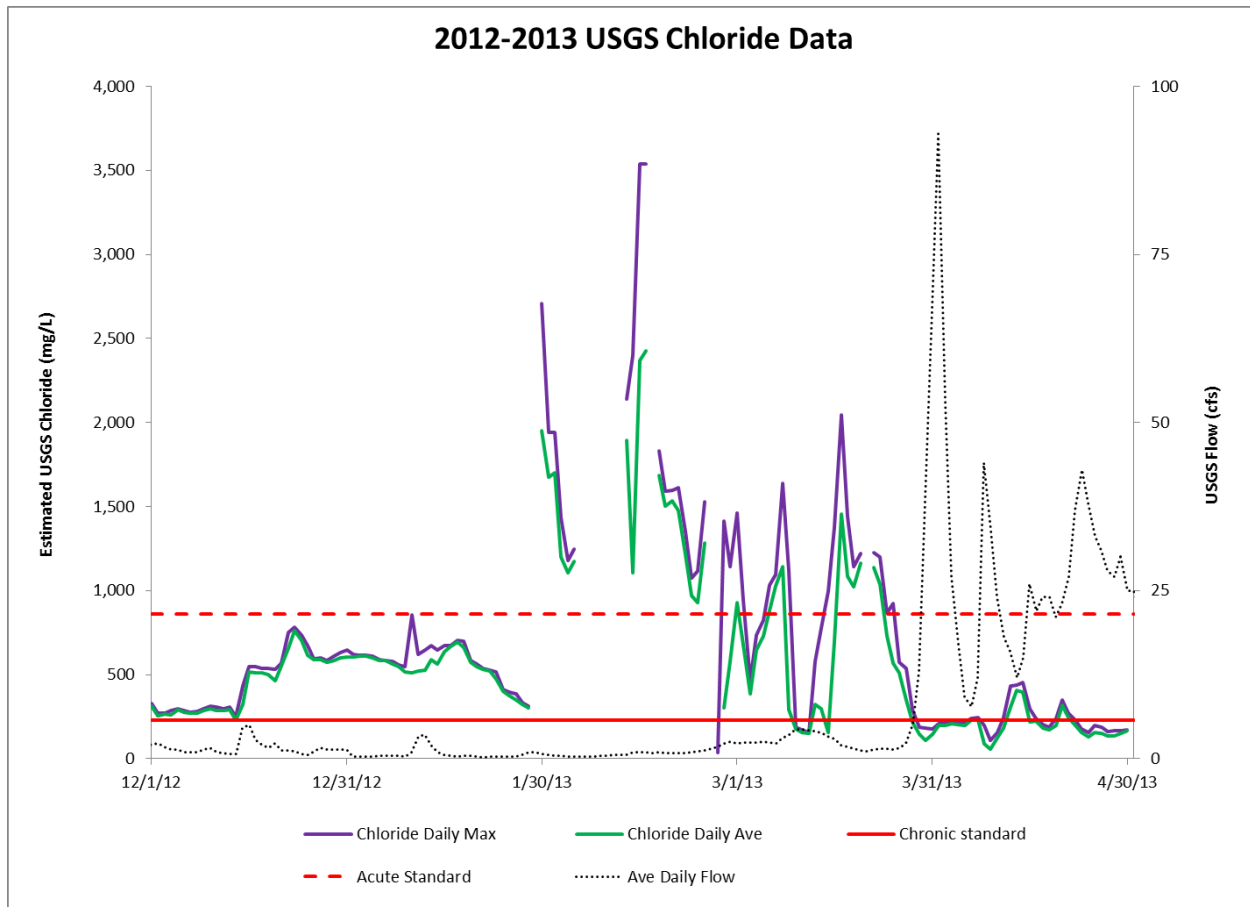


Figure 3.5. Winter and spring 2012-2013 USGS site estimated concentrations.

Figure 3.5 shows this variability for the winter and spring of 2012-2013. It also shows that these chloride exceedances are not an occasional thing, but can extend continuously over weeks or months. In 2012-2013 the chloride concentration at the USGS site exceeded the chronic standard every day for at least three months – December through the end of February and into March. As small snowmelt events occurred throughout February, runoff flushed the salt that had built up over the winter into the stream, and concentrations double or triple the acute standard were measured in the Creek. In late March and early April, when the snowpack melted very quickly, the runoff volume to the Creek increased and concentrations decreased through dilution.

Figure 3.6 shows the estimated daily average chloride concentration data from 2002-2014 at the USGS site. As with the 2012-2013 results, every average daily concentration value exceeds the chronic standard from about December to about March, every year.

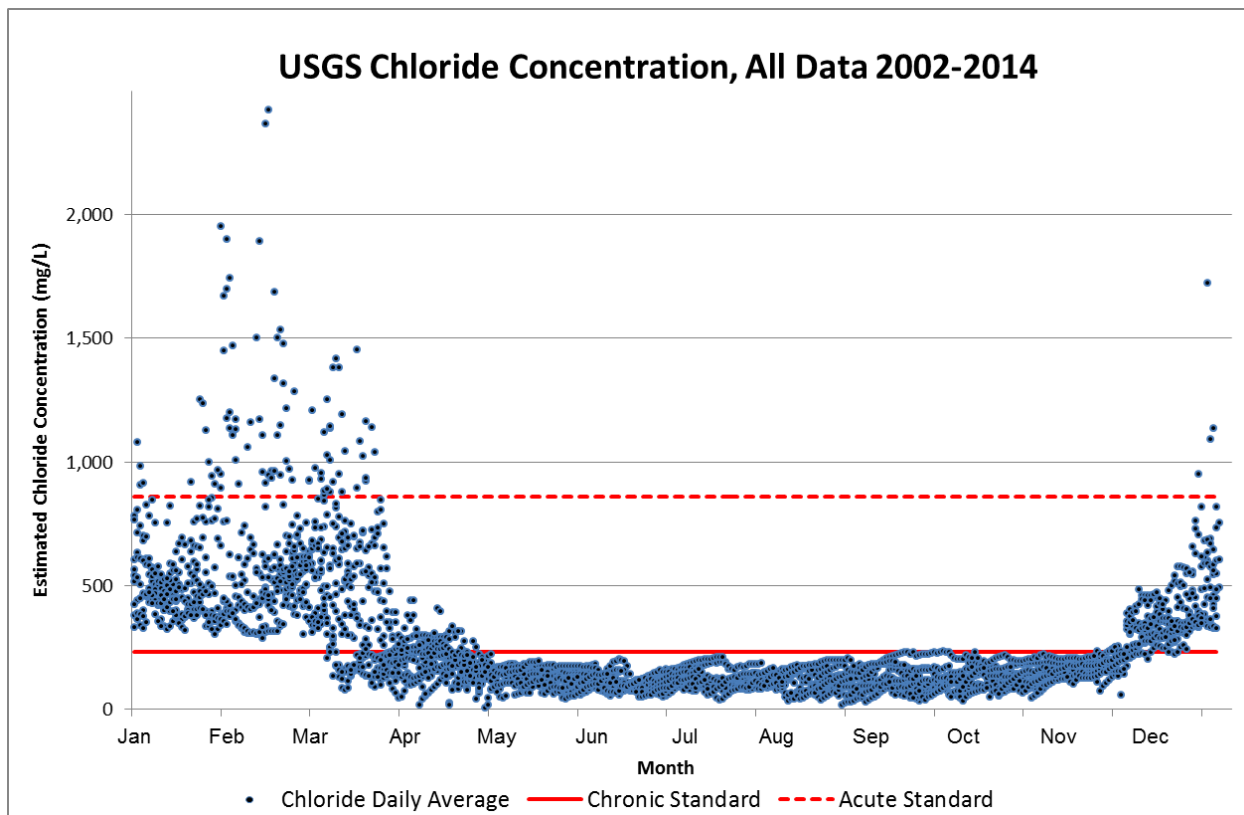


Figure 3.6. Estimated daily average chloride concentration at the USGS site, 2002-2014.

3.2.5 Biotic Impacts

Chloride is regulated by the MPCA because it is a biotic stressor. Chloride can harm aquatic organisms by disrupting natural processes that help regulate their metabolism. Both Shingle Creek and Bass Creek are listed for Biotic Impairment. The Stressor Identification Study completed for the Bass and Shingle Creeks Impaired Biota and DO TMDL identified five primary stressors to aquatic life in these streams, and evaluated the potential for chloride to impact the fish and macroinvertebrate communities.

A key factor in evaluating the potential role of chloride as a stressor in Shingle and Bass Creeks is the timing of peak concentrations. Fish and macroinvertebrate spawning and emergence in cold climates generally occur from late April through August, depending on water temperature. In Shingle Creek the highest chloride concentrations occur during winter and early spring snowmelt, and by late April, when fish and macroinvertebrate spawning occur, concentrations fall below the 230 mg/L chronic exposure standard (Figure 3.6).

However, individual species have elevated sensitivity to chloride at chronic exposure levels less than those acute levels, and at concentrations that Shingle Creek may exhibit for extended periods of time in the late spring. For example, Environment Canada noted that the No-Observed-Effect Concentration (NOEC) for the 33-day early life stage test for survival of fathead minnow was 252 mg chloride/L. Fathead minnow are present in Shingle Creek at the USGS monitoring site, and were the dominant species in terms of number of individuals collected at the Bass Creek monitoring site.

Environment Canada (2001) estimates 5% of aquatic species in streams would be affected at chloride concentrations of about 210 mg/L, and 10% of species would be affected at chloride concentrations of about 240 mg/L. Because Shingle Creek often experiences periods when chloride concentration approaches those levels, chloride may be contributing to the lack of species that are intolerant of poor water quality conditions.

The most chloride-sensitive macroinvertebrate taxa found in Shingle Creek where there are more than just a few individuals present are caddisflies and black flies. These were most prevalent at SC-0 (Webber Park) and in Brookdale Park in Brooklyn Park, both at sampling locations with small riffles nearby and a sandy gravel streambed. This suggests that in the presence of desirable habitat saline-sensitive taxa may be able to tolerate the current levels of chloride in Shingle Creek.

3.3 SUMMARY OF PROGRESS

BMP Implementation. The implementation Plan identified various BMPs that could be undertaken, which are similar to BMPs recommended by agencies such as Environment Canada and by many of the northern tier of states in the US, including New Hampshire, Michigan, Maine, Pennsylvania, Massachusetts, and Minnesota in the Metro Area Chloride Project (MPCA 2014b). The road authorities in the watershed have undertaken most if not all of these BMPs, including those that can most significantly reduce road salt application. Table 3.3 summarizes the major BMPs that have been implemented, with more information available in Appendix D.

Table 3.3. BMPs implemented.

BMP	Actions Taken
Pre-wetting and anti-icing	Six of the 10 road authorities surveyed have outfitted every plow truck with pre-wetting equipment, which uses road salt more effectively so that less can be applied. Three of the other road authorities are outfitting their trucks as they are replaced, and it will be a few more years before that transition is complete. One city plans to implement pre-wetting in the future if funding is available. Operators and street supervisors believe that by using the pre-wetted salt, they are applying up to 30 percent less than untreated salt. The per-event salt application data reported by the road authorities seems to bear this out, although the trend is difficult to discern due to daily, monthly, and annual variability. Anti-icing is being practiced, mainly on ice-prone areas such as bridge decks. Weather subscription services help road authorities predict the optimal time before a snow event to anti-ice.
Calibration and optimal application rates	Every road authority reports they calibrate spreaders and other equipment at least annually. All but one report they use temperature sensors and base application rates on pavement temperature.
Good housekeeping, training and storage	Good housekeeping measures are practiced, including promptly sweeping up spills, loading indoors, and storing road salt in enclosed spaces with drainage systems. Operators are trained at least annually, with followup coaching where necessary. Many of the operators have achieved the MPCA salt applicator certification.
Alternative products	Alternate materials are used in limited ways, such as high-priority areas or when conditions are too cold for road salt. Road authorities have tried salt treated with brine or alternate products as well as sodium chloride alternatives, which can be double or up to 10 times more expensive than regular road salt. They are a supplement rather than a substitute for road salt.
Keep abreast of new technologies	The Commission and Robbinsdale partnered on a study evaluating the effectiveness of porous pavement at ice control. The Commission has a continuing interest in additional research of new technologies. Key city personnel attend training, conferences, the Road Salt symposium, the Snow Rodeo, and other events with opportunities to learn and share information.

Stream Response. There is no apparent trend of improvement yet in the in-stream chloride concentration or in number of days the Creek exceeds the chronic or acute state chloride standards. It could be that there is so much residual salt in the surficial groundwater, lakes, wetlands, and ponds that it will take a long time to flush the higher concentrations out of the system. Or, since stream response is often not linear, it may be that it will take a much greater load reduction from the watershed than has already been achieved before a response is finally clearly seen. However, on a positive note, there is no apparent trend of degradation in the in-stream chloride concentration.

It will take a significant effort to meet the state chloride standards given that under current conditions Shingle Creek continues to exceed the chronic standard for months at a time. As noted above, the road authorities in the watershed are already implementing most if not all the BMPs generally identified as most likely to reduce road salt application rates and resulting chloride loads. Barring a significant new technology, any new load reductions to Shingle Creek will be incremental as all the road authorities implement all the BMPs identified in the TMDL.

There are benefits to reducing road salt use other than stream water quality. Road salt damages pavement and corrodes bridge decks and vehicles. It damages roadside plants and sensitive ecosystems. A literature review (Fortin 2014) completed for the Twin Cities Metro Area (TCMA) Chloride Project reports the estimated cost of damage ranging from \$803 to \$3,341 per ton of road salt applied. Any amount of chloride load reduction results in a public benefit simply in reducing the cost of repairing this damage.

Base Flow. There do appear to be elevated chloride concentrations in groundwater and base flow that are likely contributing to the chloride impairment, especially in summer. Elevated chloride concentrations in the groundwater may be contributing to the biotic impairment as fish and macroinvertebrates are more active spring to fall, when baseflow is the predominant component of streamflow.

Another benefit of reducing road salt use is to slow the increase in chloride concentrations in groundwater. This has implications not only for impacts to wetlands, streams, and lakes that receive groundwater contributions, but also for human health. Drinking water wells that draw from surficial aquifers are at risk of exceeding drinking water guidelines established by the EPA.

4.1 IMPLEMENTATION PLAN

4.1.1 Principles and Focus

The stakeholder group that developed the first Implementation Plan established five principles to guide implementation (section 2.2 above). In this second, five-year Implementation Plan, those principles are reaffirmed, focusing actions on:

- Continuing to implement BMPs to maximize achievable load reduction.
- Striving to reduce the conditions that are most harmful to the biota.

4.1.2 Priorities

The Commission and road authorities will concentrate on the following over the next five years:

1. The road authorities will continue to implement the BMPs identified in the TMDL, with the goal of 100% implementation by all the road authorities in the watershed. The Commission will develop a simple form for reporting BMPs, and request that each road authority annually report to the Commission its road salt management activities.
2. The road authorities and the Commission will focus not only on watershed-wide reductions, but also on minimizing road salt use in critical areas. Many of the winter acute exceedances occur during small melt events. A critical area is the “directly connected” tributary area, which is that part of the watershed that drains directly through pipe, channel, or overland to the Creek without an intervening lake, pond, or wetland that may store runoff from those small events until the spring flush. Minimizing application in these directly connected areas may help to attenuate acute exceedances when those small melt events convey road salt directly to the Creek.
3. To reduce potential harmful effects on the biota, the interim goal for Shingle Creek and Bass Creek for the upcoming five years will be to strive to reduce the incidences when chloride concentrations are at their most potentially lethal to the biota.
 - a. No exceedances of the acute standard.
 - b. Reduce the annual number of days the stream exceeds the chronic standard by 20% from the 10-year average of 140 to 112.
4. The Commission will seek funding to conduct a paired subwatershed study to evaluate pollutant loading and cost effectiveness of using traditional sodium chloride road salt compared to alternate de-icing products.
5. The road authorities will continue to report road salt application by plow route to the Commission, and the application data and in-stream concentration data will continue to be assessed and set forth in the Commission’s Annual Water Quality Report. The Commission will also collect road salt purchase data and analyze trends in salt yield to the Creek.

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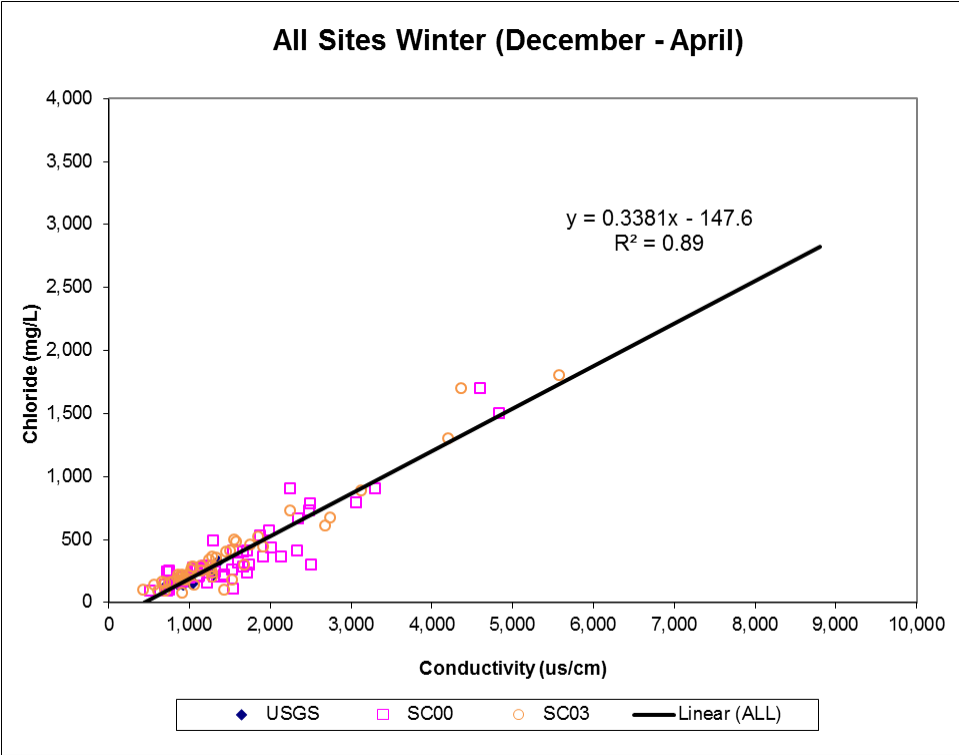
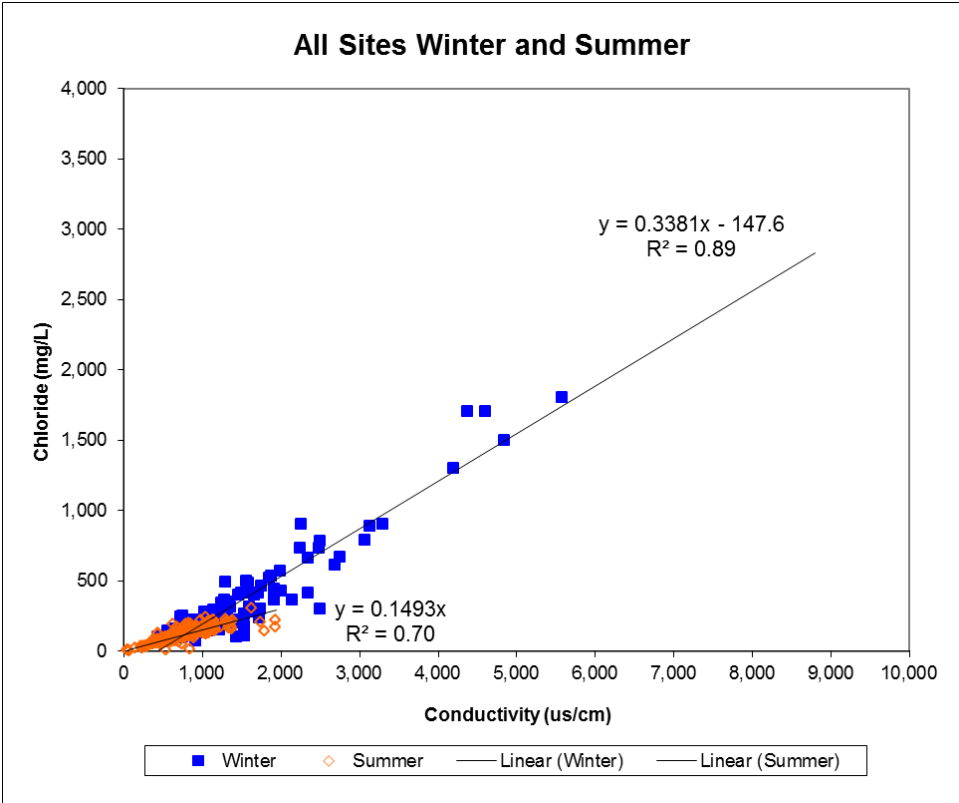
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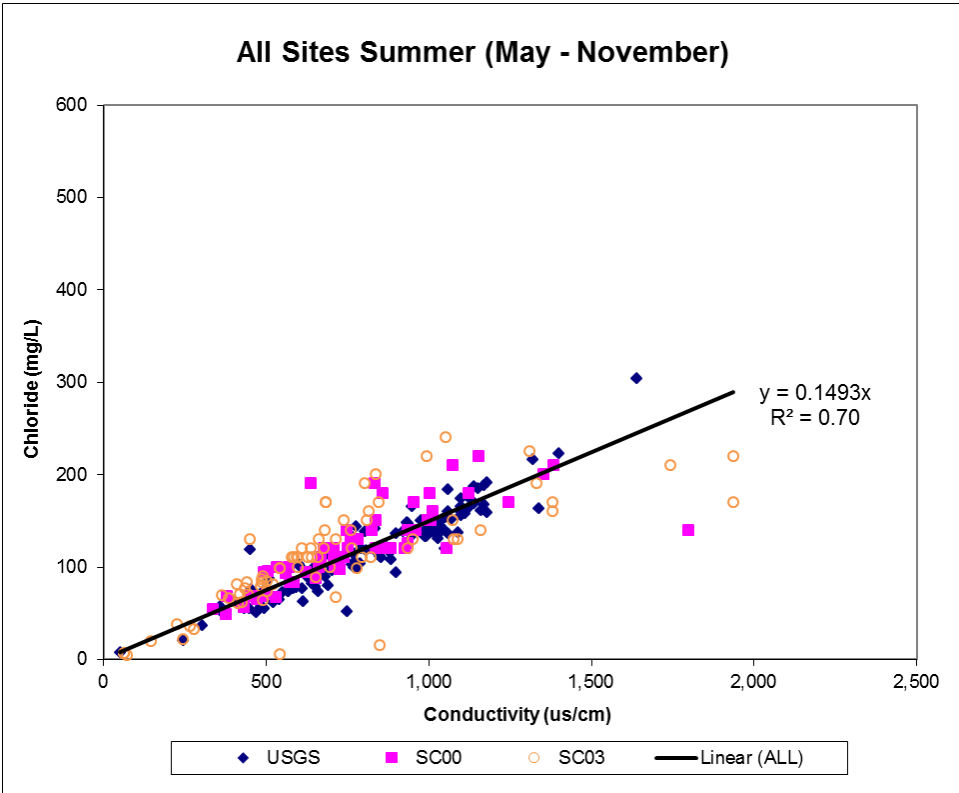
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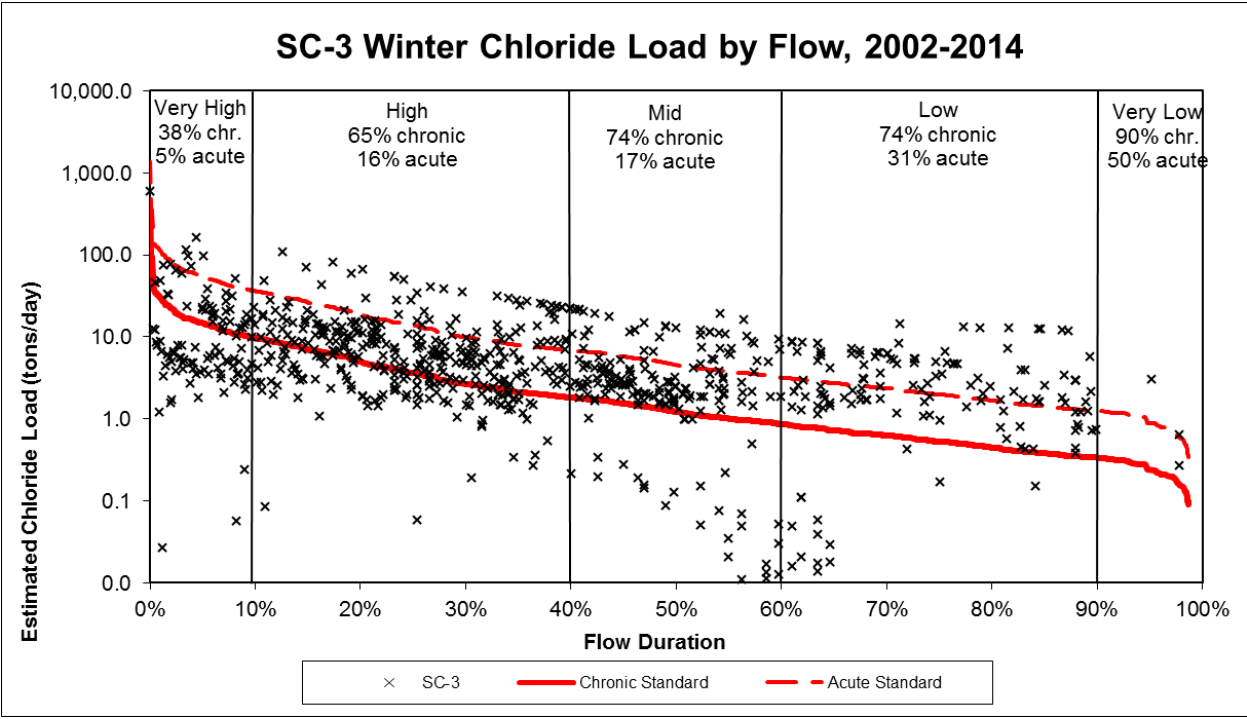
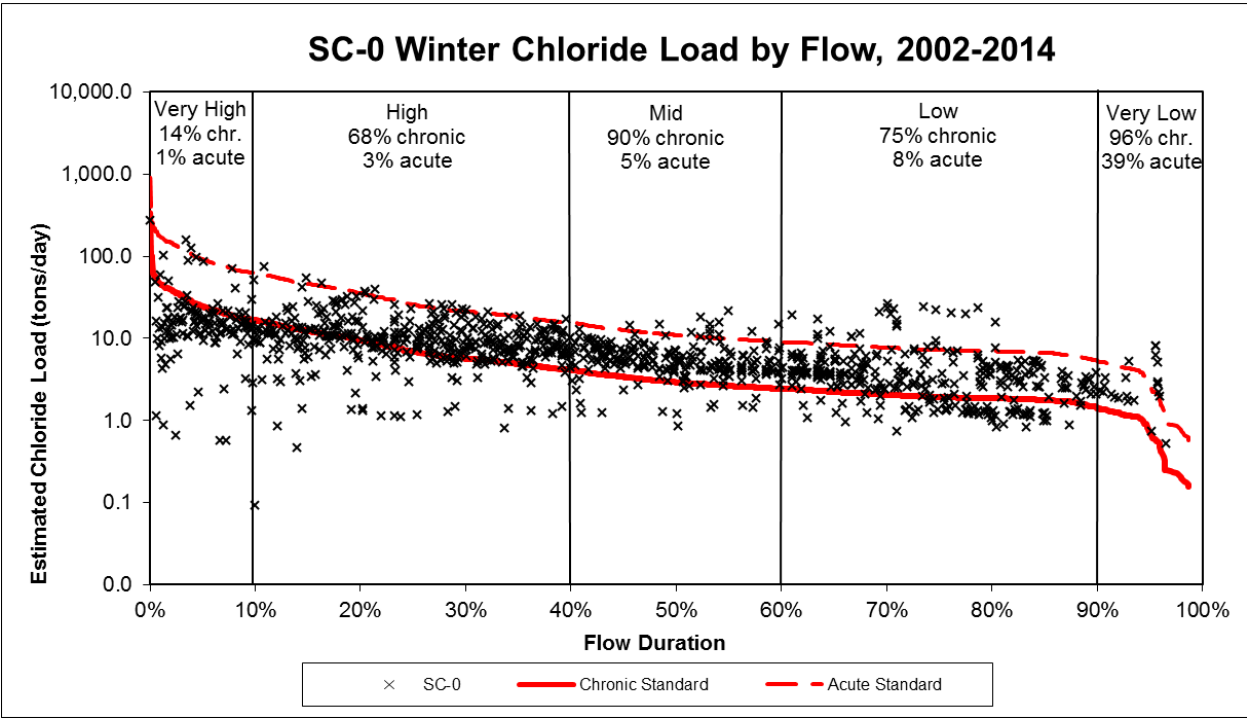
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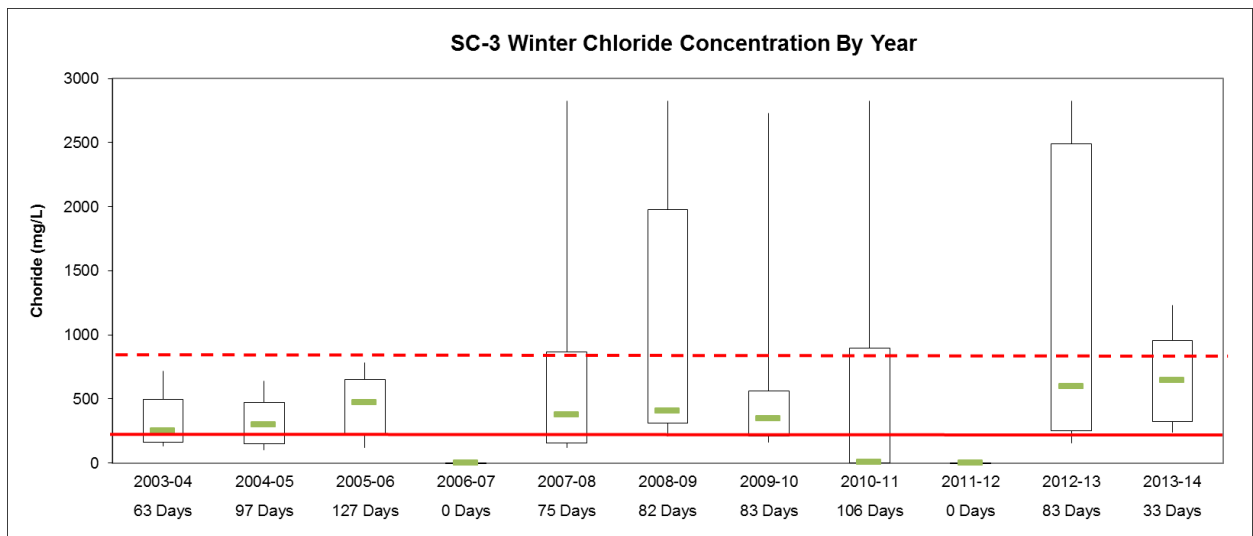
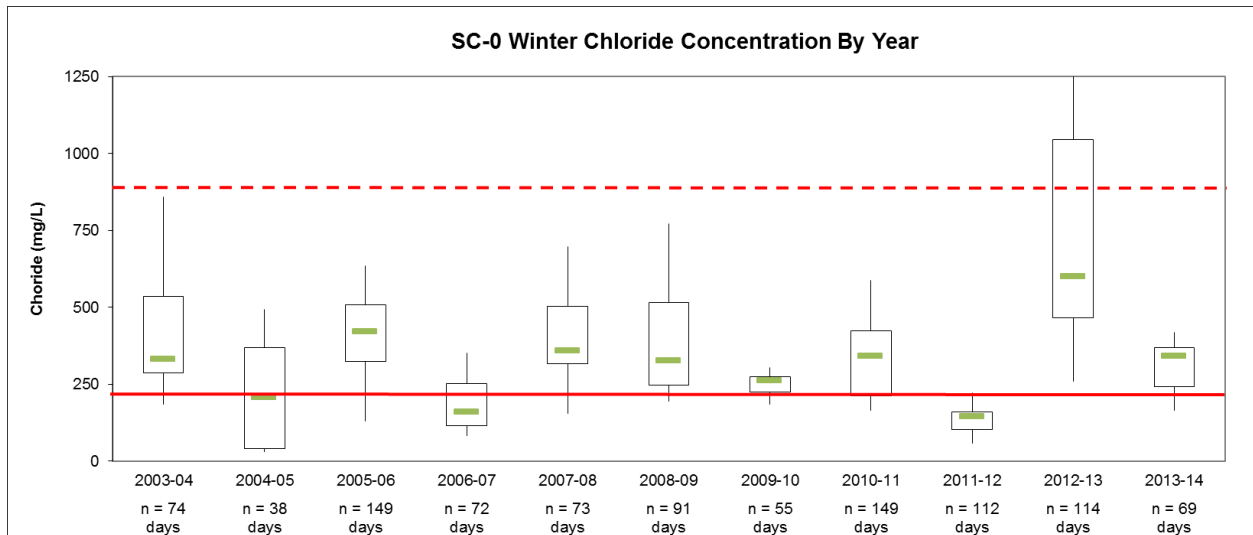
Chloride-Conductivity Relationships



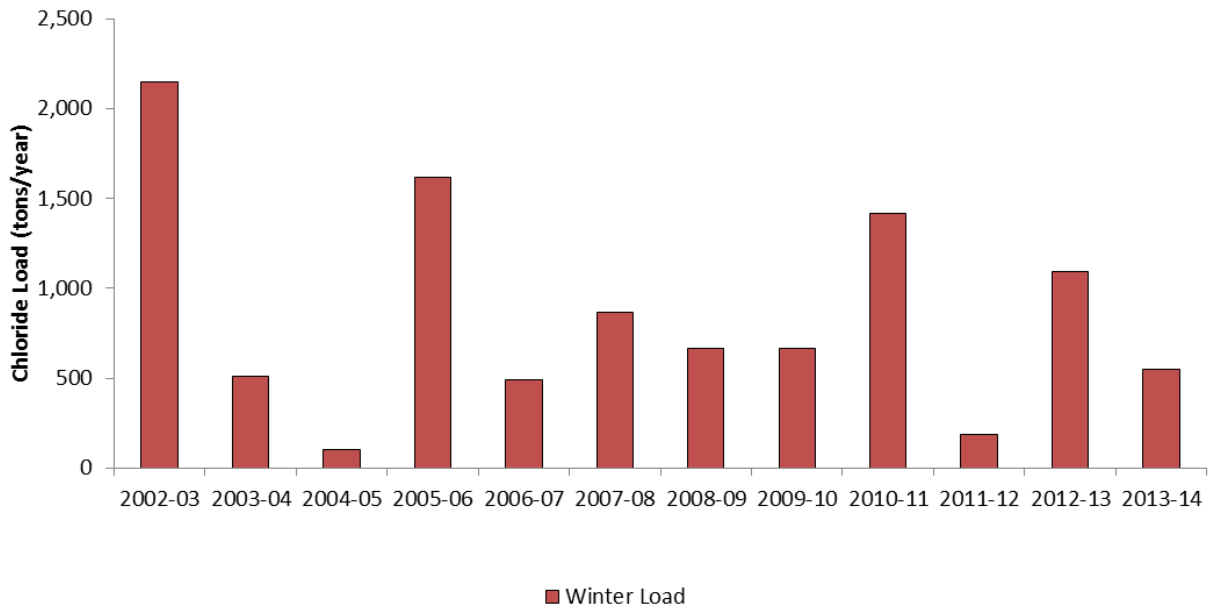


**Water Quality Trend Data
Monitoring Sites SC-0 and SC-3**

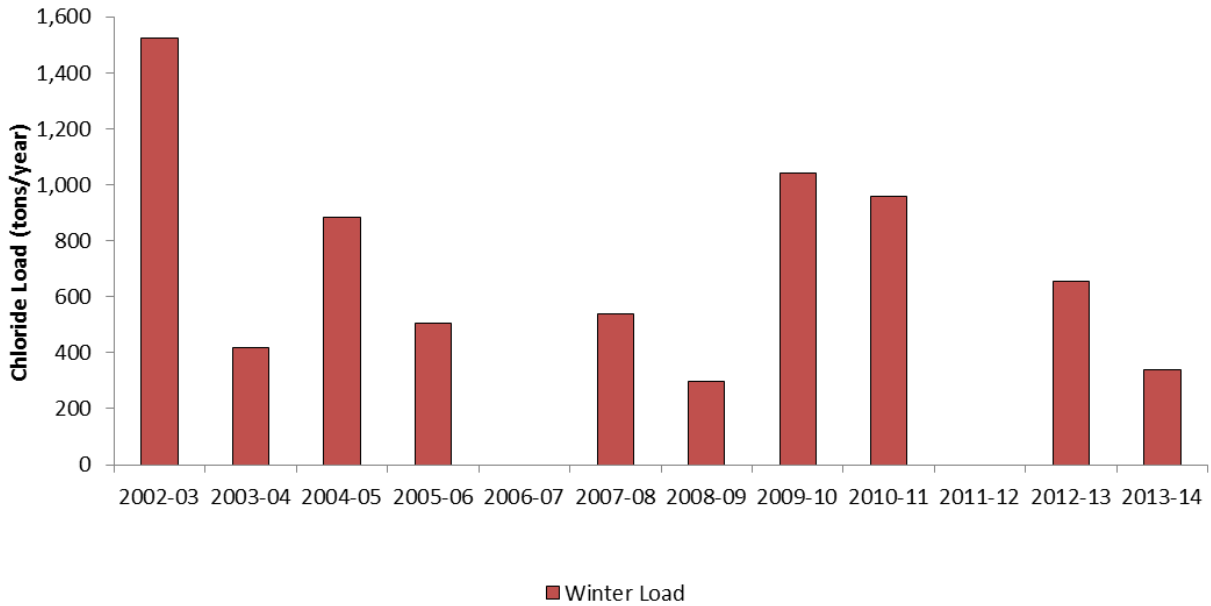


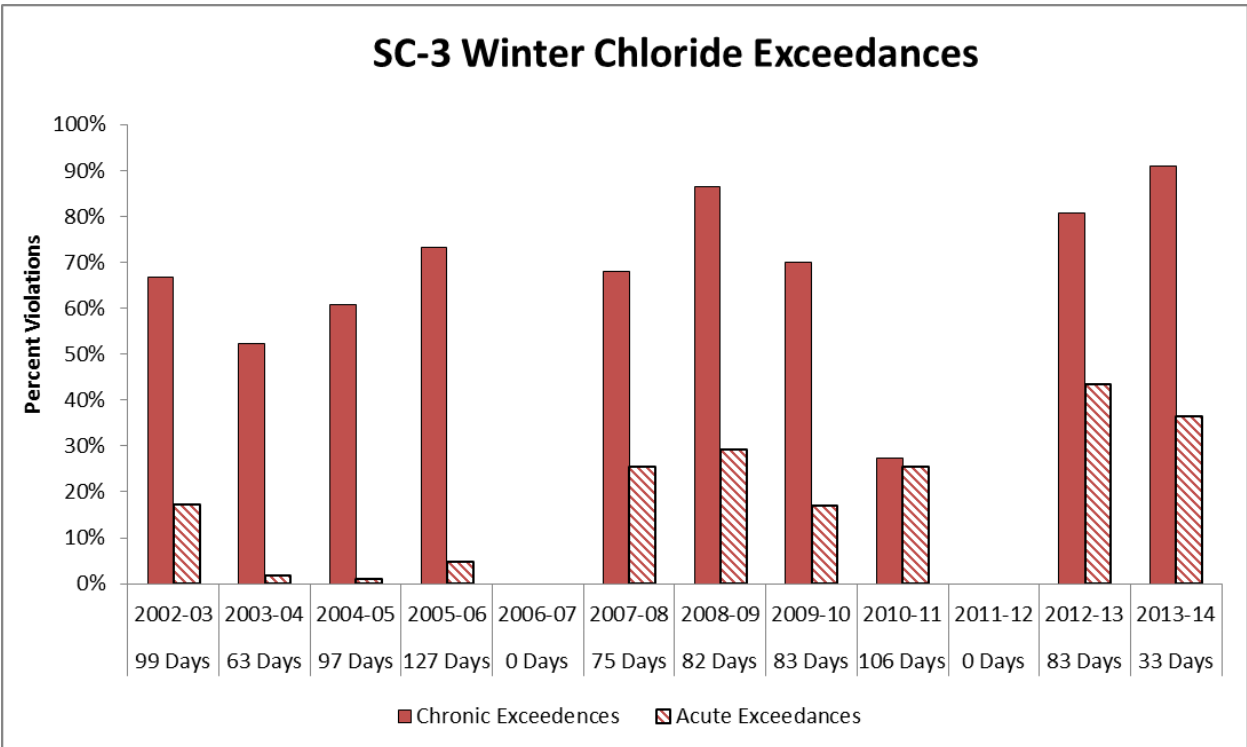
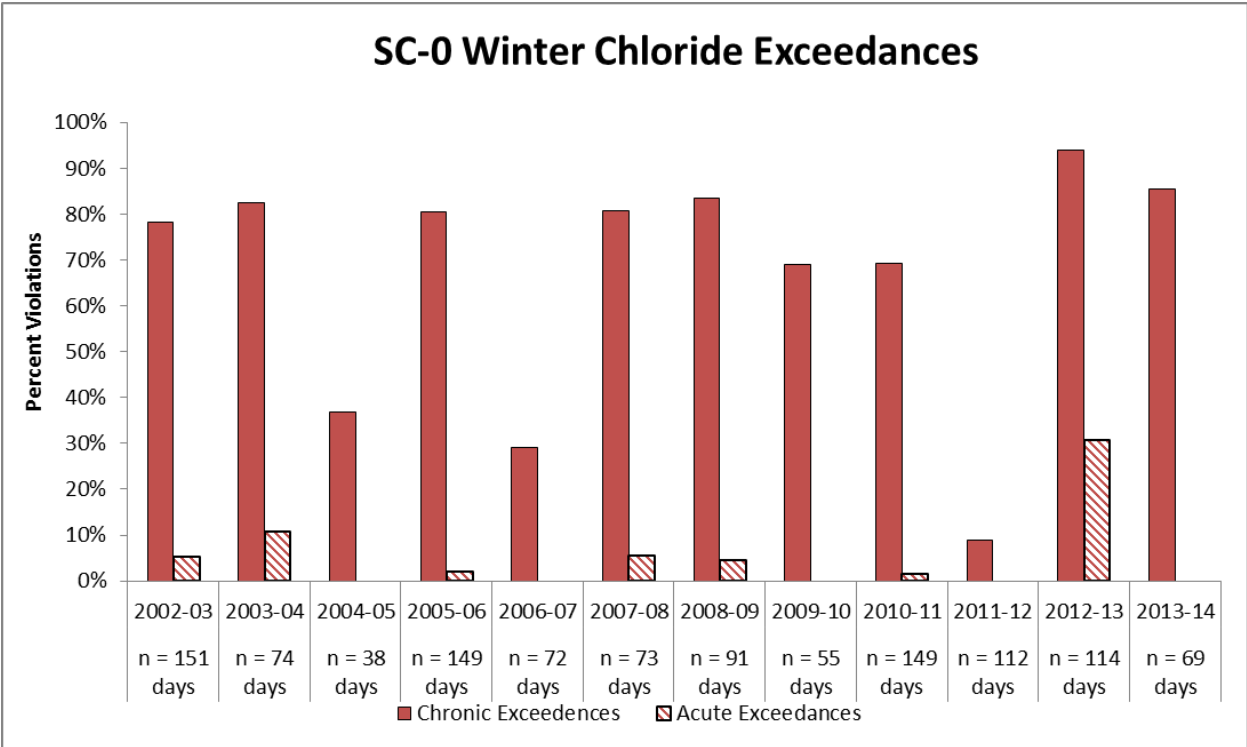


Winter Chloride Loads by Year at SC-0

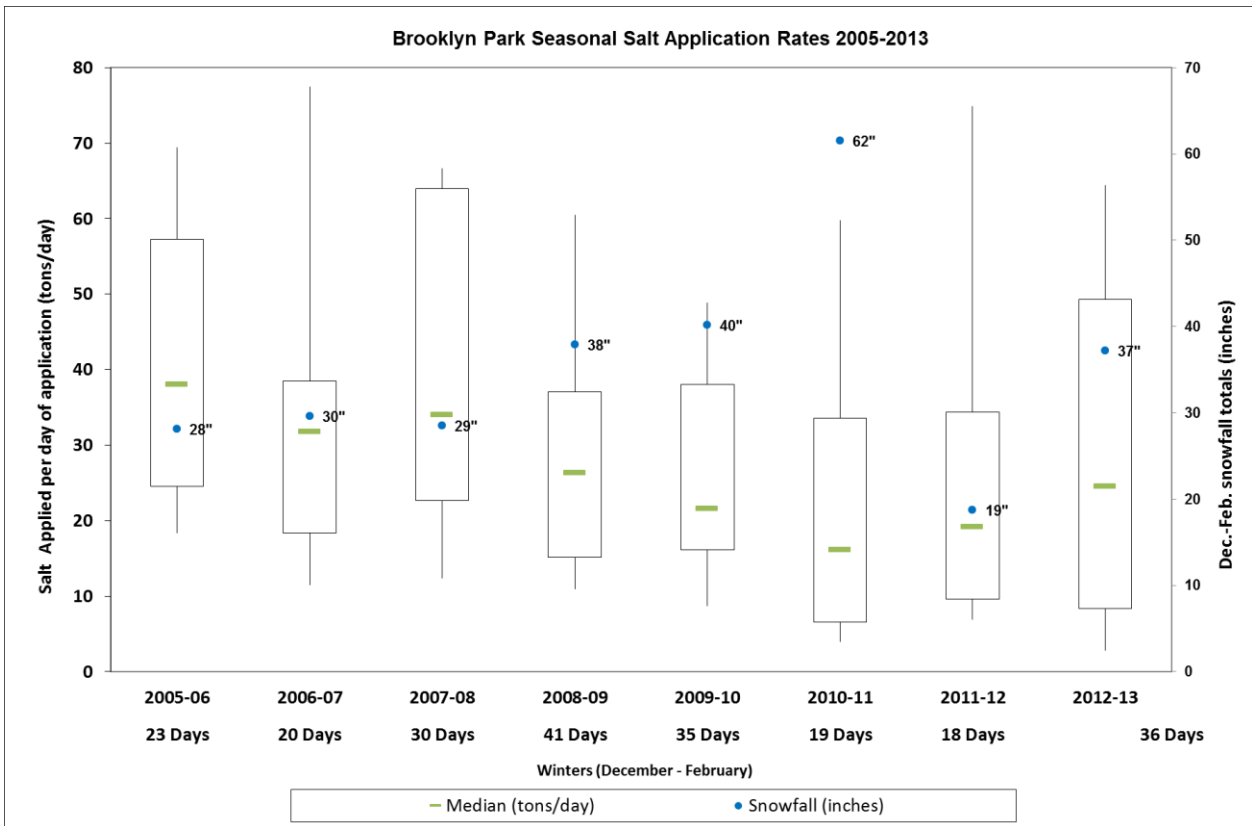
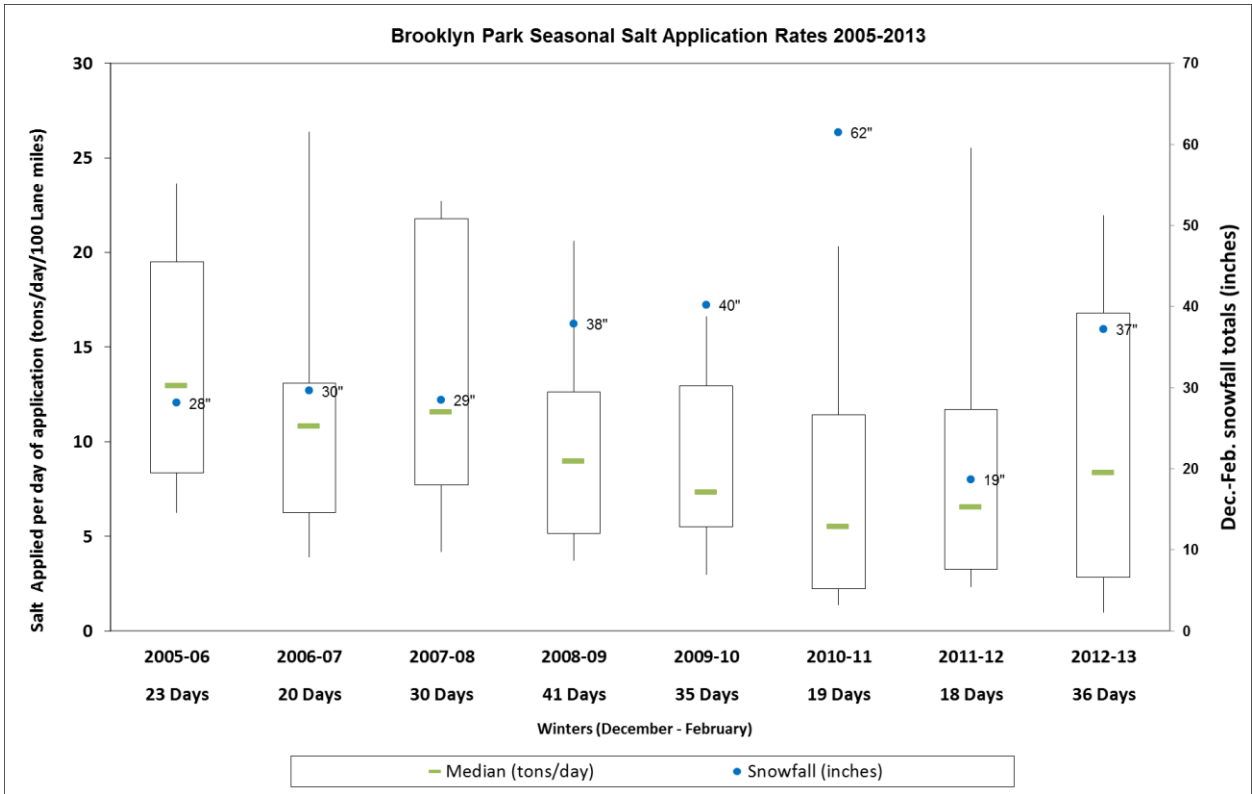


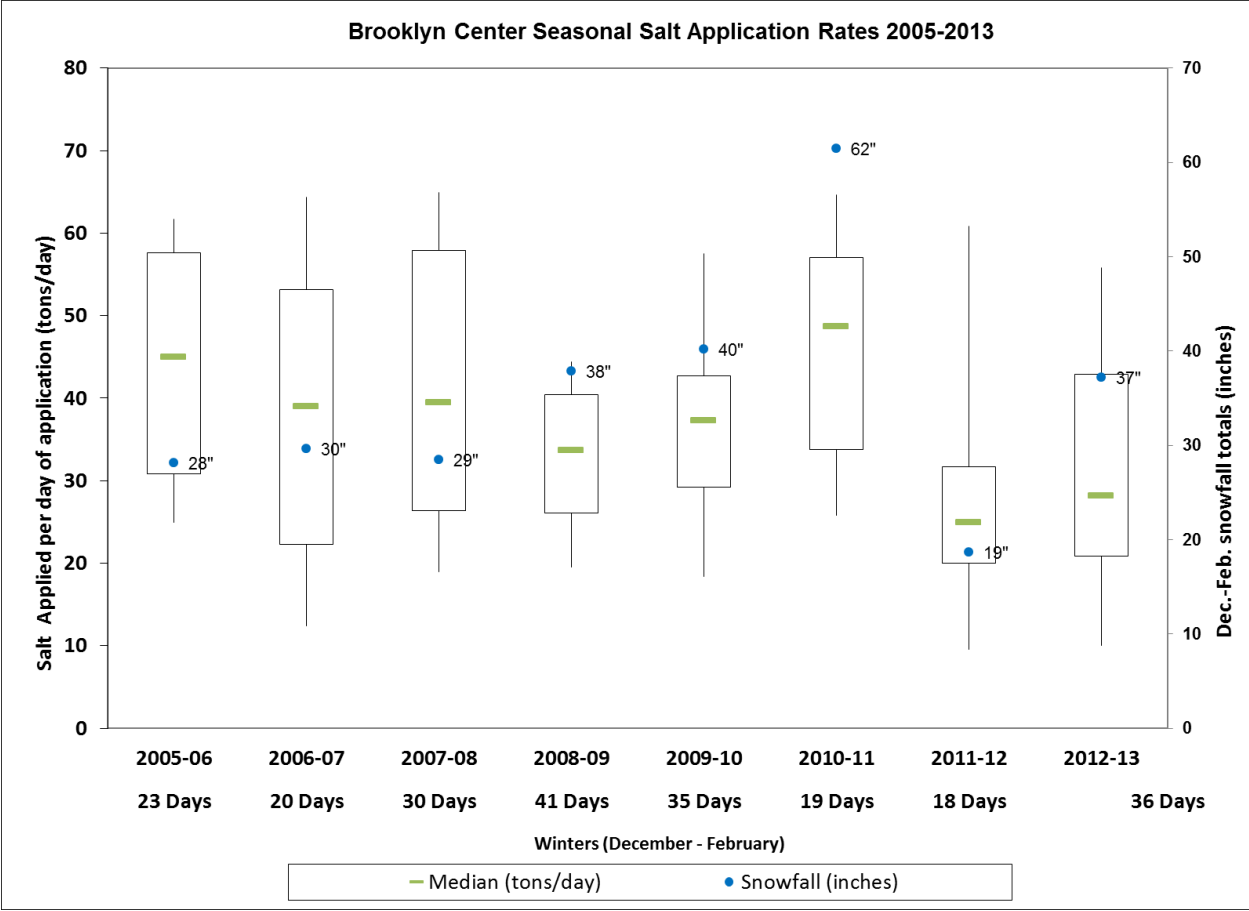
SC-3 Winter Loads by Year

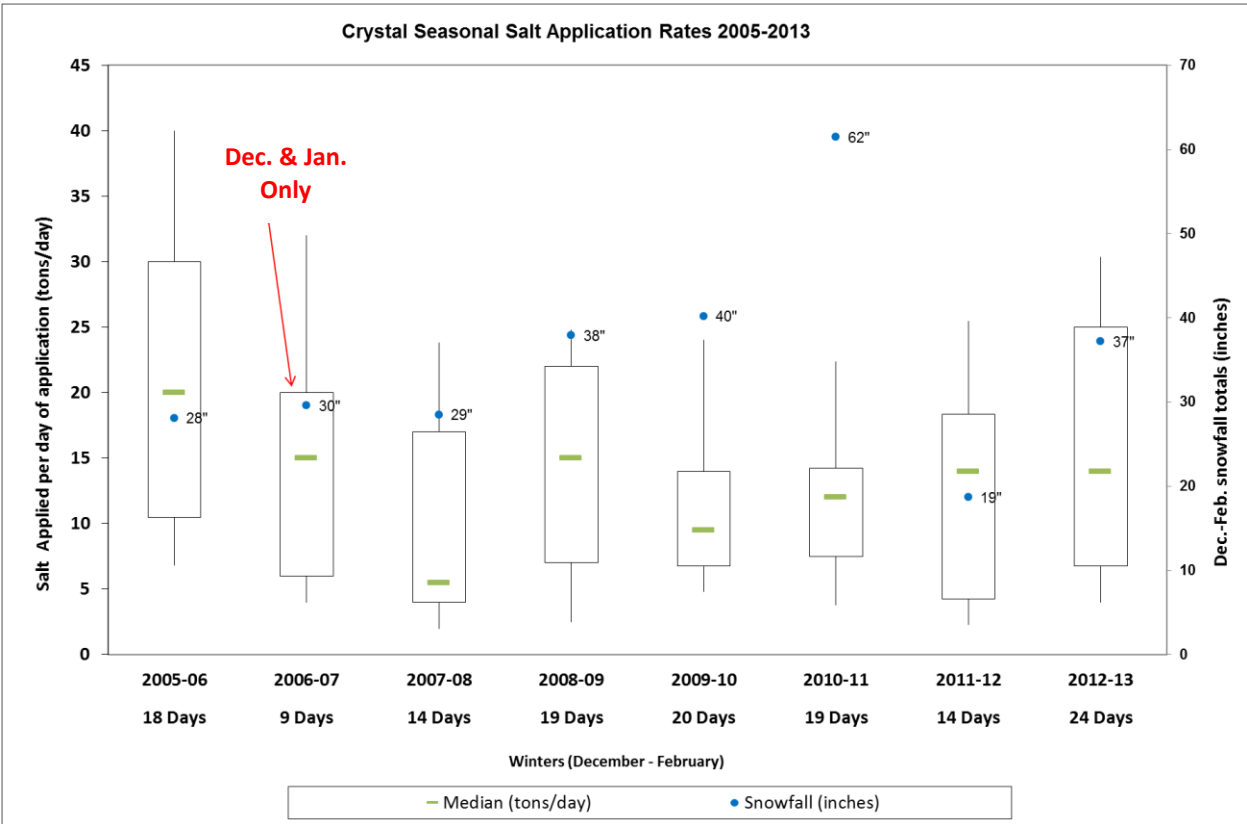
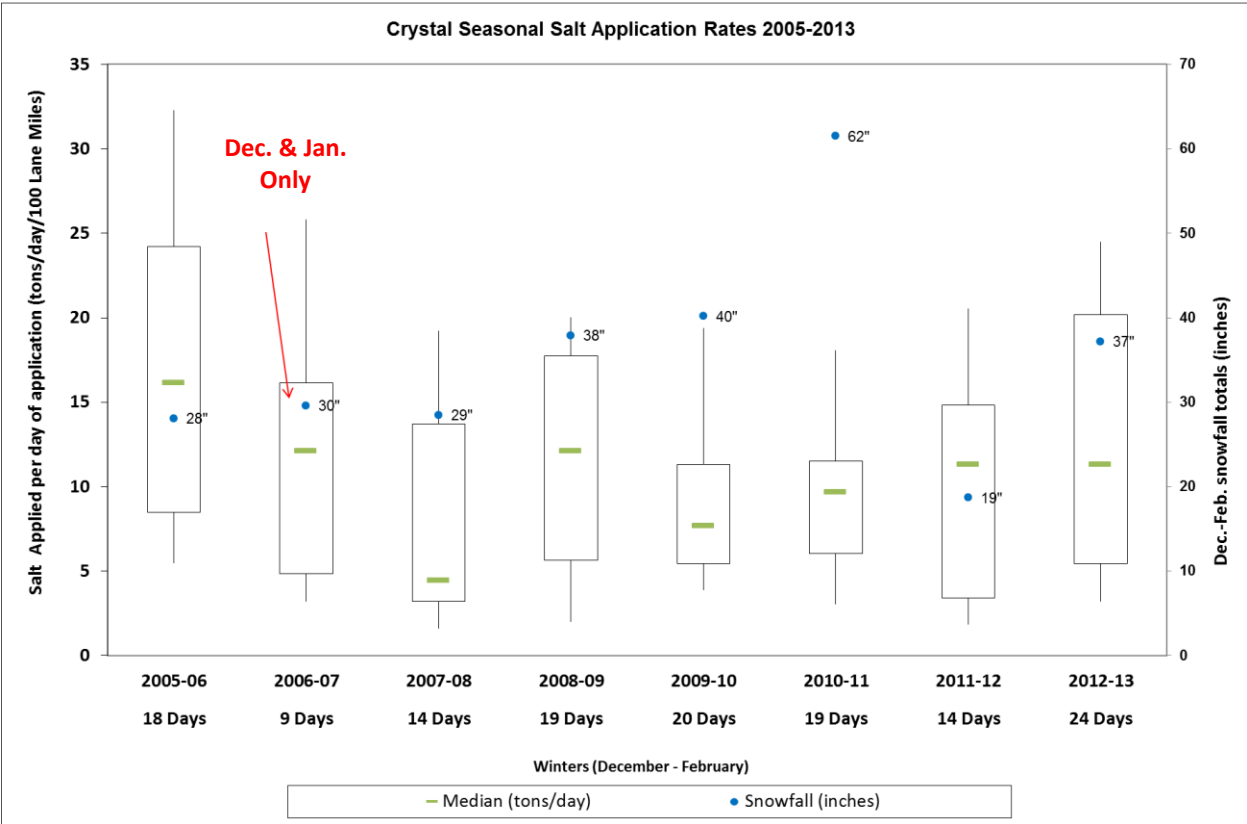


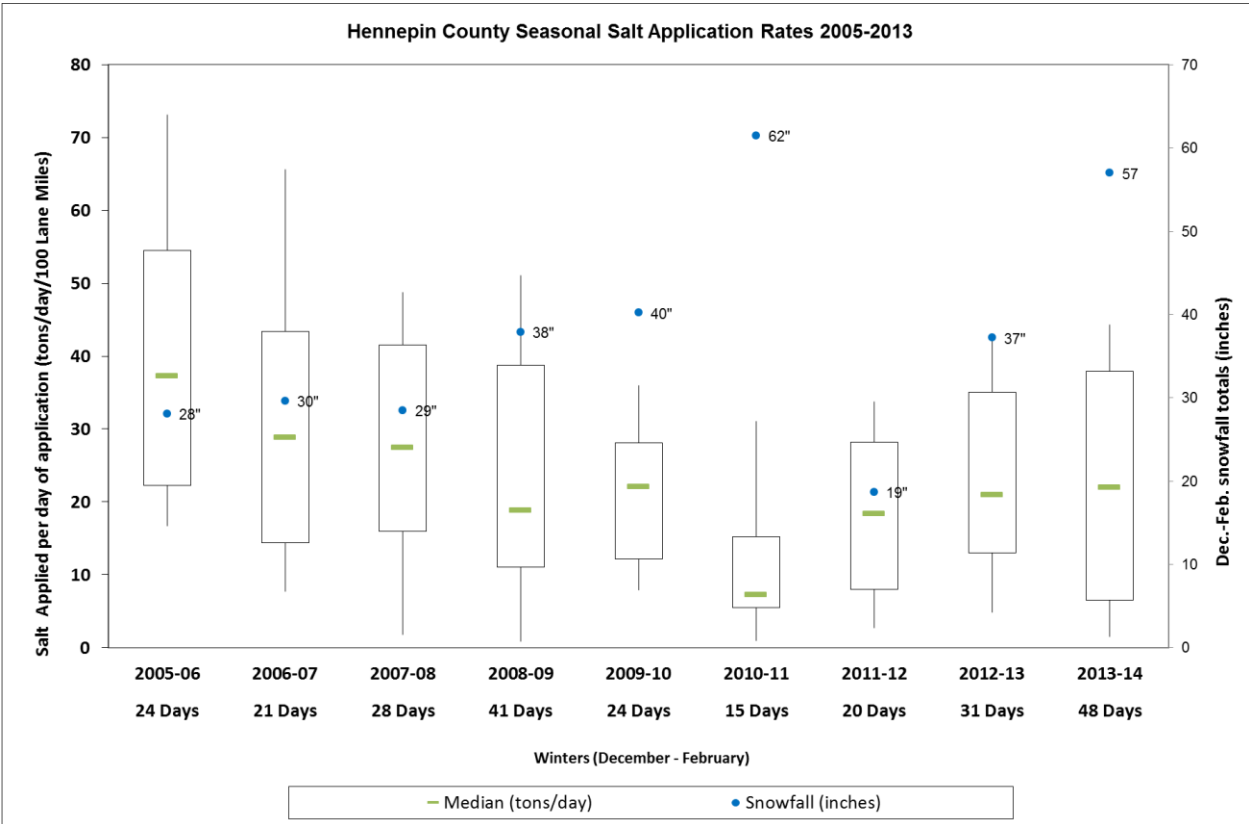
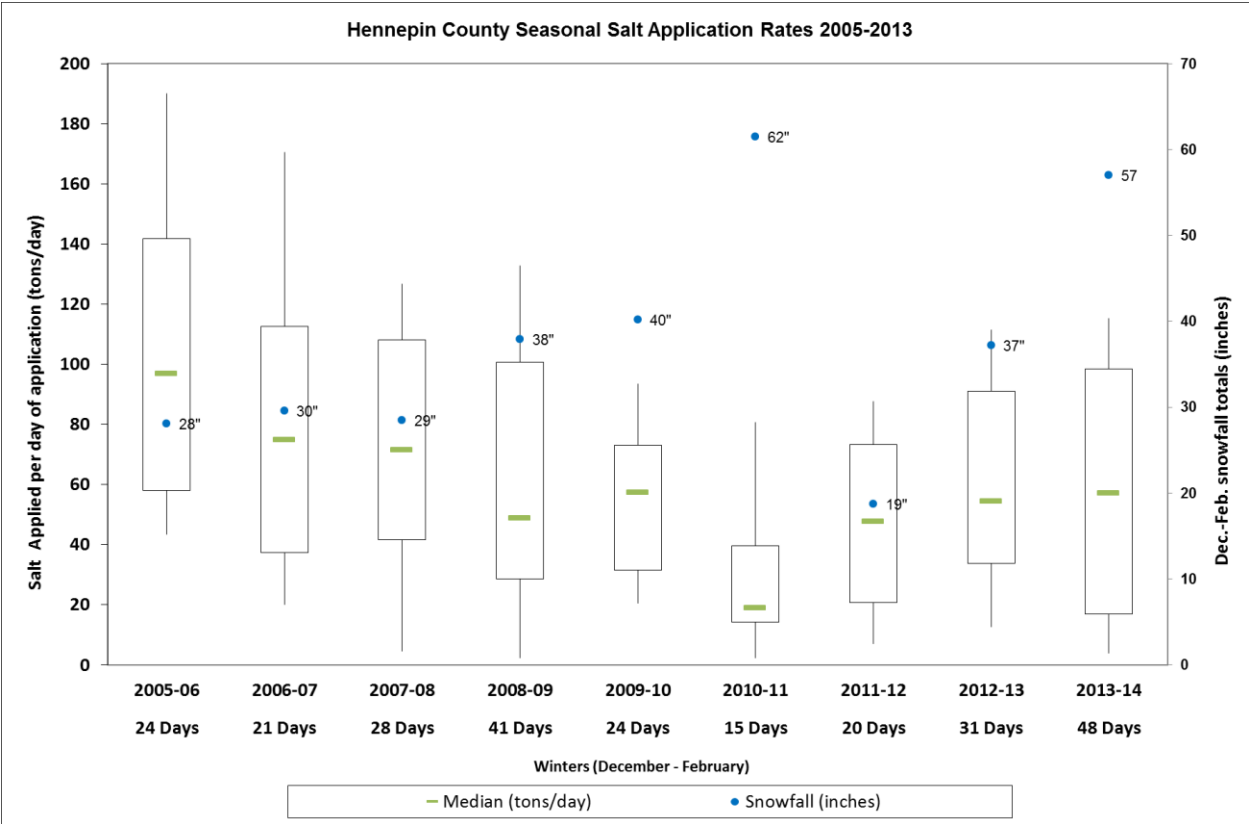


Road Salt Application, Selected Jurisdictions









Road Authority BMP Survey

Table D.1. Road authority BMP survey results, April 2013.

Question	Crystal	Robbinsdale	Minneapolis	New Hope	MnDOT Metro District
Are your spreaders calibrated at least annually?	Yes.	Yes.	Yes.	Yes	Yes.
Do you use temperature sensors to improve application decisions?	Yes, use a hand-held sensor.	No.	Yes, on some trucks.	Yes, on all trucks.	Yes, on all trucks.
How do you use the Road Weather Information Service (RWIS) or other sources of weather information such as the National Weather Service to improve application decisions such as the amount and timing of application?	We handle each snow event on a case by case basis looking at high and low temps for the 24-hour period and determine if pre-wetting before the snow would be cost effective.	Forecast used for timing of the storm and then application of Anti-icing, type of material (treated salt-vs-regular salt) as needed for the conditions and temp.	Will monitor Mn/DOT RWIS sites. One of our weather forecasting service providers includes response and application recommendations as part of service.	To help determine start time We do have deicing application rate guidelines chart, and the (RWIS) helps us plan for application rate.	We use the system to monitor road temps, wind direction and speed, movement of the event such as direction and travel speed, humidity and cameras.
Do you pre-wet salt before application?	Yes, on all trucks.	Yes, on all trucks.	Yes, on some trucks.	No, but plan to in the future.	Yes, on all trucks.
If you do not use pre-wetting on all your vehicles, what keeps you from implementing?			Can only upgrade vehicles as they are replaced, a slow process.	We use treated salt. Need to do some remodeling to fit the brine tank.	
If not on all vehicles now, when do you anticipate having your fleet fully outfitted for pre-wetting?			Indeterminate at this time.	0-5 years.	
Tell us about your experiences with pre-wetting generally. Do you see a difference in application rates and salt use? Any operational issues?	Yes - reduction of salt usage by about 30%. No operational issues of consequence.	Material starts to work faster letting us know where we need to concentrate our application resulting in using less material and re-application.	Limited use due to small portion of fleet outfitted so far. No firm data at this time. Not sure we see a big advantage in our urban core environment.	Pre-wetting works faster. Our treated salt works at colder temps and use less.	Pre-wetting is a very useful tool in jump starting the melting process and in reducing salt usage in minimizing salt loss to scatter and bounce into to the shoulder and ditch area and keeping it in the target area.
Have you used alternate, non-salt products such as ClearLane or IceBan? If so, what has been your experience?	Yes. Only in small quantities for specific applications depending on weather conditions..	No.	Yes. Has some practical use in the right conditions.	Yes. Use less and works at colder temps.	Yes. These products work well in reducing salt usage and assisting in the melting process to reduce loss of salt to traffic blow off.
Are your product stockpiles covered?	Kept in salt shed.	Kept in salt shed.	Kept in salt shed.	Kept in salt shed.	Kept in salt shed.
Are your product stockpiles kept on a hard surface?	Yes.	Yes.	Yes.	Yes.	Yes.
Describe your good housekeeping practices for handling road salt.	Sweep up salt dropped in vicinity of salt shed.	All salt is kept under cover when not in use and is added back to the stock pile.	See above.	Immediately put in shed. Sweep up all spillage.	Salt sheds have a covered loading area and staff cleans up areas after each event. Building is inspected each year for any defects that would cause issues of run off.
What training do you provide your operators? How frequently?	Every two years at conference.	Road salt calibration yearly. We also refresh our operators with our procedures for treating Streets and parking lots.	Annual in-house training, or as needed. LTAP bi-annually or as needed. SPOT training at Mn/DOT to "train trainers."	Sent them to Snow and Ice Control Best Practices conference, Road Salt Symposium. Yearly meeting to discuss proper plowing and salting procedures.	We provide annual training to our employees on proper application of materials when-where and how to apply to reduce over application and placing in the right place to be most effective. We discuss environmental issues and good housekeeping.
How do you track the amount of road salt used?	By event, route, and vehicle.	By vehicle.	By event and vehicle.	By event and vehicle.	By route.

Question	Crystal	Robbinsdale	Minneapolis	New Hope	MnDOT Metro District
How do you use tracking data?	To evaluate operators' operating habits.	Totals by area and timing of application related to storm totals.	Looking at trends in: annual use, event use for ordering material (we don't stockpile for the season; order and take delivery on 24 hour notice), and operator use to make corrections if needed.	Submit results to Shingle Creek Watershed Management Commission Review data after each storm and go over results with drivers	To verify proper application routes and reduction in material usage.
Do you share tracking data with the operators?	Yes.	Yes.	As needed for application corrections and training.	Yes.	Yes.
How frequently do you sweep the entire city?	Twice, spring and fall. Try to sweep a third time weather and manpower allowing.	Twice, spring and fall. Also, 1-2 times additional during summer.	Spring and Fall comprehensive sweeps, plus other area sweeping all season at varying and prioritized service levels.	Twice, spring and fall, Sweep watershed area more frequently.	Once in spring.
Do you have areas of the city that you sweep more frequently?	Yes, heavy traffic areas.	Yes, around our lakes and our downtown areas.	Yes, Downtown, commercial corridors, parkways, etc. done at a higher frequency than general sweeping.	Yes, Watershed areas.	No.
What sweeping equipment do you own, rent, or contract and use for routine street sweeping?	Brooms, Regenerative air.	Brooms.	Brooms, Regenerative air.	Brooms, Vacuum.	Brooms, Regenerative air.

Question	Brooklyn Center	Maple Grove	Brooklyn Park	Plymouth	Hennepin County
Are your spreaders calibrated at least annually?	Yes.	Yes.	Yes.	Yes.	Yes, Also whenever the truck has work done on the sander or controls.
Do you use temperature sensors to improve application decisions?	Yes, use a hand-held sensor.	Yes, on some trucks.	Yes, on some trucks.	Yes, on some trucks.	Yes, use a hand-held sensor.
How do you use the Road Weather Information Service (RWIS) or other sources of weather information such as the National Weather Service to improve application decisions such as the amount and timing of application?	Use all of the above in addition to local forecasts.	Self forecasting.	Air temperature, surface temperature, time of day, time of year, moisture content of the snow and amount of traffic dictate the amount of salt that is applied		We have access to the MnDot RWIS systems and will on occasion review this data. We also review the state's roadway cameras.
Do you pre-wet salt before application?	Yes, on some trucks.	Yes, on all trucks.	Yes, on some trucks.	Yes, on all trucks.	Yes, on all trucks.
If you do not use pre-wetting on all your vehicles, what keeps you from implementing?	No political will.		Can only upgrade vehicles as they are replaced, a slow process. We now have them on almost 100% of vehicles.		
If not on all vehicles now, when do you anticipate having your fleet fully outfitted for pre-wetting?	5-10 years, adding to trucks in scheduled replacement cycle.		0-5 years.		
Tell us about your experiences with pre-wetting generally. Do you see a difference in application rates and salt use? Any operational issues?	Prep-wetting activates salt quicker reducing need for second applications. Application rate settings have been reduced. No operational issues, partner with City of Brooklyn Park to supply brine.	Yes. Less salt use. Better distribution.	Not really. Due to budget constraints we reduced the amount of salt we applied by reducing the locations we applied salt. We received very few complaints so even when our budget was increased we continued to limit where salt was/is applied.	Approx. 30% reduction in salt.	At first there was reluctance on the part of the operators (just more work) once they started to catch on we have had a lot of positive comments from the operators. We believe that salt usage has gone down. We purchase brine from another agency and need to run transports to supply outlying shops. This can cause issues during busy times.

Question	Brooklyn Center	Maple Grove	Brooklyn Park	Plymouth	Hennepin County
Have you used alternate, non-salt products such as ClearLane or IceBan? If so, what has been your experience?	Yes, used in conditions where temperatures are below 15 degrees, see quicker activation over sodium chloride.	Yes, Works better at lower temps and is visible.	Yes, Some operators think it is better, some don't see any difference.		Yes. We purchase treated salt off of the State contract. Our experience has been positive. At colder temperatures the treated salt can be applied at a lower rate.
Are your product stockpiles covered?	Kept in salt shed.	Kept in salt shed.	Kept in salt shed.	Kept in salt shed.	Kept in salt shed.
Are your product stockpiles kept on a hard surface?	Yes.	Yes.	Yes.	Yes.	Yes.
Describe your good housekeeping practices for handling road salt.	Sweep salt loading area after salt deliveries and after loading trucks; sweep excess salt spills on roadways. Do not overload trucks to prevent spillage.	Spill shields intact and cleanup of excess.	Trucks are loaded on impervious surface and any salt that spills is cleaned up. Also, we have a storm water detention pond on our property to contain any salt deposits.		Keeping salt in the shed. Try not to move it around too much as this causes crushing.
What training do you provide your operators? How frequently?	Provide annual training for all operators, conduct tailgate application meeting prior to each ice control event, all operators have MPCA Salt Applicator Certification.	Annually.	No formal training but directions regarding when/where to apply salt is given before each snow/ice event.	Annually.	We provide sensible salt training and provide coaching whenever needed and send operators to the Salt Symposium.
How do you track the amount of road salt used?	By event, operator, route, & vehicle.	By event and operator.	By event, operator and vehicle.	By vehicle.	By event, operator, route, & vehicle.
How do you use tracking data?	To supply data to SCWMWC, to monitor operator application quantities and compliance to established application rates.	Annual and event estimation.	If one operator appears to be using more salt than other operators we talk to that person.	Precise GPS.	Data is reviewed at weekly management staff meetings. Operators that fall outside the established guidelines may be coached.
Do you share tracking data with the operators?	Yes.	Yes.	Yes.	Yes.	Yes.
How frequently do you sweep the entire city?	Twice, spring and fall. Generally a third sweeping late spring.	Twice, spring and fall. Daily spot sweeping.	Twice, spring and fall. If weather permits we will complete a third round and we also try to sweep up as many leaves as possible.	3 times, spring, mid-summer, early fall before leaves drop.	Once in spring.
Do you have areas of the city that you sweep more frequently?	Yes, Downtown business district adjacent to Shingle Creek..	Yes.	Yes, Areas with mature trees.	No.	No.
What sweeping equipment do you own, rent, or contract and use for routine street sweeping?	Brooms.	Brooms.	Brooms.	Brooms, Regenerative air.	Brooms, Vacuum.