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DEVELOPMENT OF CHLORIDE REDUCTION TRAINING

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A report of the findings of
ICT-R27-147
Development of Chloride Reduction Training

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16. Abstract

The purpose of this project was to create a training program that could be used for Illinois Department of Transportation (IDOT) personnel who operated snow plows and spread road salt during winter storms.

The training message was built around the three main goals of winter maintenance: safety, mobility, and environmental protection. The concept of winter maintenance operations being a system was introduced early in the training and stressed throughout.

Another goal of the project was to develop a method or tool by which the effectiveness of the training could be measured. Achieving that goal requires the ability to compare quantities of salt used by IDOT (or some subset of IDOT, such as a maintenance garage) over winters before and after the training is provided. The method presented herein uses a storm severity index, summed over the whole winter season. This allows for comparison between two winters to be made by use of the index.

Thus, as shown in the report, for the Moline maintenance district, the winter of 2012–13 can be compared with the winter of 2013–14. This comparison shows that the cumulative index for the 2012–13 winter was 13.20, while it was 26.88 for the 2013–14 winter. In other words the winter of 2013–14 was significantly worse than the winter that preceded it.

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Members of the Technical Review panel were the following:

Tim Peters (IDOT), TRP Chair
Justan Mann (IDOT)
Dean Mentjes (FHWA)

EXECUTIVE SUMMARY

Recent studies (e.g., Kelly, Panno, and Hackley 2012) show that there are a number of locations in the State of Illinois in which chloride ions exceed acute levels as determined by the Illinois Environmental Protection Agency (IEPA). Such studies have found that one of the major sources of these chloride ions is road salt, and the studies make it clear that spikes in chloride levels coincide with times when road salt applications are typically made.

The purpose of this project was to create a training program that could be used for Illinois Department of Transportation (IDOT) personnel who operated snow plows and spread road salt during winter storms. The goal of the training was twofold:

- Demonstrate the impacts of road salt on the environment; and
- Show how required levels of service could be attained on roads in winter while also reducing the quantity of road salt used to attain those levels of service.

The training was developed in such a way as to keep training attendees focused on the delivered materials. This was done by using small information “chunks” separated by pertinent but diversionary video clips that could provide some light relief (and a cognitive reset) for the attendees.

The training message was built around the three main goals of winter maintenance: safety, mobility, and environmental protection. These goals were presented in the context of sustainability. The concept of winter maintenance operations being a system was introduced early in the training and stressed throughout. The need to involve the public in the winter maintenance process was also discussed.

The specifics of the training concentrated on a number of key points:

- We do not use road salt to melt snow and ice but rather to break the snow–pavement bond.
- Preventing the formation of a bond between snow and pavement is much more efficient than allowing that bond to form and then break it.
- The key temperature to consider is the pavement or road surface temperature.
- The level of service is our destination.
- When we apply road salt to the road, we should pre-wet it in almost every case.
- We have to measure what we do, or we cannot improve it.

The training itself is broken into eleven parts:

- Introduction
- Purpose of Winter Maintenance
- Chloride Contamination Issues in Illinois
- Levels of Service Goals
- How Salt Works
- Salt Skills
- Drifting Issues
- Material Delivery Equipment

- Application Rates and Calibration
- Plows and Cutting Edges
- Forecasts and Storm Tactics

The slides used in the training are presented in the appendix of the report. Corresponding to each of these topic areas, a short video was produced as an alternate way of making the information available outside of a classroom setting.

Another goal of the project was to develop a method or tool by which the effectiveness of the training could be measured. Achieving that goal requires the ability to compare quantities of salt used by IDOT (or some subset of IDOT, such as a maintenance garage) over winters before and after the training is provided. The method presented herein uses a storm severity index, summed over the whole winter season. This allows for comparison between two winters to be made by use of the index.

Thus, as shown in the report, for the Moline maintenance district, the winter of 2012–13 can be compared with the winter of 2013–14. This comparison shows that the cumulative index for the 2012–13 winter was 13.20, while it was 26.88 for the 2013–14 winter. In other words the winter of 2013–14 was significantly worse than the winter that preceded it. This index can be used to normalize salt use for the two winters (or however many winters IDOT wishes to compare). Accordingly, it would be possible (as long as other confounding factors such as salt shortages during a winter can be controlled for) to determine whether the training results in a reduction of road salt use.

CONTENTS

CHAPTER 1: INTRODUCTION

This report presents the results of a six-month project to develop training for Illinois Department of Transportation (IDOT) employees in the general subject area of winter maintenance. The specific purpose of the training was to educate trainees about how road salt works, so that application rates of could be adjusted to appropriate levels. Driving this requirement was the observation that in some surface water bodies in Illinois, levels of chlorides are increasing and have, at some times of the year, exceeded allowable levels. The intent of the training is to ensure that employees know when to use road salt, when not to use road salt, and how much road salt to use in particular circumstances and during specific storms.

1.1 CHLORIDE CONTAMINATION ISSUES

A recent study (Kelly, Panno, and Hackley 2012) reported on levels and sources of chloride ions in surface water for the State of Illinois. Information from that study indicates that the major source of chloride ions in surface water in Illinois is road salt (followed by fertilizer, treated wastewater, and water conditioning salt). The study notes that the United States Environmental Protection Agency (USEPA) has established chronic and acute levels of chloride contamination for surface water at 230 mg/L and 860 mg/L, respectively. The Illinois EPA (IEPA) uses an acute level of 500 mg/L and has not established a chronic level at this time.

The data presented in the Kelly, Panno, and Hackley (2012) report indicate that chloride levels in surface waters in the Chicago area are highest during winter months (see, for example, Figure 12 in that report) and that there appeared to be some degree of correlation between chloride levels and snowfall (see Figure 13 in that report). Some of the data shown in Figure 13 indicate that the acute level of chloride concentration established by the IEPA had been exceeded. Finally, Figure 17 in the Kelly, Panno, and Hackley report shows that chloride levels in the Illinois River at Peoria were increasing over time.

The bottom line about chloride in surface waters in Illinois is that road salt is a contributor to that contamination. To reduce the contamination levels, it was determined by IDOT that training was required for their operators to address the issue of appropriate use of road salt. The purpose of this project was to develop such training.

CHAPTER 2: PROPOSED TRAINING CONTENT

In creating a training program, two factors are of particular importance. First, the key messages that the training must impart must be front and center throughout the training and be repeated and emphasized so that at the end of the training the learners develop a very clear understanding of the information presented.

Second, the format of the training should be designed to overcome the natural tendency for learners to "tune out" the training. The latter factor is particularly important when training winter maintenance operators, who typically are engaged in physical activity during the workday and for whom sitting at a desk and listening is not a natural behavior. If the training is to be successful, then the format of the training must engage these learners

2.1 CONTENT ISSUES

With regard to the key messages of the training, use of the smallest quantity of road salt consistent with achieving desired levels of service was central, but this message was bolstered by the following other key concepts in the training.

- Winter maintenance has three main goals—safety, mobility, and environmental protection. This concept dovetails with the notion of sustainable winter maintenance, which should also be introduced as a factor.
- Winter maintenance operations comprise a system, driven primarily by the level of service selected for a particular roadway or part of the road system. Figure 1 shows how this system can be represented.
- Winter maintenance is not conducted in a vacuum. The operations are intended to serve the public. Ideally, the public partners with the agency doing the winter maintenance, but often this ideal is not achieved. What steps can be taken to improve this partnership?

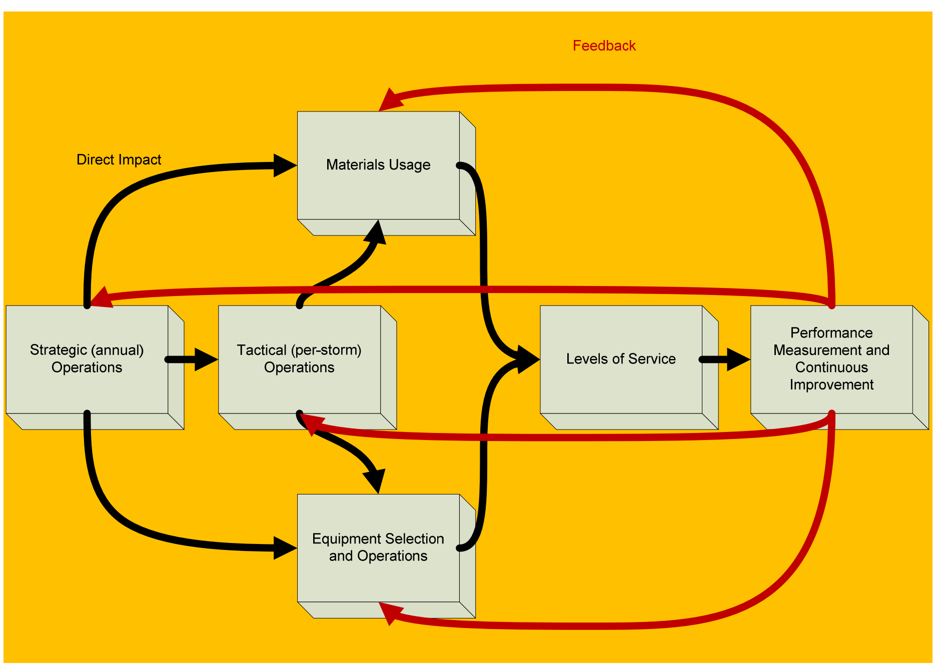

Figure 1. Schematic systems representation of winter maintenance.

Within these broad concepts, the following six key messages for the training were established:

- Road salt is not used to melt snow and ice. It is used to break, or prevent the formation of, the bond between the road and the snow or ice so that plows can more easily and effectively remove the snow or ice from the road surface.
- Preventing the formation of a bond between snow and pavement is much more efficient than allowing that bond to form then breaking it. Studies suggest that if formation of the bond is prevented, it is possible to use about a quarter of the total road salt required to break the bond and achieve the same levels of service.
- The critical temperature to consider is that of the pavement or road surface. This temperature drives winter maintenance work, and in particular drives how much road salt must be used to achieve a given level of service.
- The level of service is the goal, and it must be kept in mind throughout all winter maintenance activities.
- When road salt is applied to the road, it should be pre-wetted in almost every case. Pre-wetting not only minimizes scatter of the road salt (allowing the use of about 30% less material to achieve the same goal), but it also jump-starts the bond prevention process in the salt.
- We have to measure what we do, or we cannot improve the outcome. If we do not measure what we do, we are not serious about doing the best possible job in our winter maintenance work.

Obviously, there are other messages that can be stressed during the training, but those six points are critical to best practice in winter maintenance.

2.2 TRAINEE ATTENTIVENESS

It was important to ensure that trainees remain attentive during the day-long training. Studies indicate that any activity that continues for longer than 15 minutes will result in some trainees losing focus. This means that a method should be used to “change things up” in the training every 15 minutes or so. The following methods are suggested for use with this training:

- Videos (short ones)
- Discussion points: trainees work in groups to talk about an issue or topic that has just been covered
- Demonstrations or experiments
- Chemicals or pieces of equipment: the instructor displays and/or passes these items around the group

While it may seem that such methods are a distraction (and one level, they certainly can be distractions), in practice they allow trainees to reset their attention. This objective is particularly important given the demographics of the training group (snow plow operators).

2.3 LEVEL OF TRAINING

To ensure that the training messages were delivered optimally to the trainees, it was important to ensure that the learning material itself was suitable for the trainees. The appropriate level was determined in two ways. First, the project team used their own experience in training plow operators around the country to determine an appropriate level of material, which was then presented to the members of the Technical Review Panel (TRP) and other stakeholders. Second, the learning material was adjusted and revised based on feedback from the TRP.

2.4 MODES OF PRESENTATION

The training material was made available in two formats. The first, more traditional format is a PowerPoint presentation, including embedded videos, that can be presented by any training personnel or supervisors within IDOT as they see fit. The second mode of presentation is a series of short videos that present the training material in short (typically 3- to 5-minute) chunks. These two modes of presentation provide IDOT flexibility in the training approach. For example, if an IDOT employee is hired after the training sessions have been presented, he or she can receive the training via videos. Further, given that people have different learning styles, the availability of two modes of presentation increases the number of learning styles covered by the training.

CHAPTER 3: TRAINING MATERIALS

The training consists of the following 11 topics:

- Introduction
- Purpose of Winter Maintenance
- Chloride Contamination Issues in Illinois
- Levels of Service Goals
- How Salt Works
- Salt Skills
- Drifting Issues
- Material Delivery Equipment
- Application Rates and Calibration
- Plows and Cutting Edges
- Forecasts and Storm Tactics

The PowerPoint slides are provided in the appendix of this report, along with notes for the trainer/presenter.

Corresponding to each of these topic areas, a short video has been produced as an alternate way of making the information available outside of a classroom setting. The training material consists of five videos, three of which are relatively light hearted or humorous. The fourth video (shown second during the training) is from a traffic camera in Wisconsin, showing cars involved in a pile-up in snowy conditions. The purpose of that video is to emphasize the point that drivers who are careful (in this case, those going at an appropriate speed) were safe, while those going too fast almost all ended up in the ditch. The final video in the training series thoroughly demonstrates the spreader calibration process.

CHAPTER 4: MEASURING TRAINING EFFECTIVENESS

4. 1 BACKGROUND

A variety of studies (see, e.g., Kuemmel and Hanbali 1992) have shown that effective winter maintenance saves lives and reduces economic loss due to loss of mobility. At the same time, under most circumstances, effective programs require the use of freezing-point depressant materials that are, of necessity, placed into the environment. If used excessively, such materials can result in levels of chlorides that are close to or, in some cases, exceed allowable limits (assuming that the freeze-point depressant materials themselves are chlorides; by far the largest quantity of such materials are chlorides, with sodium chloride being the most prevalent).

Prior studies (see, e.g., Stone et al. 2010) have also shown that with the use of best practices, the amounts of chlorides released into the environment can be held to levels that do not create short- or long-term negative impacts. In other words, following best management practices can help avoid the potential negative impacts of chlorides on the environment.

Because IDOT has developed new training materials, it is important that the department be able to measure the extent to which the new training improves (i.e., lessens) chloride use. To that end, a method of normalizing salt use with respect to winter severity should be applied. This chapter describes the proposed method of normalization and shows how it can be used to compare different seasons at one maintenance yard.

4. 2 METHOD OF NORMALIZATION

Obviously, a major measure of the success of the new training program would be a reduction in the use of salt in winter seasons after personnel were trained. However, if a given winter is more severe or less severe than the previous winter, the amount of salt used would be expected to vary. Accordingly, the need exists to create an index by which the amount of salt used in a given winter can be normalized to account for variation in the severity of the winter.

The notion behind this method is that the severity of a winter can be reduced to a single number, with which effort expend by an agency (in this case, IDOT) should correlate. The scope of winter-to-winter variation is significant, as can be seen in Table 1, which summarizes annual salt use in tons by IDOT.

Table 1. Annual Rock Salt Use by IDOT for Past Five Years

Fiscal Year	Winter Season	Tons of Rock Salt Used
10	2009–10	536,900
11	2010–11	562,400
12	2011–12	235,200
13	2012–13	456,500
14	2013–14	802,341

The variation in use between a mild winter (2011–12) and a severe winter (2013–14) is a more than threefold increase. Clearly, unless the severity of a winter is taken into consideration, there will be no way of determining to what degree the training (or, indeed, any other innovation in practice) has reduced salt use.

A variety of indices can be used to measure winter severity (see, e.g., PIARC 2006). The various indices use different measures to develop their index value and often are derived from what might be called different starting points. Thus, for example, there are a number of indices that attempt to measure winter severity from the viewpoint of agriculture to determine when planting might begin to be possible during the spring immediately following a given winter. It would not be realistic to expect such an index to track well with winter maintenance efforts, although for a given winter it might.

Determining the right index to use to normalize winter severity for the purposes of winter maintenance is an iterative process. It may be that any index proposed for such purposes will need to be adjusted to ensure optimal performance. This might result in slightly different versions of the index being used in different locations across a state, for example, with the index for each location being modified using historical data. Such fine-tuning is reasonable, provided the end result is an index that correlates well with the effort required (and therefore the amount of salt required—although the two are not completely synonymous) to provide optimal winter maintenance in that location.

One of the more successful indices for winter highway maintenance was developed by Boselly, Thornes, and Ulburg (1993). However, that index is intended to measure the severity of the entire winter. To bring such an index down to a storm level, a methodology to describe winter storms is needed, which was provided by Nixon and Stowe (2004). These two approaches were combined into a storm severity index by Nixon and Qiu (2005).

In the current work, the Nixon and Qiu (2005) index will be used in a cumulative manner. For each day in the winter season being studied (which will be defined as October 1 through March 31), the index will be used to generate a number between 0 and 1. The more severe the winter weather on a given day, the closer the index value will be to 1 for that day. The index includes precipitation type and severity, wind speeds, and pavement temperatures during and after the storm to generate the value. Then, once values have been determined for each day during the winter period (a total of 182 days, or 183 days if a leap year is involved), a final severity index is obtained for the season. The inclusion of October in the calculation of the index is likely to add little to the final score, but early storms do require the use of salt, and to exclude them arbitrarily might be inappropriate.

Two factors should be noted in regard to the index. First, it does not consider frost. Frost can be handled by adding a small value to the cumulative winter index each time a frost treatment is applied. In this case, it is suggested that a value of 0.1 be added to the cumulative index for each frost application. Second, this index works best when the region under consideration receives essentially uniform weather across the area. This means that the index must be applied to a relatively small area, if at all possible.

The index is as follows:

$$SSI = \left[\frac{1}{b} * [(ST * Ti * Wi) + Bi + Tp + Wp - a] \right]^{0.5}$$

Table 2 shows the values of the variables used in the index. The variables *a* and *b* are normalizing constants used to ensure that the index ranges between 0 and 1. Specifically, *a* = –0.0011 and *b* = 1.6722.

Table 2. Values of Variables Used in the Index

Storm Type (*ST*)	Freezing rain	Light snow	Medium snow	Heavy snow
Value	0.72	0.35	0.52	1
Storm Temperature (*Ti*)	Warm (33°F+)	Mid (25–32°F)	Cold (15–25°F)	
Value	0.25	0.4	1	
Wind Conditions in Storm (*Wi*)	Light (< 15 mph)	Strong (> 15 mph)		
Value	1	1.2		
Early Storm Behavior (*Bi*)	Starts as snow	Starts as rain		
Value	0	0.1		
Post-Storm Temperature (*Tp*)	Same	Warming	Cooling	
Value	0	–0.087	0.15	
Post-Storm Wind Conditions (*Wp*)	Light	Strong		
Value	0	0.25		

4. 3 PRELIMINARY RESULTS

The methodology has been applied to Moline, Illinois, in IDOT District 2 for two winters: 2012–13 and 2013–14.

Figure 2 shows the cumulative monthly storm indices during the 2013-14 winter for Moline.

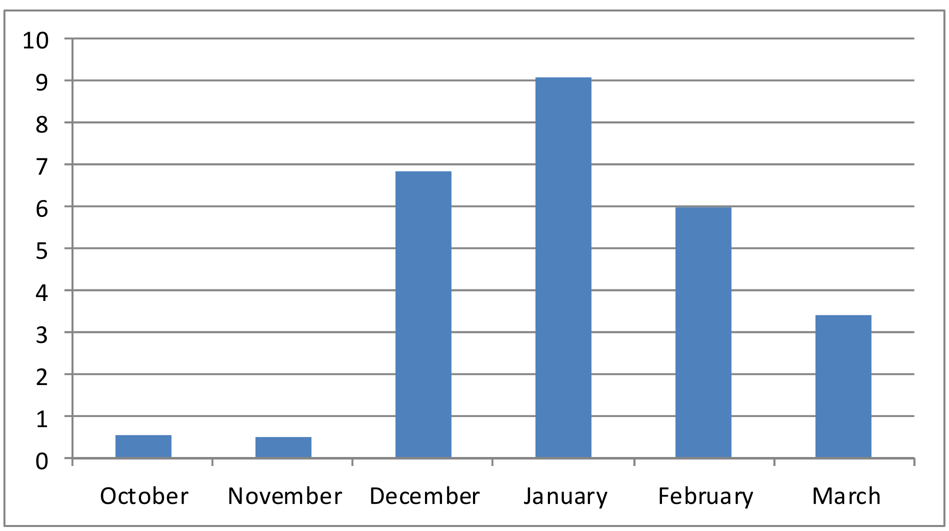

Figure 2. Cumulative monthly storm indices for Moline, Illinois, 2013–14 winter.

There was one freezing rain storm in October 2013, and two light snow storms in November 2013. Then winter arrived with a vengeance. There were 14 days with storm events in December, 17 such days in January, 11 in February, and 8 in March.

In contrast, Figure 3 shows the same indices for the 2012–13 winter for Moline.

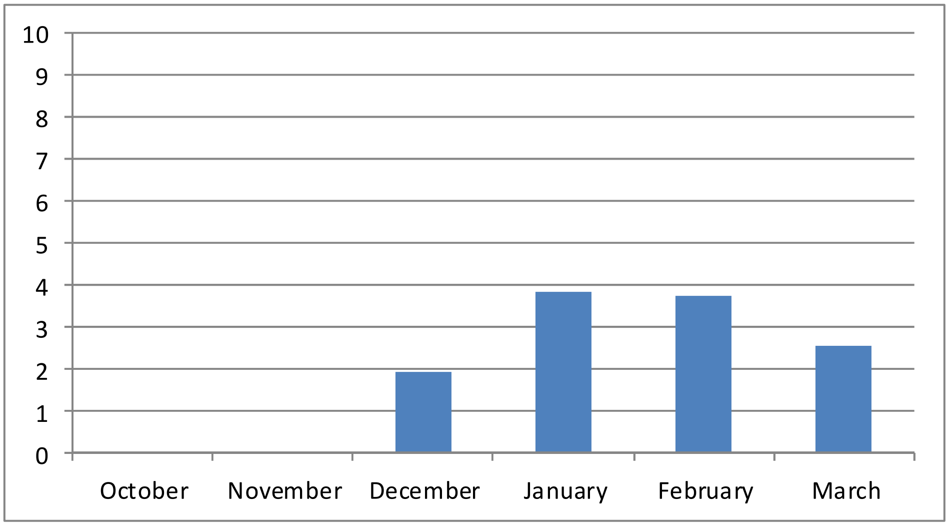

Figure 3. Cumulative monthly storm Indices for Moline, Illinois, 2012–13 winter.

There were no events in October or November 2012. In December 2012, there were 5 days in the latter half of the month with storm events. January 2013 had 9 days with storm events, February 2013 had 10 days with storm events, and March 2013 had 6 days with storm events. Not only were there many fewer events in the 2012–13 winter than in the 2013–14 winter, the individual events were on average less severe. Average storm severity in 2012–13 was 0.403, while in 2013–14 it was 0.499. However, it should be noted that at this time it is not possible to say to what degree this average storm severity difference is statistically significant.

When the monthly indices are compared with salt use, an interesting pattern emerges. Figure 4 shows salt use (in tons) against the monthly index value for the 2013–14 winter in Moline. There is a clear increase in salt use as the monthly index value increases.

In Figure 5, which shows the same data for the 2012–13 winter in Moline, there is also a similar relationship, but it is interesting to note that while the monthly indices were much higher in 2013–14 than in 2012–13, the peak values of salt used were not much different.

There are three possible explanations for this finding. It may be that salt use in 2013–14 was limited by availability (i.e., more salt was not available to be spread even if it were warranted). It may also be that salt use in general is limited by capability (i.e., the district did not have the equipment and personnel to spread more salt than they did, even though the road conditions warranted it). Or it is possible that in the 2012–13 winter, more salt was sometimes applied than was needed; therefore, those application numbers should in fact have been smaller in that winter than was actually observed. The data available for this study cannot distinguish between these three possibilities.

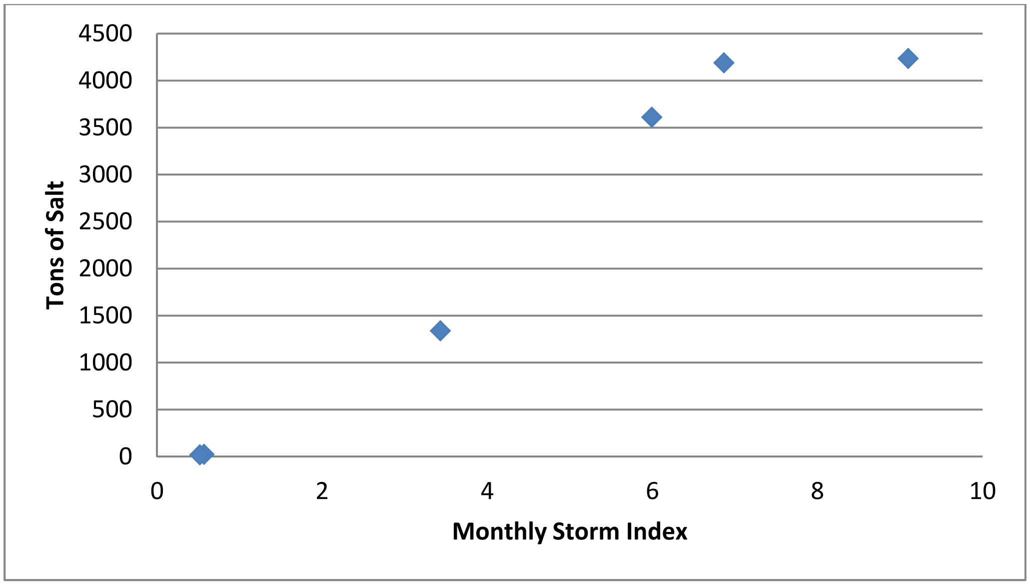

Figure 4. Salt use vs. monthly index for the 2013–14 winter in Moline, Illinois.

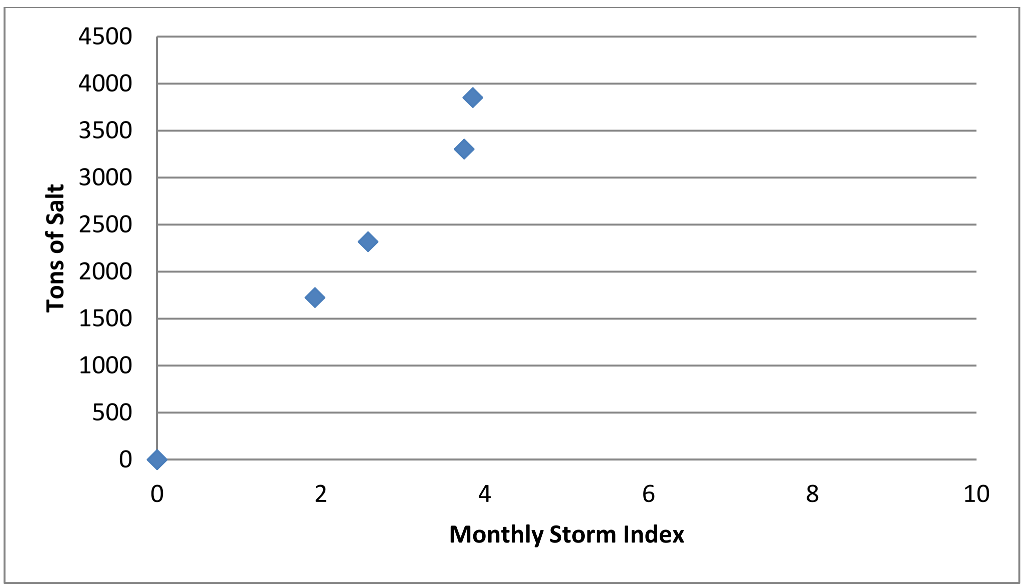

Figure 5. Salt use vs. monthly index for the 2012–13 winter in Moline.

The tool allows us to compare salt use between the two winters on a normalized basis. Thus, Table 3 shows the total winter index for each season, together with the total tons of salt used for each season. Table 3 also show tons of salt used for each index point. This tabular comparison makes clear the difference in salt use between the two winters, but, as noted above, there are a number of possible explanations for those variations in salt use. Furthermore, in this comparison, the more-efficient salt use cannot be a function of improved training because the new training was not available before the 2013–14 winter maintenance season.

Table 3. Index-Based Comparison Between 2012-–13 and 2013–14 Winters at Moline, Illinois

Winter Season	Total Winter Index	Total Tons of Salt Used	Tons of Salt per Index Point
2012–13	13.20	11,196	848
2013–14	26.88	13,418	499

To create a useful measure of the value of the training, it would be necessary not only to run a comparison between winters for a single area, but also to run the comparison for multiple areas—some of whose personnel received the training and others who did not. The comparison, however, may be possible after the end of the 2014–15 winter season.

CHAPTER 5: CONCLUSIONS

A training program was developed and presented to the Illinois Department of Transportation with the purpose of instructing program attendees on the negative impacts of chlorides on surface waters and how the appropriate application of road salt can still provide an acceptable level of service for the traveling public while minimizing chloride loading on the environment.

A method was presented whereby salt use in an area (most typically, for a maintenance garage or yard) can be compared on a year-to-year basis while taking into account the variation of the weather in each winter of comparison. This tool can be used to easily determine the effectiveness of the training in reducing chloride use.

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APPENDIX: TRAINING SLIDES AND NOTES

Note: Speaker notes can be found by hovering your mouse over the "dialogue bubble" in the upper left corner of a slide. Not all slides have speaker notes.

Reducing Chloride Application Rates

Training for Winter Maintenance Personnel

Illinois Department of Transportation

Logistics

- Exits, bathrooms, facilities information
- Break times and end times
- Lunch options
- Exams

Illinois Department of Transportation

Course goals

- When you have completed today's training you will be able to:
  - Explain why there is a need to reduce chloride application on highways in Illinois
  - Describe how chlorides work as a tool in winter maintenance
  - Detail the best ways to use chlorides in various conditions to achieve level of service goals while minimizing chloride impacts on the environment.

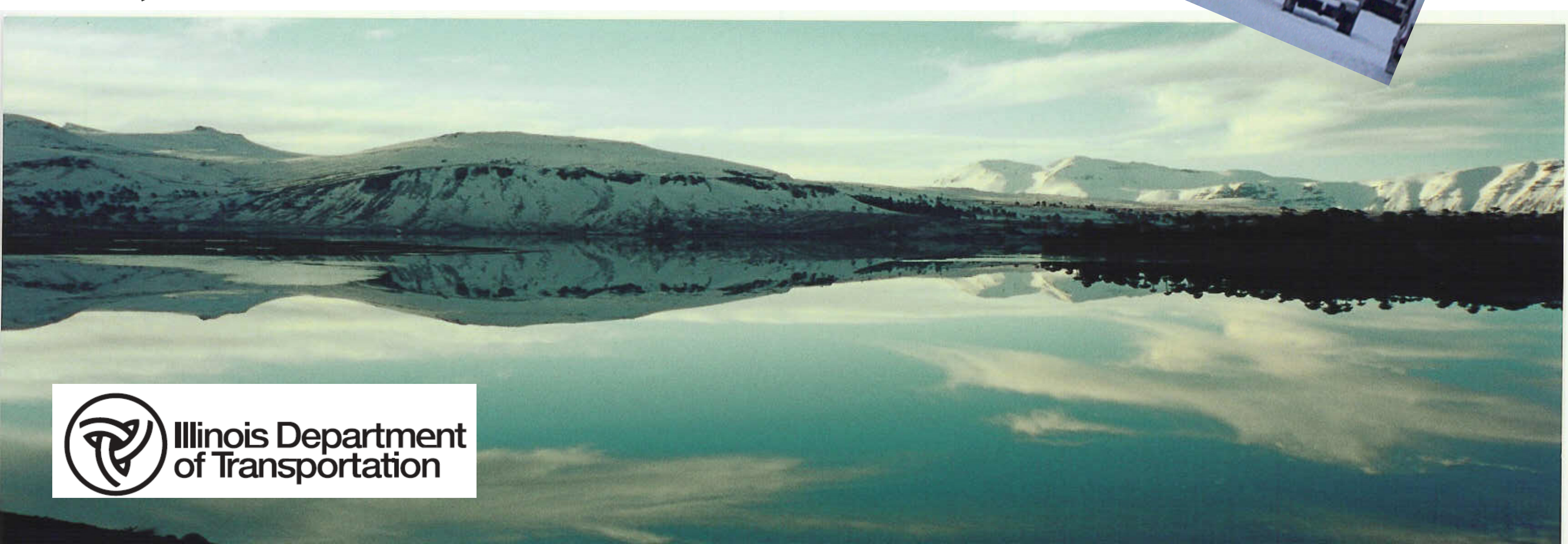
Illinois Department of Transportation

What are Key Goals in Winter?

Safety

Mobility

The Environment



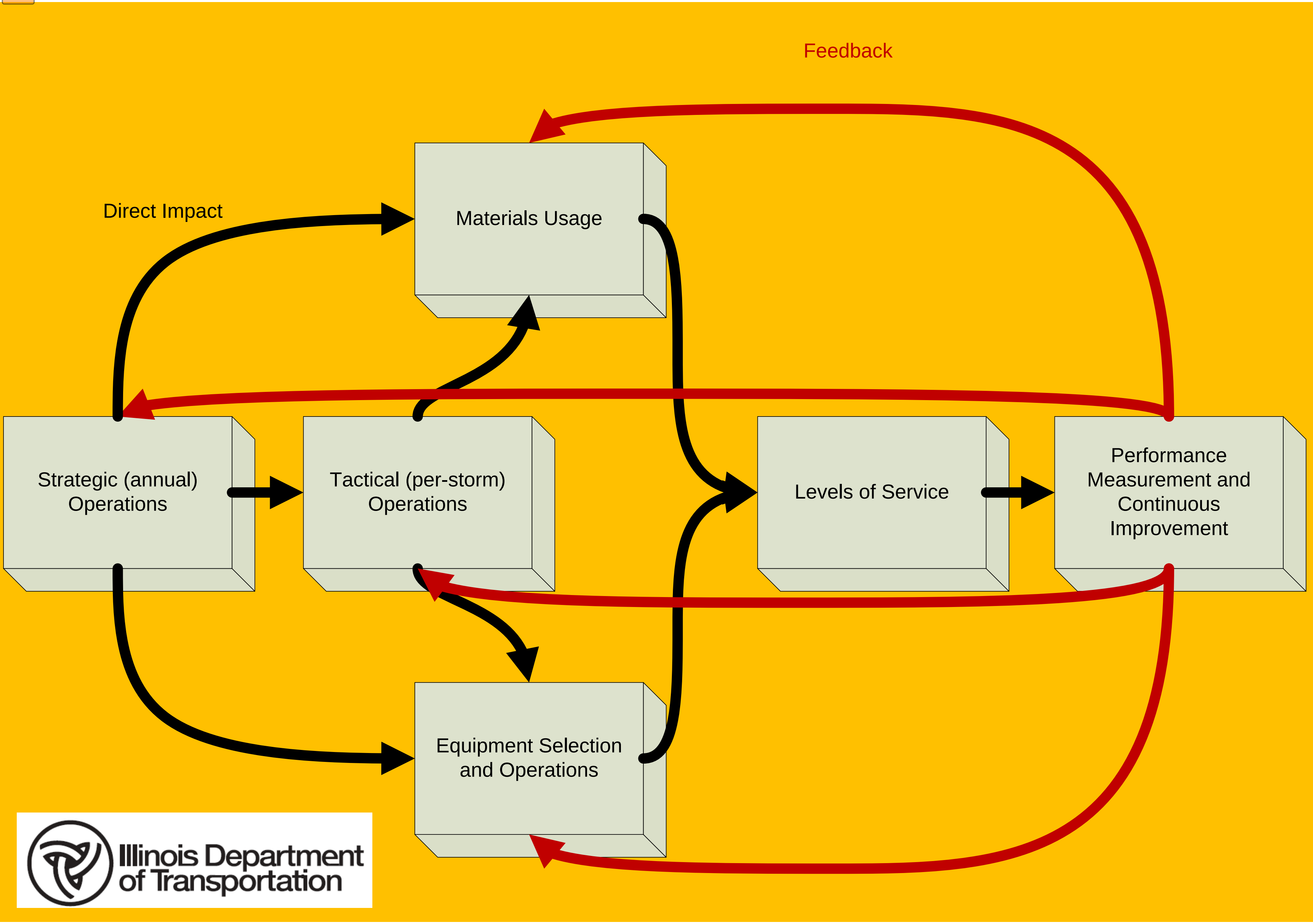
Illinois Department of Transportation

Sustainable Winter Maintenance

Sustainable winter operations are utilizing the most appropriate snow and ice control equipment, processes, and materials for the unique objectives and conditions that each agency encounters in a manner that does not compromise the ability of future generations to do likewise.

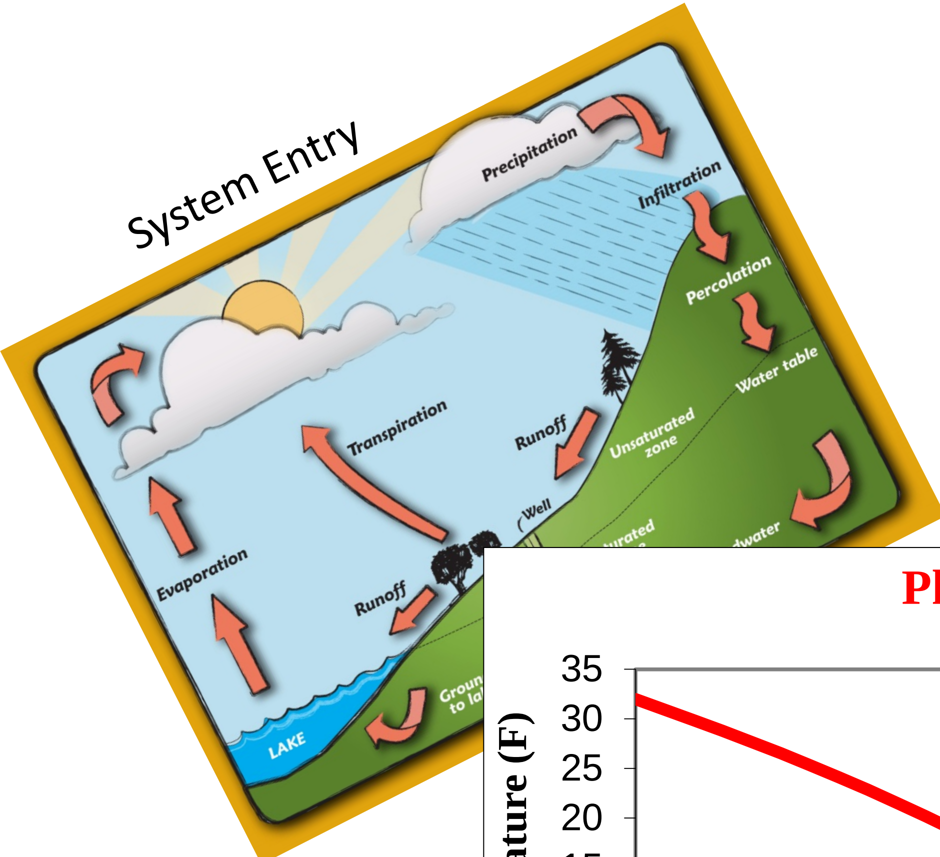
Illinois Department of Transportation

[Three Reasons Video Here]

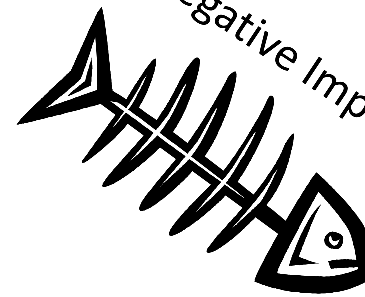

Feedback
Direct Impact
Materials Usage
Strategic (annual) Operations
Tactical (per-storm) Operations
Levels of Service
Performance Measurement and Continuous Improvement
Equipment Selection and Operations
Illinois Department of Transportation

Key Goals for This Section

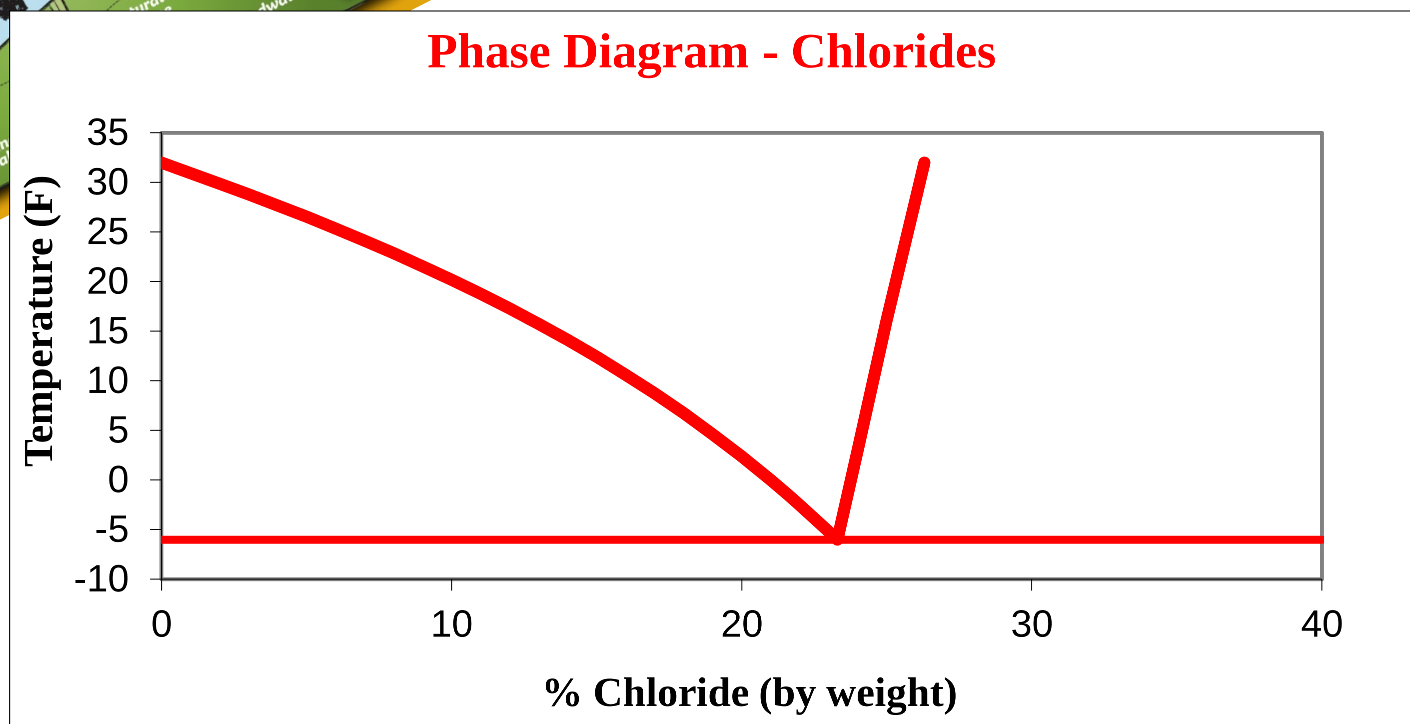
System Entry



Negative Impacts



The Science of Salt



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Chloride Levels of Concern

- Three levels of concern
- Secondary drinking water standard of 250 mg/L
- Surface water standards – two levels – chronic and acute for federal
- Chronic – 4-day average of 230 mg/L occurrence interval once every 3years
- Acute – 1 hour average of 860 mg/L every 3 years
- Illinois EPA level 500 mg/L

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Putting The Numbers in Context

- What does 500 mg/L mean?
- 1 lb of salt puts 250 gallons of water over the limit
- 1 ton of salt puts 500,000 gallons of water over the limit
- 471,000 tons of salt puts about 240 billion gallons of water over the limit!
- Why 471,000 tons…

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Where does the chloride come from?

Table 1. Annual Chloride Fluxes in Illinois

Source	*Flux (metric tons)*
Treated Wastewater	
MWRDGC	175,000
Remainder of state	125,000
Atmospheric	18,000
Road Salt	471,000
Water Conditioning Salt	135,000
Fertilizer (KCl)	373,000
Livestock	139,000
Lake Michigan withdrawals	34,000
Groundwater withdrawals	
Public supply wells	12,500
Industrial/commercial	5,300
Irrigation	10,000
Oil-Field Brines	23,000

Note: The treated wastewater fluxes do not include road salt inputs.

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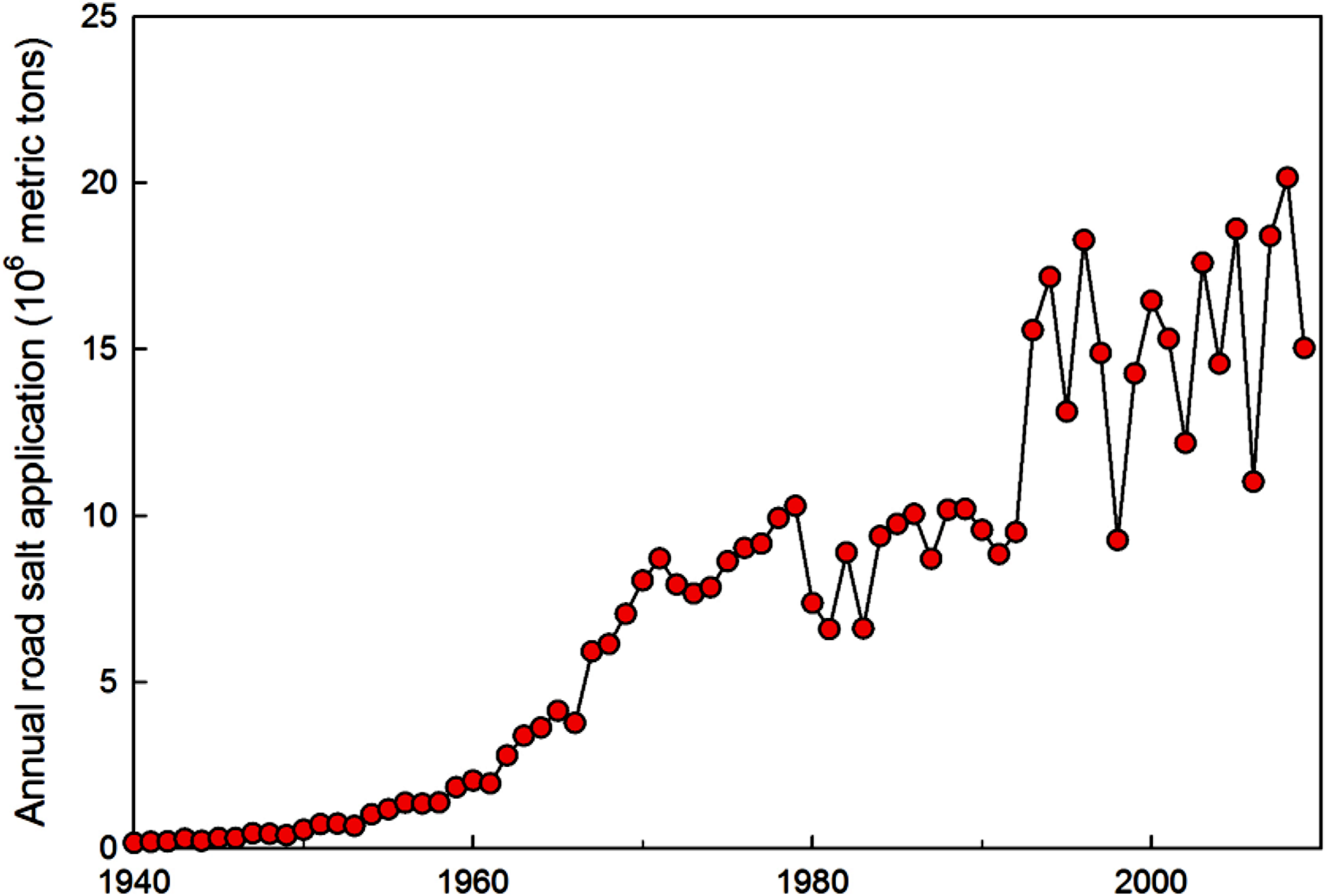

Figure 3. Yearly U.S. highway salt sales. Data from Salt Institute, 2011.

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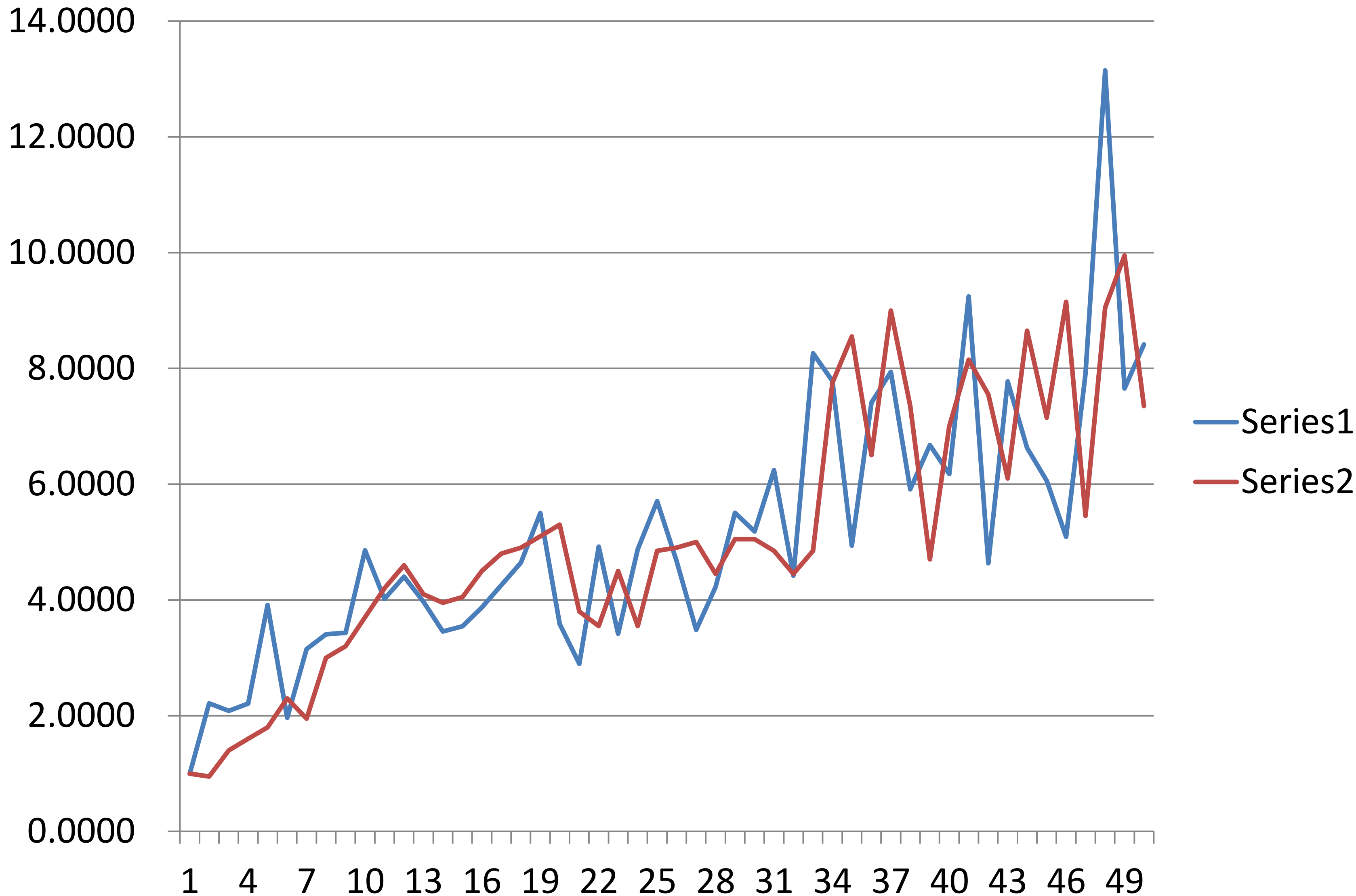

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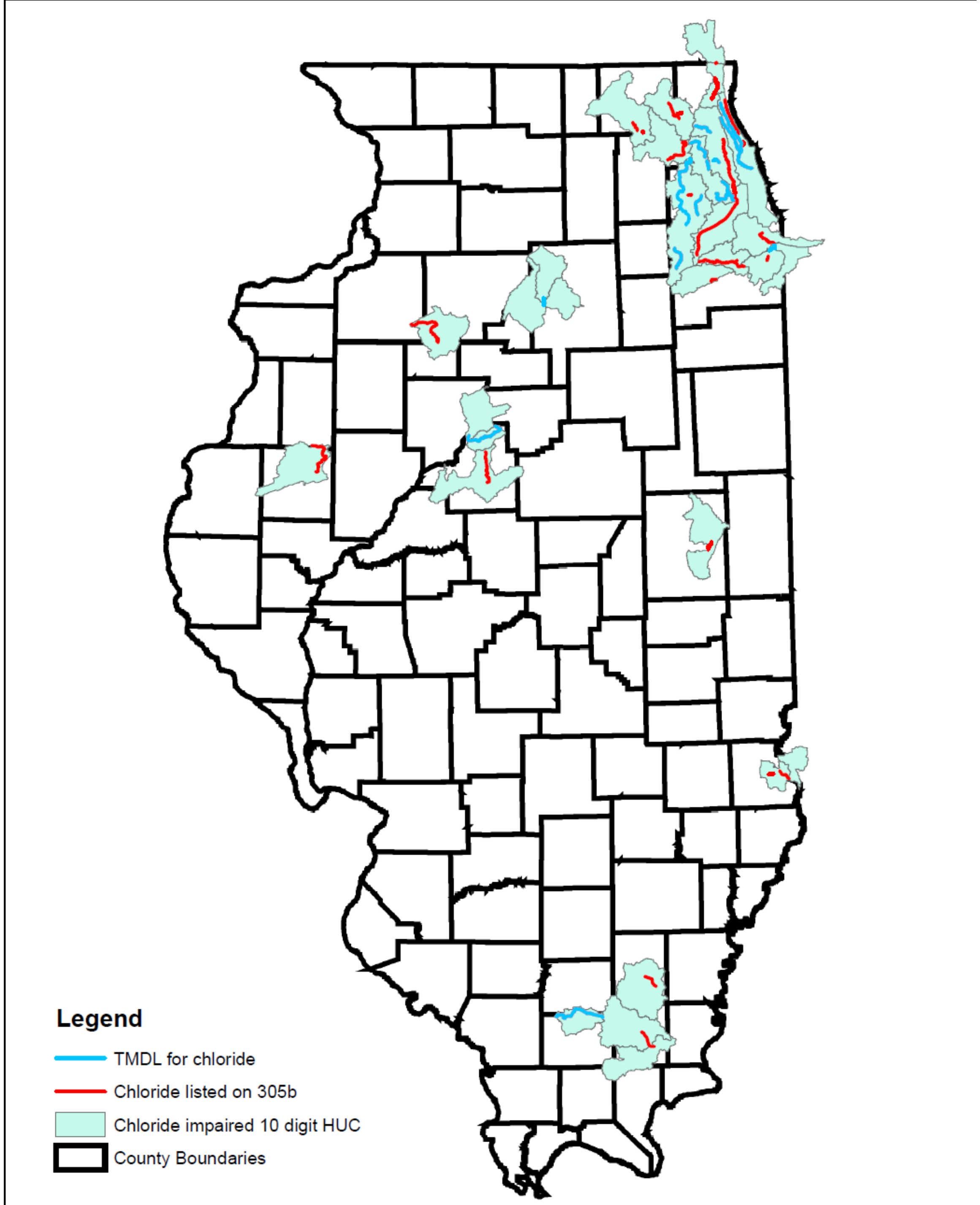

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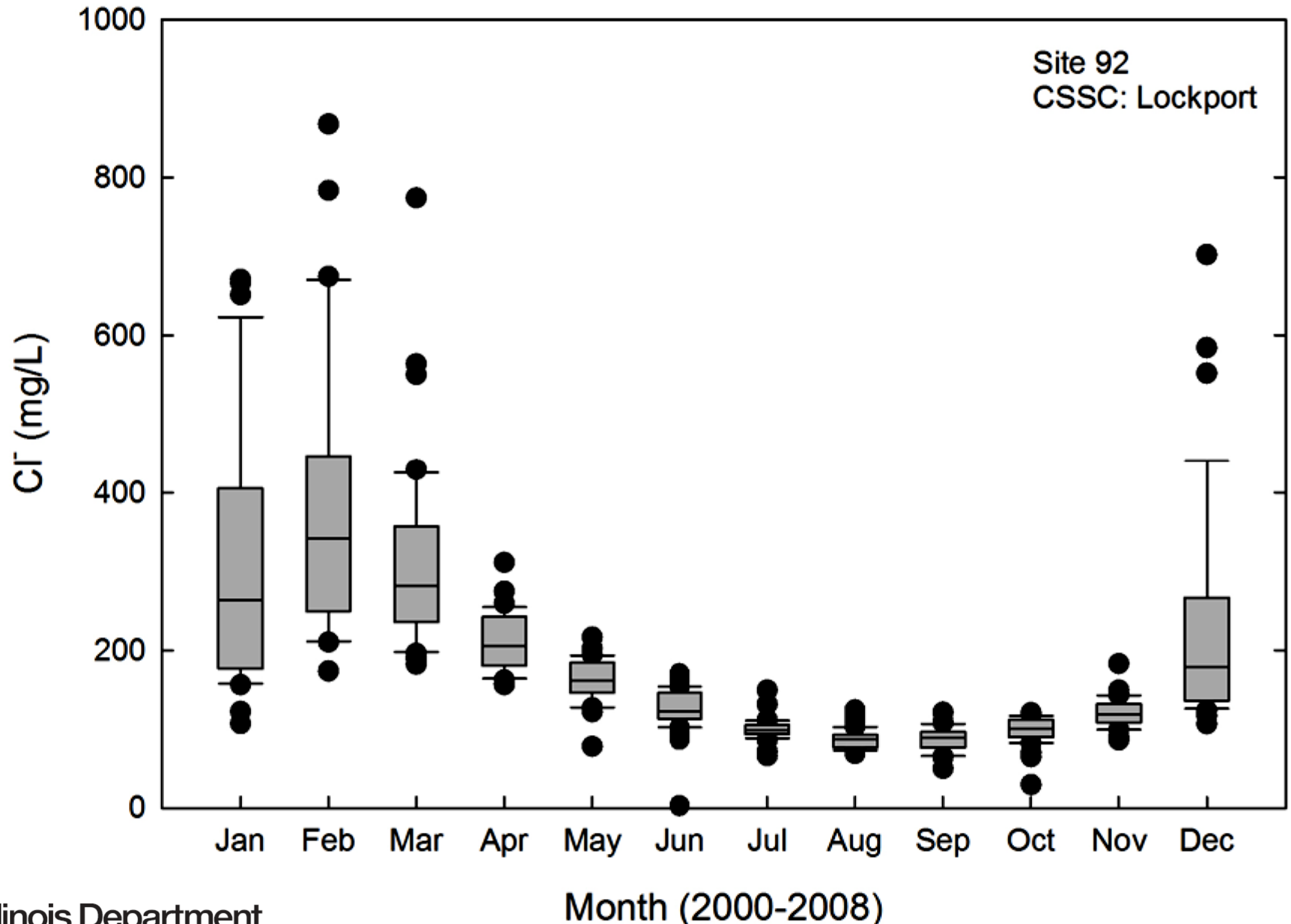

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Figure 12. Chloride concentrations by month for MWRDGC station 92 (CSSC at Lockport) between 2000 and 2008. The site was sampled weekly.

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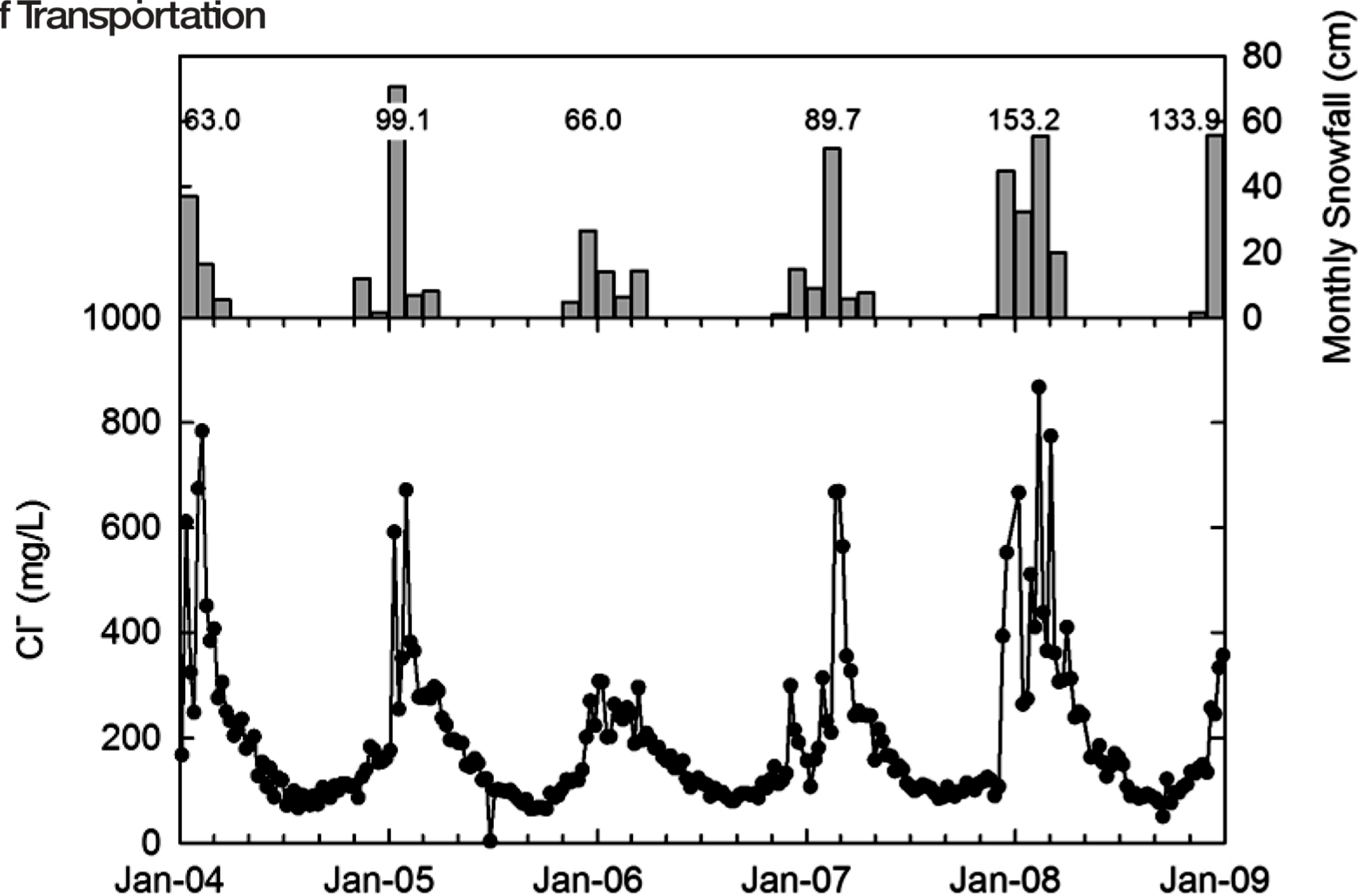

Figure 13. Chloride concentrations at MWRDGC station 92 on the CSSC at Lockport, IL, and monthly snowfall totals in Chicago (winter totals shown above bar). Snowfall data from NOAA, 2010.

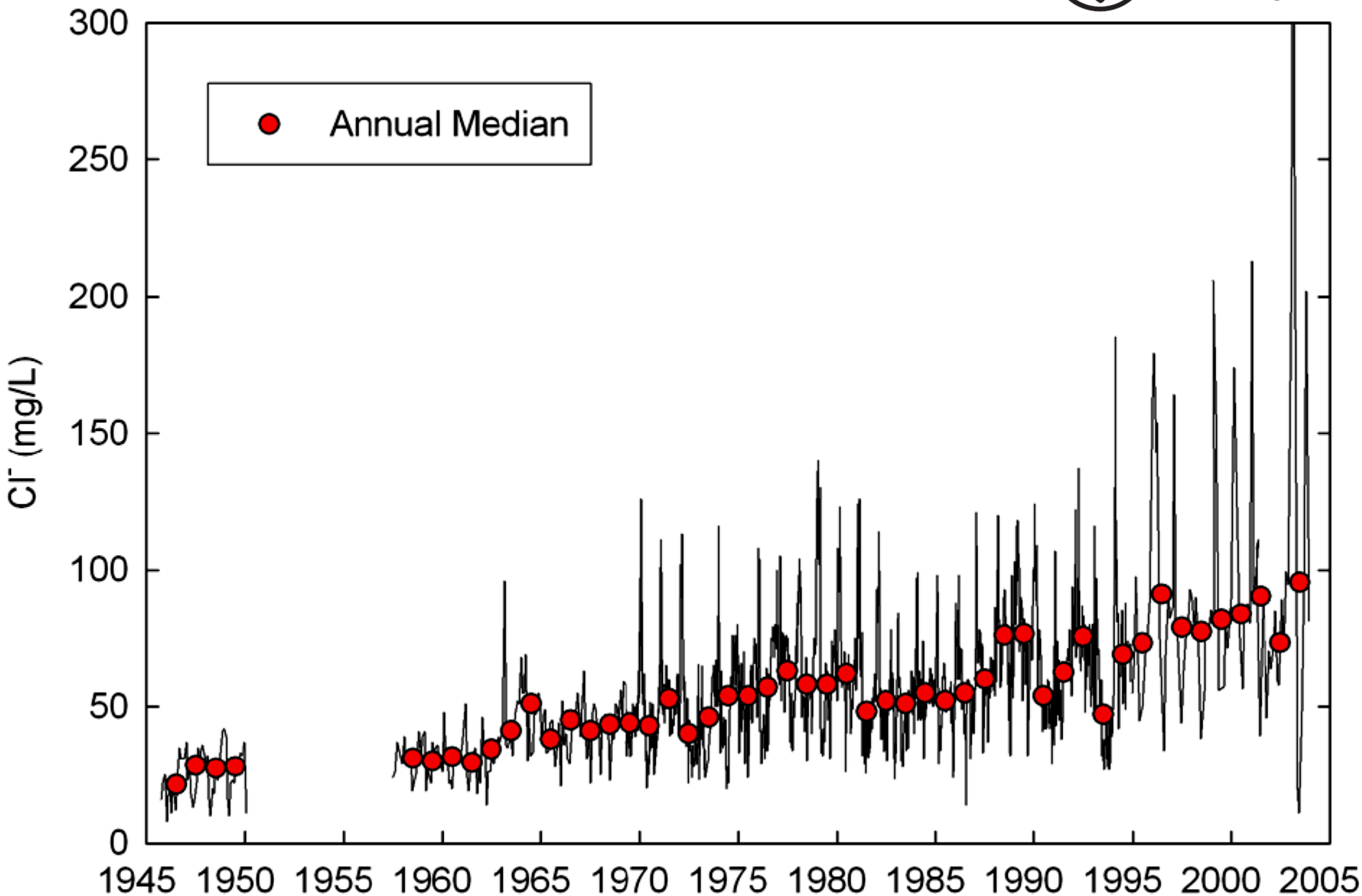

Figure 17. Chloride concentrations in Illinois River at Peoria. Data from ISWS and USGS.

Chloride Summary

- The road salt we use is impacting the various water bodies in Illinois
- The impact is increasing over time
- Already some locations are being monitored for this contamination, and this monitoring is likely to increase over time

End Point: We need a paradigm shift when we are using road salt

- In other words doing it the same old way won't work any more

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[Wisconsin Highway 41/45 video]

Levels of Service for IDOT

- Manual divides into roads with more than 3,000 AADT; 3,000 to 1,000 AADT; and AADT less than 1,000
- Specifies resources assigned to the roads
- Specifies when target goals are to be achieved

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6-200.3.1 All Highways with Greater than 3,000 Average Daily Traffic (ADT)

Highway Classification	Snow Route Approximate Center Line Mileage	Trucks Assigned
6-Lane Interstate and Ramps	14	3
6-Lane Routes	14	3
4-Lane Interstate and Ramps	14	2
4-Lane Routes	20	2
Other Multi-Lane	20	2
2-Lane Over 3,000 ADT	20	1

Level of Service:

Attain Code 3 pavement condition as soon as practical after a storm (pavement clear except for narrow strip along edges and centerline). Achieve Code 1 pavement condition (all clear) as quickly as practical.

REPORTING CODE 3: 75% BARE
Pavement clear except for a narrow strip on the edge

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REPORTING CODE 1: ALL CLEAR
Pavement is clear of ice and snow.

6-200.3.2 Highways with 1,000 to 3,000 ADT

Level of Service:

Attain Code 6 pavement conditions (road is open but covered with ice or packed snow). Achieve Code 1 pavement condition (all clear) as quickly as practical following the storm.

6-200.3.3 Highways with less than 1,000 ADT

Level of Service:

Try to attain Code 6 pavement conditions (road is open but covered with ice or packed snow). Occasionally, temporary blockage may occur and the level of service can be reduced to accomplish other required operational needs. Achieve Code 4 pavement condition (strip of ice or packed snow along the centerline and pavement edges) as quickly as practical following the storm. Achieve Code 1 pavement condition (bare pavement) after all other pavement with higher ADT's are reported Code 1.

REPORTING CODE 6: SNOW COVERED
When pavement on a route or portion of the District is covered with ice or packed snow.

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REPORTING CODE 4: 50% BARE

When a strip of ice or packed snow, some 4’ wide, remains in the center of the pavement with a 2’ to 3’ strip along each edge.

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And What Do They Have in Common?

- End goal is bare pavement
- Requires chemical usage
- Traditional approach – apply chemical after snow pack has formed – not very efficient
- Use chemicals NOT to melt snow and ice, but to break the bond

[Wrong way in Arlington Video here]

Mechanics of Salt and Ice

- Salt lowers the freezing point of water
- A saline solution has a lower freezing point than pure water (up to a point)

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The Lab Info

- As we add salt, up to 23% by weight, we lower the freeze point of water down to -6°F.
- That point on the diagram is called the eutectic point.
- In the lab, we will still get very slow melting at the eutectic point – but in the field it will be so slow as to be useless.
- The eutectic is not the low temperature for salt – about 10-15°F is the low point – do not use at **Pavement Temperatures** below that

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Nobody Mentioned Pavement Temperatures!

- I just did, and yes, they are critically important.
- They are the temperatures the salt and snow/ice are experiencing in the field.
- They are THE temperature that matters.
- Nothing else – air temperature, wind chill, dew point, anything else – matters anywhere close to as much as pavement temperature.

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The Field Info

- As soon as we apply salt, it starts to go into solution (as long as there is some moisture present…)
- As it goes into solution it lowers the freezing point – it starts working
- As it starts working, it starts to dilute out as well – it works by diluting out
- Given enough time, it WILL refreeze

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The Clock Is Ticking – or How Much Time?

- It depends on four things
  - Pavement temperature
  - Cycle time
  - Moisture content of the snow
  - Quantity of salt applied
- The lower the temp, the longer the cycle time, the wetter the snow, the more salt I need
- AND THE REVERSE IS TRUE!

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Say NO to Chemical Plowing!

- Not melting the snow, but breaking the bond
- We just need to melt a thin layer (a few thousandths of an inch) between pavement and snow – then we plow it off with the blade
- And, if you want to melt 1” of snow at 23°F, you will need 3,000 lb per lane mile
- DO NOT DO THAT!

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Dealing with the Bond

- Preventing the bond = pro-active = anti-icing
- Breaking the bond = re-active = de-icing
- Much better to prevent than to break
- How much better? About four times less salt needed

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Salt Skills

- A number of techniques that make our salt go further
- Pre-wetting, additives, liquids or solids, application rate variation
- Review these and see what we can gain

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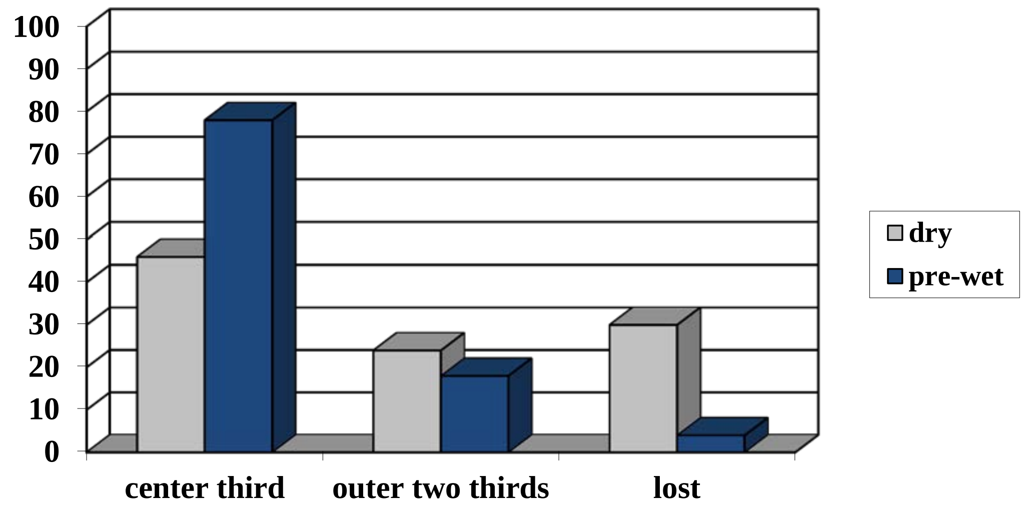
Pre-Wet the Material…



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Additives

- Many chemicals are now offered with some sort of additive
- Intended to reduce corrosion, and enhance melting capacity
- In the past ten years, many of these have been from agricultural by-products

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Solids or Liquids?

- It is all liquid when it is working!
- Each has benefits, each has drawbacks, ideally has both
- Having both is not a luxury – it is getting the right tools in your tool box

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Solid Thoughts

- Best practice – most of the time (more than 90%) should be applied pre-wet or using treated salt
- Almost all solids are sodium chloride
- Snow pack and freezing rain really need solids
- Will take longer to dilute than liquids, so good if you have long route times

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Liquid Thoughts

- Act fast, dilute fast
- Excellent for pre-treatments, especially for frost management
  - But very little value if dealing with freezing rain
- Be very careful using on snow pack or ice
- Appropriate equipment selection (e.g., trailers) allows for easy liquid pre-treatment and solid in-storm application
- Blending can allow enormous versatility

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Liquid Management

- The "basic" liquid is salt brine
- Easily made, easily stored, easily handled, easily used
- Also possibilities with blending using other chemicals

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Delivering the Materials

- Liquids and solids if possible
- Pre-wet (or pre-treat) is a must
  - typical rates of 4 gallons per ton, but more is also used and works well
- Variety of different solutions out there
- Interesting work on slurries too

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Drifting Issues

- Fairly common to have rising wind and dropping temperatures at end of storm
- A recipe for blowing and drifting snow
- If the road is wet?
  - Snow sticks to the wet road
  - Dilutes out any chemicals there
  - Refreezes
- We can end up fighting the storm long after it quits snowing!

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Dealing with Drifting Issues

- Need the road dry (or close to it) at the end of the storm
- Stop using chemicals as the storm winds down
  - Just plow instead
- Goal is to dry out the road
- Also make sure (if you can) that snow is piled on the downwind side of the road (not always possible)

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UDOT's
Pup Liquid Spreader w/Broom Plow

Roll-Off Unit

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MNDOT’s New Hook Lift System?

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That had to leave a mark!

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Tandem Slurry Generator

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Slurry Generator


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Typical Application Rates

- Hugely variable between agencies
- A step toward uniformity in the FHWA Manual of Practice for an Effective Anti-Icing Program
- Variations as functions of storm type, road surface temperature, and route cycle time
- Refined by experience and becoming incorporated into MDSS-type solutions

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NOTE:

Maximum Spread Width is **20’**

No Exceptions!

3 ton	Holds 6 tons of salt	Application Rate (Lbs./lane mile)	Lane Miles Covered
		100	120
		200	60
		350 *(Max. Primary)*	34.28
		450 *(Max. Expressway)*	26.66
		700 *(Blast)*	17.14

6 ton	Holds 12 tons of salt	Application Rate (Lbs./lane mile)	Lane Miles Covered
		100	240
		200	120
		350 *(Max. Primary)*	68.57
		450 *(Max. Expressway)*	53.33
		700 *(Blast)*	34.28

Super Truck	Holds 16 tons of salt	Application Rate (Lbs./lane mile)	Lane Miles Covered
		100	320
		200	160
		350 *(Max. Primary)*	91.42
		450 *(Max. Expressway)*	71.11
		700 *(Blast)*	45.71

Slurry Generator with 740 Gallon Brine Tanks	Holds 9 tons of salt	Granular Application Rate (Lbs./lane mile)	Liquid Application Rate (Gallons/Minute)	Lane Miles Covered
		200	30 GPM	320
		300	50 GPM	160
		700 *(Blast)*	50 GPM	45.71

	Pavement Temperature Range				
Storm Type	Above 32°F and constant	Above 32°F but dropping	20-32°F	5-20°F	Below 5°F
Light Snow	Apply nothing – just monitor	100-150 lb/lane mile	100-150 lb/lane mile	150-250 lb/lane mile	Apply no salt
Light to Moderate Snow	Apply nothing – just monitor	100-200 lb/lane mile	200-250 lb/lane mile	250 -350 lb/lane mile	Apply no salt
Moderate to Heavy Snow	Apply nothing – just monitor	100-150 lb/lane mile	200-250 lb/lane mile	250-500 lb/lane mile	Apply no salt
Freezing Rain	Apply nothing – just monitor	75 -100 lb/lane mile	150-300 lb/lane mile	250-500 lb/lane mile	Apply no salt

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Application Rate Comments

- When the pavement temperature is above freezing and not dropping, we do not apply chemicals; we just monitor
- When pavement temperature drops below 10°F we need to be very careful about using salt because it will have minimal benefit
- For frost treatments, it is best to pre-treat, with rates from 20–60 gallons per lane mile (less at warmer pavement temperatures)
- If frost forms, treat with pre-wet salt at 75–500 lb per lane mile (less at warmer pavement temperatures)

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[Calibration Video Here]

Calibration Review

- Calibration should be done at least once a year for every spreader.
- A careful methodical approach is a must.
- Good record keeping is critical.
- It also becomes a good time to check that everything on the unit is working before the first snowflake falls.

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So, Now Plow

- Major advances
- New cutting edges, plow types, hydraulics, control systems, others

Tow Plows

Towing position, plow up

Plowing position, plow down

w/Liquid Chemical Tank

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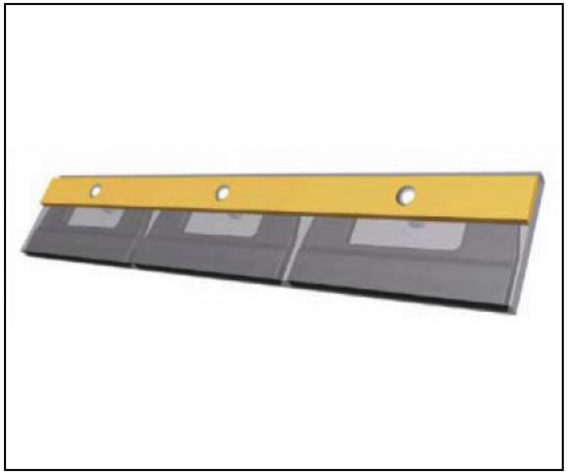
Cutting Edges



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SUPERIOR SCRAPING AND LESS VIBRATION/NOISE

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Multi-Blade Plows

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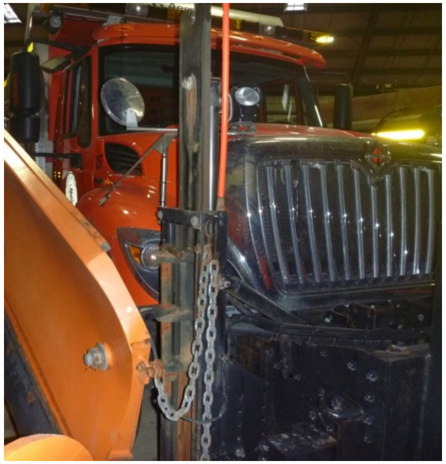
NEW WING POST DESIGN



TRADITIONAL POST

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Information

- Lifeblood for winter maintenance
- What do we need? Lots!
- Weather data
- Pavement temperature
- Information on equipment and materials being deployed
- Information on road conditions

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Weather Information

- Winter operations require a forecast that includes several special features
- Pavement temperature is a MUST
  - That is where the bond needs to be melted
- Storm start and end times are critical
  - So resources can be scheduled appropriately
- The nature of the precipitation is very important
  - Each type of storm requires differing responses – e.g., freezing rain vs. snow
- Post-storm behavior is also important
  - High winds and low temperatures means the road must be dried out by the end of the storm

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Winter and Traffic Management

- Plowing in a traffic jam is not very effective!
- By linking operations with traffic management, pre-treatment and in-storm plowing can be diverted around problem areas to avoid cascading impacts
- Traffic can also be diverted from snow- and ice-related trouble spots in real-time, thus simplifying clean-up
- However, while there are no technical barriers to such communication, it is not common in the U.S.

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[Jon Stewart Atlanta video]

Traffic and the Forecast

- In the ideal, the forecast acts as an early warning system
- Allows operations to prepare for and mitigate the impacts of the incoming weather
- Allows road users to adjust their travel plans to avoid any delays associated with the weather
- This has a beneficial feedback effects
- For example, the more people stay home in a winter storm, the easier it will be to clear the roads
- BUT, the forecast is not always correct…

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The Different Storms

- Many storms are not that different, but there are a few things that make big differences
  - Starting with rain
  - High winds
  - Heavy snow
  - Freezing rain
  - Dropping temperature after a storm (along with winds picking up)
  - Hitting at rush hour (don't they all?)
  - Etc…

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The Different Tactics

- So, how do we respond to those special conditions?
  - Liquids or solids (no liquids with freezing rain)
  - Chemicals or not (very cold pavements, or strong winds, means keep the pavement dry, so no chemicals)
  - Heavy snow might mean limiting chemical application during the storm – apply chemicals at the start and during clean up, but not otherwise
- Also, some general guidelines for those common storm types (like the application rate chart)

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