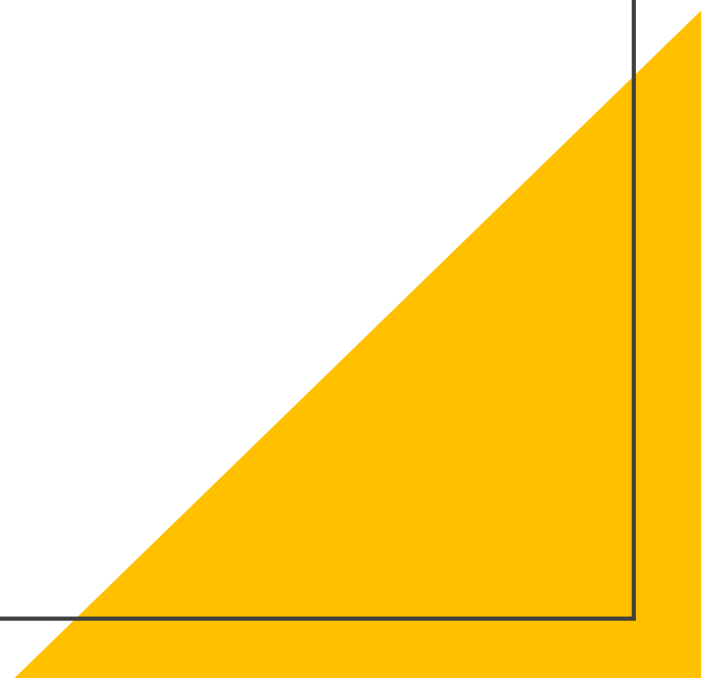


Chemicals, Liquids, Slurries, Oh My!

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Outline



How do chemicals work and what do they do for us?



What are the drawbacks of chemicals?



How and why are agencies using chemicals most effectively?



What are the good practices in using chemicals?

Why Do We Do Winter Maintenance?

Two primary reasons, both well established by research

Safety – Marquette University study showed proper use of road salt resulted in:

- Crashes reduced by 88%
- Injuries reduced by 85%
- Accident costs reduced by 85%

University of Waterloo Study showed proper use of road salt resulted in a 95% reduction of crashes on four-lane highways

Related University of Waterloo study showed that chloride levels were reduced by 50% when best practices were used

Not Just Safety - Mobility

Study by Global Insights looked at the impact of a one day shutdown for a State due to a winter storm. They found:

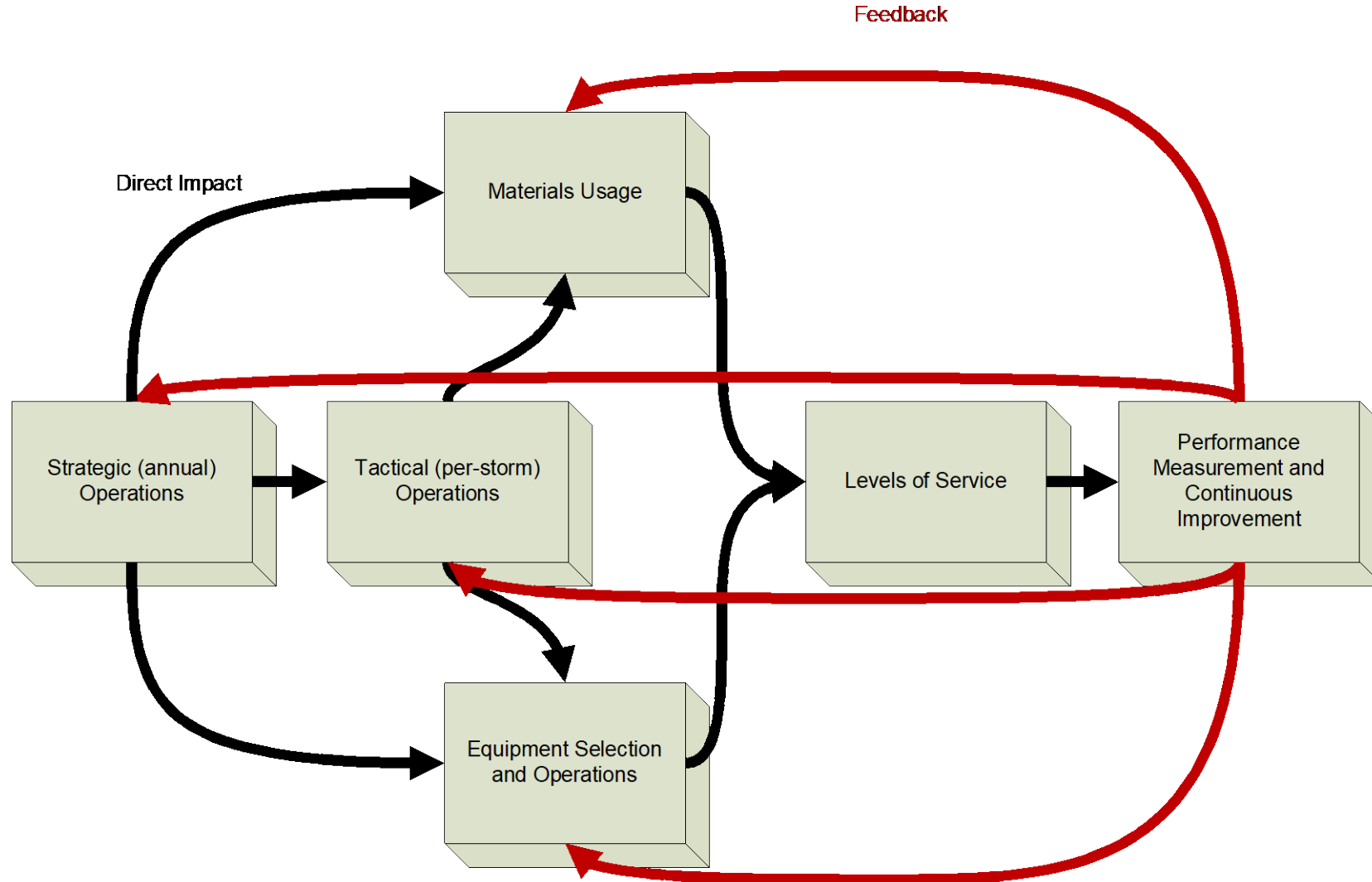
- A one-day major snowstorm can cause a state \$300-\$700 million in direct and indirect costs
- The economic impact of snow-related closures far exceeds the cost of timely snow removal
- Snow related shutdowns **harm hourly workers** the worst

Other studies have shown that safe and sustainable snowfighting when applied to a winter storm pays for itself in the first 25 minutes of operations

Plus, a high level of service is what we expect...

Winter Maintenance Goals

- Provide **safety** and **mobility** to road users
- Do this without negatively impacting the **environment**
- Do this within budget
- Provide the right **level of service**
- Address the **social expectations** of our community
- Has to be a systems based approach
- Every step along the way requires attention
- Needs cooperation and collaboration between all stakeholders
- Sustainability requires such cooperation to be effective



A Goal Statement?

- Achieve our desired level of service in a timely manner, with an appropriate use of resources and materials, taking into account the severity of the storm conditions that we are facing...

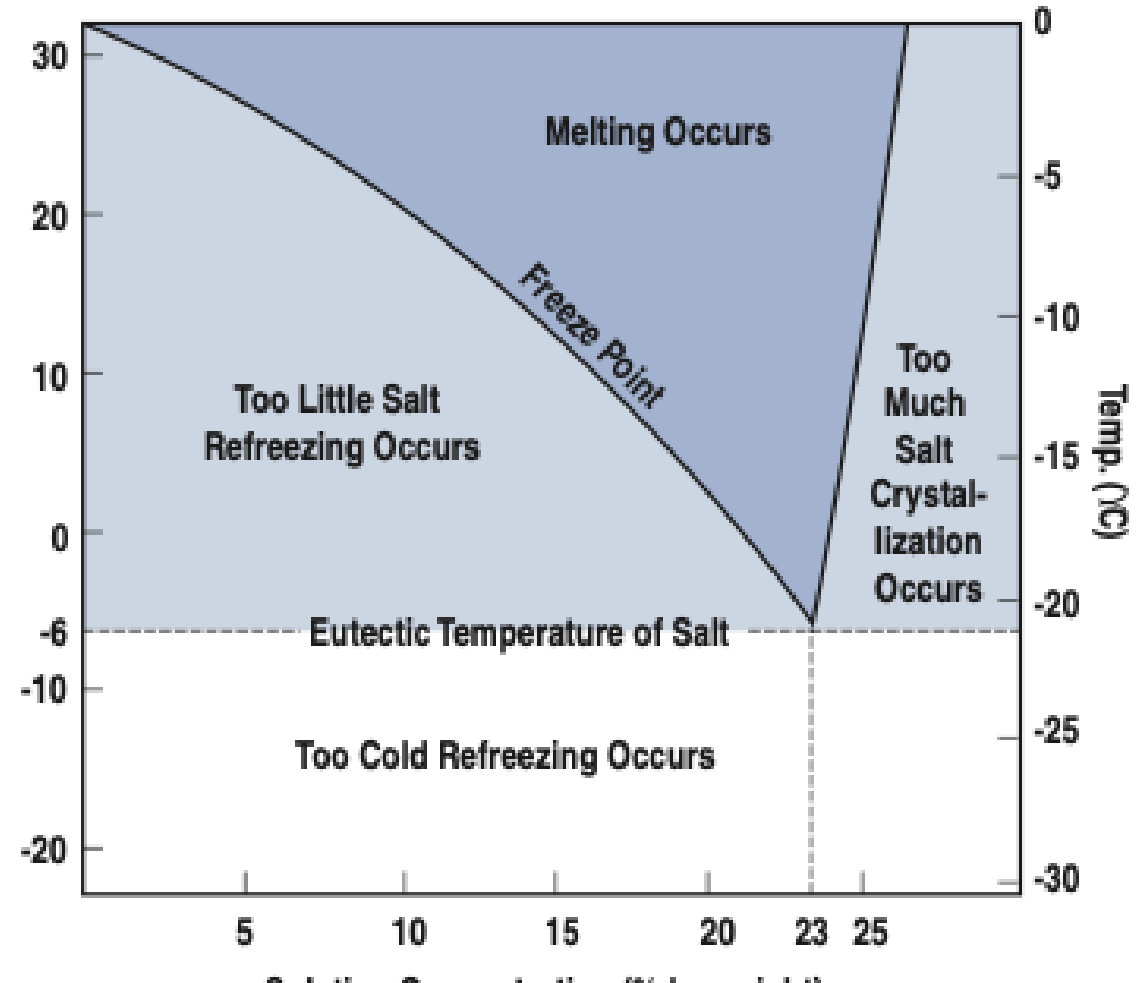
To Understand De-Icers...

- We will look at salt, not because it is “best”, but because it is most commonly used
- Lots of salt information in the “Safe and Sustainable Snowfighting Handbook,” from Salt Institute
- <https://professionalsnowfightersassociation.org/wp-content/uploads/2019/04/SASS-Handbook-2016-copy.pdf>

Salt, Concentration, and Temperature

- Salt is less effective at lower temperatures
- Salt dilutes out as more liquid is present (or as more snow is melted)
- We summarize this in a phase diagram
- We "want" to be in the part that says "Melting Occurs"

Phase Diagram for Salt



Salt and Temperature

Pounds of Ice Melted Per Pound of Salt

Pavement Temp. °F	One Pound of Salt (NaCl) melts	Melt Times
30	46.3 lbs of ice	5 min.
25	14.4 lbs of ice	10 min.
20	8.6 lbs of ice	20 min.
15	6.3 lbs of ice	1 hour
10	4.9 lbs of ice	Dry salt is ineffective and will blow away before it melts anything.
5	4.1 lbs of ice	
0	3.7 lbs of ice	
-6	3.2 lbs of ice	

It is not cost-efficient to apply salt (sodium chloride) at pavement temperatures less than 15° F.

Thoughts about Salt and Temperature

The temperature is the pavement temperature

- Nothing to do with air temperature, wind chill, or anything else
- Not reported in the weather report by NWS or by any TV or Radio station
- Needs special equipment to measure it

Drastic reduction in snow melted as we get colder

Also, takes much longer to melt as we get colder

- At 30° F it takes 5 minutes, at 15° F it takes an hour...
- Most of that hour is getting into solution
- If we start in solution...

A Critical Thing about that Melting

- At 25° F a pound of salt melted 14.4 pounds of ice
- So if we spread 300 pounds per lane mile of salt on a road at 25° F, we melt 4,320 pounds of water – a lot!
- But spread over a lane kilometer that is a 0.011 inch thickness of water (also known as “Diddleley-Squat”)
- 300 lbs of salt per lane mile works very well at 25° F, so what the ... is happening here?

We do not use salt
(or any other de-
icer) to melt the
snow and ice

We use salt (or any
other de-icer) to
break the bond
between the snow
and the pavement

**“Bond;
Ice Bond”**



Why Does Breaking the Bond Matter?

- The number one tool for removing snow and ice from a road or other paved surface is the plow
- A well-applied de-icer makes plowing significantly more efficient
- If you prefer, it reduces substantially the snow and ice left behind after plowing
- At the very least we want to break the bond
- It is much better (we need about $\frac{1}{4}$ of the salt) if we can prevent the bond in the first place

Summarize the Challenge

Get	Make	Figure out	Look
Get the material onto the pavement surface	Make sure it stays there long enough to work	Figure out how much we need for a given circumstance	Look at ways of reducing what we need to achieve our goals

Take a Diversion

- What are our goals?
- Referred to as “Levels of Service”
- Not everything has to be completely free of snow and ice
- But, all of these have somewhat “bare pavement” so all need de-icers
- Know when we reach our goal, and then stop!



Why Use Liquids?

- Trying to get to our goals using as little salt (or other chemical) as possible
- For salt to work, it MUST go into solution (i. e. become a liquid) so why not help it along by using in solution right from the start?
- But what about all that water we are putting down on the road along with the salt?



Liquids Pros and Cons

- Pros
 - Works right away
 - Operationally effective at lower pavement temperatures than dry salt
 - When applied to the pavement surface, it stays there
- Cons
 - Dilutes and refreezes more quickly than dry salt
 - Cannot penetrate significant snowpack or ice
 - May need changes in equipment and materials storage

Terminology of Treatment Types

1. De-icing – traditional approach to snow and ice control Anti-icing – sometimes referred to as pre-treating or direct liquid application (DLA)
 1. Typically with liquids
 2. Pre-wetted solids
2. Pre-wetting – applying liquids to solids before placement on surface or roadway
 1. In stock pile (pre-treated salt)
 2. At discharge
3. High Volume Output
 1. High amounts of liquids combined with some solids
 2. Direct Liquid Application for de-icing – high amounts of liquids

Anti-Icing & De-Icing

- Anti-Icing
 - Prevents snow from freezing & bonding to a surface
 - Frost prevention
- De-Icing
 - Breaks the bond of snow that has already froze to the surface



Anti-Icing

- Proactive use of melting agent to prevent formation of bond between snow/ice and road surface
 - Includes application of liquids (direct liquid application/DLA), pre-wetted or pre-treated salt
 - Usually applied prior to start of event but can also be reapplied during
-
- Benefits - Snow is easier removed by plow, as snow/ice is prevented from bonding to road surface
 - Creates safer road conditions quicker with less chemicals used than de-icing (*reactive*)
 - Especially effective in frost/black ice conditions including bridges



Pre-wetting – How?

01

Treat the stockpile

- Simple way to get into liquids with no equipment investment (*agricultural based products only)

02

Apply liquids at point of discharge

- Preferred approach. More consistent distribution of material

03

Overhead spray of trucks

- Not recommended & outdated

Pre-Treat

- Apply liquid to stock pile
- Typically w/ Mag, Calcium, or Ag product
- Helps w/ bounce and scatter
- 5 - 10 Gal/Ton

Source: Village of Downers Grove, IL

Pre-Wetting Background

- Introduction of a liquid chemical to NaCl just prior to the dry salt being applied to road
 - Less bounce & scatter
 - Salt sticks to surface better
 - Salt works faster as it is in brine solution sooner
- Spreading speeds can increase
 - Goal is to pre-wet salt as late as possible before salt hits the road
 - Standard application of salt brine to salt is 4%-8% (8-15 gal/ton or 32-63 l/tonne) but may go to 20% (40 gal/ton or 165 l/tonne) or more depending on equipment used

High Volume Applications

First method

- Direct Liquid Application (DLA)
- Using liquid throughout the storm without any use of solids

Second method

- In conjunction with solids (shake and bake...)
- Excellent tool for breaking through ice and snowpack

An aerial photograph of a winding, two-lane asphalt road that snakes through a desert landscape. The road is flanked by sandy, yellowish-brown terrain and patches of white, possibly snow or salt deposits. The road's path is highly irregular, with several sharp turns and loops. The text "Liquid Only Routes" is overlaid in the center of the image in a white, sans-serif font.

Liquid Only Routes

Case studies



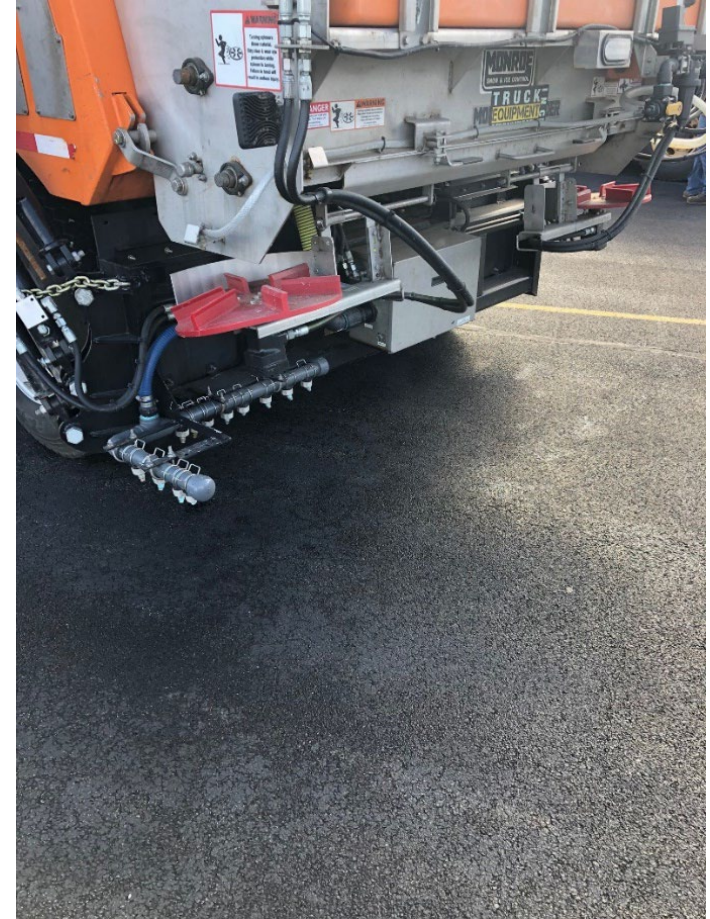
Concentrates the liquid at the middle of the road.



This is a direct liquid application modification



The taper of the road allows the liquid to work its way across the pavement

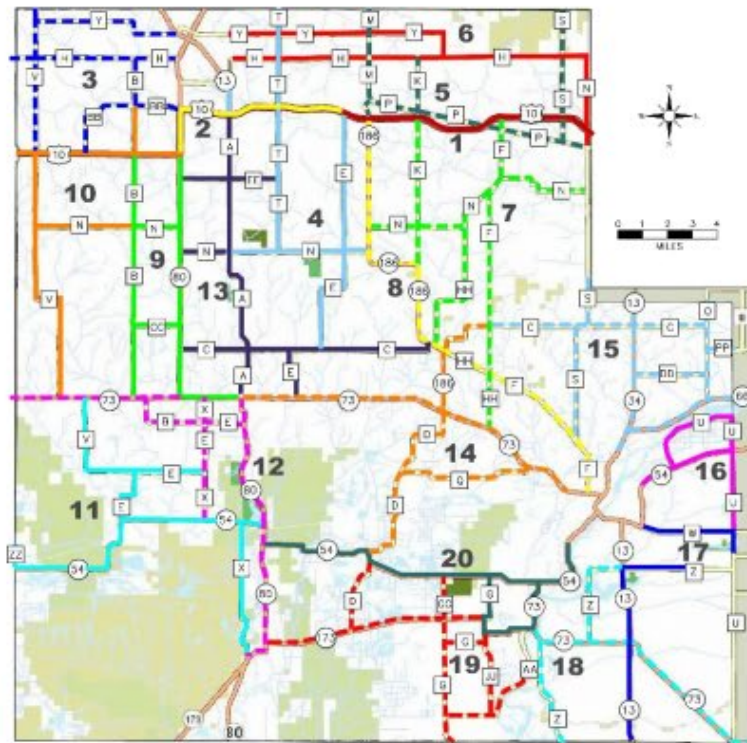


Wisconsin modified unit – the L Bar

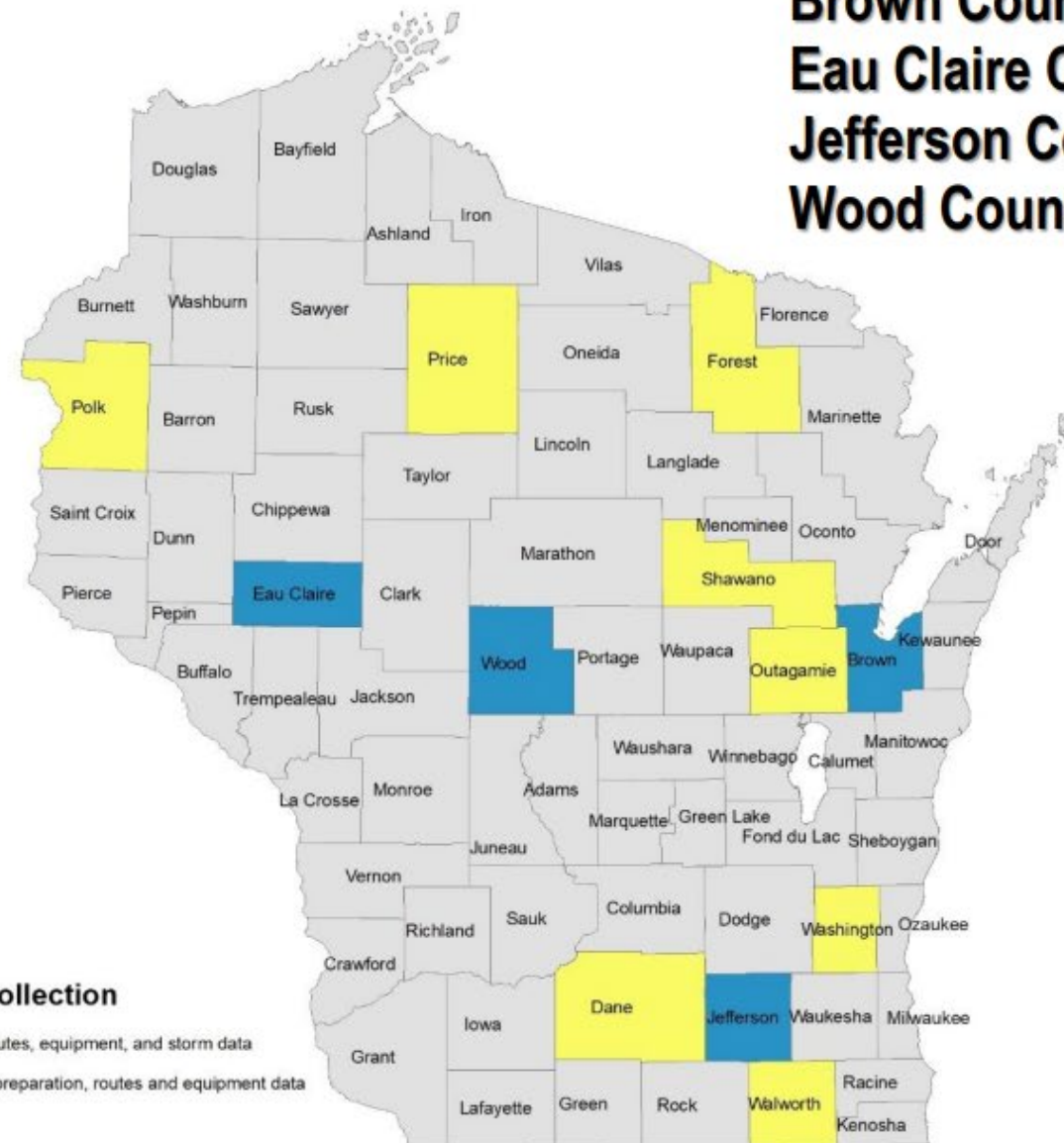
Methodology

Data Collection

Wood County Winter Maintenance Routes



Brown County
Eau Claire County
Jefferson County
Wood County



Data Collection

- Routes, equipment, and storm data
- In preparation, routes and equipment data



Results Comparison Group Analysis

Wood County

Description	Study	Control	Comparison	
Salt usage (lb/ln-mi)	155	298	-143	-48%
Cost w/ salt brine \$0.08/gal (\$/ln-mi)	\$8.6	\$16.5	-\$7.9	-48%
Cost w/ salt brine \$0.14/gal (\$/ln-mi)	\$14.3	\$16.6	-\$2.3	-14%
Time to Bare/Wet (hr)	9.8	12.5	-2.7	-22%

Jefferson County (two control routes)

Description	Study	Control	Comparison	
Salt usage (lb/ln-mi)	965	\$1,471	-622	-36%
		\$1,097	-180	-14%
Cost w/ salt brine \$0.08/gal (\$/ln-mi)	\$42.0	\$63.9	-\$22	-46%
		\$47.7	-\$6	-12%
Cost w/ salt brine \$0.14/gal (\$/ln-mi)	\$47.9	\$63.9	-\$16	-34%
		\$47.7	+\$0.2	+0.4%
Time to Bare/Wet (hr)	9.7	16.8	-7.1	-42%

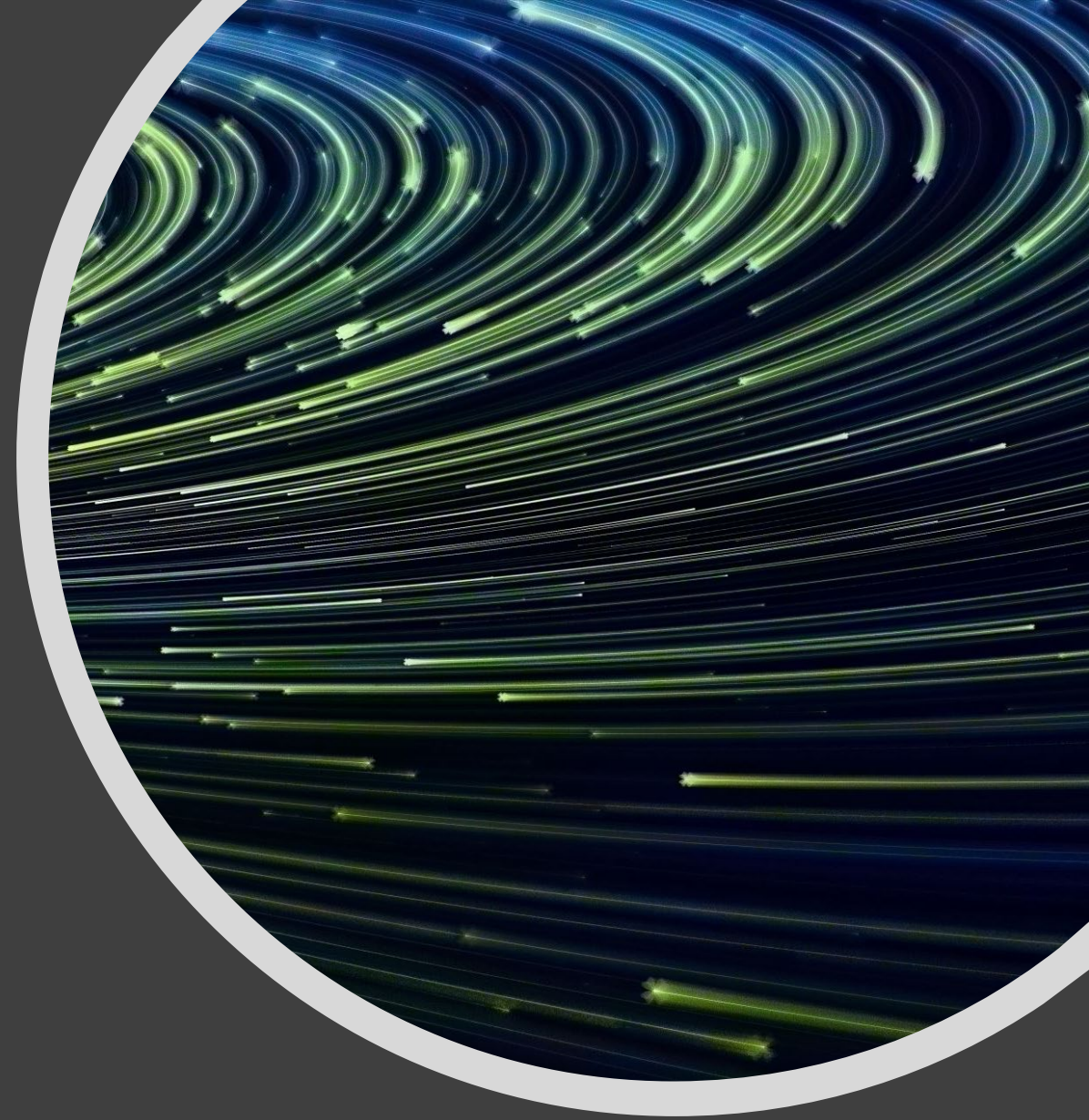
Liquids in a De-Icing Mode

Add liquids (in high volumes) to solids

Goal is to allow the solids to work more quickly
(and thus break down snow pack)

Can be done in two ways

- With very heavy on-board pre-wetting (90 gallons per ton) which needs extra storage and bigger pumps on the truck
- With two trucks, first applying solid next applying liquid



Getting Started in Liquids



Make, store, transfer the liquid



Store the liquid on the truck



Deliver the liquid to the solid (pre-wetting) or directly to the pavement (DLA and anti-icing)



Brine Making is Cost Effective

- ✓ Can be done manually for small batches
- ✓ Consider regional partnerships to get started



You Can Start Small

- ✓ Nome, Alaska
- ✓ Started at 1,000 gallon capacity. Expanded to 23,000 gallons



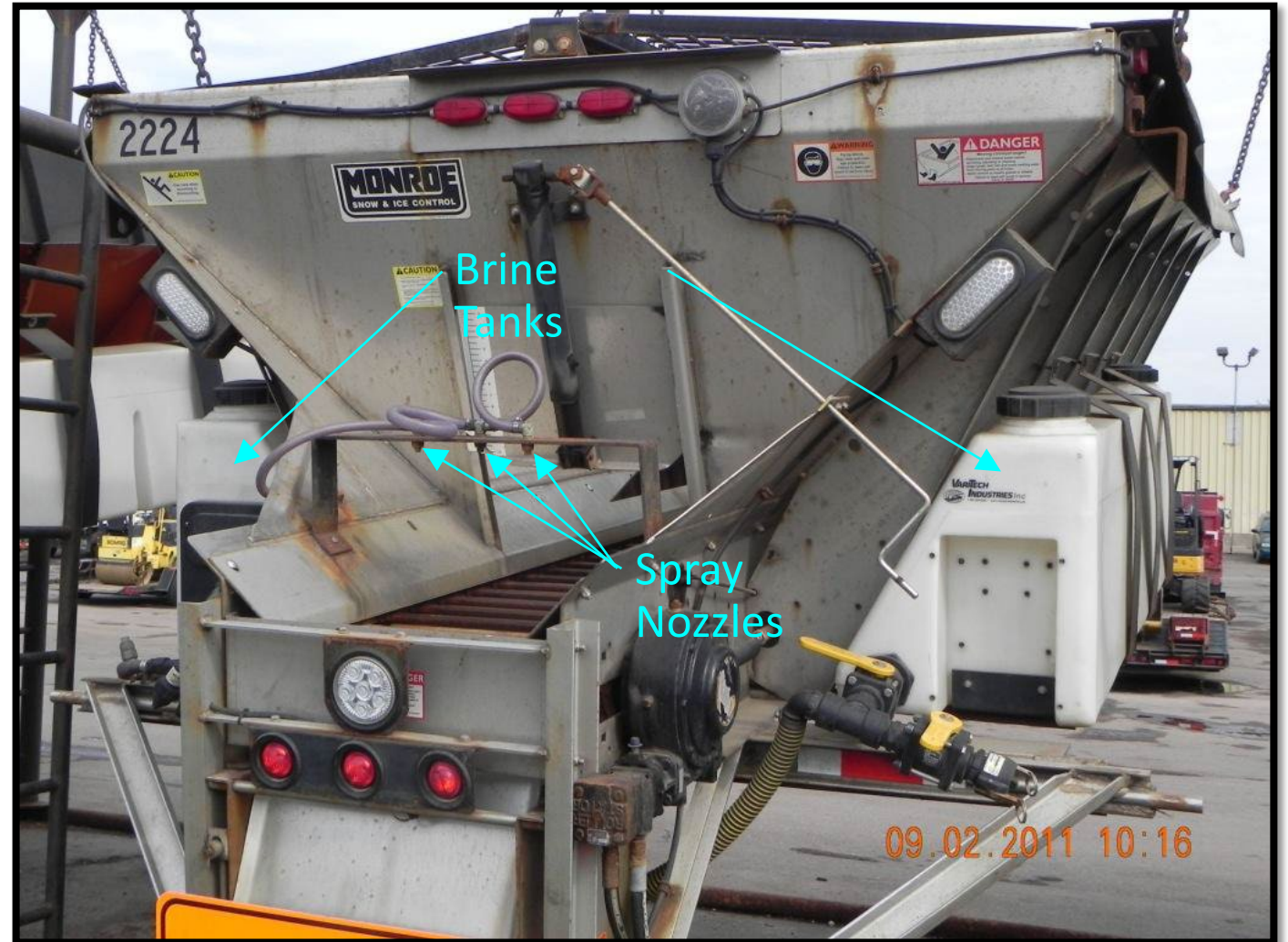
Early (2000s) Brine Facilities

Liquid Storage – Best Practices



- Above ground storage
- Proper containment system
- Double walled tanks
- Sufficient storage
- Blending liquids

Pre-Wet Equipment



Anti-Icing (Direct Liquid Application) Equipment



Anti-icing

- Streamer nozzles
- 8" – 12" spacing (2-300 mm)
- "Less is best" – 20 gal to 50 gal per Lane-mile
- Better friction, established chemical layer and improved public perception



Conclusions

- Chemicals are an awesome tool but they are not the only tool you need
- Used correctly, and with plowing, they allow us to achieve our goals more efficiently, effectively, and sustainably
- Lots of information out there – feel free to contact me if you need more info
- Wilf@psassoc.org