Using Winter Severity Indices for Winter Maintenance Performance Management

TRB Winter Maintenance Committee

AHD65

https://sites.google.com/site/trbcommitteeahd65/

Max Perchanok

July 29 2015

Winter Maintenance Committee

- Identify, propose, coordinate and promote research in winter highway maintenance
- Membership: 15 US, 7 international
  - Academic, government, private sector
- TRB Annual Meeting sessions
- International Conference & Workshop
  - February 2016, on-line
  - April 2016, Colorado

Sponsored Research

- Recently Completed
  - Strategies to Mitigate the Impacts of Chloride Roadway Deicers on the Natural Environment, Project 20-05/Topic 43-12
  - Winter Operations and Salt, Sand and Chemical Management, in Environmental Stewardship manual of the AASHTO Center for Environmental Excellence, Project 20-07/Task 318
  - Methods for Estimating the Benefits of Winter Maintenance Operations, Project 20-07/300
  - Alternative Methods of Delivering Winter Operations Services, Project 20-07 Task 329
- In Progress
  - Guide for Performance Measures in Snow and Ice Control Operations, Project 14-34

Winter Severity

- Managing materials
- Managing performance
- Reporting performance
- Environmental sustainability

Introduction

DEEPAK GOPALAKRISHNA (ICF)

The challenge

Increased pressure on winter maintenance groups to measure impacts and performance

Fiscal pressures mounting

Allocation of funds between regions/years

Assigning responsibility

Rewarding success

Agencies want a consistent, reliable and easy way to measure performance that allows them to make informed decisions between regions and seasons taking into account their differences

Every storm is different and practices are different

Geographic and temporal variation of events

Diversity of agencies and contractors involved in winter weather

Winter Severity Indices

Simply – An index that combines various weather impacts into a single value that allows an agency to compare and normalize performance geographically and temporally

Not so Simply - SHRP2 (1993)

$$WI_{SHRP} = a\sqrt{t_{seasonindex}} + b\ln\left(\frac{S_{daily}}{10}+1\right) + c\sqrt{\left(\frac{d_{freeze1}}{T_{range1}+10}\right)} + d \qquad ($$

where $t_{seasonindex}$ = average value of $t_{dayindex}$ over season ($0 \le t_{seasonindex} \le 1$)

$t_{dayindex}$ = 0, if minimum air temperature (T_{min}) is above 32° F (0° C)
1, if maximum air temperature (T_{max}) > 32° F (0° C) while $T_{min} \le$ 32° F (0° C)
2, if $T_{max} \le$ 32° F (0° C)

S_{daily} = Mean daily values of snowfall (millimeters)

$d_{freeze1}$ = Mean daily values of the number of days with minimum air temperature at or below 32° F (0° C) ($0 \le d_{freeze1} \le 1$)

T_{range1} = Mean monthly maximum air temperature minus the mean monthly minimum air temperature (° C)

- Not the band.

- Source: Development of a Roadway Severity Index, WTI, 2005

Growing usage but evolving field

State/Author(s)	Seasonal WSI	Storm-by-Storm Index	WSI Primary Function	Comments
Qiu (2008)	No	Yes	Traffic operations and maintenance	Storm severity index that observes severity on a storm-by-storm basis. Index is used in a final traffic operation formula.
Strong et al. (2005)	Yes	No	Traffic operations	Approximates seasonal accident rates based on winter severity.
Boselly et al. (1993)	Yes	No	Maintenance	SHRP winter index. Designed to assign a seasonal winter severity score to any location without geographic discrimination.
Cerutti and Decker (2011)	No	Yes	Human intrinsic value	A local winter storm scale that basis winter severity on public perception.
Decker et al. (2001)	Yes	No	Maintenance	Uses SHRP winter index to compare expenditure between three geographically distinct UDOT maintenance sheds.
Idaho	Yes	Yes	Maintenance	Created a storm-by-storm index that takes road surface state conditions into account.
Indiana	Yes	No	Maintenance	Created their own winter index based off of criteria interest and surveying maintenance crews.
Iowa	Yes	No	Maintenance	Winter index that favors time constant. Considers duration of precipitation and snow consistency.
Kansas	Yes	No	Maintenance	Uses SHRP winter index.
Massachusetts	In Progress	No	Maintenance	WSI under development by contractor.
Minnesota	Yes	No	Maintenance	Uses SHRP winter index.
Ontario	Yes	No	Maintenance	Created a modified version of the SHRP winter index.
Wisconsin	Yes	No	Maintenance	Created a modified version of the SHRP winter index.

- Source: UDOT Research Report, Utah Winter Severity Index Appendix A

Source: 2013 State Survey

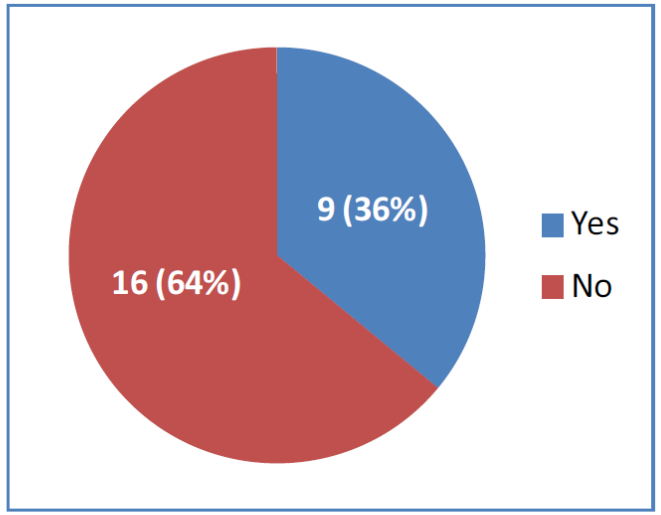


Figure 4-18. Does your State DOT Calculate a Winter Severity Index?

- Still an evolving field. (Source: FHWA RWMP Performance Measures, 2012-2013 update, N=25 States)

Objectives of the Webinar

Share real-world experience in development and use of WSI

Provide guidance on how an agency can get started with developing their own WSI

Speakers

Michael Adams, Wisconsin DOT

Jakin Koll, Minnesota DOT

Steven Otto, Alberta Transportation

The Wisconsin DOT Winter Severity Index

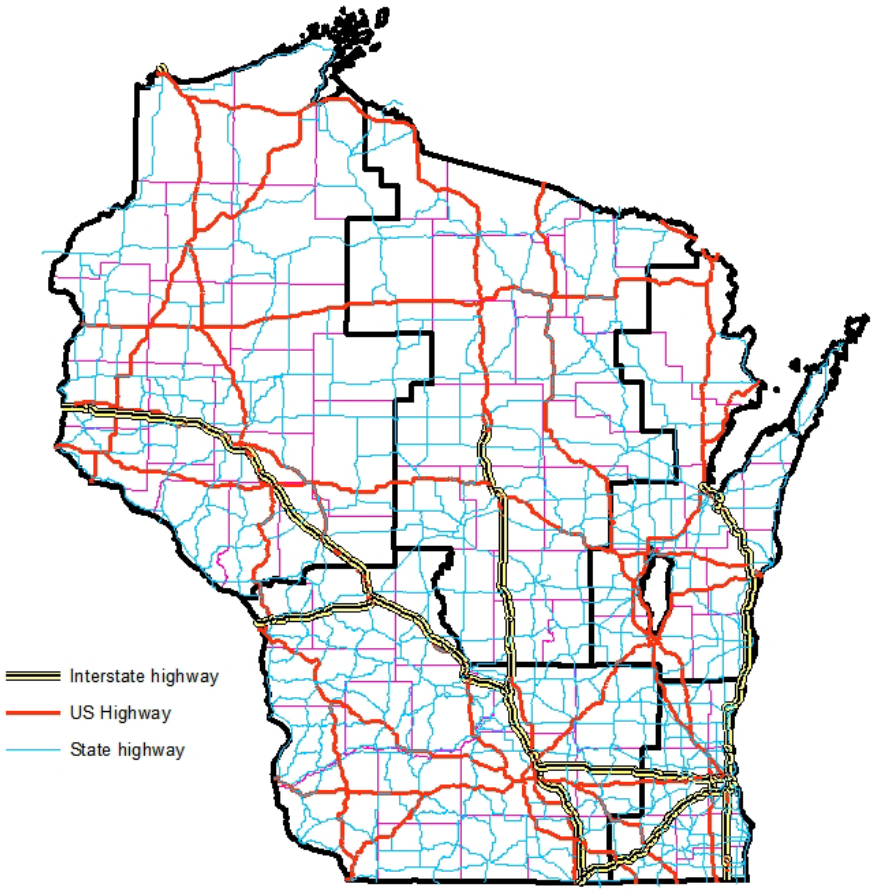
Mike Adams
Wisconsin DOT RWIS Program Manager
July 29, 2015

Overview

- Wisconsin DOT background
- Why we use it
- Development history
- How we use it
- Future plans

Wisconsin DOT

- All maintenance contracted to counties
- Responsible for 34,000 lane-miles
- Statewide average snowfall: 65 inches



Why Use a Severity Index?

- “No two storms are alike”
- Need to normalize costs
- Explain cost variance
- Winter funding reallocation
- Operations analysis

Development History

1996

- Formed ad hoc committee
- Determined important criteria
- Examined data availability
- Computed indices back to 1992

2005

- Modified definition of “incidents”

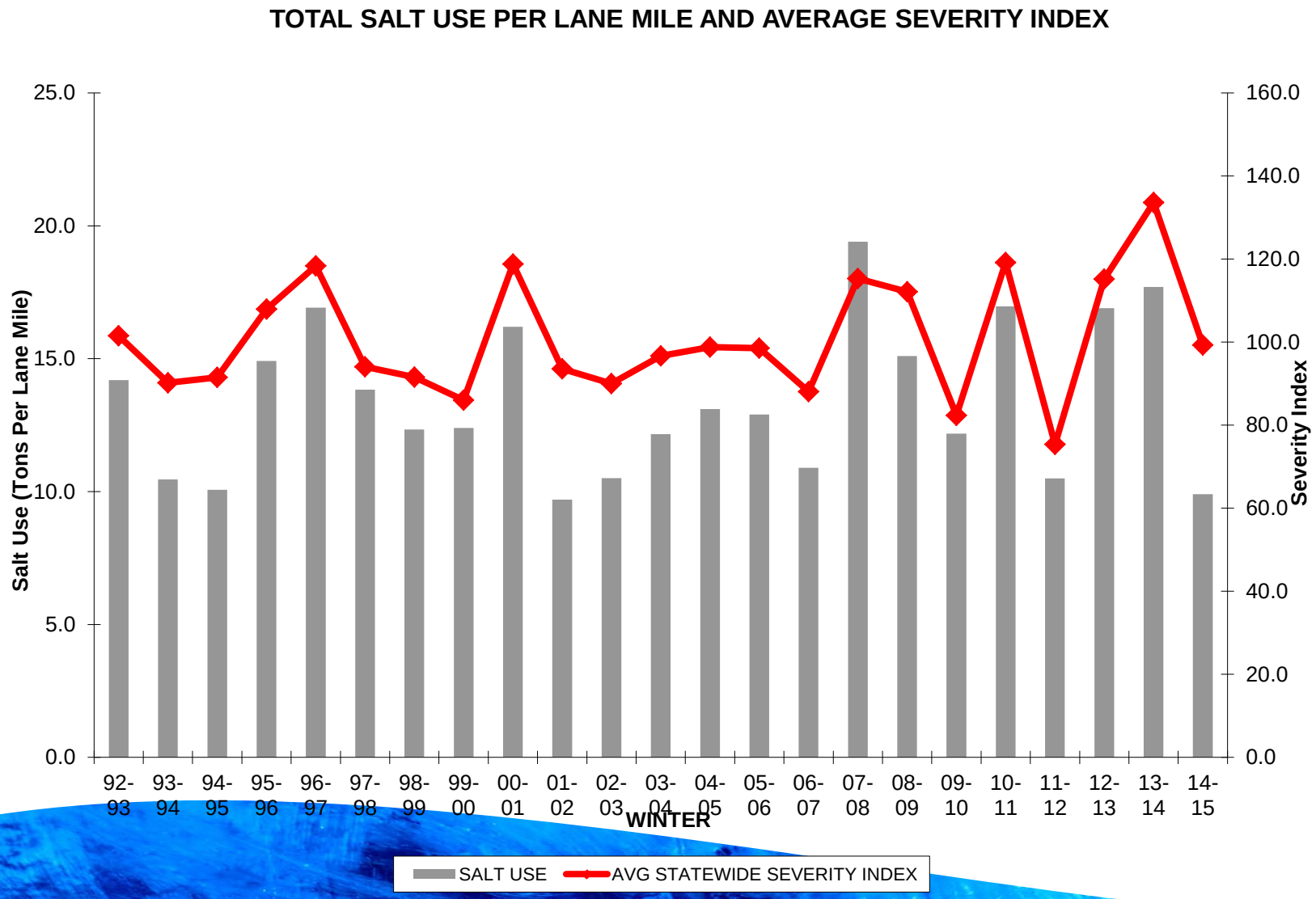
2010

- Enhanced reporting

Index Criteria

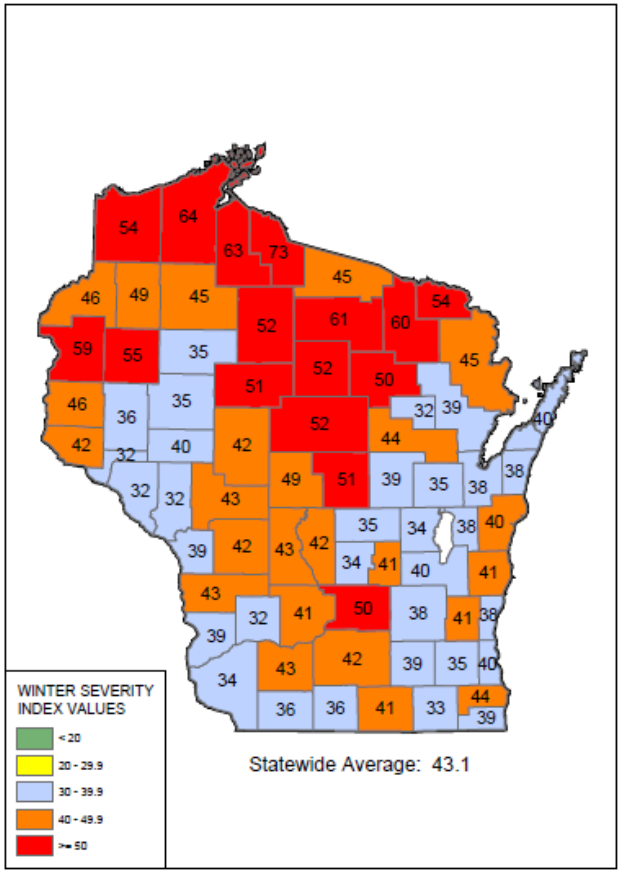
- Snow amount
- Number of snow events
- Number of freezing rain events
- Storm duration
- Incidents

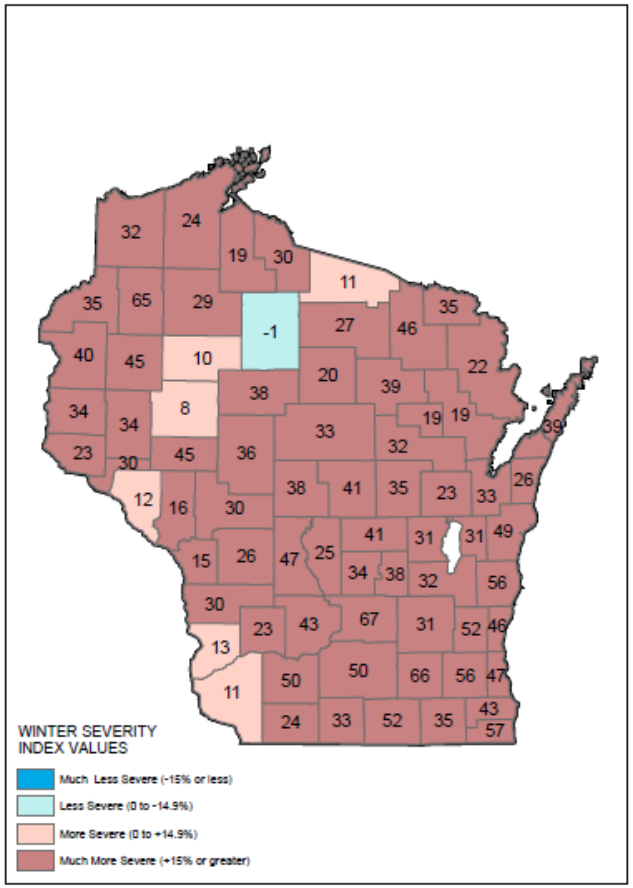
Does It Work?


TOTAL SALT USE PER LANE MILE AND AVERAGE SEVERITY INDEX
Salt Use (Tons Per Lane Mile)
Severity Index
25.0
20.0
15.0
10.0
5.0
0.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
92-93
93-94
94-95
95-96
96-97
97-98
98-99
99-00
00-01
01-02
02-03
03-04
04-05
05-06
06-07
07-08
08-09
09-10
10-11
11-12
12-13
13-14
14-15
WINTER
SALT USE
AVG STATEWIDE SEVERITY INDEX

So, How Do We Use It?

“Real-Time”

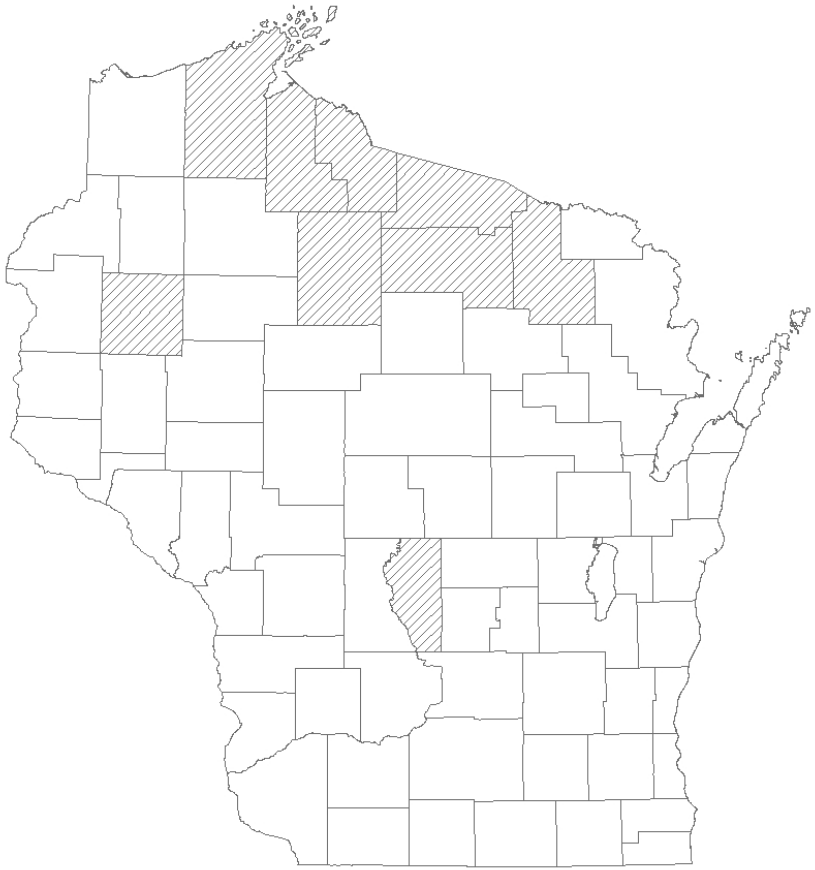

WINTER SEVERITY INDEX VALUES
< 20
20 - 29.9
30 - 39.9
40 - 49.9
>= 50
Statewide Average: 43.1


WINTER SEVERITY INDEX VALUES
Much Less Severe (-15% or less)
Less Severe (0 to -14.9%)
More Severe (0 to +14.9%)
Much More Severe (+15% or greater)

Winter Funding Reallocation

- WisDOT uses model to help allocate funds to counties for winter maintenance
  - Based on statewide average number of storms and winter events
  - Based on equipment and manpower used per facility
- Make adjustments based in part on severity index
  - Cannot receive allocation unless severity is above statewide average
  - Cannot receive allocation unless costs exceed modeled allocation

Counties Receiving Winter Distribution Last 3 Years



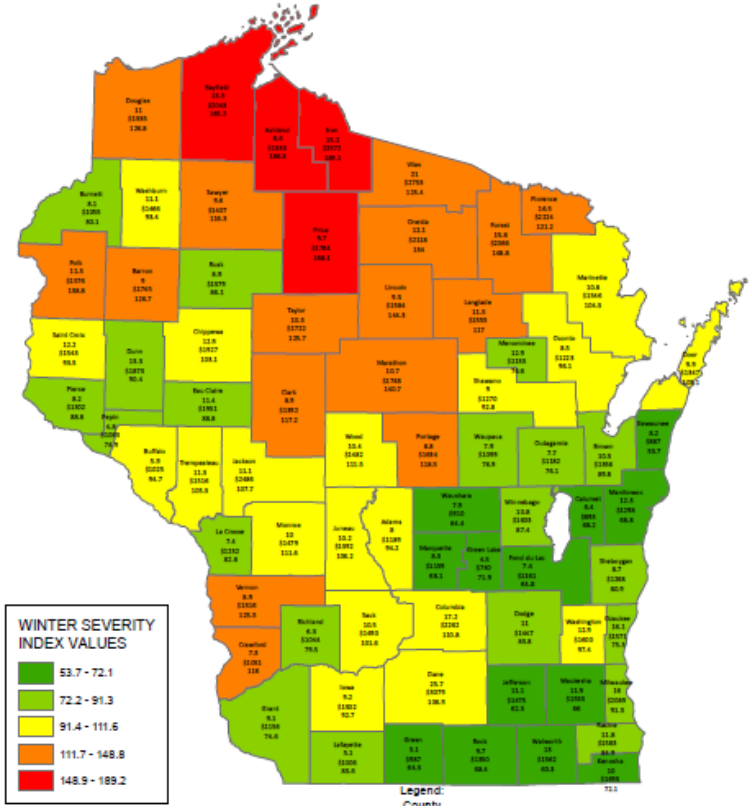
Strengths and Weaknesses

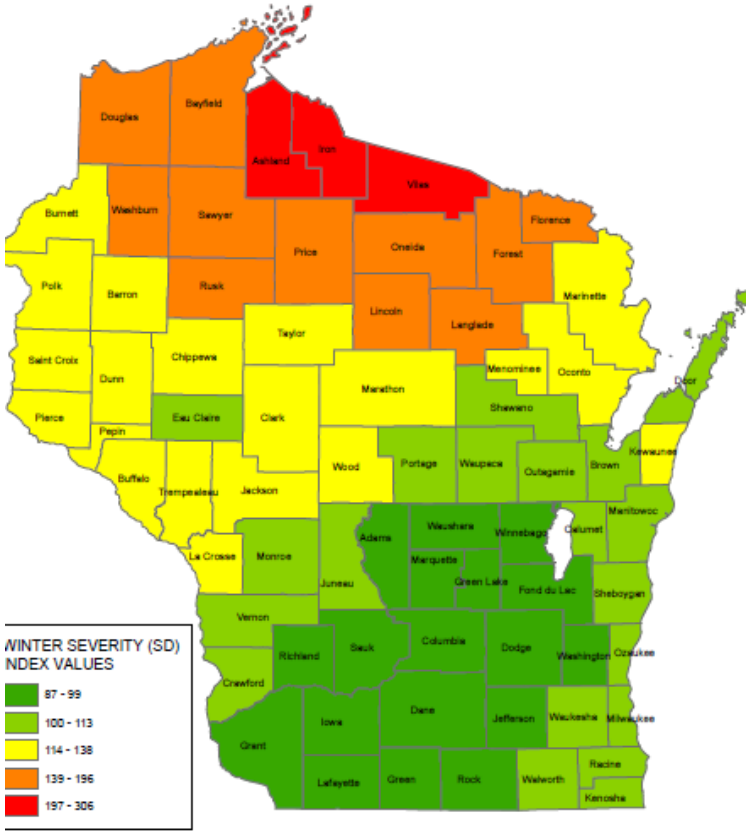
- Strengths
  - Can compare county to itself
  - Basis for decision-making
- Weaknesses
  - Self-reported data
  - Can’t necessarily compare one county to another
  - “Size bias”

Future Plans

- Use objective MDSS data as basis
  - Pooled fund MDSS has tools to create severity indices based on actual weather
  - Remove reporting biases
- Perhaps update funding model with severity index information rather than using statewide average

Old vs New


WINTER SEVERITY INDEX VALUES
53.7 - 72.1
72.2 - 91.3
91.4 - 111.6
111.7 - 148.8
148.9 - 189.2
Legend:


Douglas
Bayfield
Ashland
Iron
Vilas
Burnett
Washburn
Sawyer
Florence
Price
Oneida
Forest
Polk
Barron
Rusk
Marinette
Lincoln
Langlade
Taylor
Saint Croix
Dunn
Chippewa
Menominee
Oconto
Marathon
Door
Pierce
Pepin
Eau Claire
Clark
Shawano
Wood
Portage
Waupaca
Outagamie
Brown
Kewaunee
Buffalo
Trempealeau
Jackson
Manitowoc
Calumet
Winnebago
Waushara
Adams
La Crosse
Monroe
Marquette
Juneau
Green Lake
Fond du Lac
Sheboygan
Vernon
Richland
Sauk
Columbia
Dodge
Washington
Ozaukee
Crawford
Iowa
Dane
Jefferson
Waukesha
Milwaukee
Grant
Lafayette
Green
Rock
Walworth
Racine
Kenosha
WINTER SEVERITY (SD) INDEX VALUES
87 - 99
100 - 113
114 - 138
139 - 196
197 - 306


Thank You

Minnesota DOT (MnDOT) Weather Severity

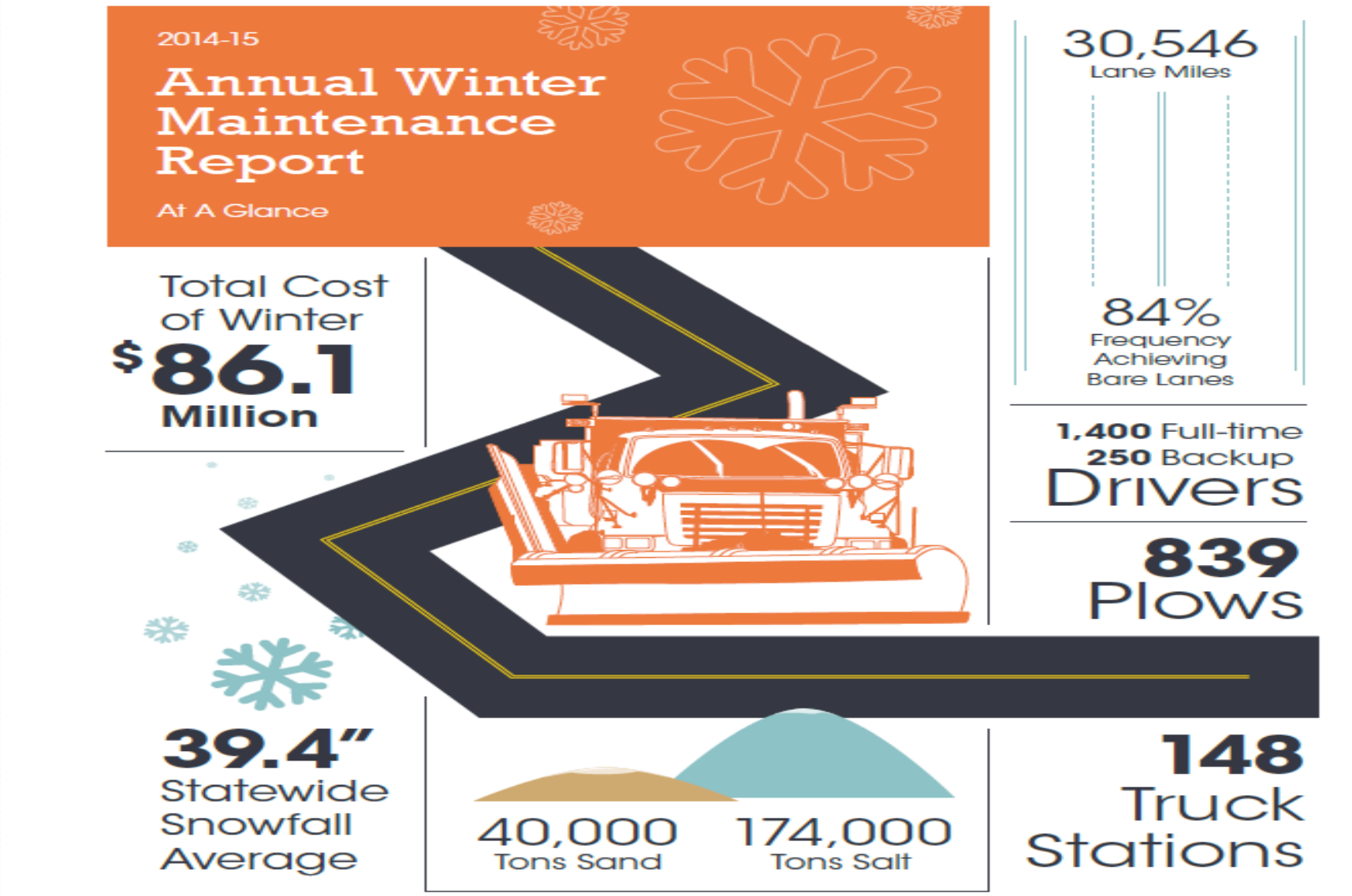
TRB Webinar on Weather Severity

July 29th, 2015

Overview

- Intro to MnDOT
- Why MnDOT wanted to look at Weather Severity
- Old Weather Severity Index
- Why did MnDOT decide to change?
- New Weather Severity Index
- Where do we go from here?

Intro to MnDOT



Intro to MnDOT

Snapshot of winter: 2-year comparison

Category	Measure	2013-14	2014-15
Infrastructure	Lane Miles	30,597	30,546
Weather	Snowfall	69.9”	32.6”
	Snowfall, statewide across districts	75.6”	39.4”
	Number of winter events, statewide average and range across districts	34.2	28.4
Materials	Salt used	275,857 tons	173,888 tons
	Average weighted cost of salt per ton	$71.14	$74.36
	Salt brine used	2.7 million gallons	2.2 million gallons
Costs and Performance	Total plowing, salting and sanding costs	$136 million	$87.9 million*
	Total plowing, salting and sanding costs per lane mile, statewide average	$4,435	$2,819
	Frequency of achieving bare lane after winter event (70% target)	79%	87%
Labor and Services	Regular labor hours	718,591	501,095
	Overtime winter labor hours	222,624	94,461

**Based on fiscal year*

Why the Need for Weather Severity?

- Show how weather varies from year to year
  - Help validate costs of maintenance to upper management, legislature, public, etc.
  - Managing Performance

- Better Stewards of the Environment
  - Is agency being efficient with material usage?

Old Weather Severity Index

- Used 4 variables
  - Snow events
  - Freezing rain events
  - Snow amount
  - Storm duration
- Represented our response to the weather not the weather severity
- Info gathered from maintenance personnel
  - Not consistent from area to area on how it was gathered
- Mixed acceptance
  - Criticized for not including other weather that we deal with on roads; i.e. wind/blowing snow, etc.

New Approach

- Management sought way to compare winters
  - District to District as well as year to year
- Didn't want it to reflect our response to the weather
- Wanted consistent way to gather data
- Needed to consider additional variables
  - Include all weather variables that affect road maintenance

New Method Approach/Methodology

- Uses data from surface weather observations at Airports and RWIS stations, radar, satellite, numerical models, meteorologist inputs, etc. to get the best representation of the weather that occurred in the State.
  - Removes subjectivity and inconsistences in data gathering
- It's safe to say that pretty much everything that is important in the weather as it impacts roads is considered in the process.

Weather Variables include:

- Air temperature
- Dew point/relative humidity
- Wind direction/speed/gusts
- Precipitation type/amount (liquid, ice, snow)
- Cloud cover, and its impacts on solar (shortwave) and infrared (longwave) radiation
- Pavement temperature
- Sub pavement temperature
- Blowing snow

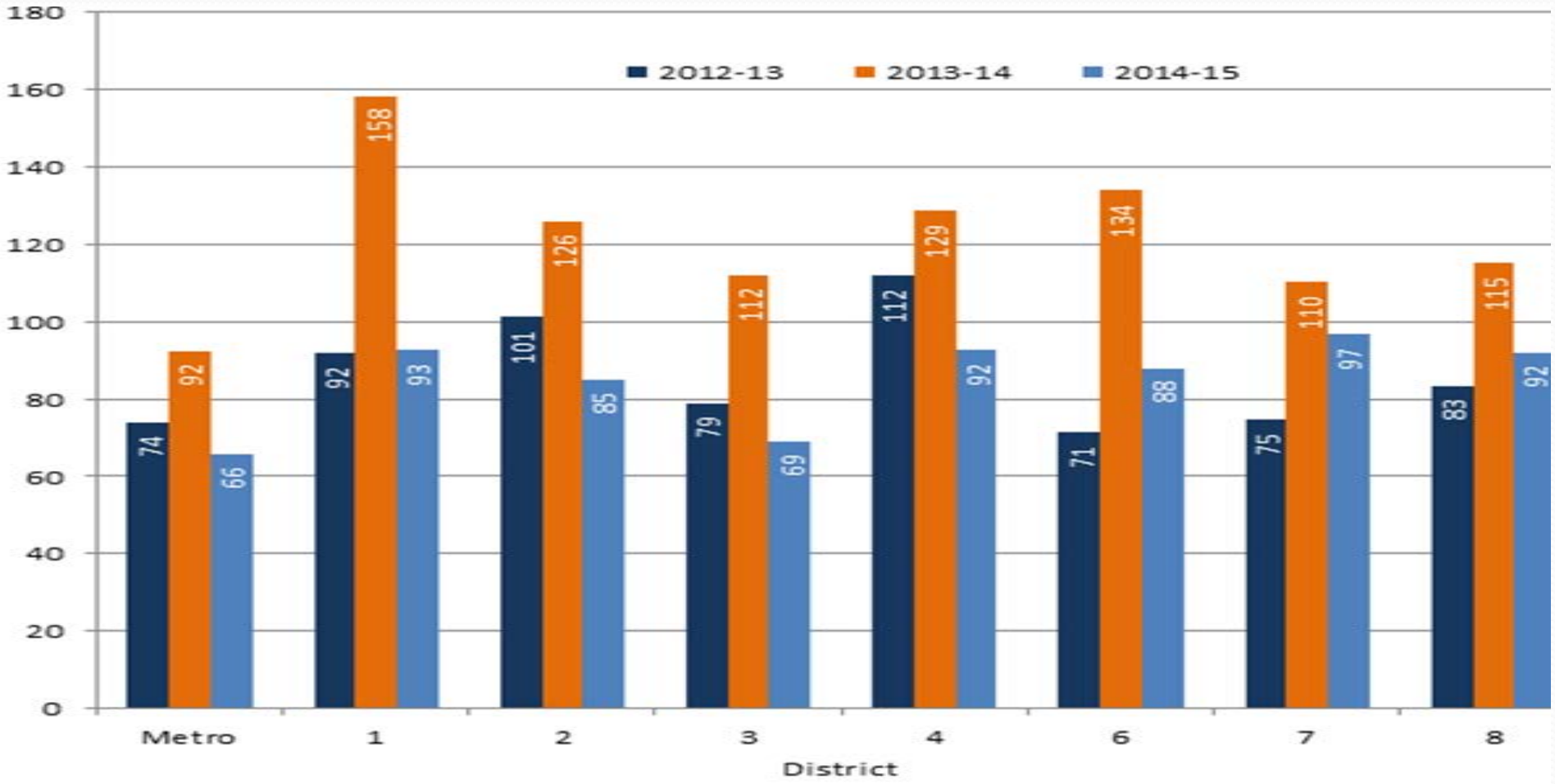
Features

- Objective
  - Not influenced by agency's response to events
- Scalable
  - Can produce Statewide results or area to area comparisons

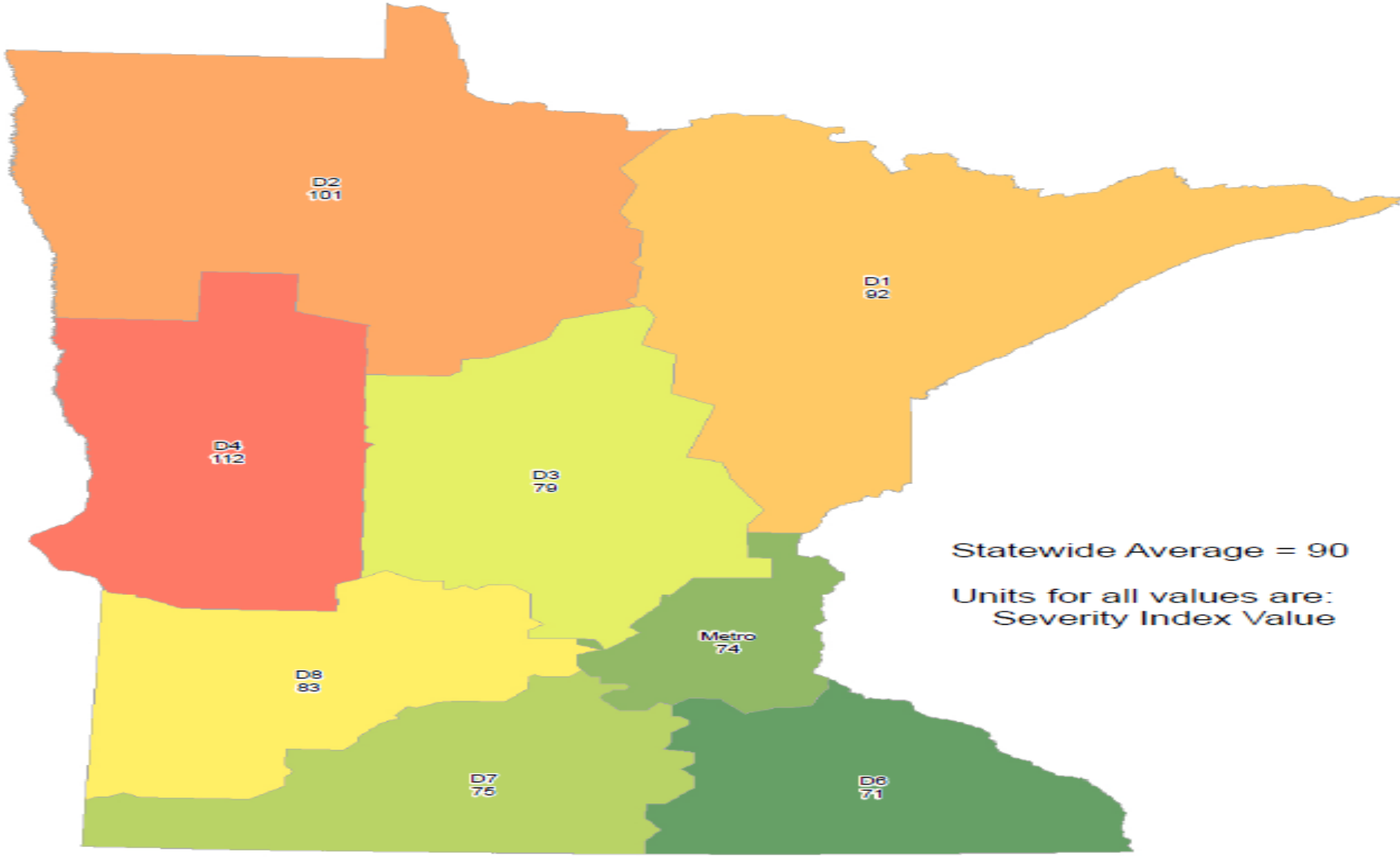
Uses

- Share with Public
  - Winter at a Glance
    - Keep public engaged in our operations
  - Legislature
    - Help validate costs
- Comparison of Winter Road Weather Severity
  - Year to Year
  - Month to Month
  - Area to Area

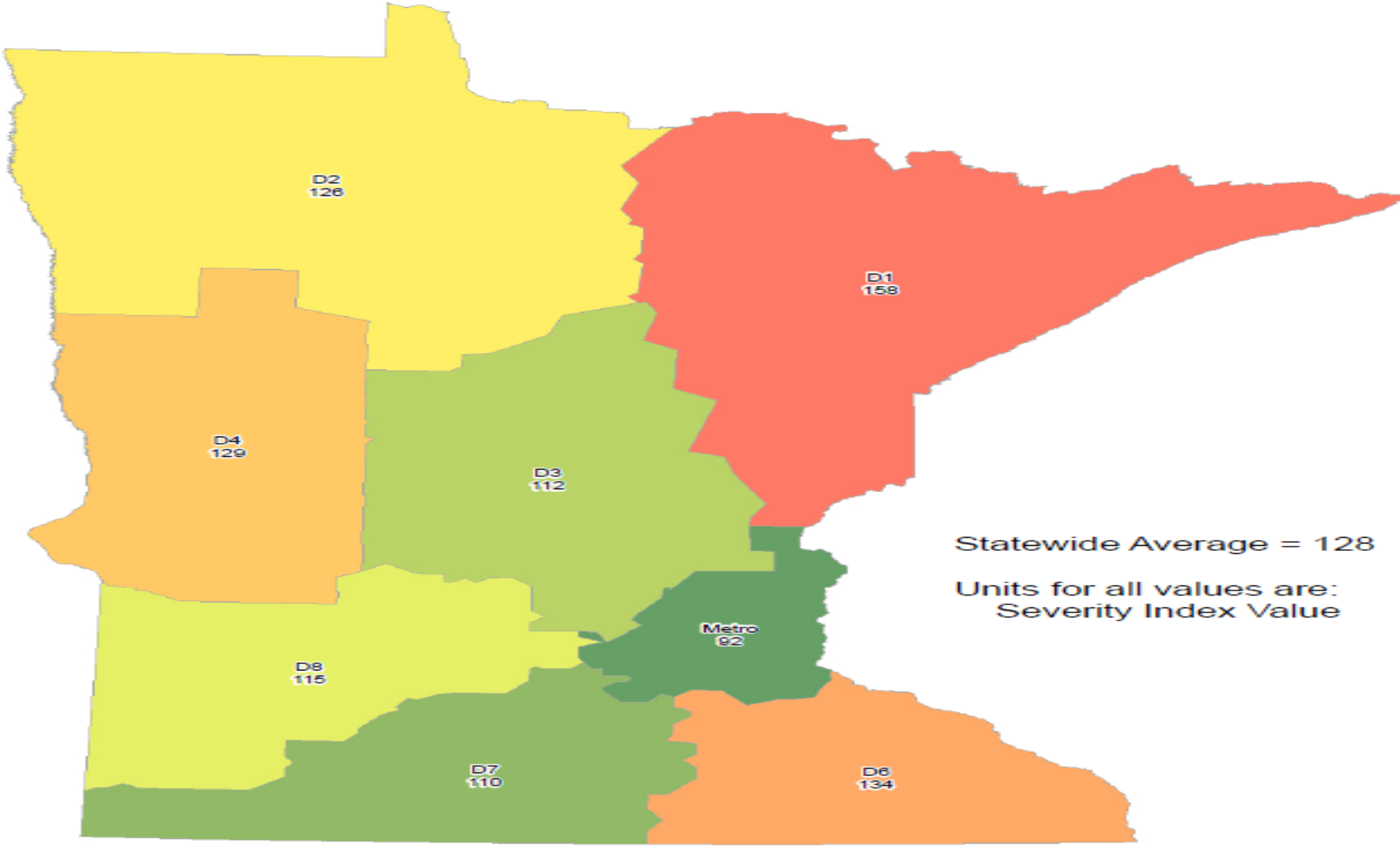
MnDOT Weather Severity Index last 3 years



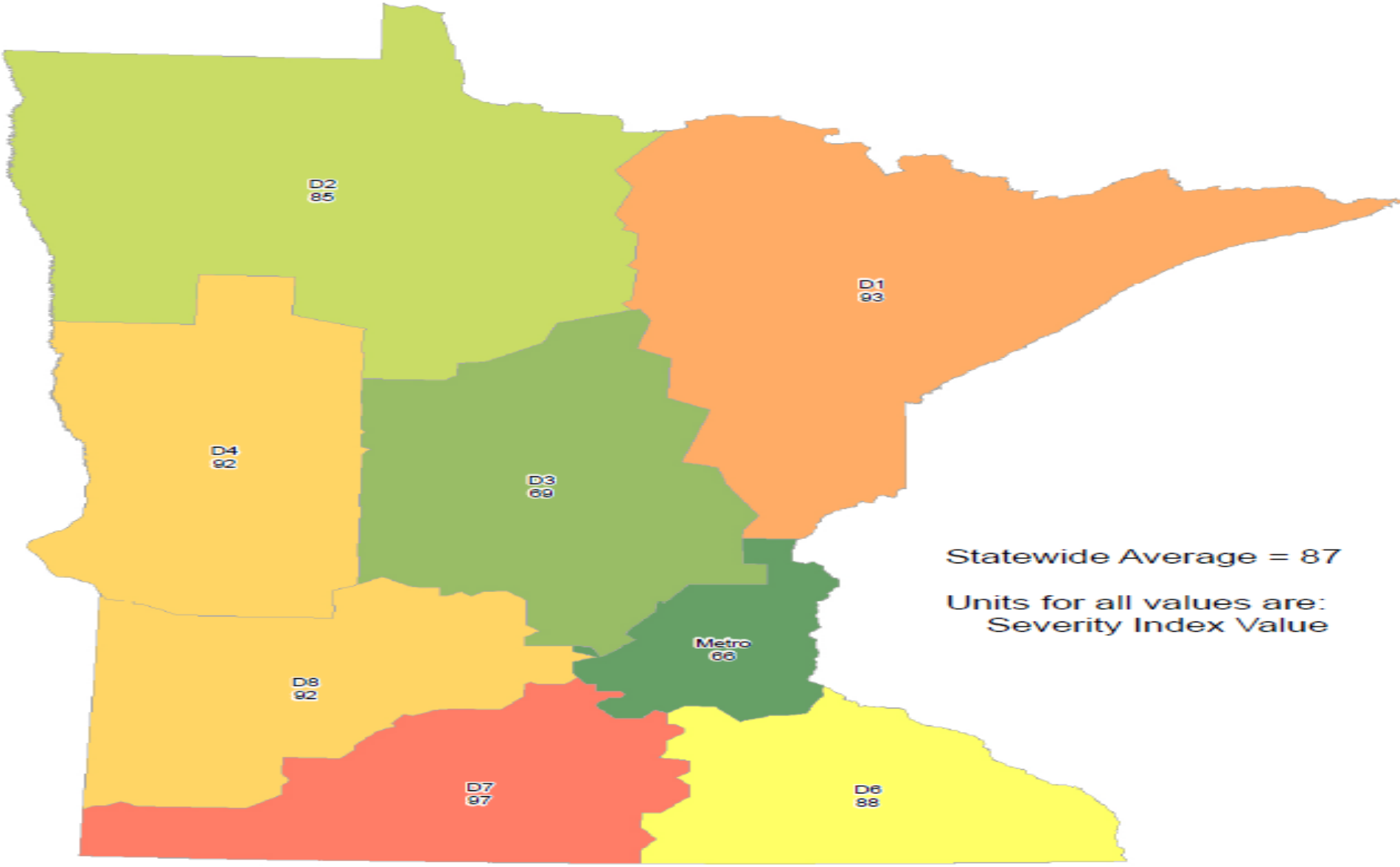
Winter Severity Index
2012-13



Winter Severity Index
2013-14



Winter Severity Index
2014-15



Next Steps

- **Winter Maintenance Response Index**
- ***Features:***

- Uses same weather variables
- Output is based on Labor, Materials and Equipment
- Uses individual plow sections
- Not normalized – reflects costs as entered by DOT, can vary area/area and year/year
- Objective – not influenced by agency response to events
- Flexible – can be used for varying time periods, day/day, month/month, year/year, winter to date, region to region
- Scalable – results can be shown as statewide, maintenance area, subarea, truck station or plow route

Winter Maintenance Response Index

- ***Uses:***
- Provides costing information to make business decisions
- Compare against cost data from maintenance management systems and/or data recorded using Automated Vehicle Location systems
  - See difference between actual costs and theoretical costs
    - Efficiency indicator
- Can run past winters data to show cost of new practices or products
  - What if scenarios
- Can show cost of increasing or reducing level of service in similar weather conditions
- Can be used to develop and verify best practices

What's Needed to Get Started?

- Clearly define what your goals/objectives are
  - Do you just want to compare weather severity?
    - Relatively easy
  - Do you want to compare costs of maintenance?
    - More difficult as you have to use actual costs, differing level of service across areas, etc.
      - Salt might cost $40/ton in south and $115/ton in the north
      - Might have weaker winter in an area that ends up costing more because of the higher level of service needed.
- Involve and engage the right people from the beginning
  - Upper Management
  - Maintenance Decision Makers

Thank You!

Alberta’s Winter Severity Index

Steve Otto
Director, Highway Operations Standards
Alberta Transportation

CREDITS:

Research and data analysis done for
Alberta Transportation
at the
Dept. of Geography and Environmental Mgmt.
University of Waterloo, Ontario, Canada

by

Dr. Jean Andrey, Lindsay Matthews, and Derrick Hambly

jandrey@uwaterloo.ca

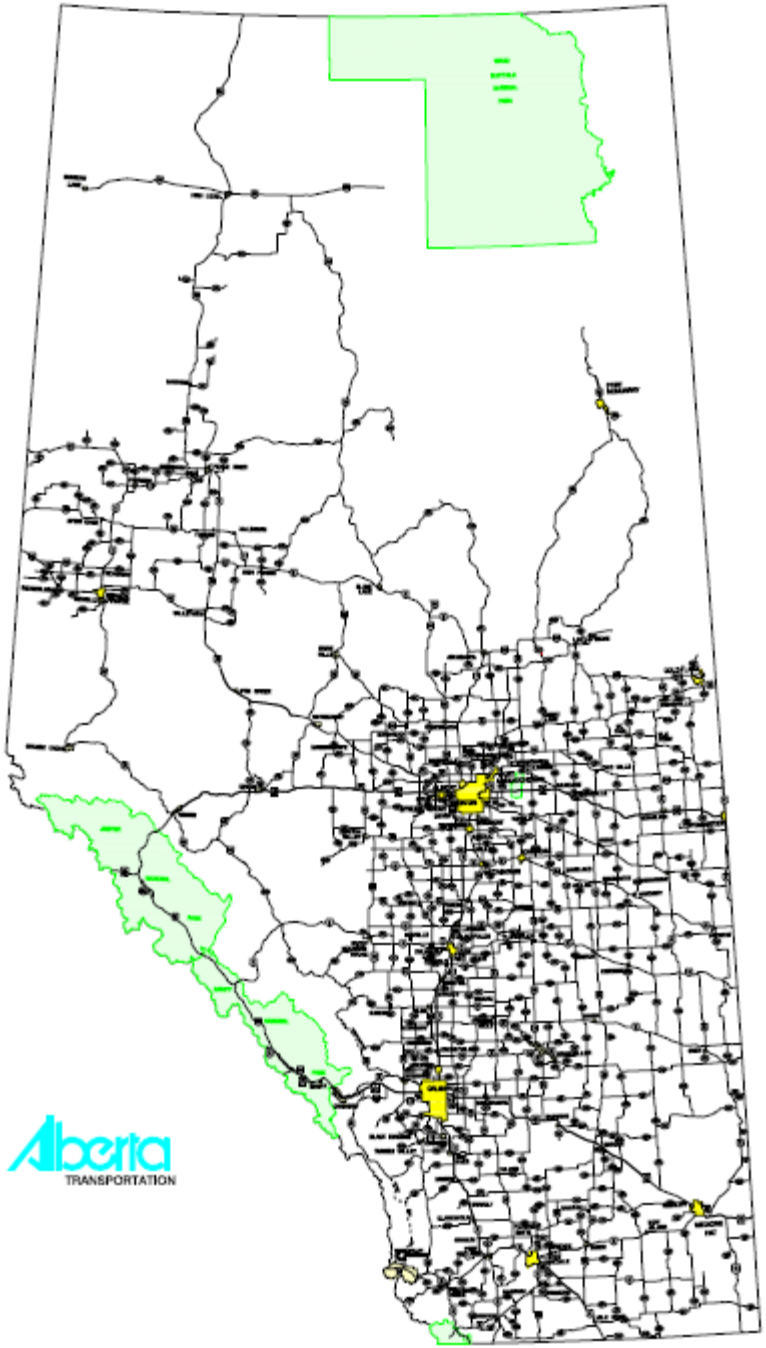
Alberta’s Provincial Highway Network

19,480 centre-line miles

17,420 paved

2,060 gravel

Does not include city or local rural roads



Climate = Dry, Cold

Annual Precipitation: 10” (25 cm)

Average Summer Temps: 50 to 85º F (+12 to +30º C)

Average Winter Temps: 20 to -8º F (-6 to -22º C)

Salt Management

Environment Canada's *Code of Practice for the Environmental Management of Road Salts (2004)*

- **Voluntary participation**

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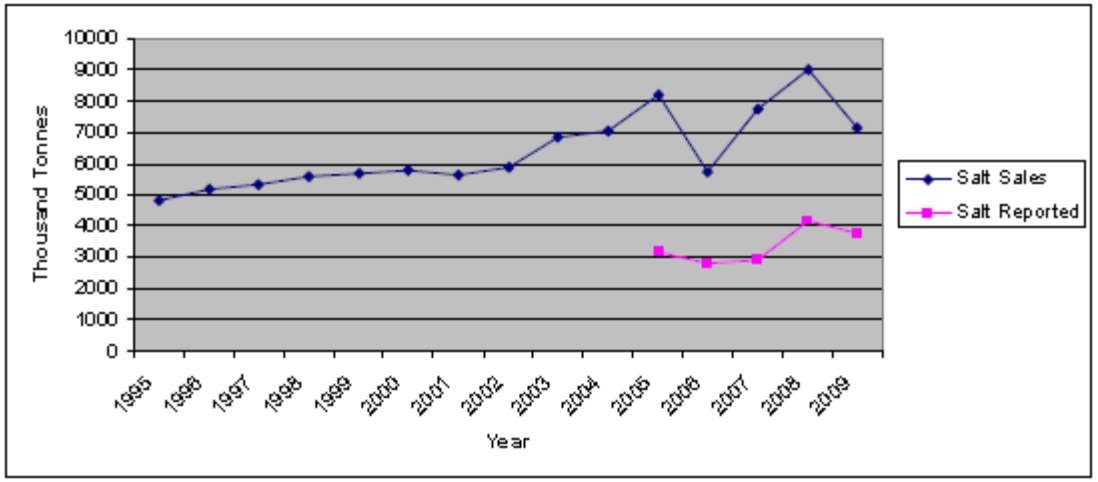

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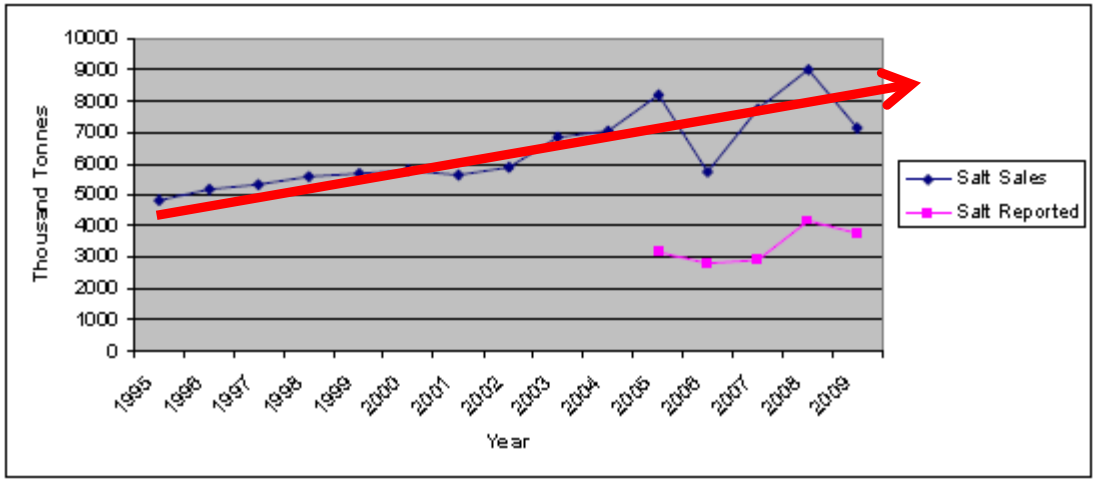

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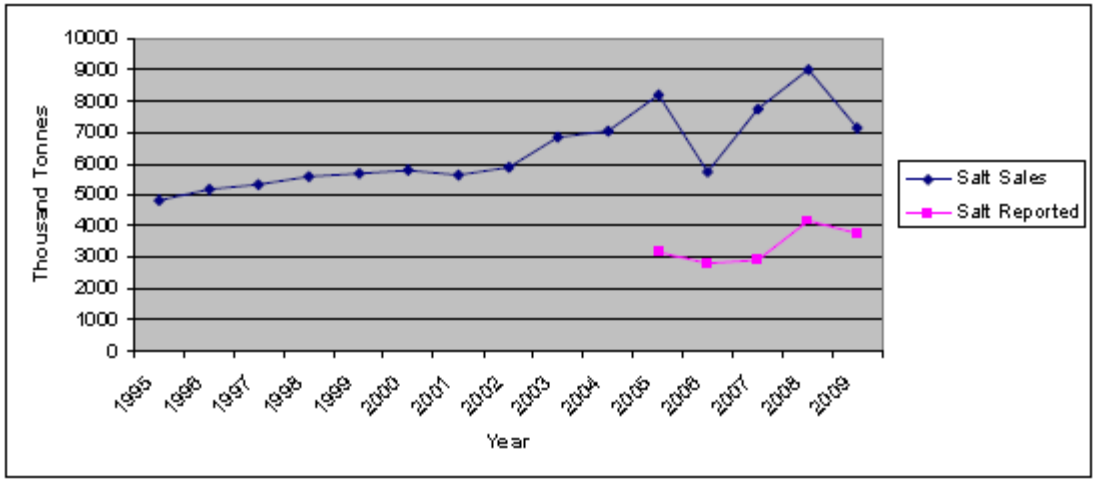

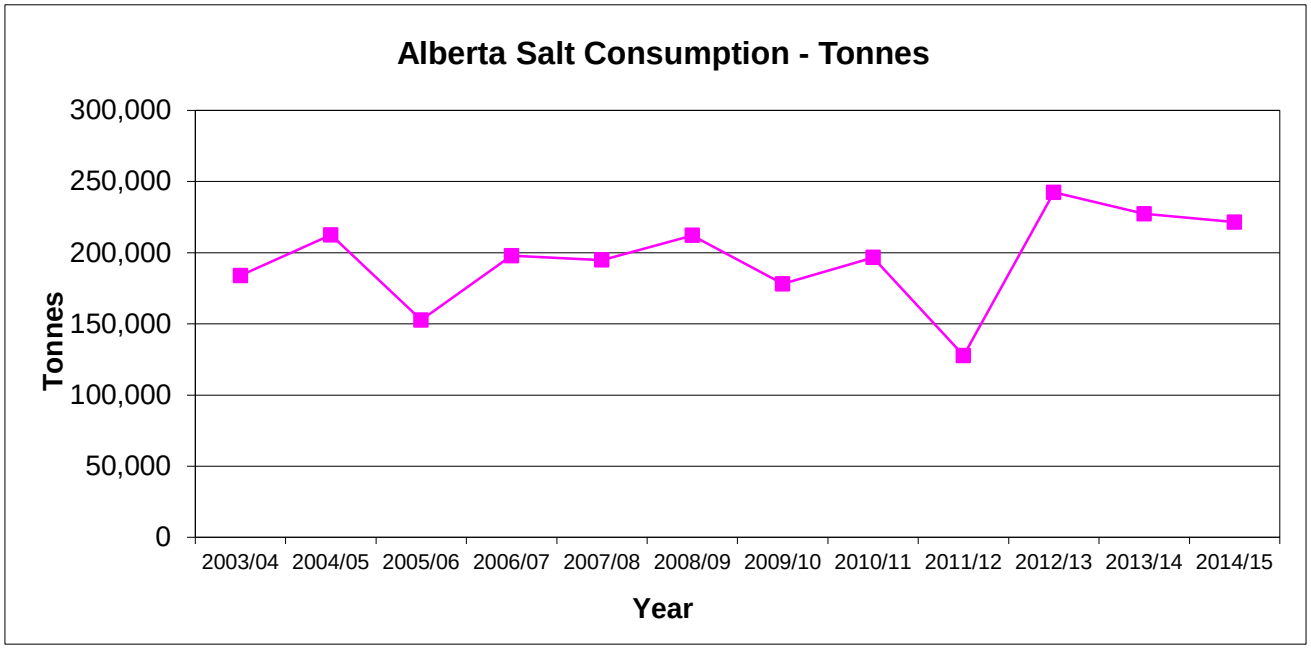

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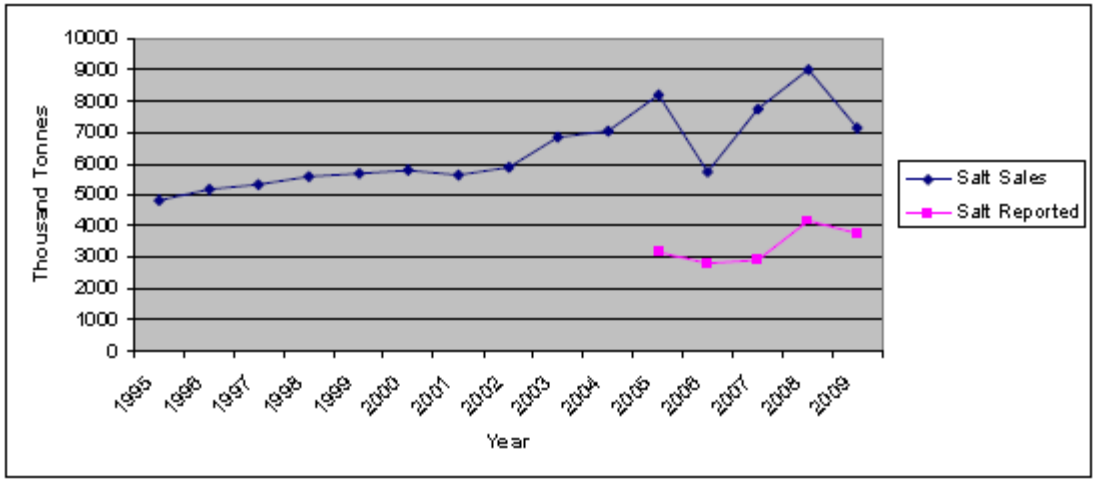

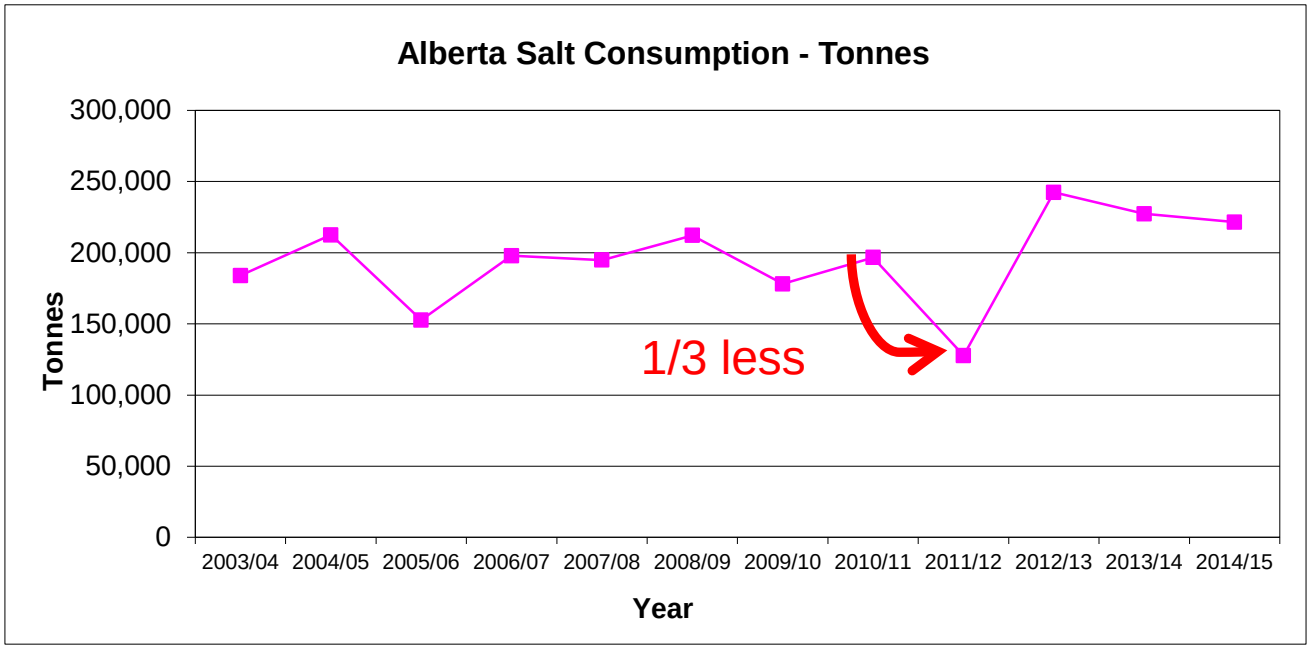

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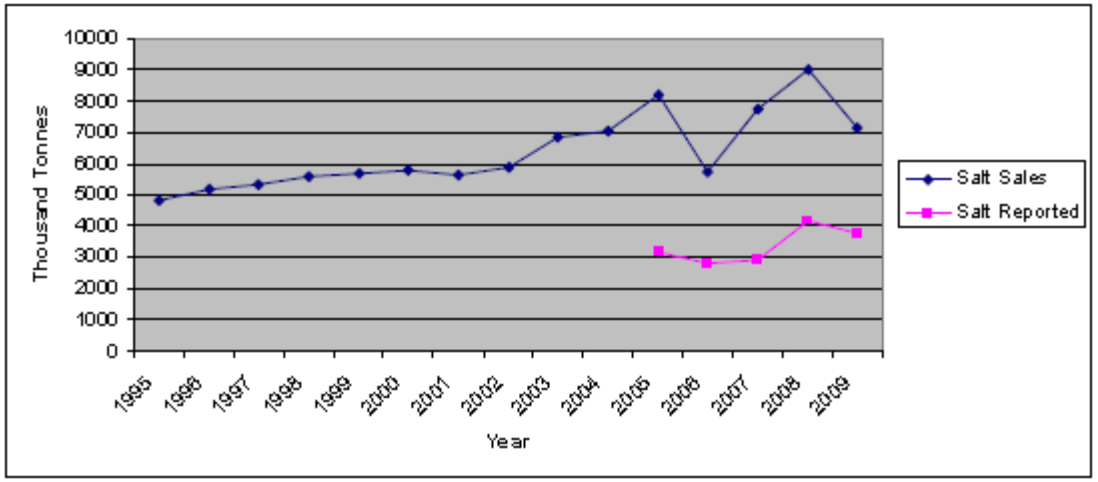
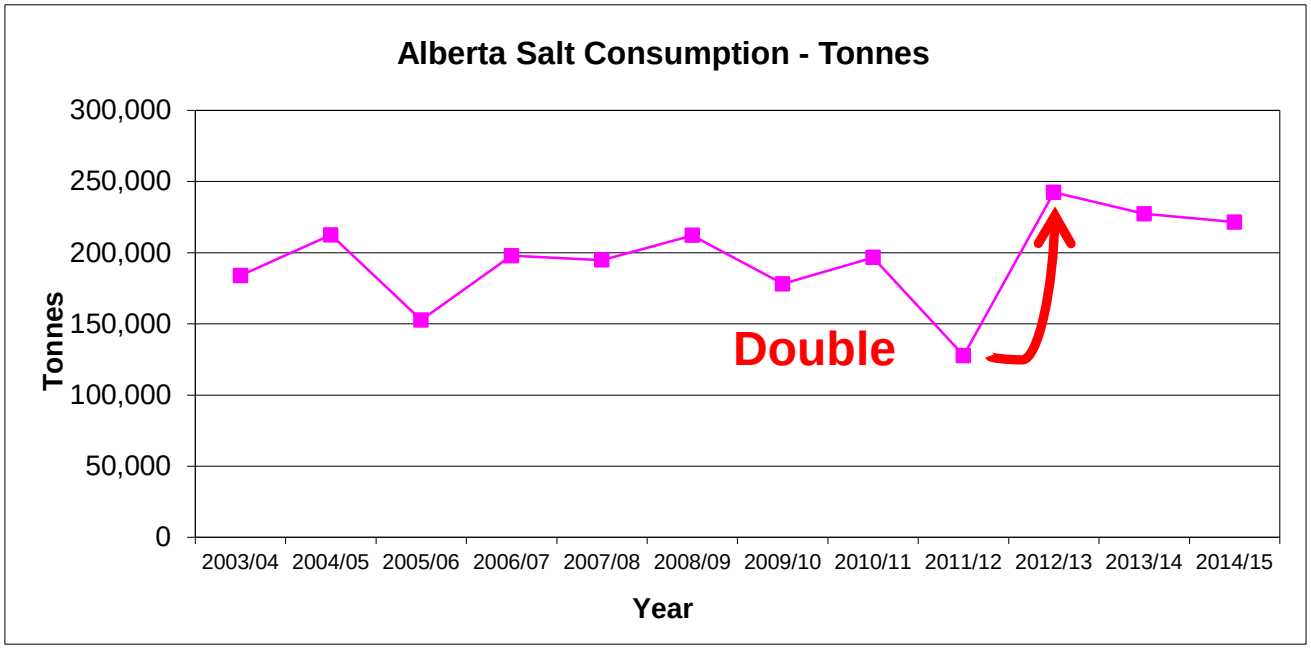
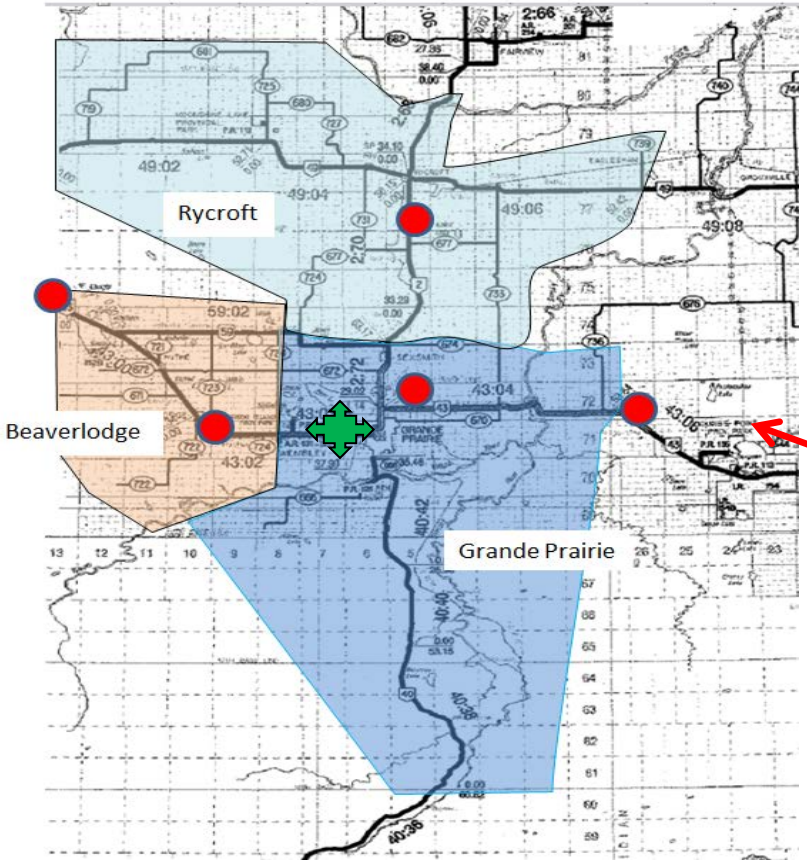


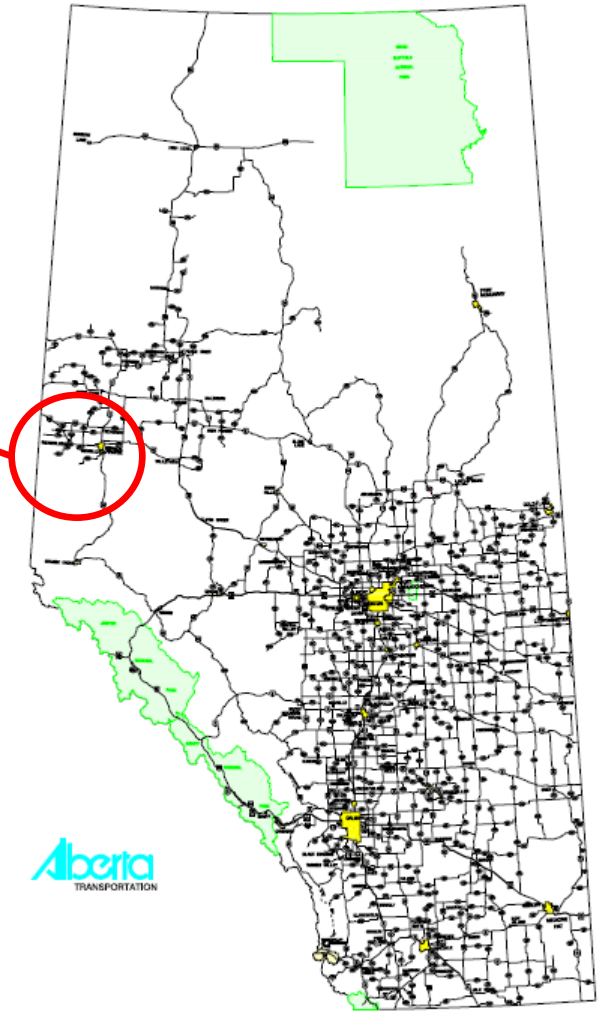


Alberta’s Winter Severity Index

1) Pilot Project 2013/14

Pilot Project Area





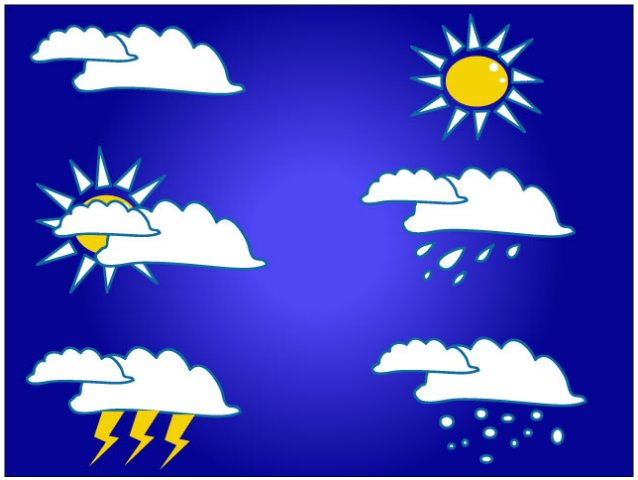
RWIS Stations

Airport

Data Sources

1. Road Weather Information System stations
   1. Atmospheric conditions (air temperature, relative humidity, atmospheric pressure, wind direction and speed
   2. Pavement temperature
   3. Other pavement conditions (freeze point, sub-surface pavement temperature, and pavement surface condition (i.e. dry, wet, ice covered))

2. Environment Canada Records
   1. Air temperature
   2. Precipitation
   3. Weather conditions (i.e. falling snowfall, freezing rain, blowing snow)



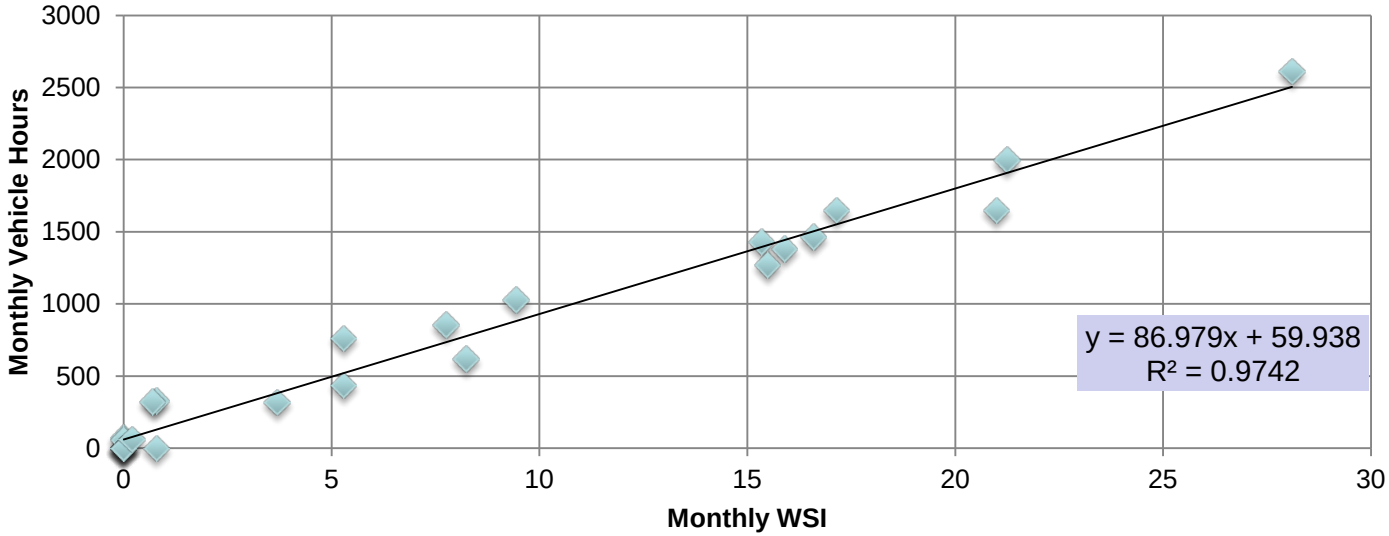
Monthly WSI calculation

- **Daily score:**
  - **0 = no maintenance**
  - **1.5 = continuous maintenance (truck hours)**

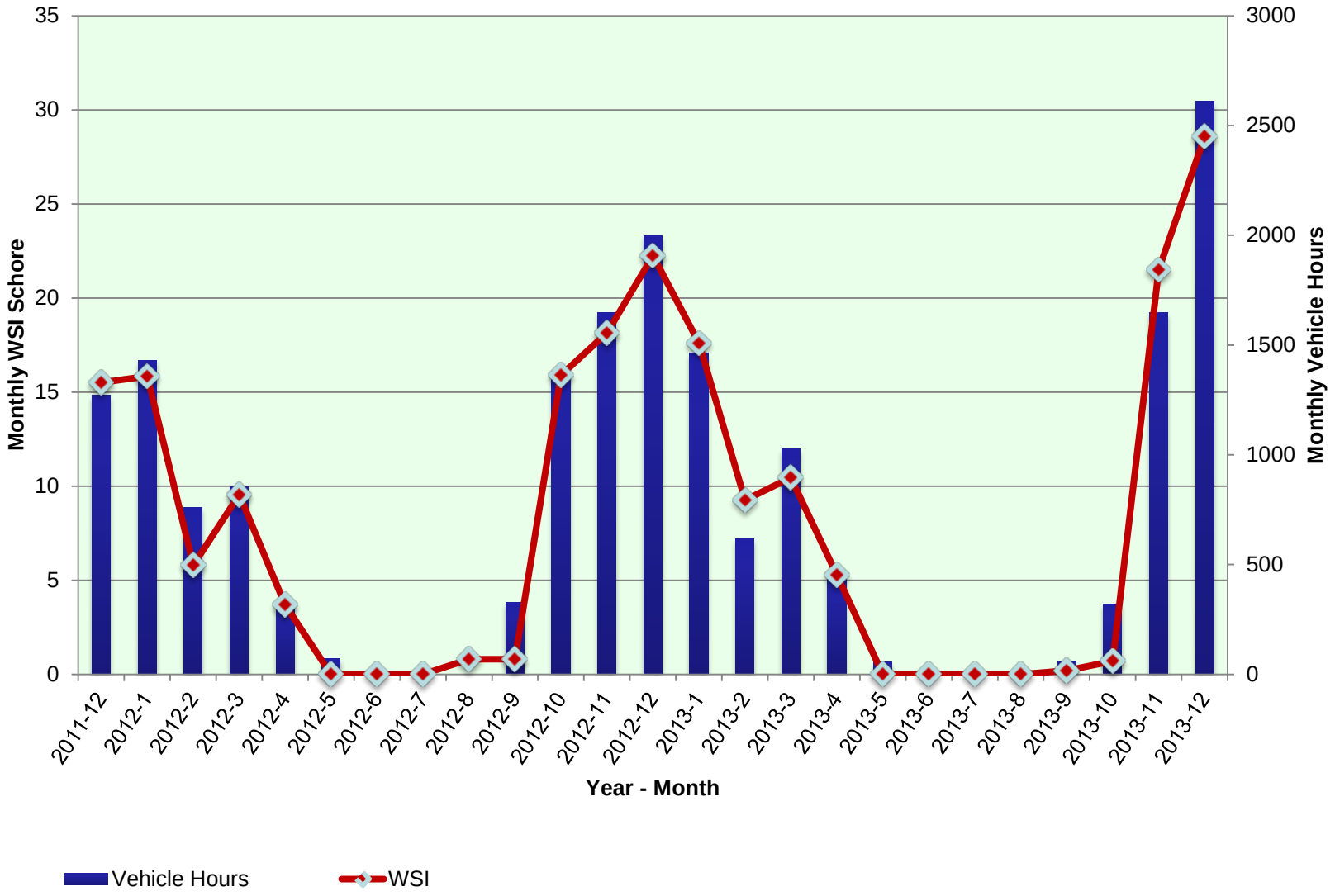
- **Data used:**
  1. **Snowfall** (snowfall data from Environment Canada)
  2. **RWIS pavement ice warnings** (ice warnings based on RWIS data)
  3. **Freezing rain** (precipitation data from Environment Canada, temperature data from RWIS)
  4. **Potential for icing** (precipitation data from Environment Canada, temp. data from RWIS)
  5. **Series of cold days** (temperature data from RWIS)
  6. **Rain with low temperatures** (rainfall data from Env. Canada, temp. data from RWIS)
  7. **Blowing snow** (Windspeed data from RWIS, snowfall data from Environment Canada)

- **Daily scored added to make Monthly Score**

WSI Model Accuracy



WSI Model Accuracy



LOOKING GOOD!

Alberta’s Winter Severity Index

2) Expanded Project 2014/15

New for 2014/15 Study

Expand study area to whole province

Looked at other maintenance activities for calibrating the model

- **Salt use**
- **Sand use**

Looked at different time frames

- **Weekly**
- **Every 2 weeks**
- **Seasonal**

Looked at different sub-areas in the province

- **Climate zones**
- **Contract areas**
- **Sub-contract areas (3 – 6 shop beats)**

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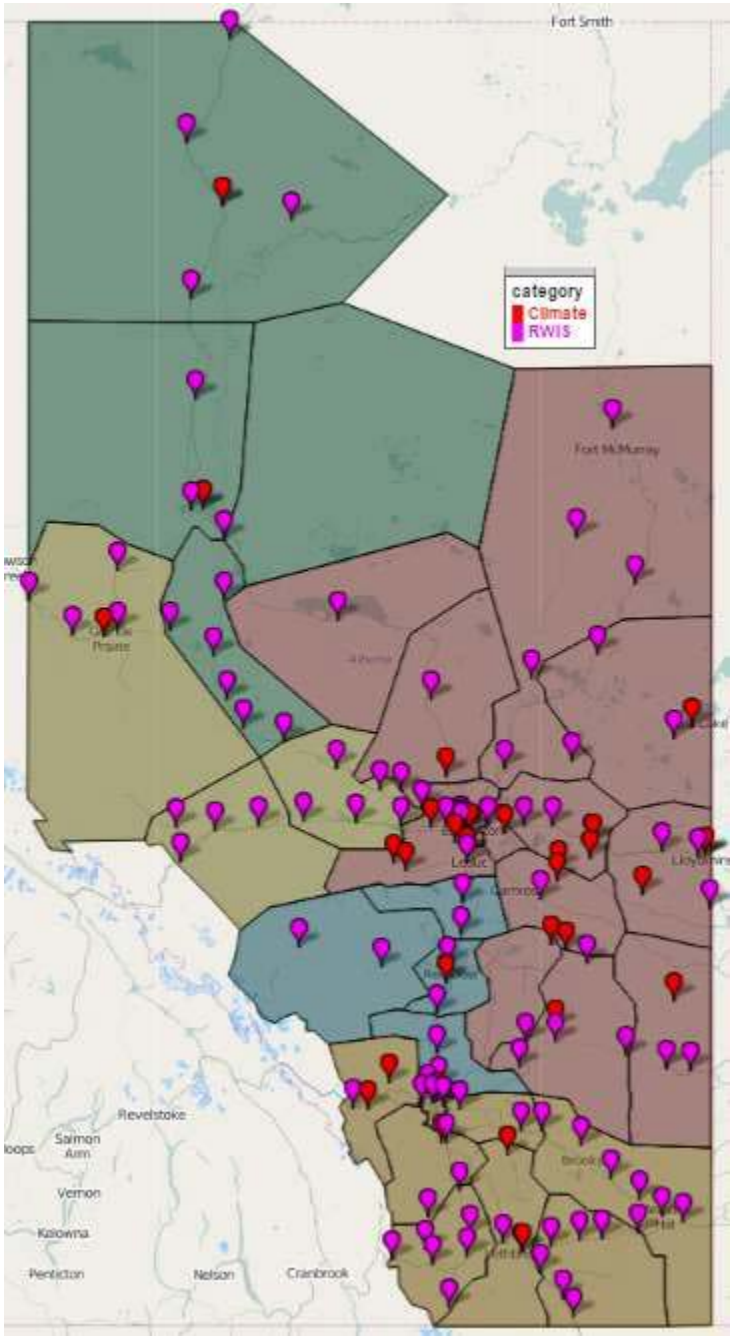
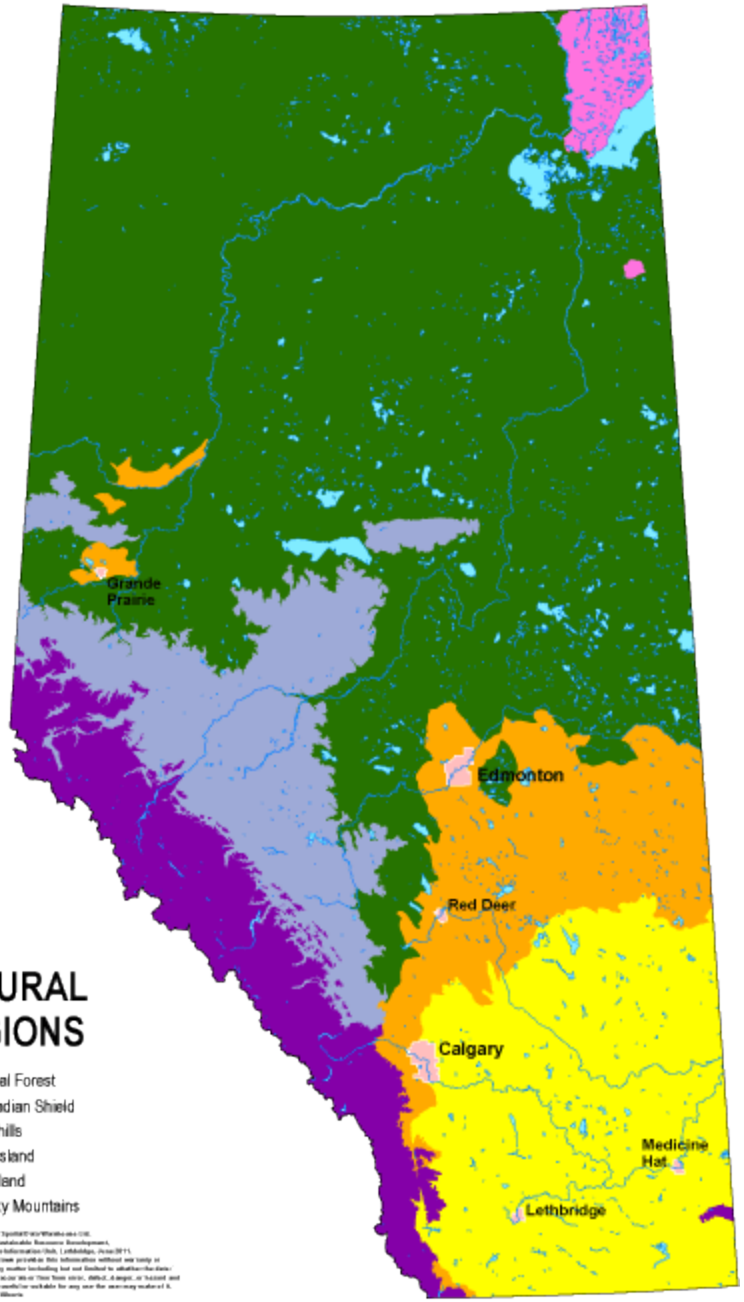
Changes to Input Data

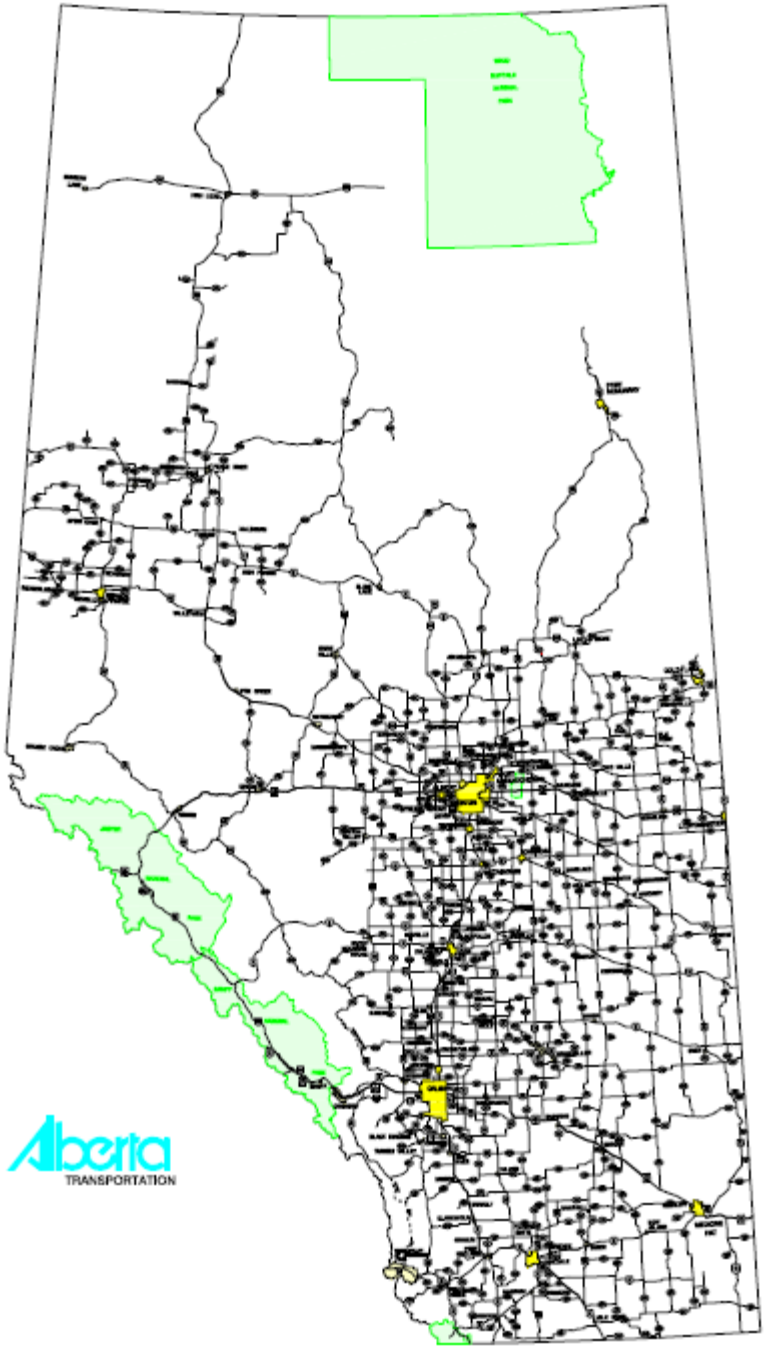
Environment Canada Data:

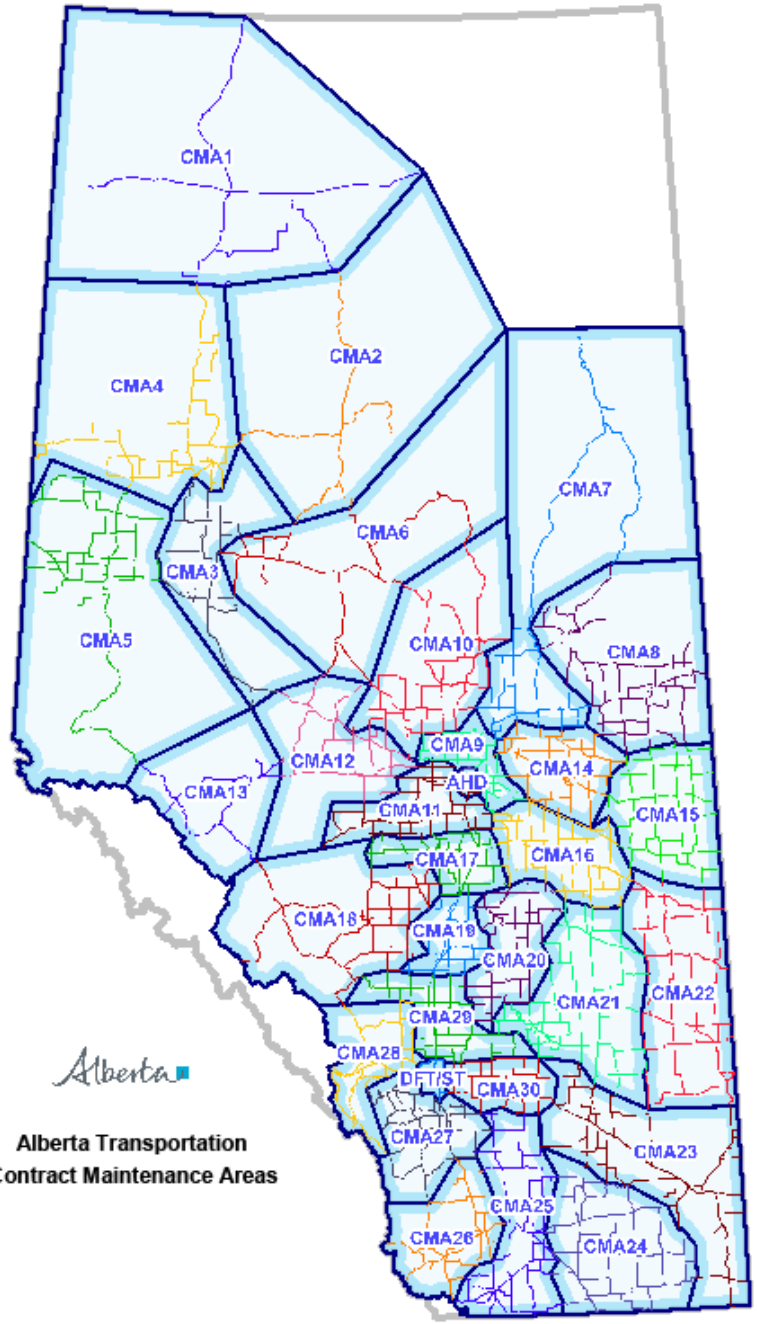
- **Snowfall Duration Not Available**
  (only Snowfall amount)
- **Potential for Icing + Freezing Rain Not Available**
  (changed to new "Rain with low temperature")

Added "Shoulder Season Correction"




Grande Prairie
Edmonton
Red Deer
Calgary
Medicine Hat
Lethbridge
NATURAL REGIONS
Boreal Forest
Canadian Shield
Foothills
Grassland
Parkland
Rocky Mountains


Alberta
TRANSPORTATION


CMA1
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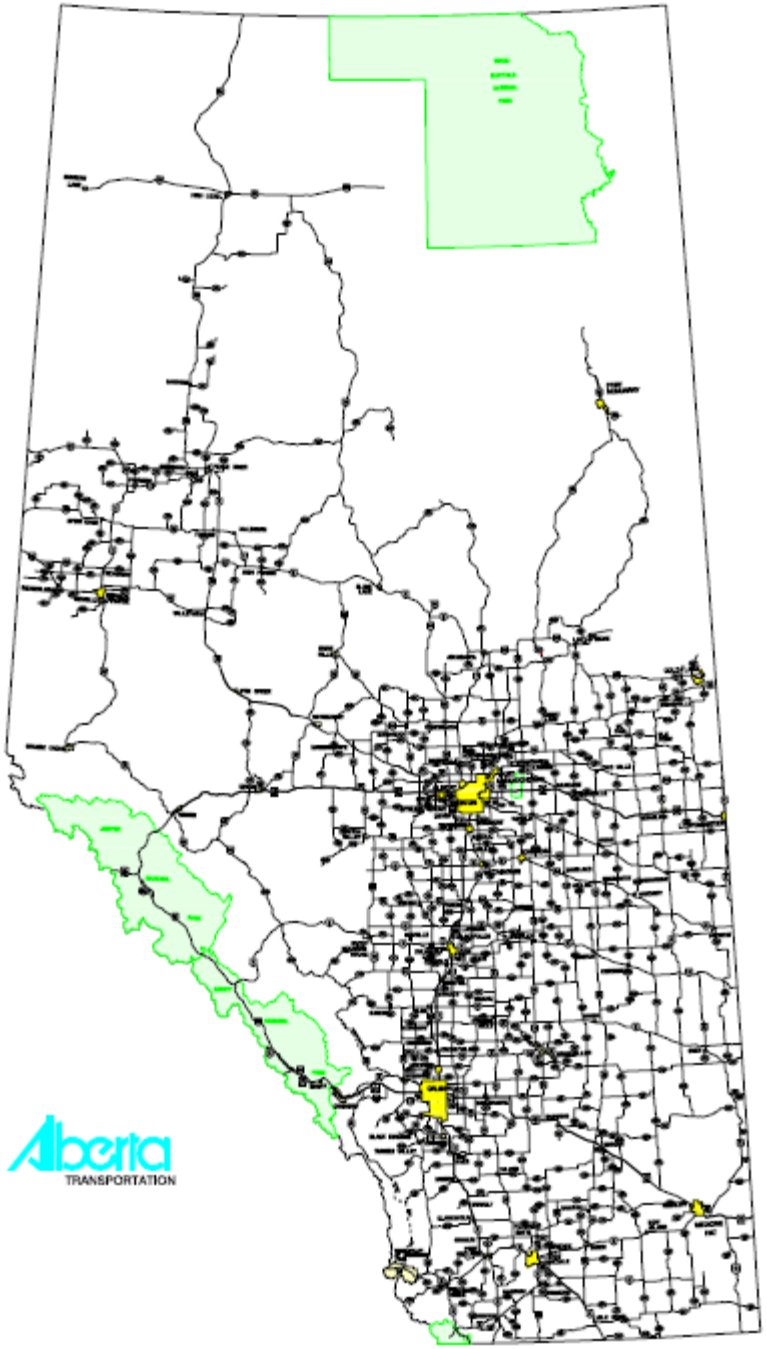
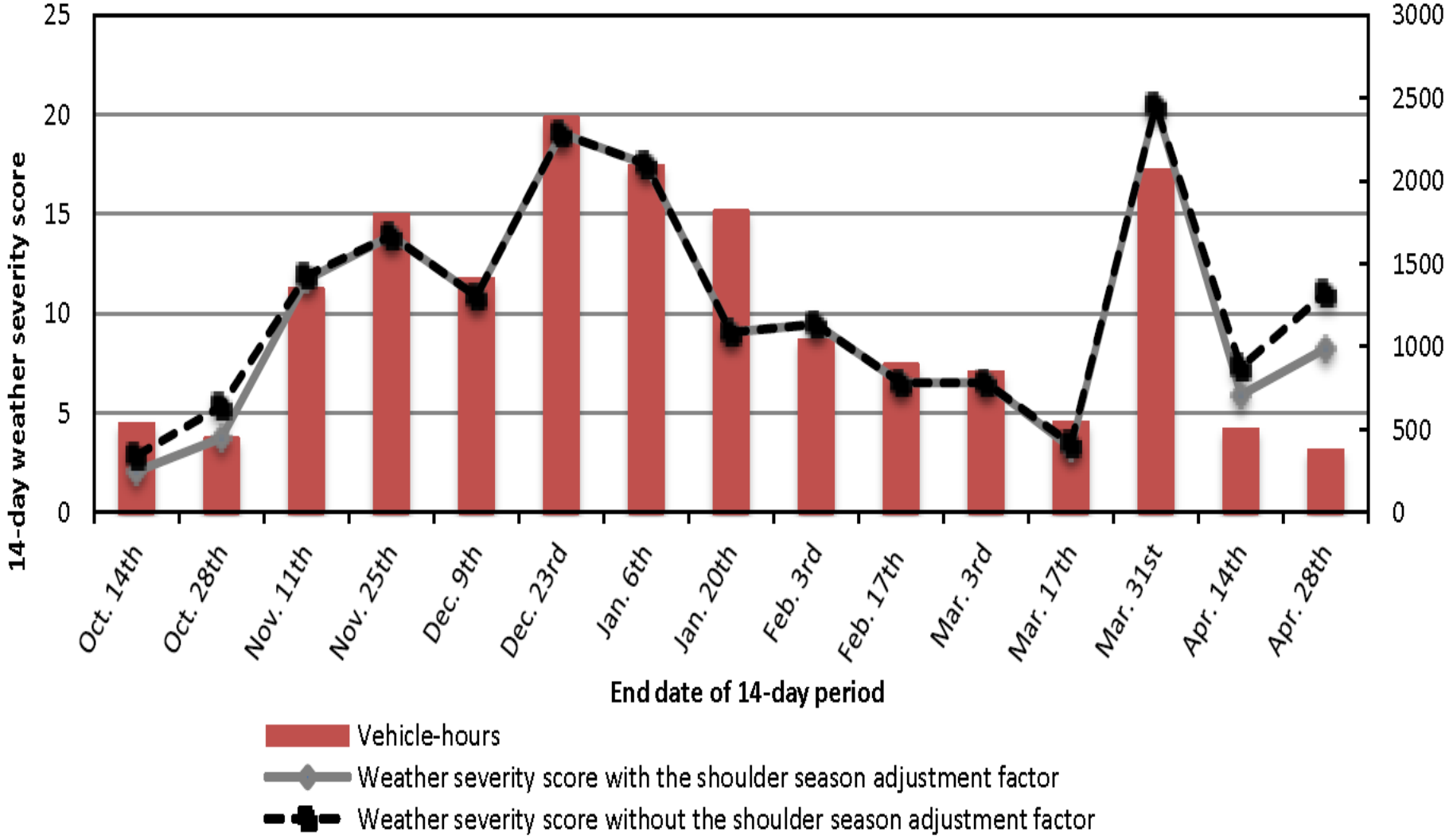
AHD
DFT/ST
Alberta
Alberta Transportation
Contract Maintenance Areas

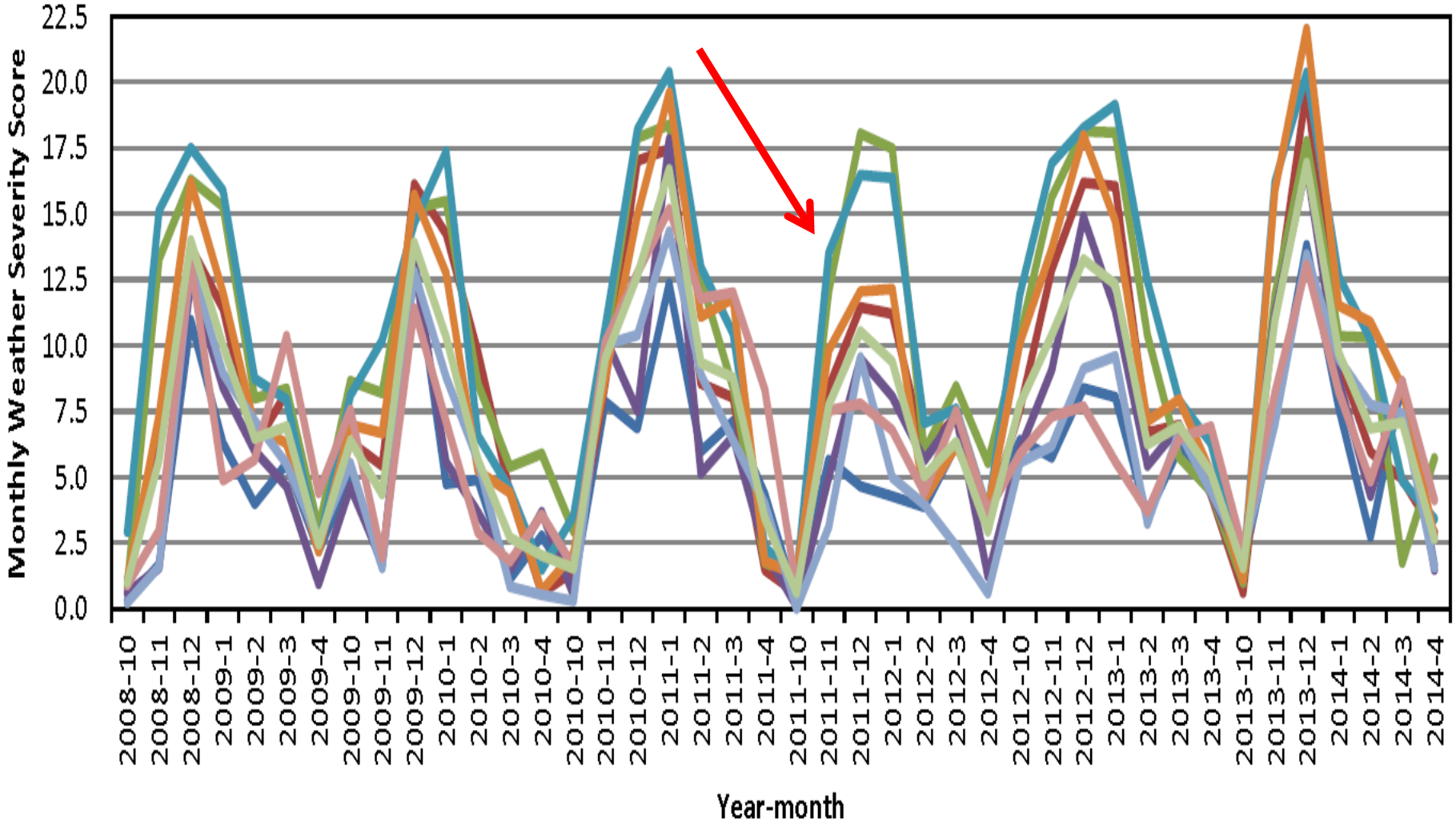

Alberta
TRANSPORTATION

	Weather Event	Weather Condition	Score
1	Snowfall amount	Low amount of snow (0.4 to 1.9 cm)	0.4
		Moderate amount of snow (1.91 to 4.9 cm)	0.75
		High amount of snow (> 4.91 cm)	1.1
2	Surface ice warning	< 0.4 mm daily snowfall, and at least 20% of road surface ice warnings	0.6
3	Series of cold days	Daily precipitation < 0.4 mm, Conditions for ice warnings not met, and Max temp in previous three days < -18 °C	0.5
4	Rainfall with low temperatures	Daily snowfall < 0.4 mm, Conditions for ice warnings not met, Conditions for series of cold days not met, Daily rainfall ≥ 0.4 mm, and Min temp < 0 °C	0.5
5	Blowing snow	Daily precipitation < 0.4 mm, Conditions for ice warnings not met, Conditions for series of cold days not met, Conditions for rainfall with low temperatures not met, Wind speeds ≥ 20 km/h and Snowfall accumulations of previous three days ≥ 5 cm	0.5
6	Shoulder season adjustment factor	If ANY of the WSI weather triggers have been met AND the average mean temperature for the 14-day period centred on the day for which the score is being assigned is > 0 °C	-0.2

Results for 14-day WSI winter 2013/14 data (one contract area only)



Results for monthly WSIS Oct 2008 – Apr 2014 data



Next Steps:

Alberta Transportation will start calculating a 14-day WSI on a sub-contract and provincial basis, starting this winter.

The WSI will be used for :

- **media releases,**
- **analysis of contractor performance,**
- **budget analysis,**
- **salt use reporting**

And we’re spreading the word about our WSI model to anyone who will listen

Questions
are
guaranteed in
life;
Answers
aren't.