

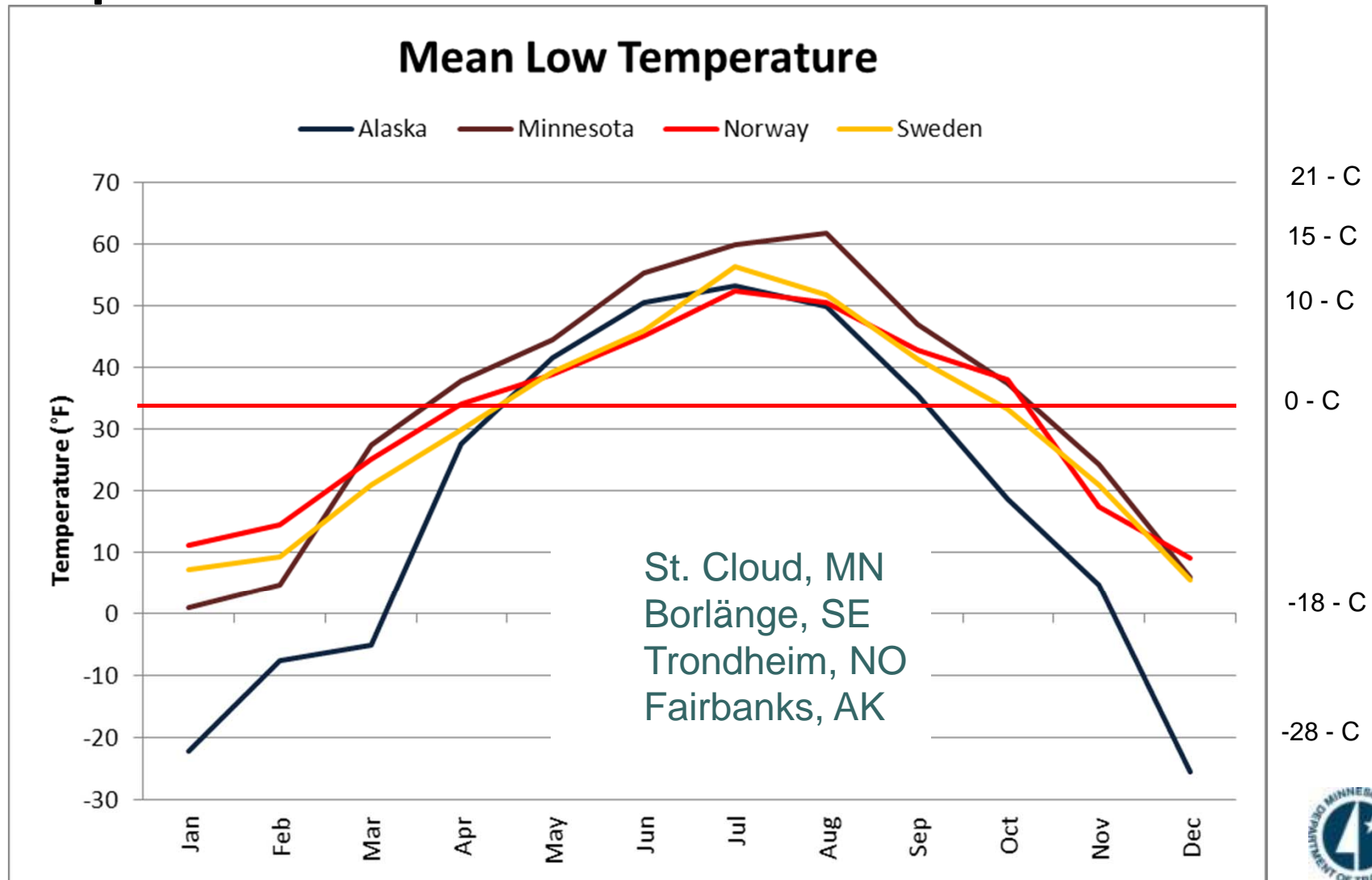


Minnesota Frost Practices and MnROAD Observations

Ben Worel
Minnesota Department of Transportation

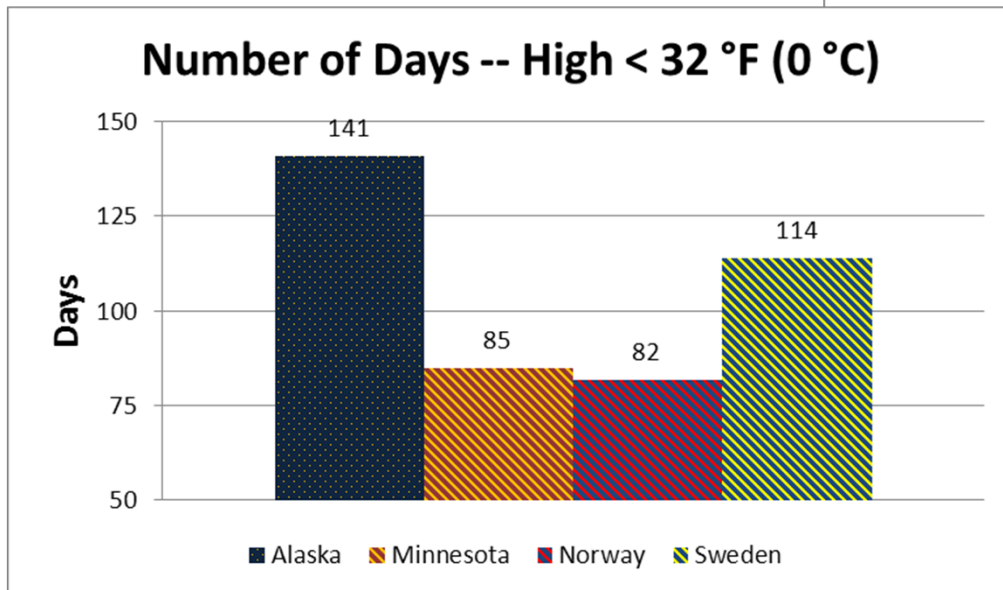
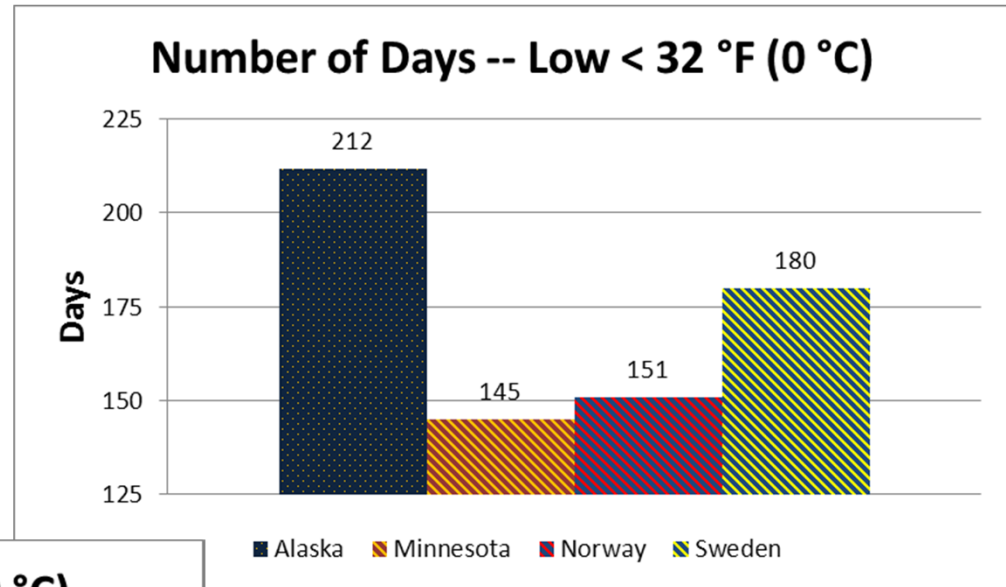


Climate Comparisons - 2010





Climate Comparisons - 2010



St. Cloud, MN
Borlänge, SE
Trondheim, NO
Fairbanks, AK



● ● ● | MnDOT Current Policy

- **Over 7 million 20-Year ESALS**
 - 36" frost free materials required
- **1-7 million 20-yr ESALS**
 - 30" frost free materials required
- **Below 1 million ESALS**
 - Do not require a minimal frost free design (process of changing).



Note - Cities and county roads do not have to follow MnDOT's lead and concrete roads do not have any frost requirement. Frost heave is not calculated





Minnesota – Frost not a big issue but still causing problems

- **Minnesota Local Road Research Board (LRRB)**
 - Frost Repair Guidelines
 - <http://www.lrrb.org/media/reports/RIS-27.pdf>
- **ASCE – CRREL Video Remake**
 - 12 min Full Length (technician, staff, students)
 - 3 min Executive Summary (County Boards)
 - Draft - <http://www.youtube.com/watch?v=mPBoBvQNZGg&feature=youtu.be>
 - Alaska, Minnesota, LRRB, FHWA, CRREL, ASCE Members



MnROAD Test Cells

History

- Open to Traffic (1994)
- 5 foot (150 cm) subcut/remix

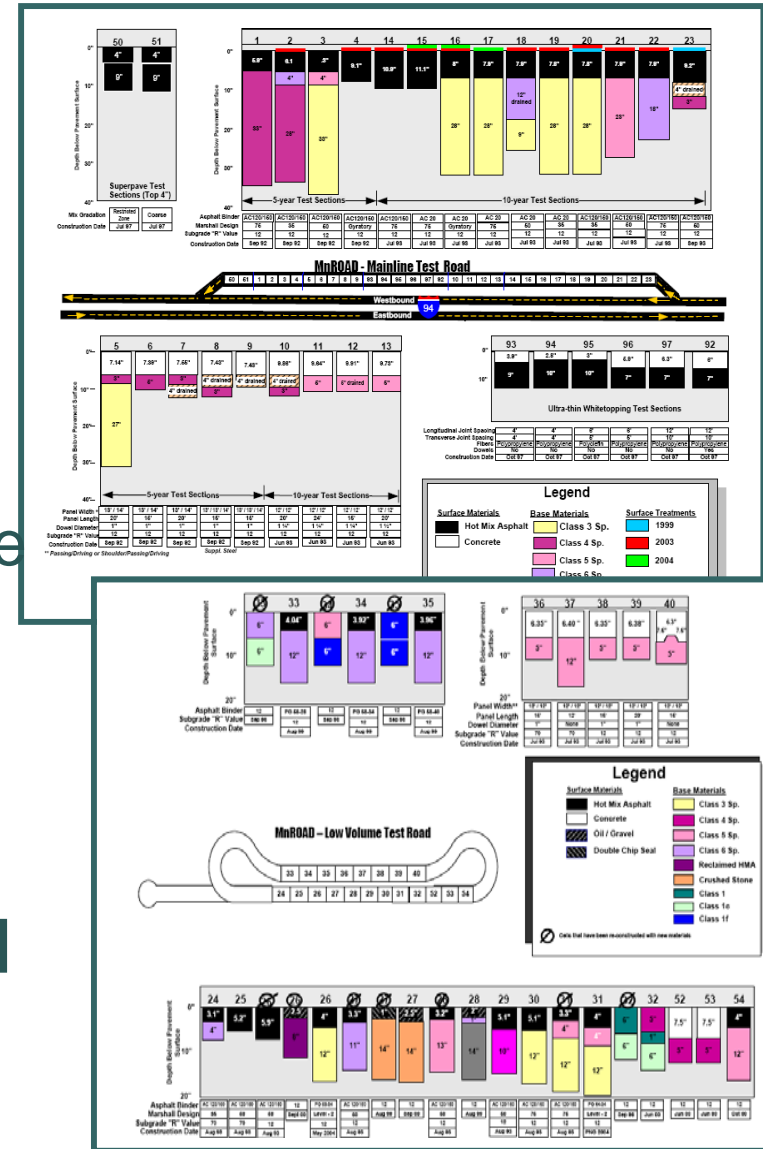
Layout and Designs

- Mainline / Low Volume
- Asphalt / Concrete / Aggregate

Major Experiments

- Phase I (1994-2006)
- Phase II (2007-present)
- Phase III (planning for 2016)

Measured Frost Depth and Frost Heave over time.



● ● ● | Research – MnROAD Sensors

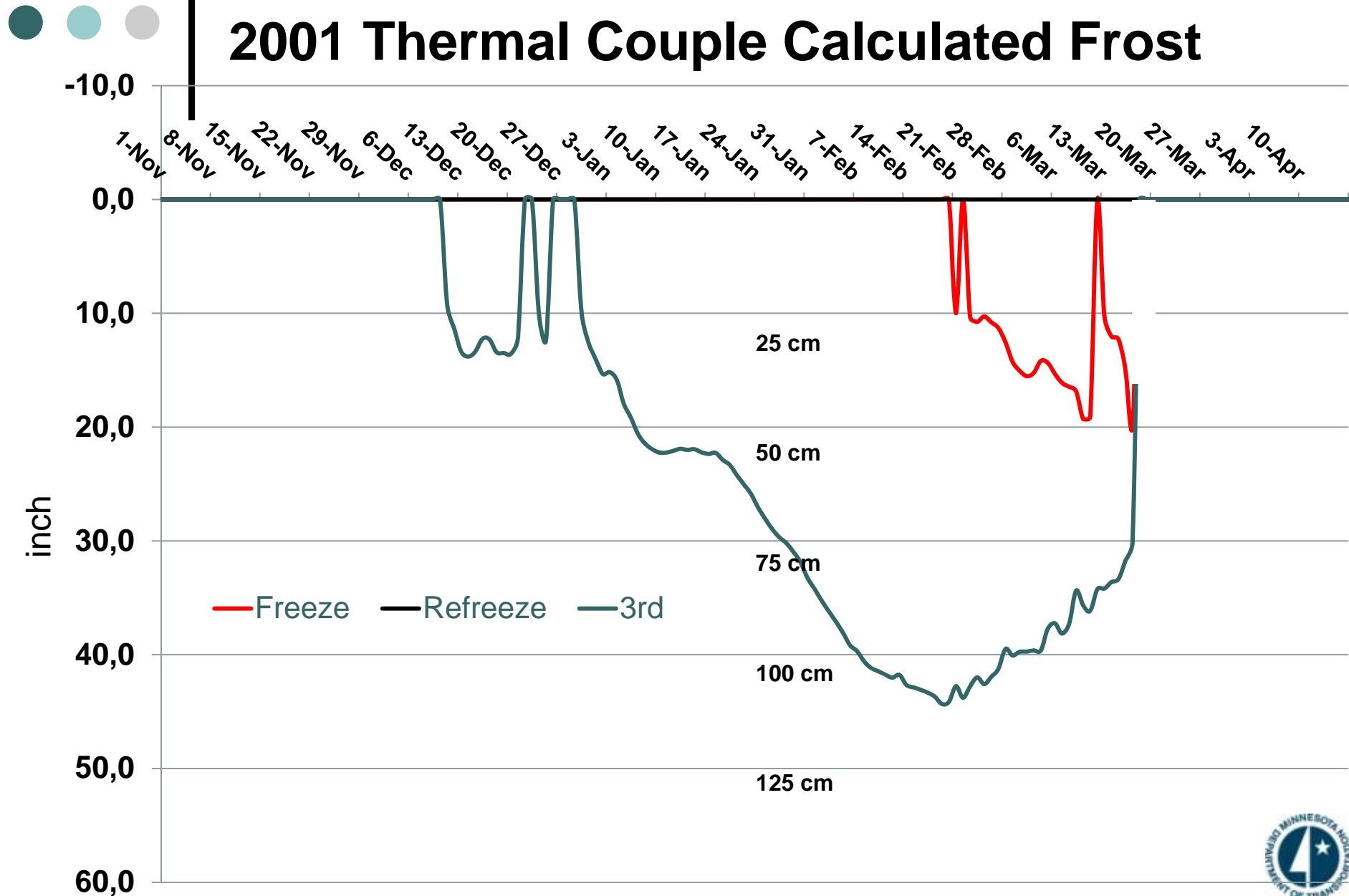
- Resistivity Probes, Moisture, and thermal couples (TC) used in the past
 - TC used in this example
 - Data from 1993-2013
 - Used a spreadsheet to determine frost depth

CELL	DAY	9	11.64	17.64	23.64	35.64	47.64	59.64	95.64
23	1/1/1994	0.8	0	-0.7	-0.9	-0.7	-0.1	2.2	
23	1/3/1994	3.9	1.9	-0.3	-0.8	-0.4	0	2.2	
23	1/4/1994	3.7	2	0.2	-0.7	-0.6	0	2.1	
23	1/5/1994	3.3	1.8	0.2	-0.7	-0.6	0	2.1	
23	1/6/1994	2.9	1.8	0.3	-0.6	-0.6	0	2.1	
23	1/7/1994	2.5	1.7	0.4	-0.7	-0.5	0	2.1	
23	3/28/1994	1.2	1.6	1	0	-0.4	0.2	2.1	
23	3/29/1994	2.6	1.8	0.9	0.1	-0.3	0.2	2.1	
23	3/30/1994	2.2	1.9	1	0.1	-0.3	0.2	2.1	
23	3/31/1994	6.9	4.1	1.9	0.4	0	0.3	2	
23	4/1/1994	6.7	4.5	2.8	0.6	-0.2	0.3	2.1	



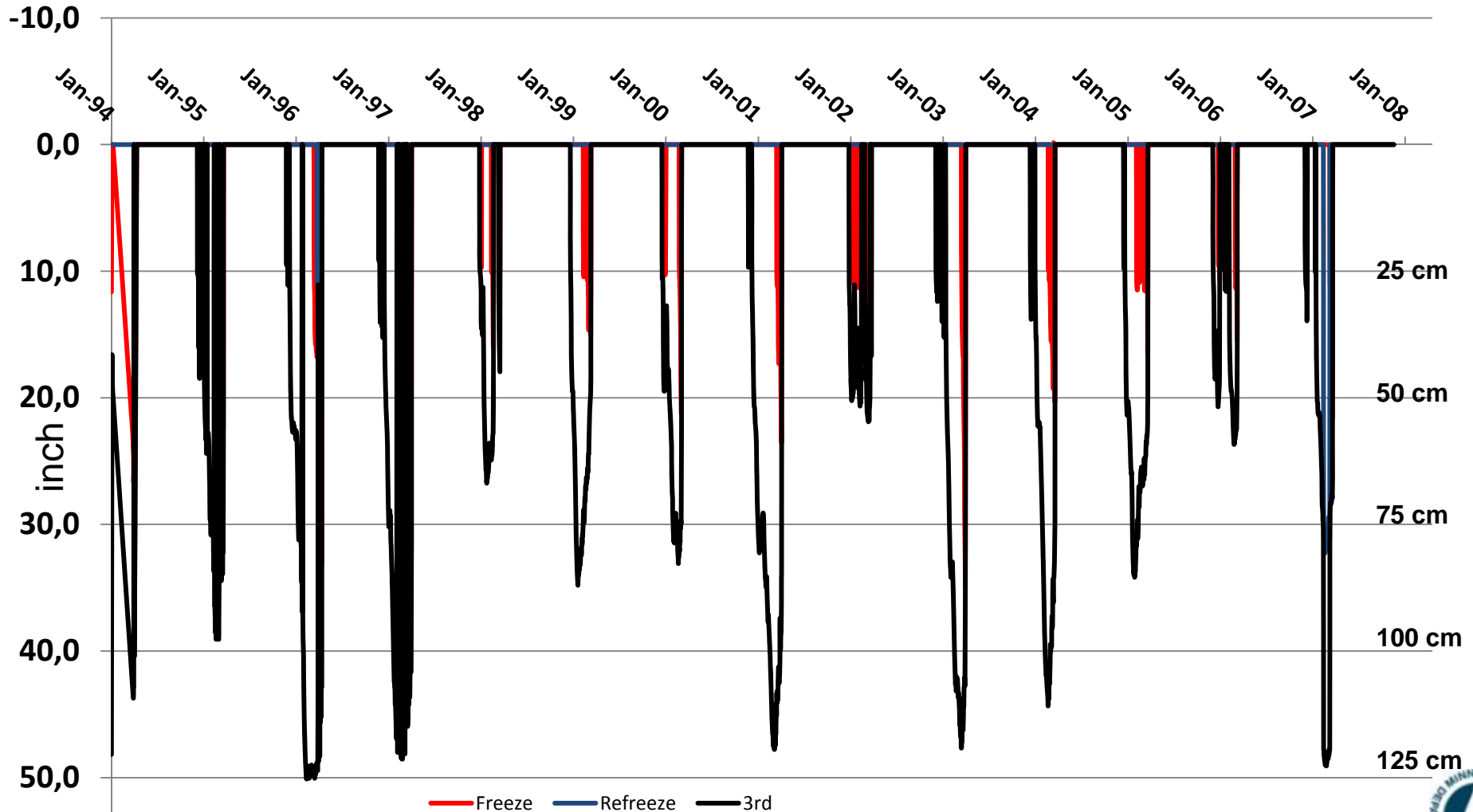
MnROAD - Cell 23

2001 Thermal Couple Calculated Frost



MnROAD – Cell 23

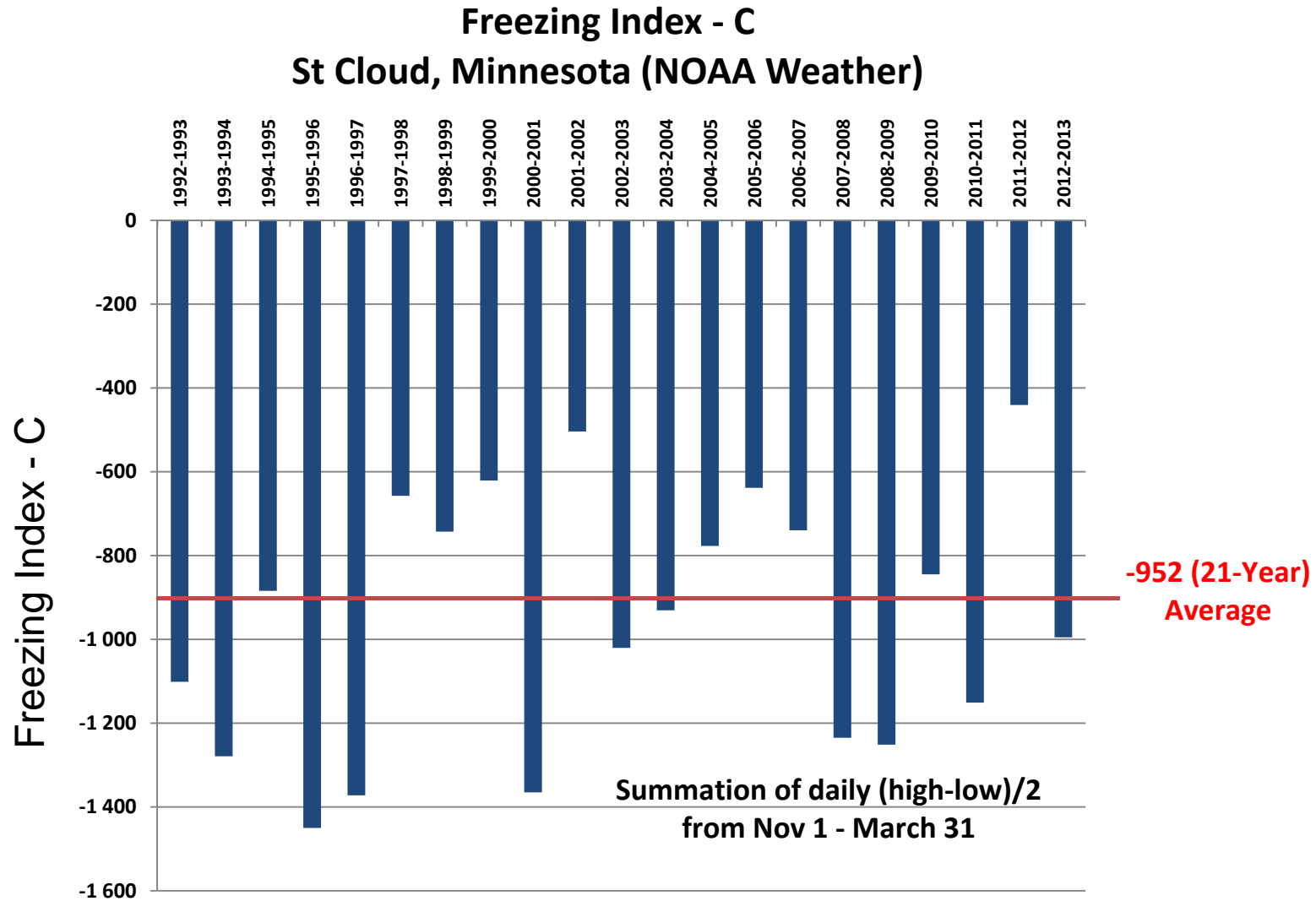
Thermal Couple Calculated Frost





Freezing Index

(St Cloud - November through March)

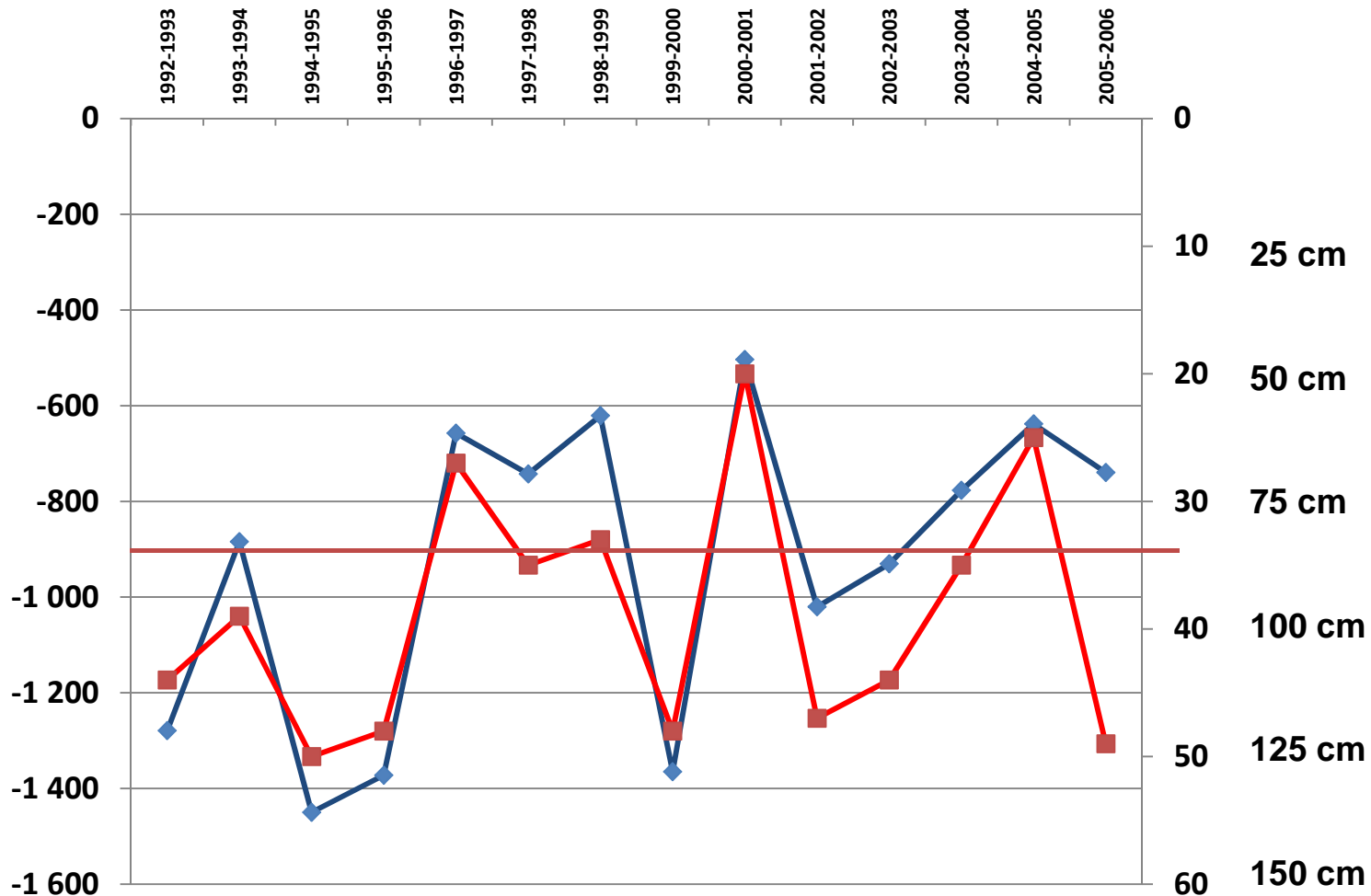




Frost Depth vs Freezing Index

Freezing Index - C

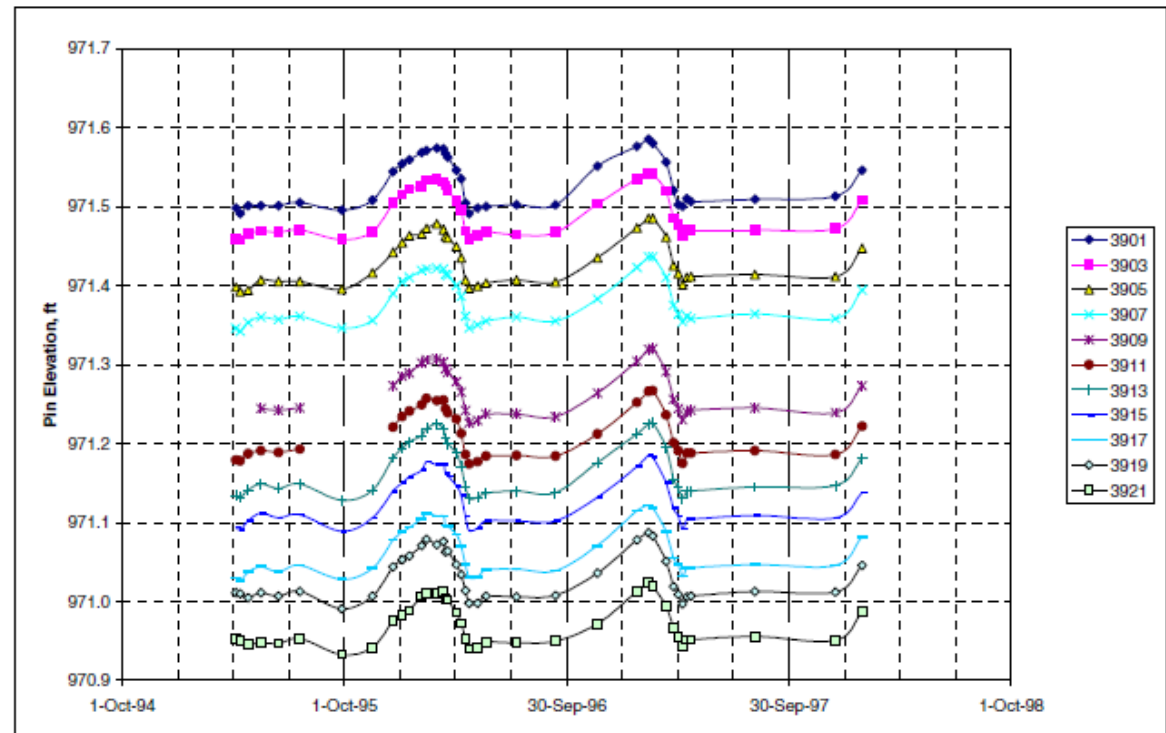
TC Frost Depth





MnROAD Frost Heave

- Measured using rod and level measurements
- MnROAD Environmental Factors that Affect Ride - <http://www.mrr.dot.state.mn.us/research/pdf/2006MRRDOC014.pdf>
 - 4 years data (two shown)
 - Variable
 - Very little heave
 - Clay 1.1" (3 cm)
 - Sand .5" (1 cm)
- 2012-2013 IRI measured every month last winter



● ● ● | **Where to go from here?**

- **Feel that MnDOT practice could be updated**
 - Take materials into consideration
 - Computers can make this easy to do
- **Starting to work with Sweden (PMS Objekt) to predict frost heave using St Cloud data to help bring a new method to Minnesota.**
 - Need to compare measured MnROAD heave with PMS Objekt heave predictions
- **Seasonal ride effects**
- **Interested in what others are also doing**

