

# Automated Soil Monitoring for Seasonal Load Limits



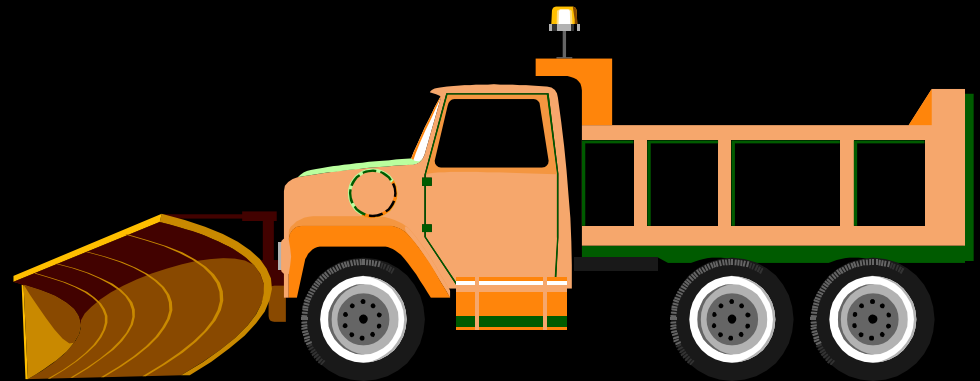
Greg Johnson

Minnesota Department of Transportation



# Use of Frost Depth Information

- Ground Truth Verification for Proper Timing for:
  - Winter Load Increases
  - Spring Load Restrictions
- Our Primary Trigger is Based on Cumulative Air Temperature



# Progression of Frost Measuring Methods



Surface Characteristics



Frost Tube



Temperature/Resistance Probes

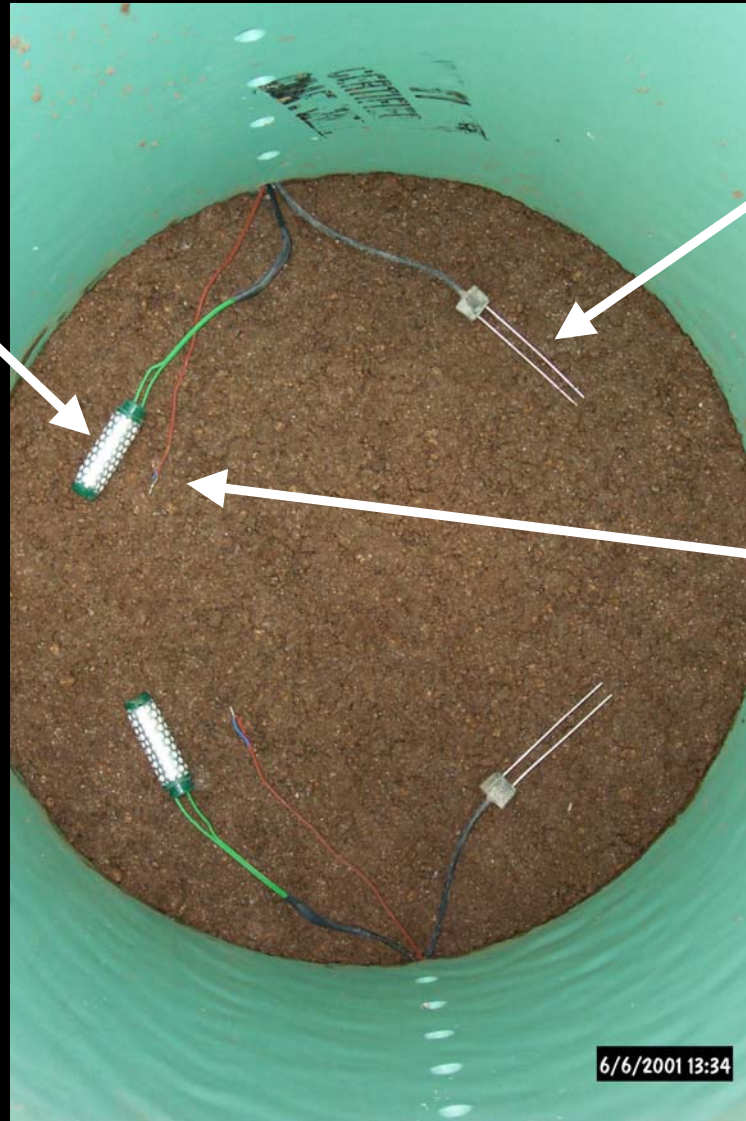


# Laboratory Comparison of Sensors

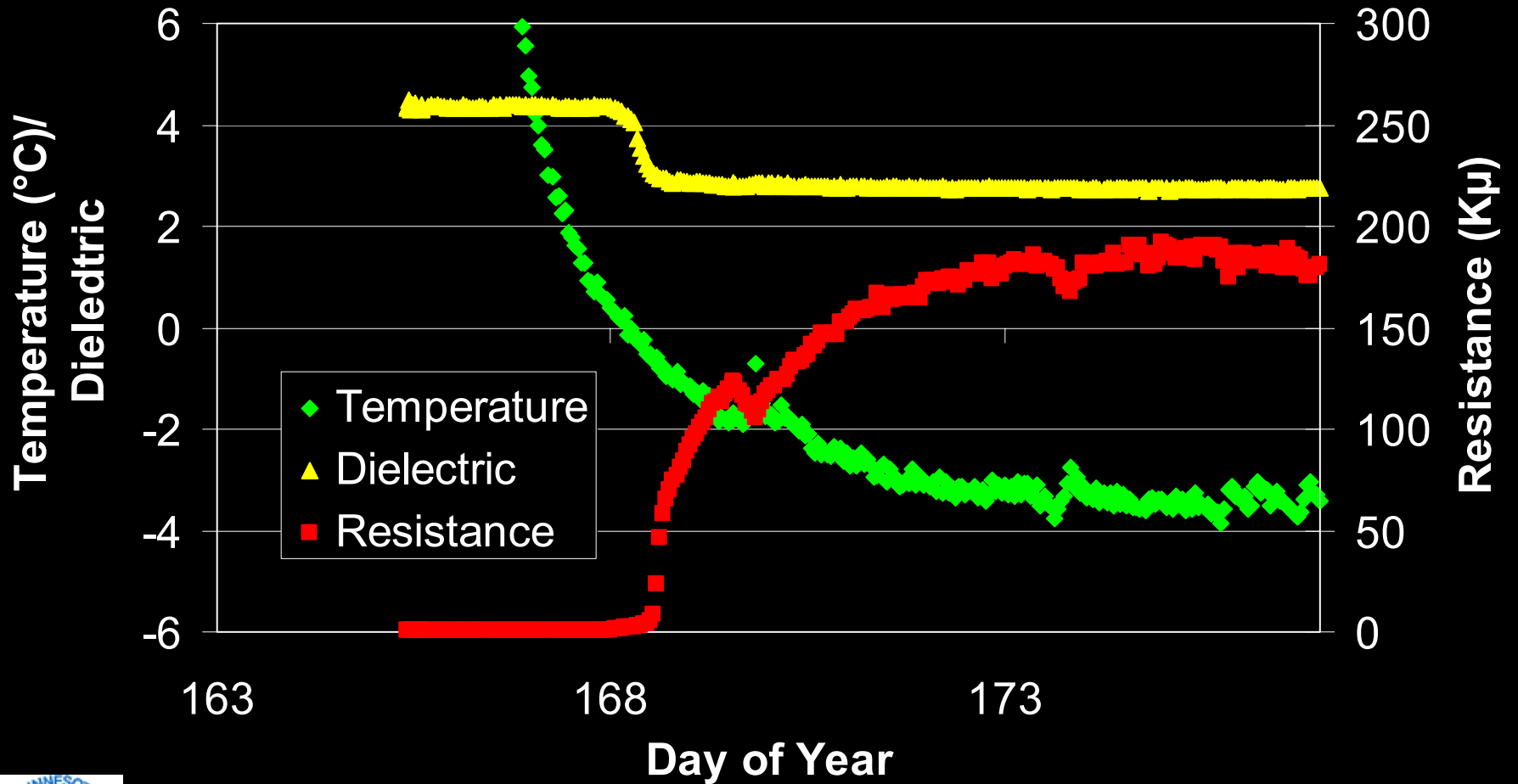
Resistance  
Block

Time Domain  
Reflectometer (TDR)

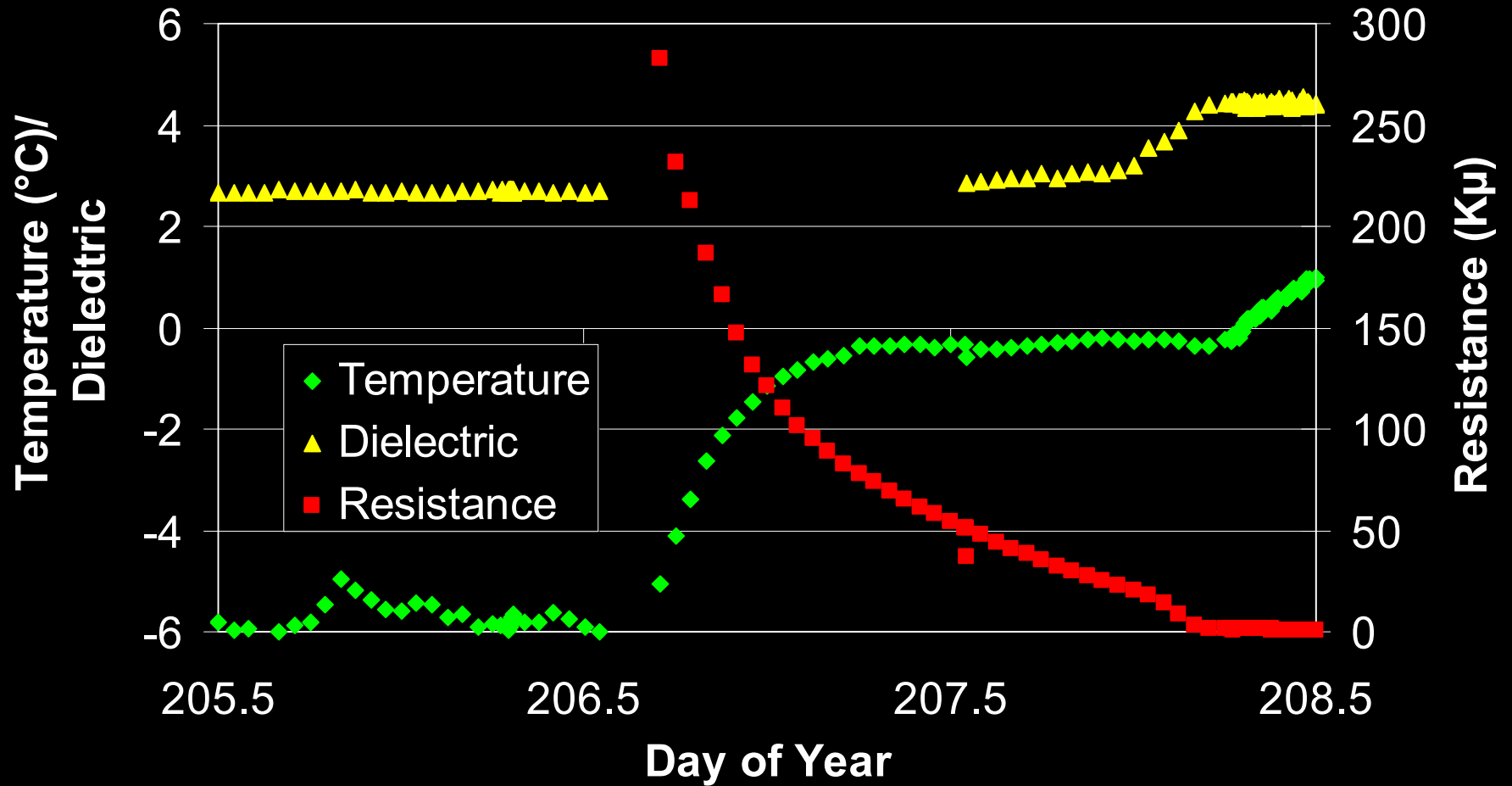
Thermocouple



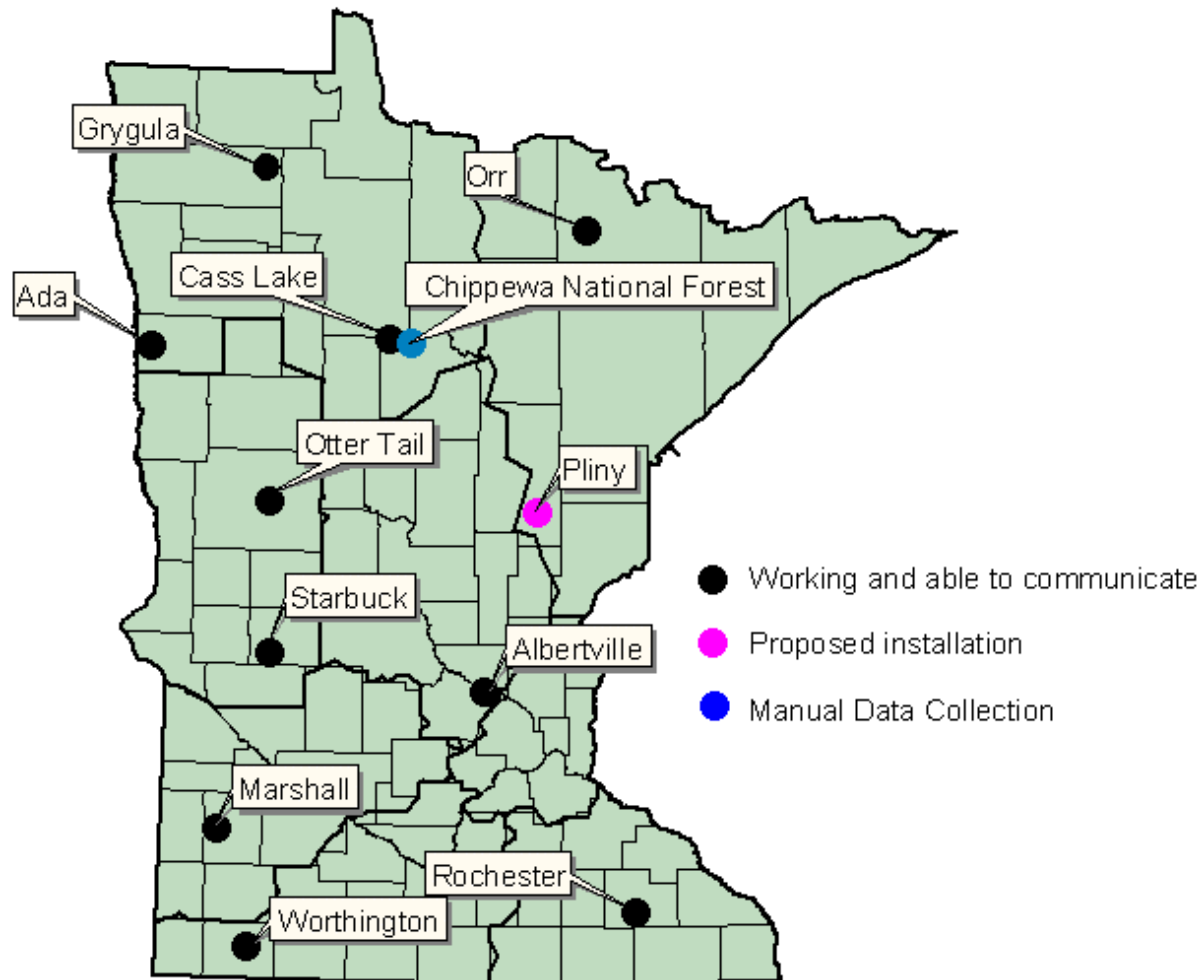
# Freezing Curve - Sensor Comparison

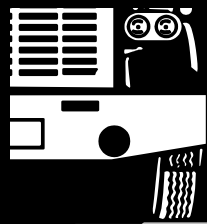


# Thawing Curve - Sensor Comparison

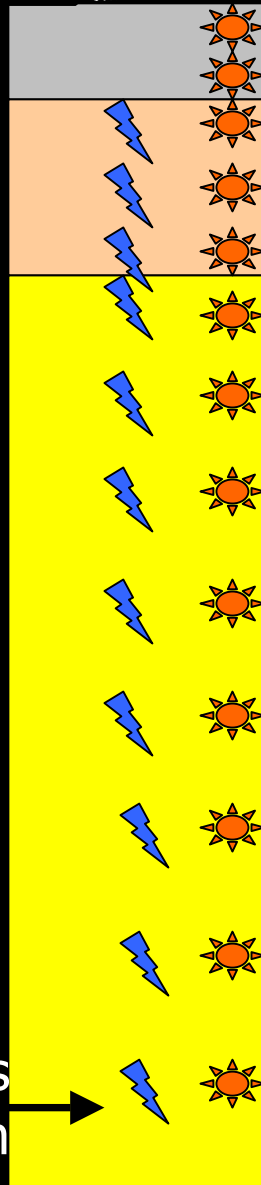


# MnDOT Frost Monitoring Sites

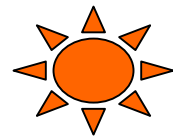




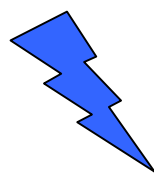
HMA  
Base  
Subgrade



96 inches  
2400 mm



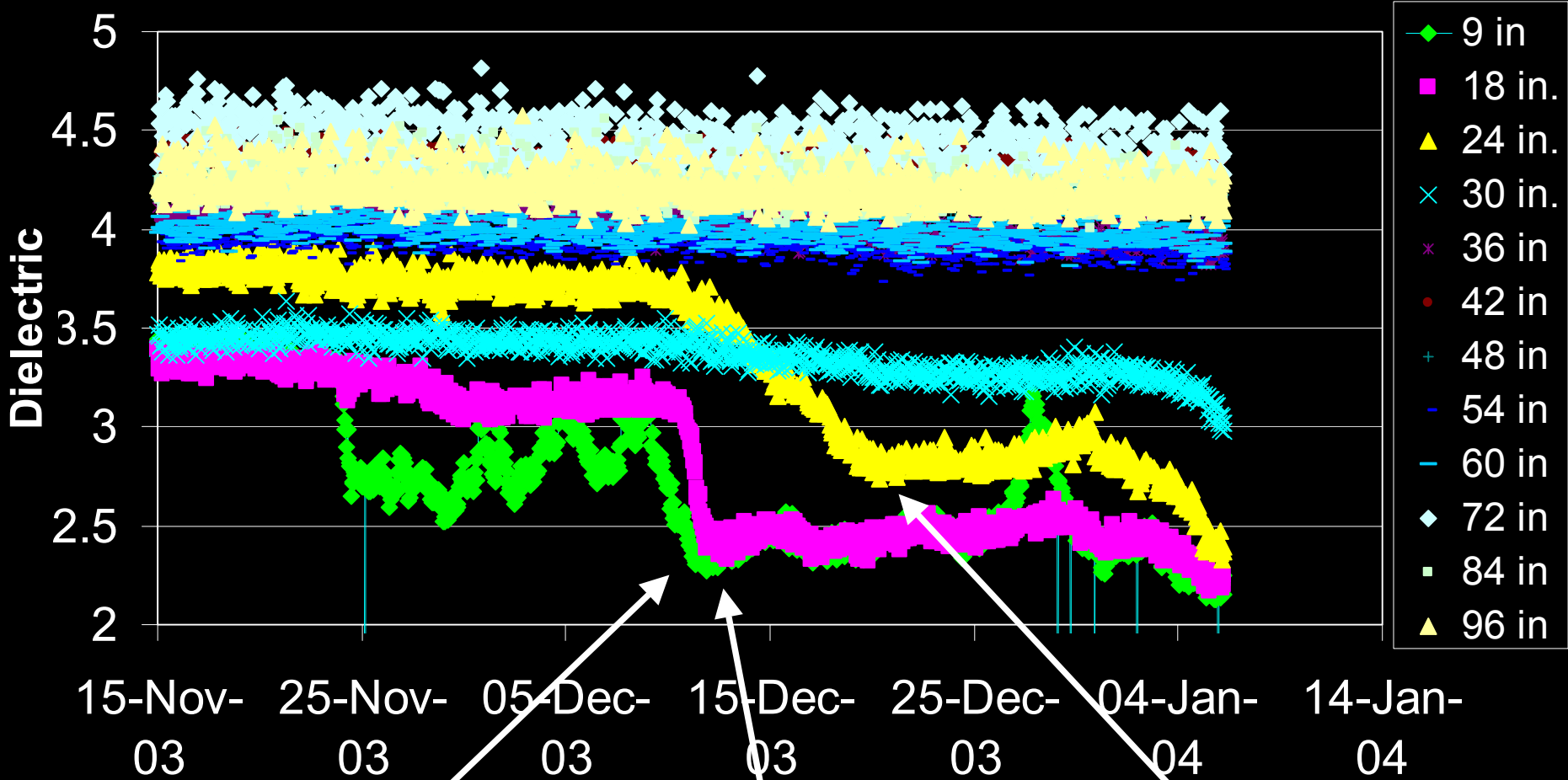
Thermocouple



Time Domain  
Reflectometer (TDR)



# Pope Co. (MN29) Dielectric



Frozen Soil at:

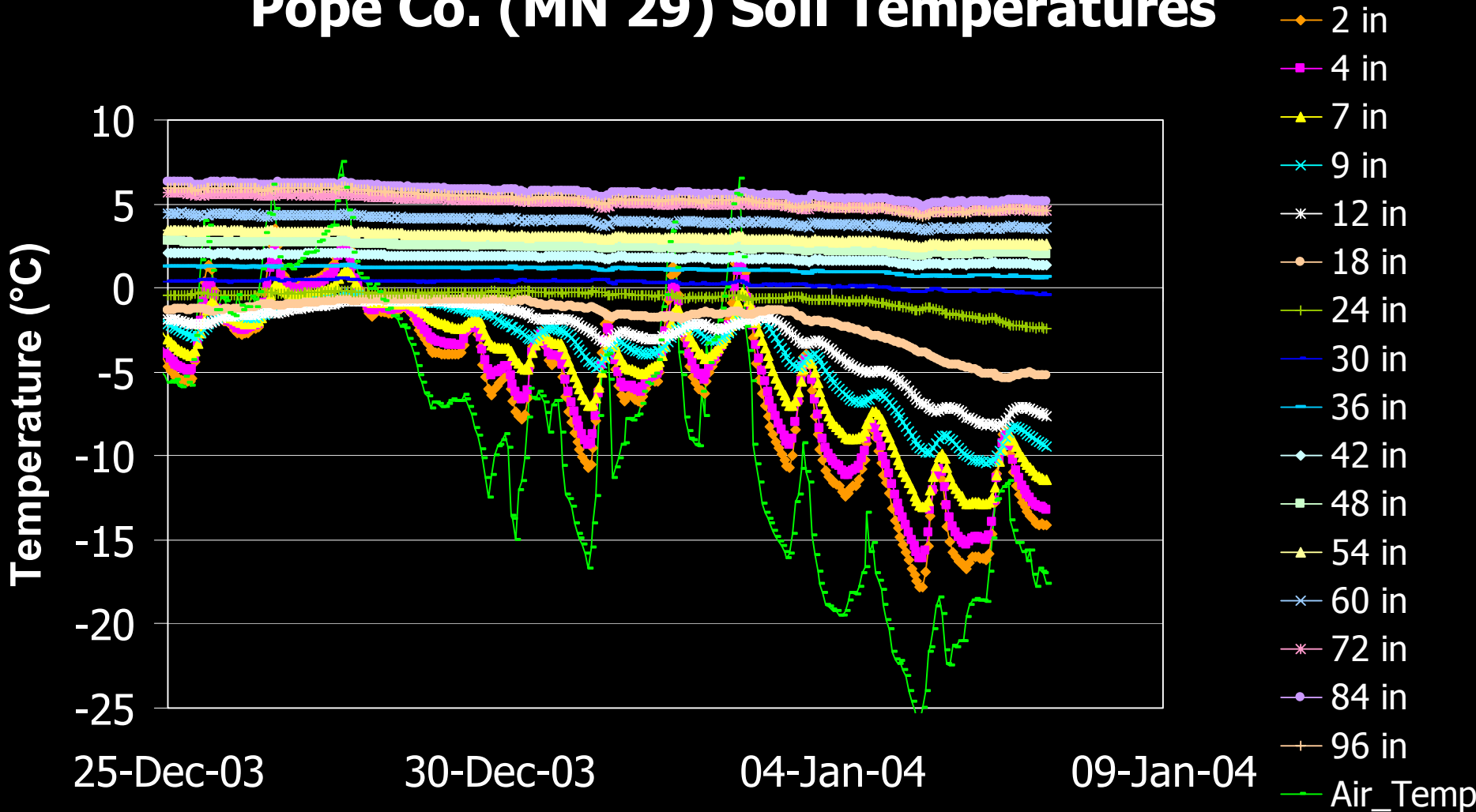
9 in. (225 mm)

18 in. (460 mm)

24 in. (610 mm)

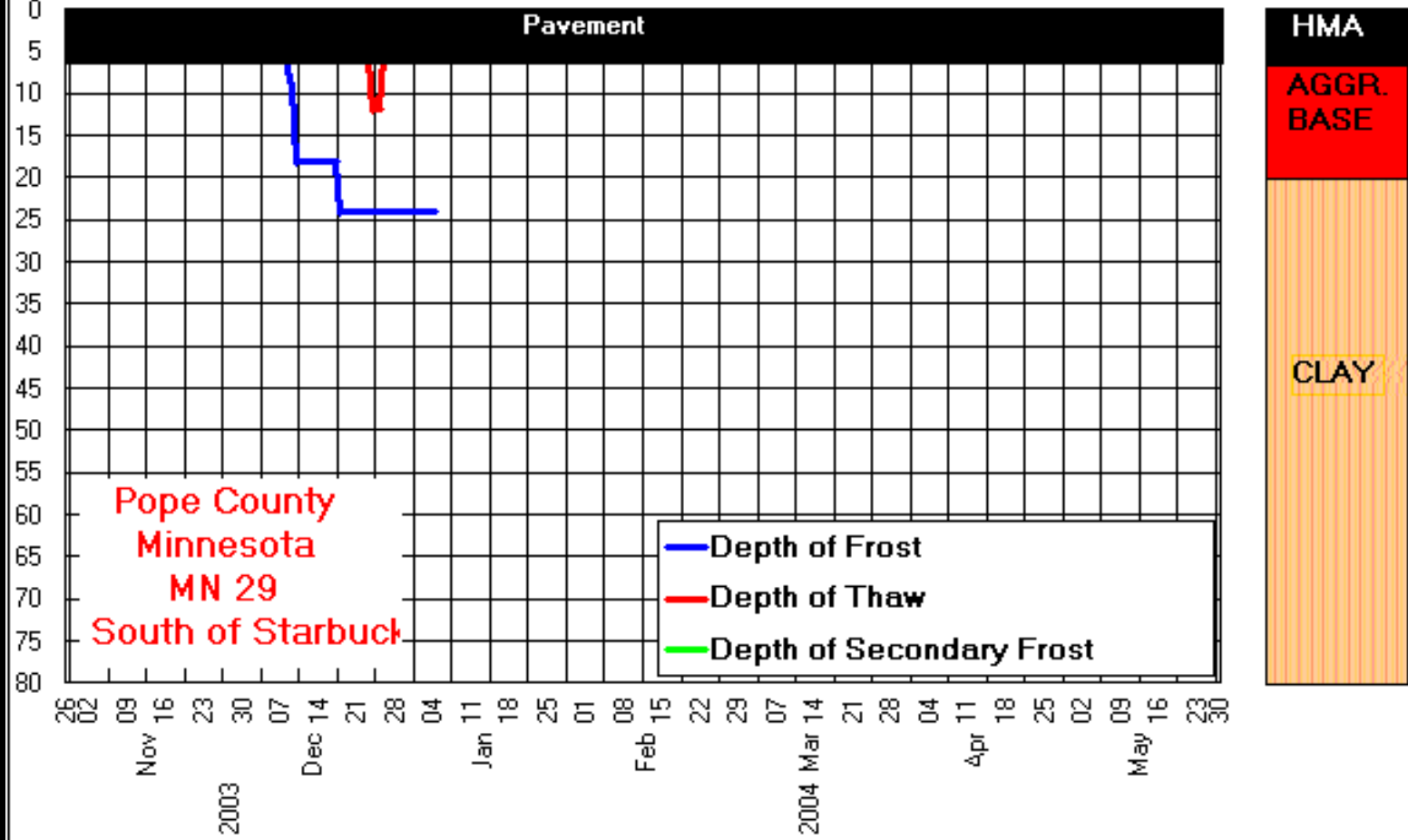


# Pope Co. (MN 29) Soil Temperatures



# Frozen Soil Profile

Depth Below Pavement Surface (inches)



# Conclusions

- Soil temperature & dielectric properties can be used to determine the zone of frozen soil.
- Automated system provides continuous data to provide prediction and confirmation of the 3 day notice given to changes in winter load limits.

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