DEPARTMENT OF LABOR AND INDUSTRY

Frost Depth Study TAG

Meeting Notes

Date: Wednesday, September 1, 2021
Meeting Location: WebEx Event

Call to order:

Dan Kelsey called the meeting to order at 9:05 AM

Attendance:

TAG Members present: Dan Kelsey (DLI), Greg Metz (DLI), Ezra Ballinger, (Braun Intertec), Mitch Okeson (Alternate -Sandman Structural Engineers), Kurt Welker (Welker Custom Homes), and Jack Nyberg (City of Moorhead)

TAG Members absent: Kurt Sandman (Sandman Structural Engineers), Don Dabbert (Dabbert Custom Homes), and Mark Hallan (Widseth)

Guests attending: Amanda Spuckler (DLI), Chad Payment (DLI), Rich Lockrem (DLI), Jeff Lebowski (DLI), Brittany Wysokinski (DLI), Steve Shold (DLI), Lisa Bode, Peter Glessing, Nathan Weber, Mark Romano, Nick Erickson, Steve Schmidt, Kevin Toskey, Grace Keliher, and Mark Brunner

1. Call to order

- WebEx instructions/procedures

2. Reviewed plant hardiness zone map for Minnesota and compared it to a map with current requirements for frost depth in Minnesota.

3. Reviewed frost depth map for the upper Midwest from the North Central River Forecast Center.

- The data provided on the map is not specific to building and does not specify if there was any snow cover when the data was collected or if the frost depth reading was taken from ground covered by a road or turf.

4. Reviewed email with Fargo, ND deep soil temperature data and pivot table of deep soil temperature for locations in North Dakota provided by Adnan Akyuz, professor of climatological practice at North Dakota State University.

- The data does not include the location conditions and geotechnical information.
- Currently available frost depth data does not address how much frost will penetrate near a heated structure.
- The Minnesota State Building Code applies to both heated and unheated structures. The exception to Minnesota Rules, part 1303.1600, subpart 2, addresses slab on grade construction of unheated structures.
- Minnesota Rules, part 1303.1600, subpart 1, permits footings of less depth when supporting evidence is presented by an engineer competent in soil mechanics.

5. Reviewed Elizabeth Tomlinson's email.

- The air freezing temperature index does not address short-term, extreme temperature events.
- The frost depth and climate changes are being studied at a national level.

6. Reviewed NOAA article "Winter Severity and Frost Depth in a Warming Climate". Also reviewed air freezing index map colored contours overlay on Minnesota county map with data from 1981-2010 and air freezing index change colored contours overlay on Minnesota county map with data from 1981- 2010. The data for the maps was taken from "Calculation and Evaluation of Air-Freezing Index for 1981-2010 Climate Normals Period in the Coterminous United States."[1] A foundation corner cross section design based on new air freezing index data was reviewed.

- The updated data shows a lower air freezing index for the center of Minnesota, including Clay county. The updated data shows an average air freezing index of 3410 for Clay county.

7. Discussed ASCE 32 shallow frost protection requirements.

- The use of ASCE 32 is a code compliant option for the design and construction of shallow frost protected foundations that does not increase costs.
- ASCE 32 is a referenced standard in the Minnesota Building Code and Minnesota Residential Code.
- ASCE 32 has not been revised based on more recent weather data and it is not known when ASCE will publish a new edition.
- Footing depths could be reduced in Clay county with interpolation of the current air freezing index map and Table A5 of ASCE 32.
- A builders' association could work with an engineer for a foundation design to mitigate costs. In the past, builders' associations have worked with an engineer to develop wall bracing and cantilever foundation guidelines.
- The use of ASCE 32 does not require a licensed design professional, but a building official can require construction documents to be prepared by a licensed design professional.

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[1] Bilotta, Rocky, Jesse E. Bell, Ethan Shepherd, and Anthony Arguez. 2015. "Calculation and Evaluation of an Air-Freezing Index for the 1981–2010 Climate Normals Period in the Coterminous United States." *Journal of Applied Meteorology and Climatology* 54 (1): 69–76.

8. Discussed and responded to public comments.

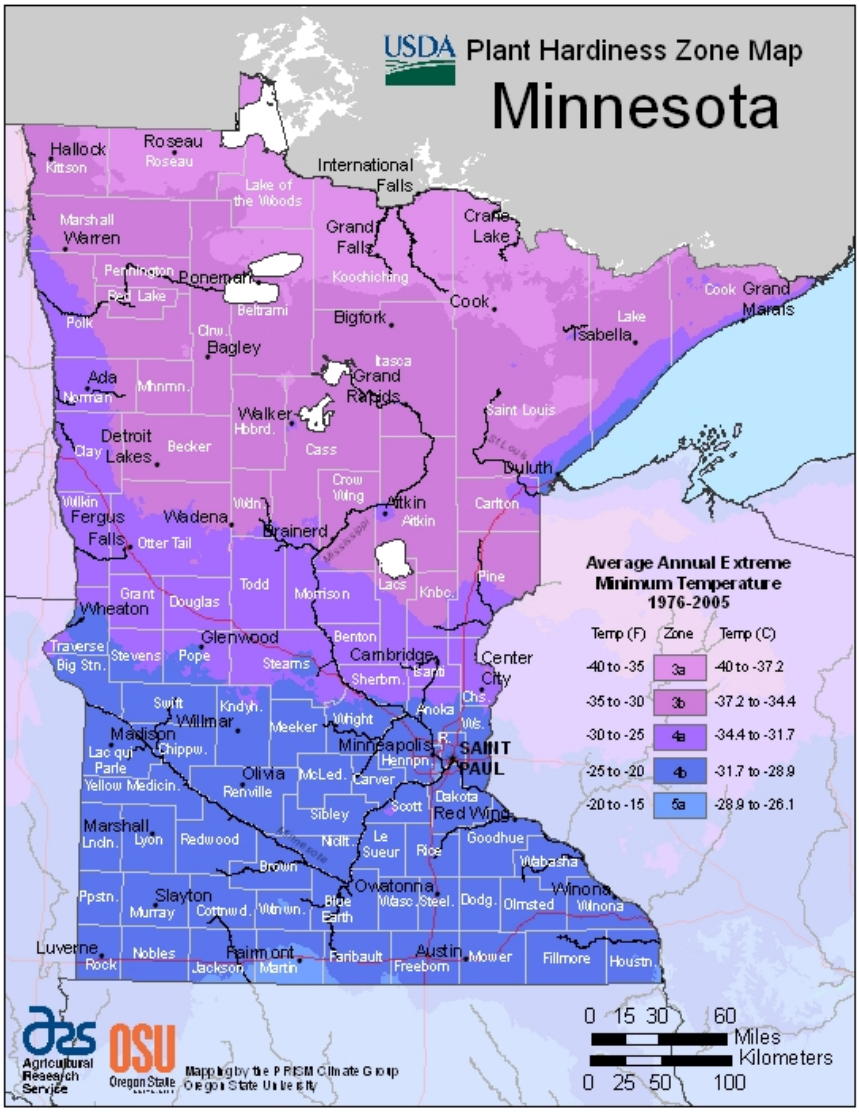
- A member of the public commented that reducing the frost depth to four feet in Clay County is estimated to reduce construction costs by $3000.
- The life expectancy of a home is 50 to 100 years. It is unknown if climate changes will result in cooling trends. Buildings could be altered to mitigate the impact if there are cooling trends. Also, buildings designed in accordance with ASCE 32 have a safety factor.

8. The TAG members' consensus following discussion:

- There is not sufficient data at this time to recommend a revision to the footing depth for frost protection. The minimum footing depths for frost protection should be reviewed and revised when a new edition of ASCE 32 is published.
- Design and construction in accordance with the 2001 edition of ASCE 32 is a code compliant method for frost protection that requires less footing depth.
- Footing depths could be reduced in Clay county with interpolation of the current air freezing index map and Table A5 of ASCE 32.
- To clarify that foundations designed and construction in accordance with ASCE are permitted by the Minnesota State Building Code, the TAG members recommended revising Minnesota Rules, part 1303.1600, during the 2024 code adoption cycle to add a subpart that provides a direct reference to ASCE 32.

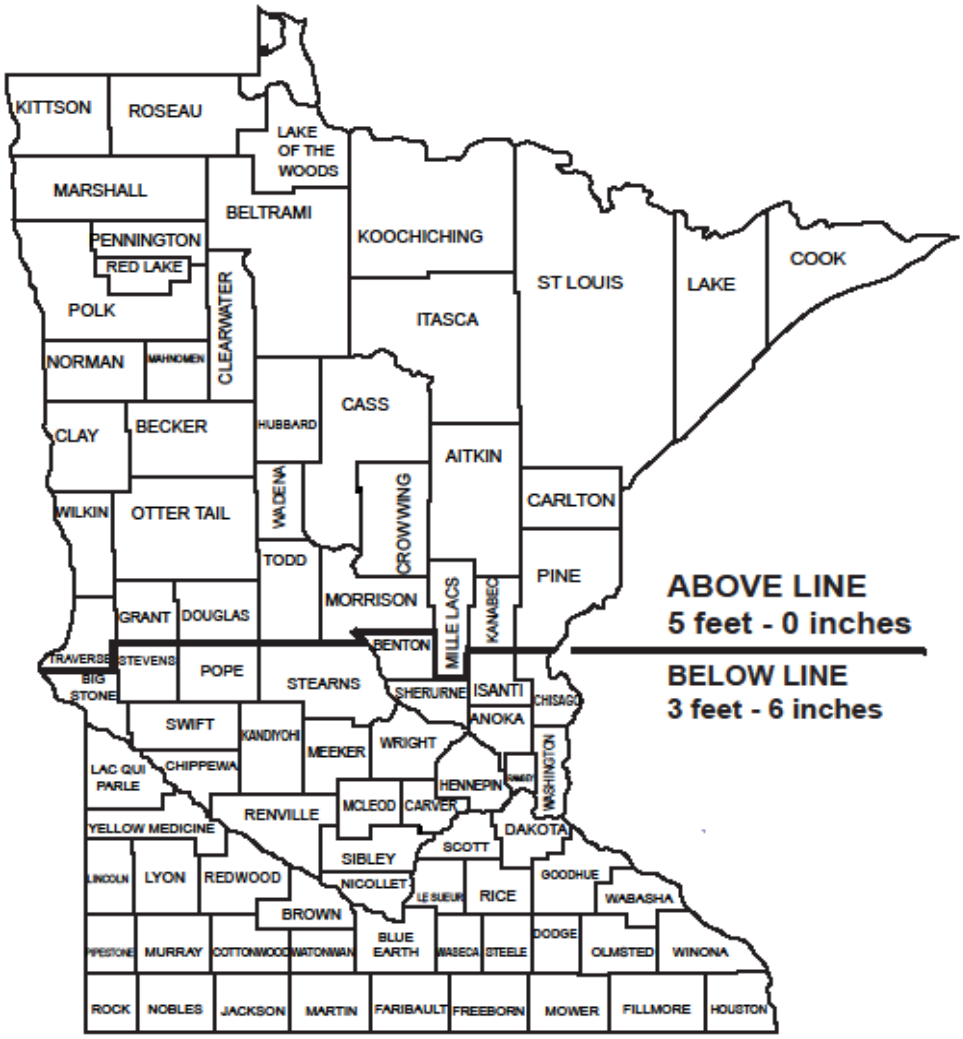
Meeting Adjourned: 11:18 AM

Prepared by: Dan Kelsey


USDA Plant Hardiness Zone Map
Minnesota
Average Annual Extreme Minimum Temperature 1976-2005
Temp (F) Zone Temp (C)
-40 to -35 3a -40 to -37.2
-35 to -30 3b -37.2 to -34.4
-30 to -25 4a -34.4 to -31.7
-25 to -20 4b -31.7 to -28.9
-20 to -15 5a -28.9 to -26.1
0 15 30 60 Miles
0 25 50 100 Kilometers
Agricultural Research Service
Oregon State University
Mapping by the PRISM Climate Group Oregon State University
Hallock
Roseau
International Falls
Lake of the Woods
Marshall
Warren
Grand Forks
Crane Lake
Pennington
Ponemah
Koochiching
Cook
Grand Marais
Bagley
Bigfork
Lake Isabella
Ada
Grand Rapids
Walker
Detroit Lakes
Becker
Cass
Saint Louis
Duluth
Fergus Falls
Wadena
Brainerd
Crow Wing
Aitkin
Carlton
Wheaton
Grant
Douglas
Todd
Morrison
Pine
Traverse
Glenwood
Stevens
Pope
Stearns
Benton
Cambridge
Center City
Swift
Willmar
Meeker
Wright
Anoka
Madison
Minneapolis
SAINT PAUL
Lac qui Parle
Chippw.
Yellow Medicin.
Olivia
Renville
McLeod
Carver
Hennpn.
Dakota
Scott
Red Wing
Sibley
Marshall
Lyon
Redwood
Nicollet
Le Sueur
Rice
Goodhue
Wabasha
Brown
Owatonna
Winona
Olmsted
Slayton
Murray
Cottonwd.
Blue Earth
Steel.
Dodge
Luverne
Rock
Nobles
Jackson
Martin
Faribault
Austin
Freeborn
Mower
Fillmore
Houstn.

FROST DEPTH

MSBC RULES 1303.1600



ABOVE LINE
5 feet - 0 inches

BELOW LINE
3 feet - 6 inches

Email with Fargo, ND soil temperature data

From: Akyuz, Adnan [redacted]
Sent: Friday, August 6, 2021 12:01 PM
To: Greg Gust - NOAA Federal [redacted]; Boulay, Peter J. (DNR) [redacted]; Ritchison, Daryl [redacted]
Cc: Kelsey, Daniel (DLI) <dan.kelsey@state.mn.us>; Blumenfeld, Kenneth (DNR) [redacted]; Romolo, Luigi (DNR) [redacted]; [redacted]
Subject: RE: Fw: MN Frost Depth: Data Clay County

Below is a pivot table of all deep soil temp locations in ND. I highlighted the Fargo location in the pivot table, showing the min temperatures in each level from 5 cm to 225 cm. Fargo's lowest soil temperature on -0.478 occurred at 125 cm (4.65'), based on the data from 2014 through 2021.

Adnan

F. Adnan Akyüz, Ph.D.

NORTH DAKOTA STATE UNIVERSITY

Professor of Climatological Practice

Distinguished Educator

North Dakota State Climatologist

American Association of State Climatologists, Past President

phone: [redacted]

mobile: [redacted]

email: [redacted]

web: http://www.ndsu.edu/ndsco/

1230 Albrecht Blvd.

Morrill Hall 304, NDSU

Fargo, ND 58102

Pivot Table of Deep Soil Temperature for Locations in North Dakota Provided by F. Adnan Akyüz, Ph.D

Row Labels	Min of 5 cm	Min of 10 cm	Min of 20 cm	Min of 30 cm	Min of 40 cm	Min of 50 cm	Min of 60 cm	Min of 80 cm	Min of 100 cm	Min of 125 cm	Min of 150 cm	Min of 175 cm	Min of 200 cm	Min of 225 cm
Adams	-13.77	-12.85	-11.85	-11.08	-9.86	-9.1	-8.41	-6.64	-4.916	-3.093	-1.704	-0.817	0.167	0.65
Amidon	-15.41	-13.35	-10.95	-8.34	-6.598	-5.133	-4.173	-2.561	-1.227	-0.012	0.098	0.137	0.337	1.343
Antelope Creek	-19.3	-16.42	-12.18	-9.24	-7.715	-6.382	-5.364	-2.623	-0.381	0.849	1.593	2.237	3.016	3.714
Ayr	0.351	0.377	0.289	0.172	0.032	-0.075	-0.132	-0.41	-0.488	-0.112	0.428	0.98	1.634	2.071
Bottineau	-8.1	-7.182	-5.894	-4.657	-3.789	-3.212	-2.56	-1.576	-0.447	0.199	0.475	0.527		
Bowman	-14.75	-13.34	-11.64	-9.6	-7.422	-5.475	-3.812	-1.339	0.233	1.023	1.571	2.026	3.278	3.767
Carrington	-16.47	-14.62	-12.26	-9.61	-7.641	-6.291	-5.277	-3.661	-2.3	-1.215	-0.702	-0.283		
Carson	20.09	20.59	21.15	20.97	20.03	18.91	18	16.49	15.3	13.92	12.71	11.61	10.41	9.67
Clyde	-0.924	-0.599	-0.542	-0.636	-0.692	-0.659	-0.528	-0.213	0.16	0.489	0.711	0.937	1.557	1.977
Courtenay	-11.89	-10.78	-9.08	-7.544	-5.695	-4.101	-44.65	-27.65	0.009	0.656	1.257	-25.12	2.58	2.971
Crane Creek	-17.52	-14.47	-9.93	-7.053	-5.099	-3.386	-2.006	-0.577	0.213	0.969	1.392	1.735	2.342	2.812
Croff	-19.23	-16.16	-12.53	-9.33	-6.419	-4.249	-2.789	-0.776	0.184	0.903	1.359	1.736	2.66	3.277
Denhoff	-7.151	-5.798	-4.51	-3.31	-2.484	-1.917	-1.295	-0.344	0.46	0.978	1.561	2.312	2.959	3.338
Dickinson	-16.25	-14.48	-12.37	-10.18	-8.36	-6.673	-5.49	-3.718	-1.406	-0.062	0.819	1.56		
Emerado	3.14	4.942	6.925	7.439	7.028	6.844	6.698	6.442	6.352	6.278	6.316	6.201	6.272	6.099
Epping	-15.41	-13.13	-9.87	-7.181	-4.991	-3.843	-2.839	-1.245	-0.558	0.063	0.417	0.732	1.353	1.88
Fargo	**-16.51**	**-14.41**	**-11.6**	**-8.99**	**-7.031**	**-5.723**	**-4.664**	**-2.707**	**-1.444**	**-0.478**	**0.125**	**0.877**	**1.736**	**2.252**
Fortuna	-15.26	-13.35	-10.7	-8.72	-6.564	-5.09	-3.695	-1.715	-0.738	-0.437	-0.12	0.142	-110.1	-50.99
Fox	-6.863	-5.582	-4.669	-3.865	-3.117	-2.36	-2.037	-1.196	-57.65	-0.063	-0.002	0.11	1.463	
Grand Forks	-17.65	-9.83	-6.935	-5.099	-3.472	-2.422	-1.865	-1.501	-1.067	-0.546	0.004	0.468	1.069	1.459
Grassy Butte	-16.77	-13.89	-9.01	-6.243	-4.974	-3.846	-2.541	-1.249	-0.361	0.566	1.318	2.032	2.633	3.322
Grenora	-19.81	-18.12	-13.93	-10.96	-9.07	-7.421	-6.023	-3.808	-2.245	-1.059	-0.032	0.871	1.989	2.57
Hettinger	-12.37	-10.6	-8.91	-7.133	-5.878	-123.8	-66.64	-17.27	-1.405	-119.3	0.787	1.757	11.09	10.22
Langdon	-16.13	-14.13	-11.56	-8.89	-7.444	-74.45	-5.527	-4.223	-2.723	-1.276	-0.411	0.121		

Logan Center	-6.514	-5.987	-4.767	-3.762	-2.656	-1.852	-1.064	-0.046	0.506	1.185	1.688	1.9	2.313	2.865
Maddock	-13.39	-11.78	-9.54	-7.463	-5.875	-4.984	-4.098	-2.676	-1.554	-0.316	0.296	0.662	1.515	2.357
Minot	-66.66	-74.43	-37.17	-71.39	-9.28	-7.647	-6.457	-39.91	-2.911	-1.962	-1.479	-2.406	1.143	-1.724
Mooreton	-18.79	-16.21	-13.01	-10.52	-8.39	-6.443	-4.676	-2.515	-1.728	-0.655	0.39	1.259	2.248	2.821
Mott	17.67	18.98	19.58	19.67	19.39	18.44	17.5	16.13	15.01	13.64	12.33	11.26	10.54	9.79
Niles	-6.416	-4.793	-3.344	-2.681	-1.976	-1.591	-1.211	-0.51	0.109	0.401	0.59	1.341	1.592	2.656
Noonan	-7.608	-6.687	-5.027	-3.653	-2.724	-1.908	-1.57	-0.98	-0.602	-0.489	-0.453	-0.243	0.63	1.048
Oakes	15.37	16.87	17.49	17.07	16.28	15.46	14.62	12.93	11.87	10.95	10.16	9.4	8.91	8.45
Palermo	6.873	7.873	8.59	8.61	8.25	7.639	6.912	5.893	5.23	4.687	4.33	4.096	3.933	3.86
Pekin	-14.34	-13.04	-10.58	-8.8	-7.061	-5.631	-4.411	-2.502	-1.127	-0.293	0.072	0.42	1.421	1.854
Perth	0.547	0.663	0.622	0.616	0.604	0.628	0.671	0.996	1.372	1.873	2.282	2.644	2.908	3.266
Portal	6.884	8.33	9.06	9.44	9.22	8.83	8.16	7.175	6.46	5.768	5.262	4.883	4.649	4.485
Prosper	-3.123	-2.527	-1.475	-0.599	0.097	0.465	0.582	0.814	1.029	1.126	2.58	3.983	4.588	5.13
Ray	12.55	13.62	14.58	14.97	14.97	14.12	13.31	11.75	10.57	9.34	8.36	7.576	7.029	6.597
Sawyer	-13.02	-11.76	-10.41	-8.55	-7.181	-6.025	-4.695	-2.871	-1.054	0.012	0.522	0.973	2.034	2.39
Steele	-12.8	-10.51	-6.836	-4.704	-3.088	-2.064	-1.473	-0.829	-0.287	0.4	1.005	1.356	1.959	2.706
Streeter	-12.38	-11.42	-8.95	-6.632	-5.145	-3.991	-3.503	-2.452	-0.994	-0.205	0.583	1.27	2.177	
Werner	13.12	13.67	14.63	15.07	14.97	14.21	13.64	12.81	11.85	10.95	10.14	9.32	8.68	8.13
(blank)														
Grand Total	-66.66	-74.43	-37.17	-71.39	-9.86	-123.8	-66.64	-39.91	-57.65	-119.3	-1.704	-25.12	-110.1	-50.99

Email from Elizabeth Tomlinson

Hi Greg,

My close contact has limited their work with ASCE's Committee on Adaptation due to her service with Biden's Administration. I have reached out to Dr. Mari Tye (chair of the ASCE committee on adaptation) and Dr. Giovannettone (chair of future weather and climate extremes). I'll make an introduction to you when they provide the best contact. Hopefully they have an expert on frost depth analysis in changing climates. I know they've published *Climate-Resilient Infrastructure: Adaptive Design and Risk Management*, MOP 140.

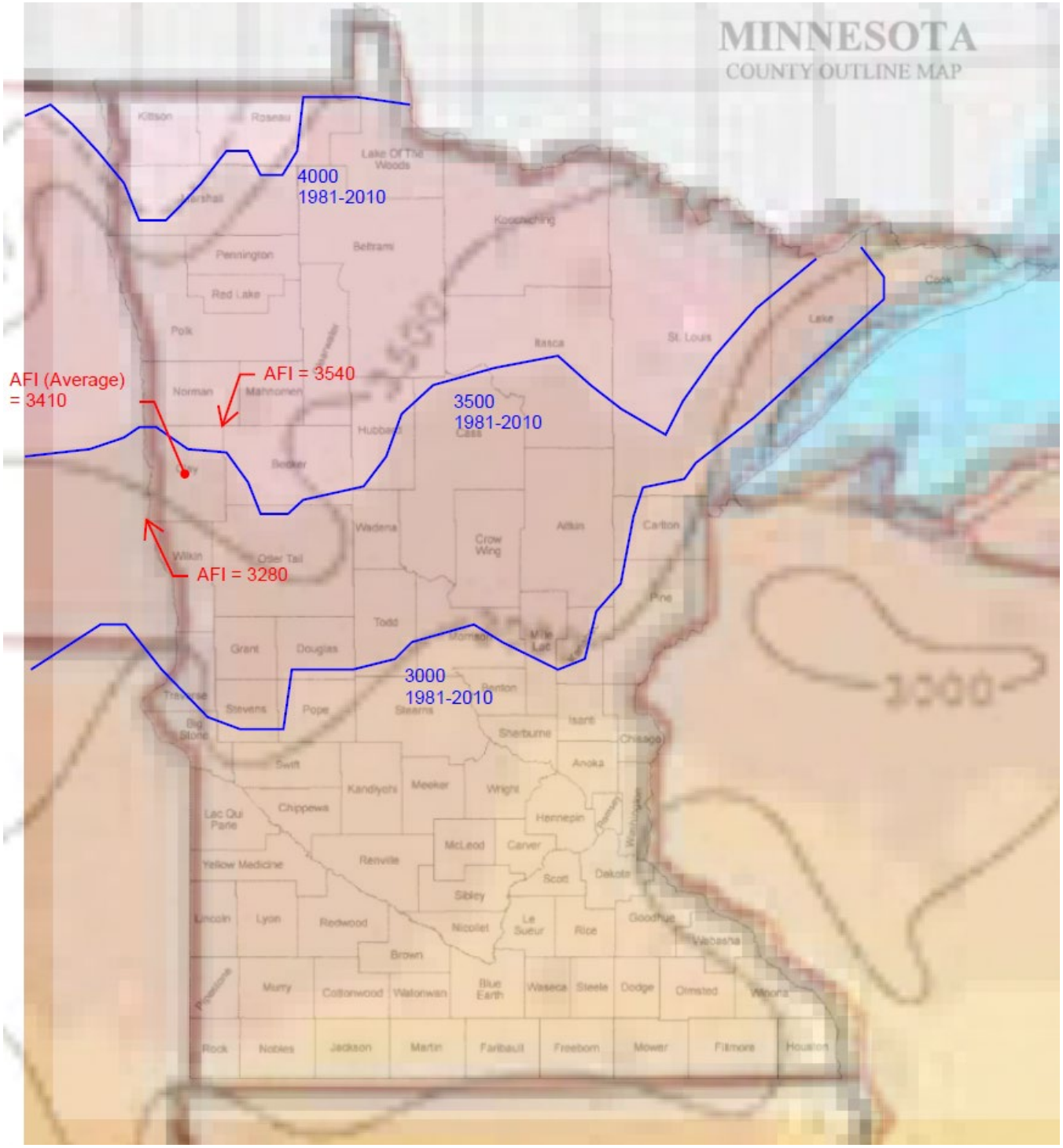
Chatting with Dr. Crawley, chair of ASHRAE TC4.2 Climatic Information/Standard 169, we both what to highlight to the TAG that ASHRAE's shifting climate zones represent ambient temperature and humidity averages only. The calculation presented for consideration during the last TAG meeting does rely on ambient air temperatures as a proxy for frost depth, but an engineer needs to also consider heat flow at the air-ground interface. Influences to those calculations include cloud cover, wind speed, surface characteristics, and snow coverage. I do not advise the TAG to raise footing levels based on ASHRAE's Climatic Zones alone, but rather consider the 'low probability/high risk' events in our changing climate that can cause structural failure. Changes to average snow coverage and long duration extreme temperature events, like a polar vortex, are specific concerns. I am not a civil engineer and respectfully defer to your TAG experts for their input on this matter.

Another resource of interest: MnDOT is currently researching climate change impacts on freeze/thaw cycles. Preliminary submission indicates a low risk of increasing freeze/thaw cycles, but I'm waiting for the peer review and publication. If this research is of interest, you may want to contact MnDOT.

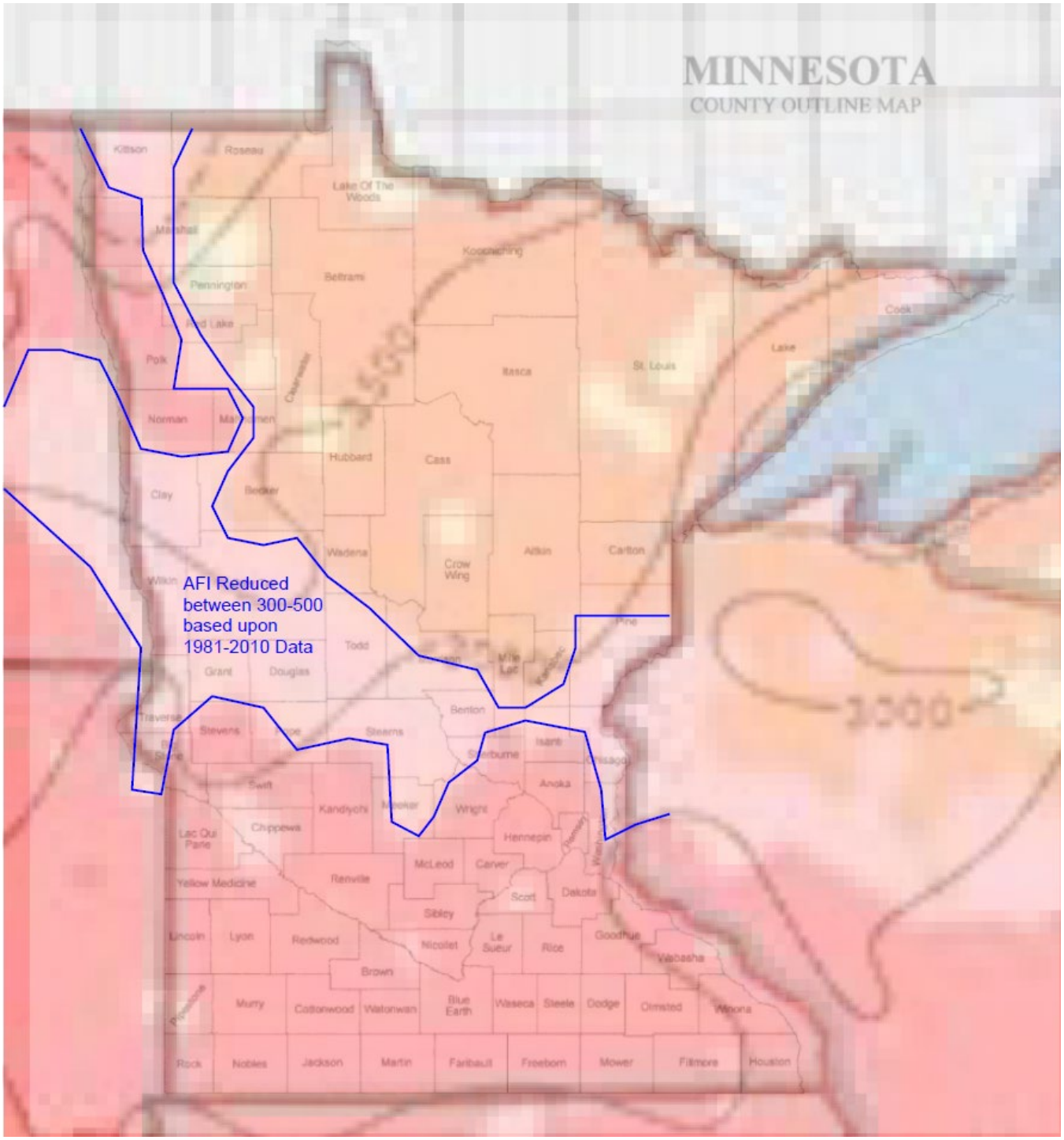
Sincerely,

Beth Tomlinson

1981-2010 AFI Colored Contours Overlay Over ASCE 32 AFI Contours Overlay Minnesota County Map provided by Mitch Okeson



1981-2010 AFI Change Colored Contours Overlay Over ASCE 32 AFI Contours Overlay Minnesota County Map provided by Mitch Okeson



Foundation Corner Cross Section Design provided by Mitch Okeson