Pipe Backfill Research and Design Standards

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Office of Project Development Conference

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North Dakota Department of Transportation

ETS Design Bridge Materials OPD Office of Project Development

Timeline

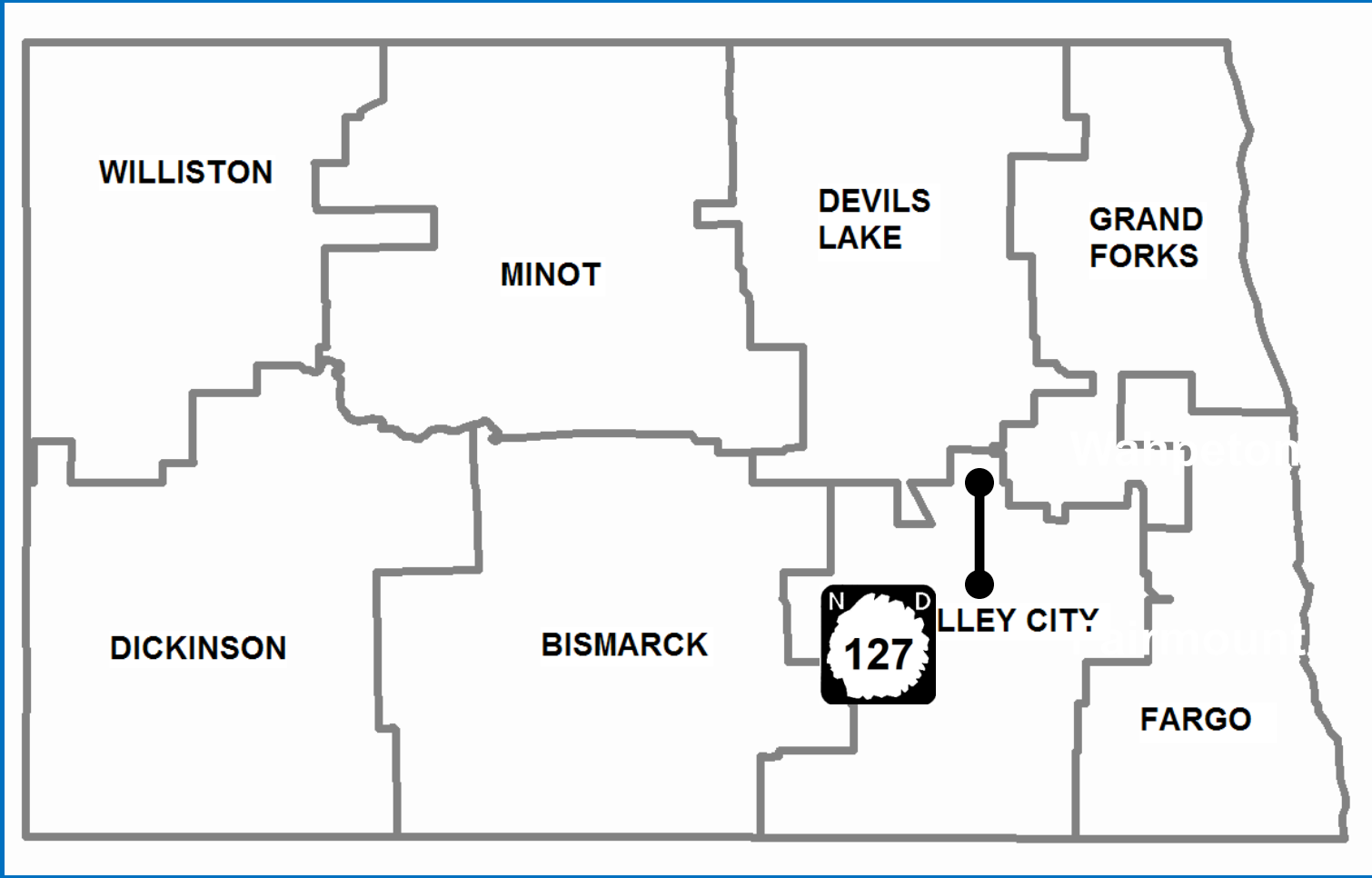
- Pre – 1997
  - No Backfill Detail
- Approx. 1997 – 2008
  - Backfill Detail(s)
- 2008
  - Standard Backfill Drawing
- 2009
  - Compaction Specification
- 2010 – 2013
  - Construction and Monitoring of Highway 127
- 2014 – Present
  - Frost Heaving Issues on Highway 1
  - Instrumentation and Monitoring in Devils Lake and Grand Forks Districts
- Future

Highway 127

Alternate Pipe Backfill Detail Test Sections

The purpose of this evaluation is to determine the factors behind the occurrences of a rough riding pavement in the form of dips or abrupt changes of the roadway profile above and adjacent to centerline pipes.

Project Location



Objective

The objective of this research is to identify a specific factor(s) or component(s) of the pipe installation that results in differential movements.

- Design
- Materials
- Construction

Design

The following are the factors that were addressed in the design phase:

- Pipe Materials – Concrete & Metal
- Backfill Material – Aggregate, Native & CDF
- Subgrade Transitioning – None, 20:1, 30:1
- Bedding Thickness – 6 Inches To 2 Feet
- Geotextile Fabric – Yes or No

Materials and Construction

- Density and Moisture Specifications
  - Aggregate Class 3M – 90% AASHTO T-180
    - 88% Success Rate
  - Native Backfill – 95% AASHTO T-99
    - 68% Success Rate

- Constructability
    - Backfill Materials

Monitoring

- Monitored 2 times per year from 2010-2013
- Visual, Physical Survey, and High Speed Profiler

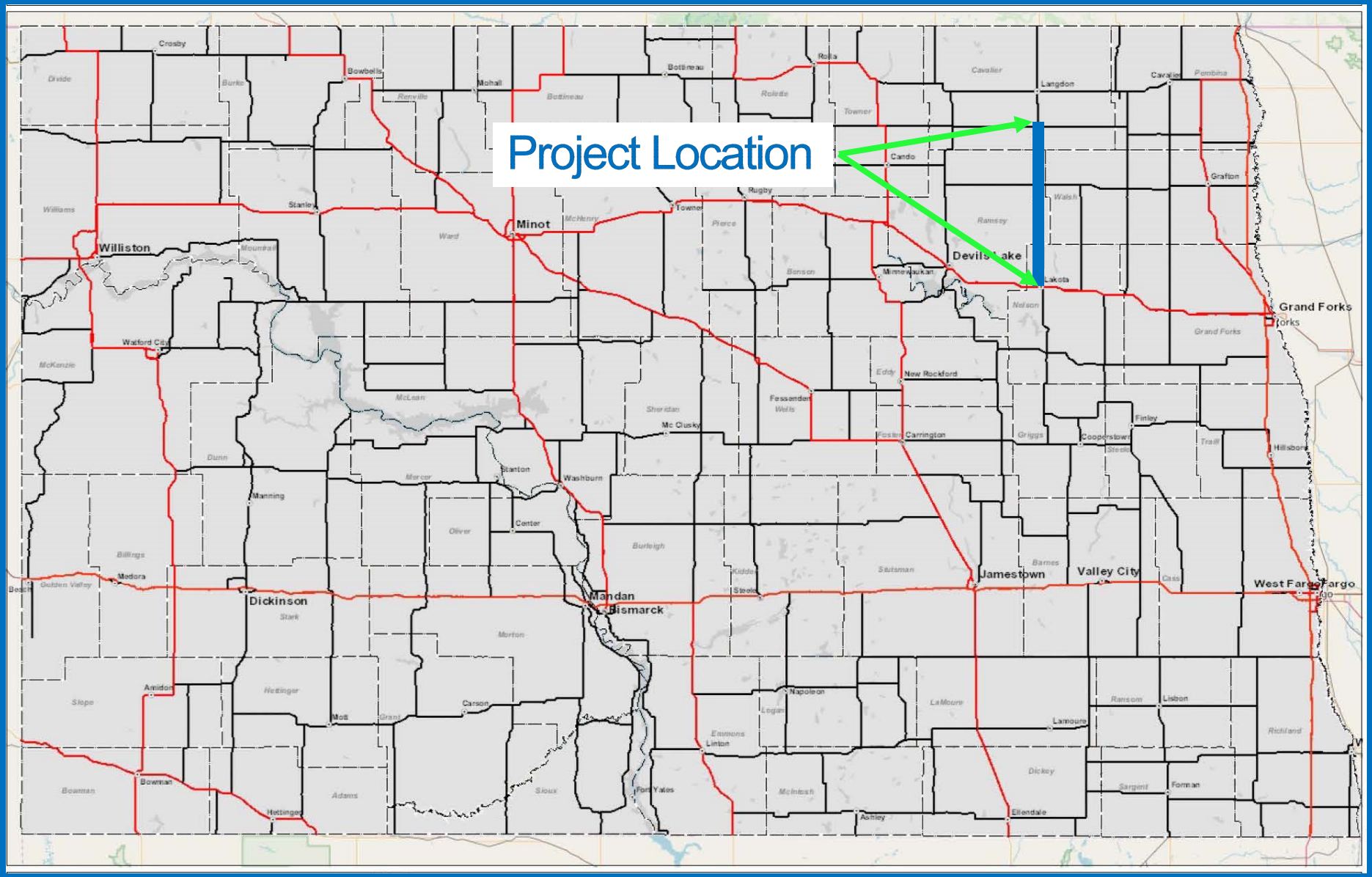
Conclusions

- Roadway performed the same for all alternatives
- With proper compaction and installation techniques the roadway rides sufficiently
- Standard backfill drawings allow pipe policy to be utilized

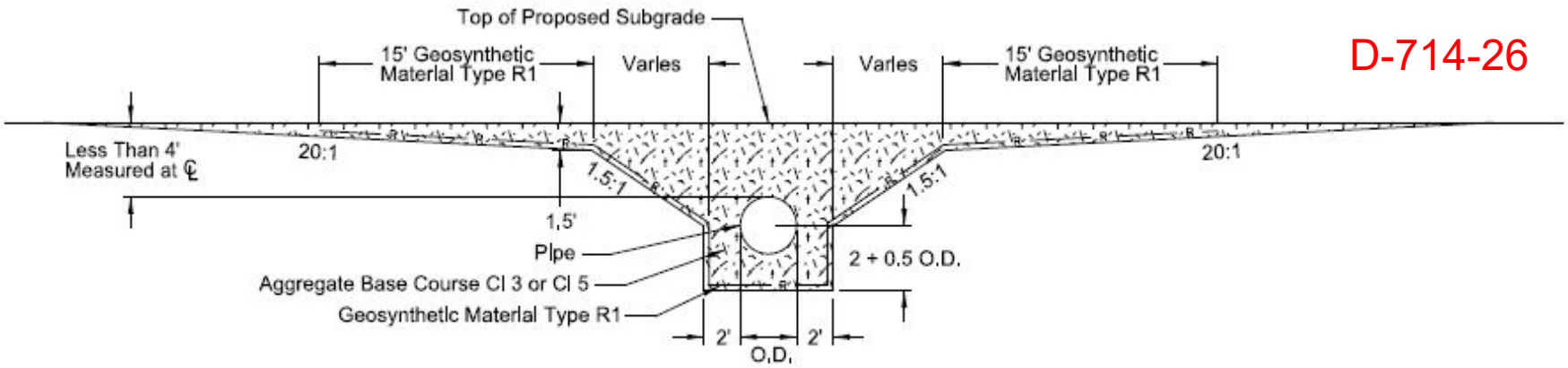
Highway 1
Severe Differential Heave at Pipes

- Replaced 111 Centerline Pipes on Two Projects on Highway 1 North of Lakota
- Pipes installed in 2013
- Severe Frost Heaving During the Winter of 2013-2014

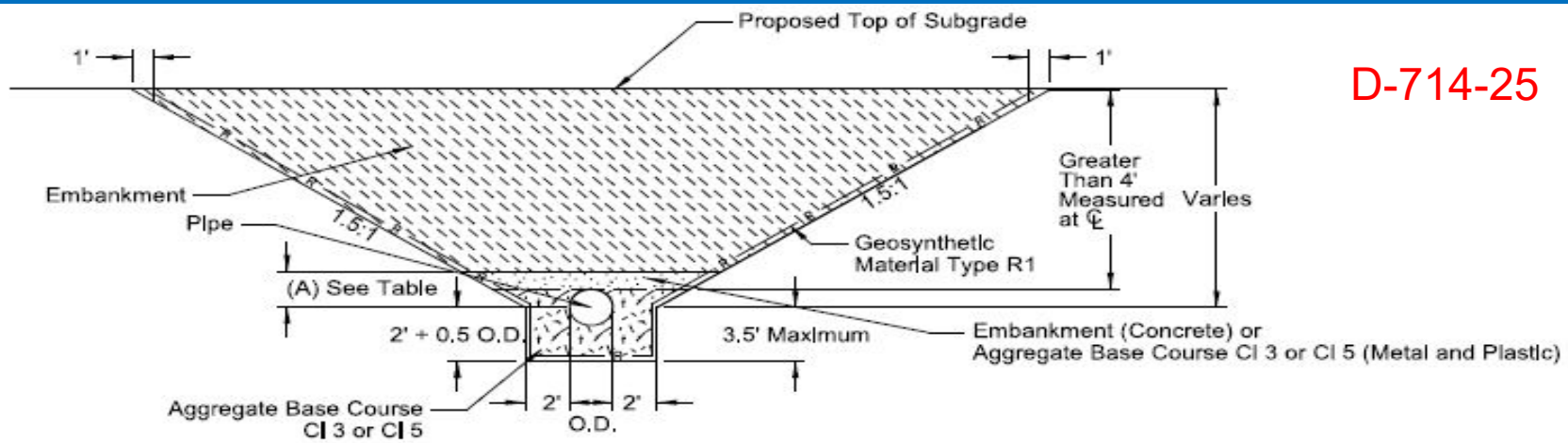
Location Map



Standard Drawings For Pipe Backfills

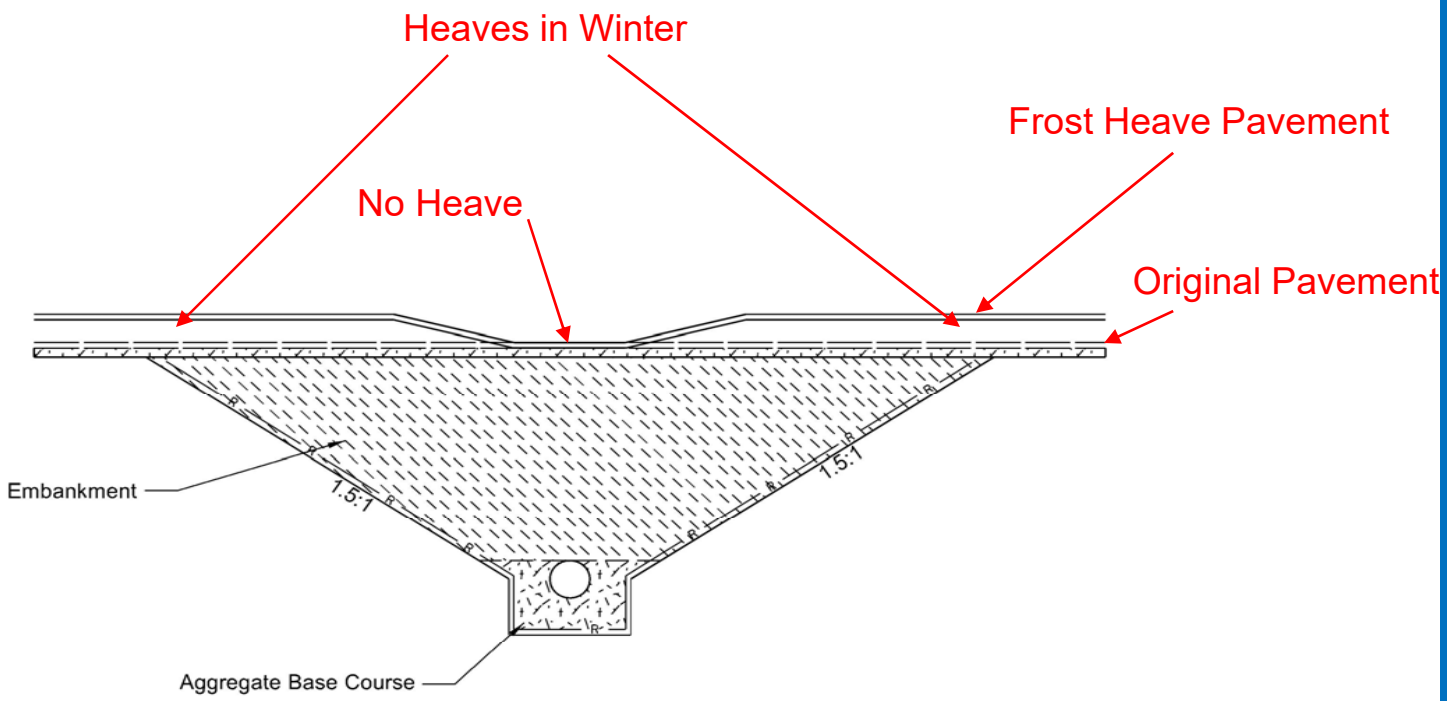


INSTALLATION DETAIL

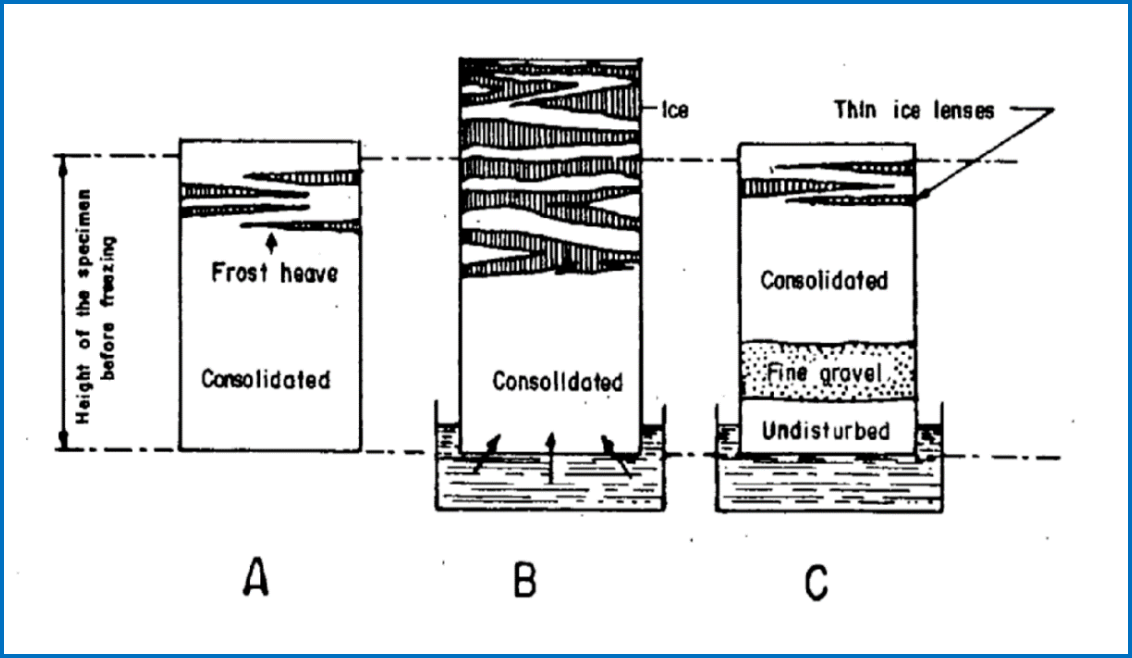


INSTALLATION DETAIL

Differential Heave in the Roadway Profile



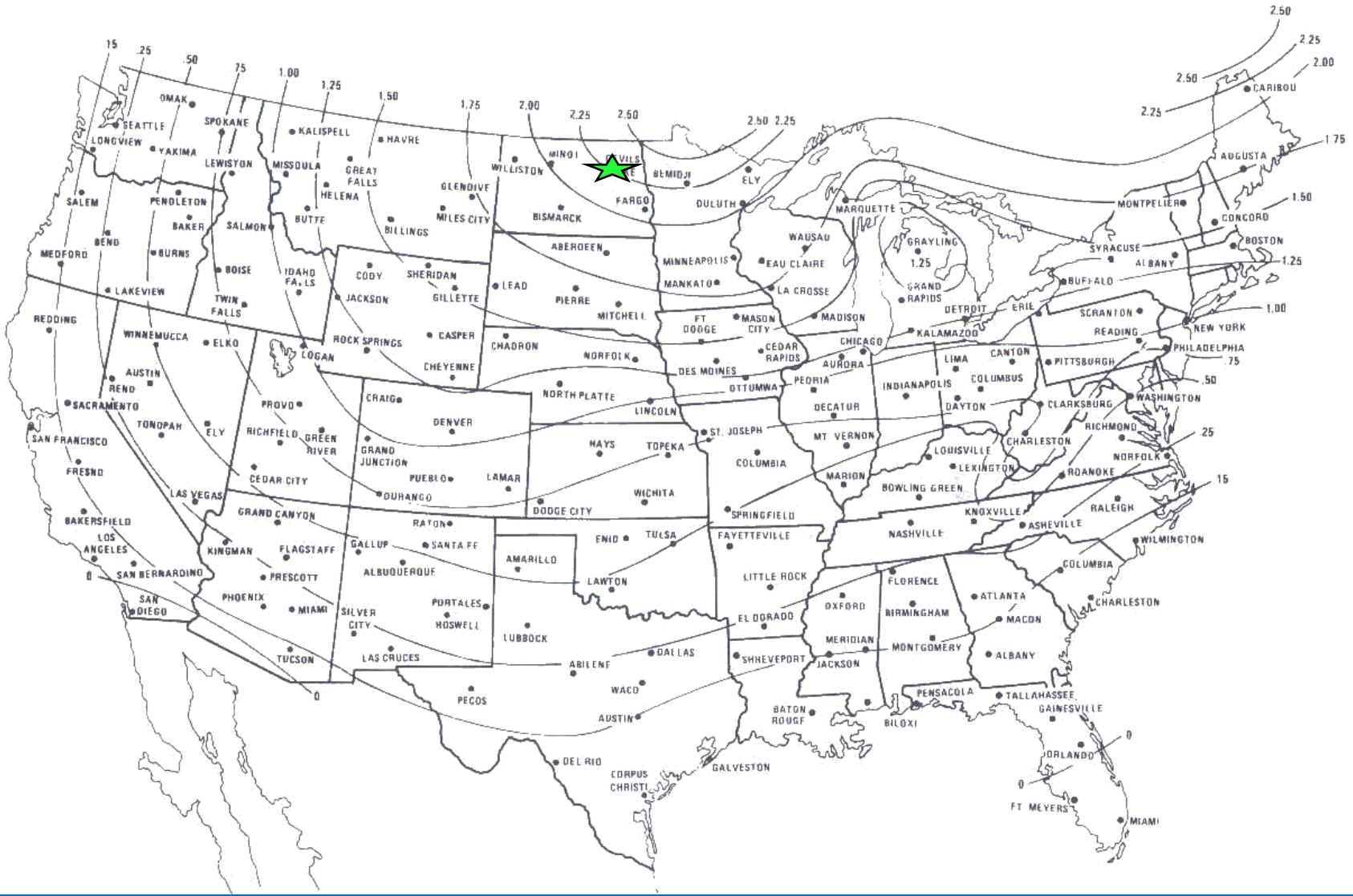
Frost Heaving



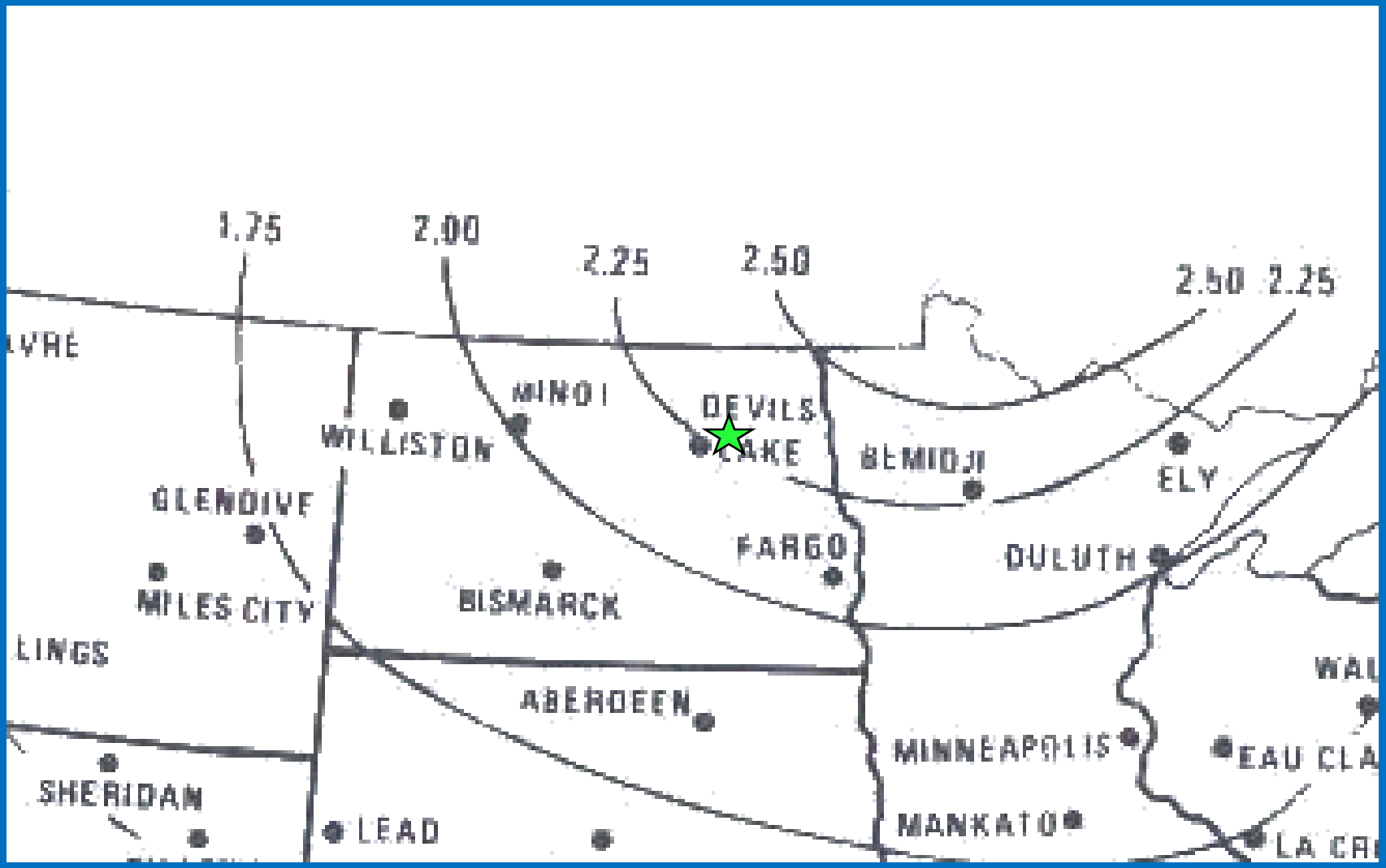
- Freezing Temperatures
- Frost Heave Susceptible Soil (Silty)
- Unobstructed access to a water source

It’s Plenty Cold….

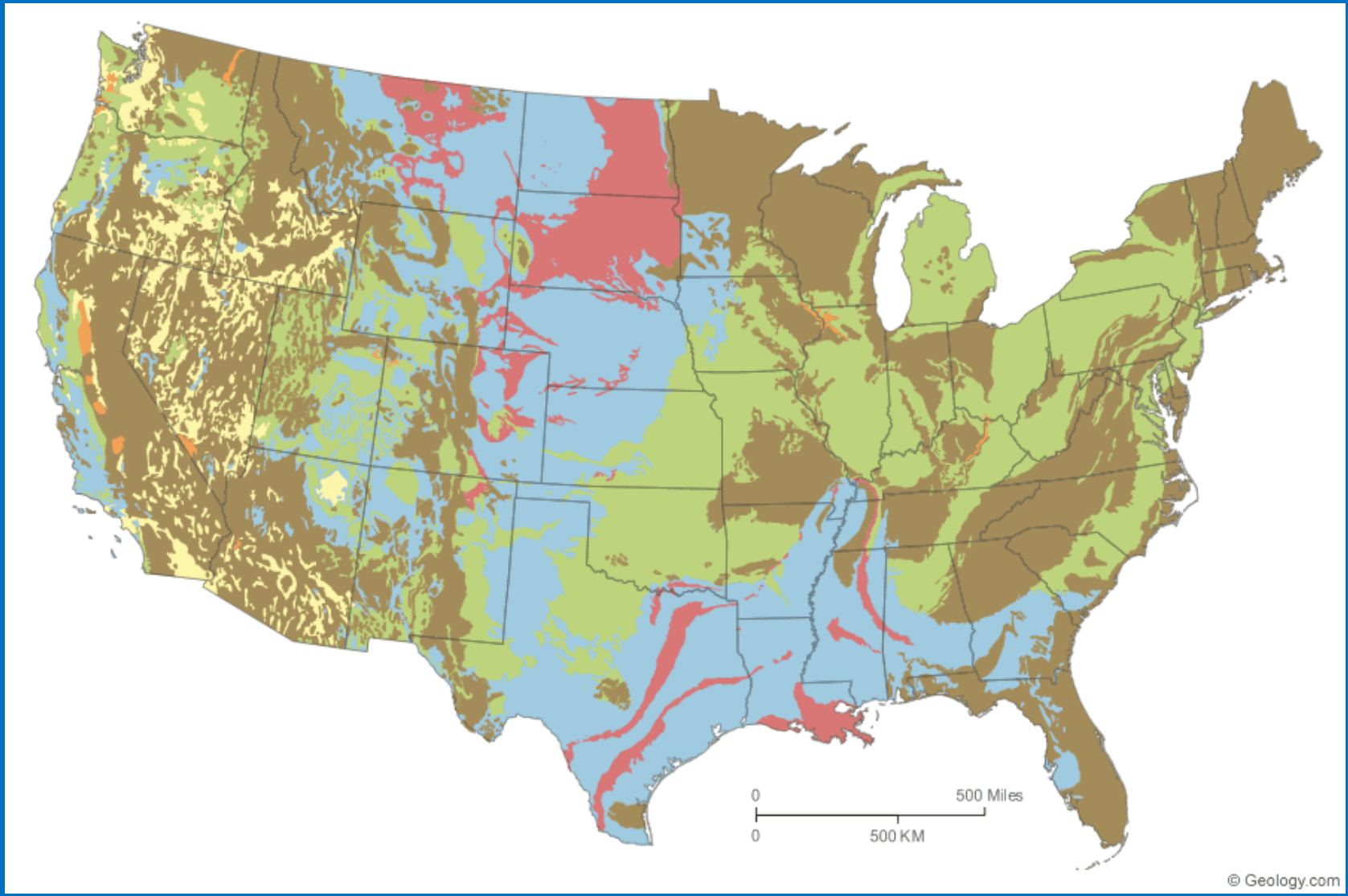
NOAA Frost Depth Map



NOAA Frost Depth Map



Expansive Soils Map



Study, Research and Collaboration

- Worked with Grand Forks and Devils Lake Districts
- Peers in Other States
- Extensive Literature Review

- What do we know?
- What do we want to know?

Instrumentation of Frost Heaving at Pipe Locations

- Instrumentation Procured by M&R
- Transportation Innovative Program (TRIP)

Instrumentation Locations

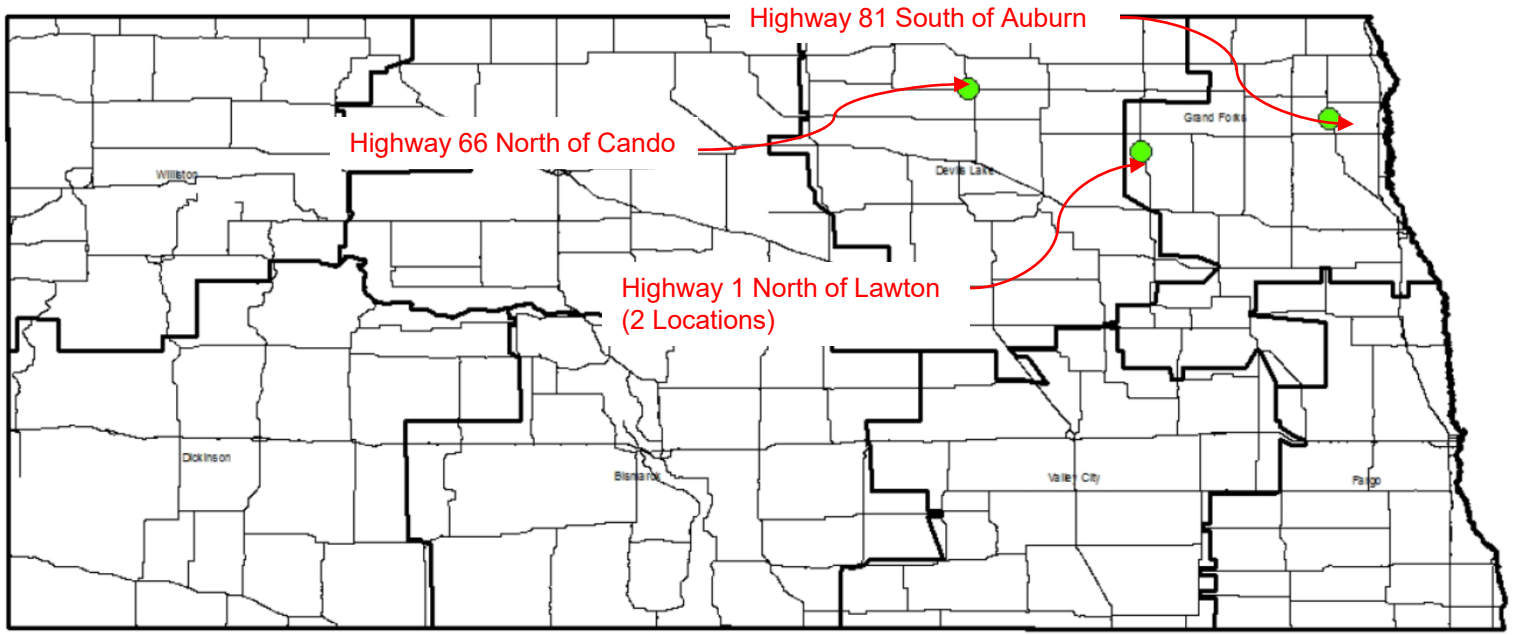


Figure 1: Installation Locations

Thermistors

- Thermistors placed on strings will measure temperature at one foot intervals in the roadway embankment

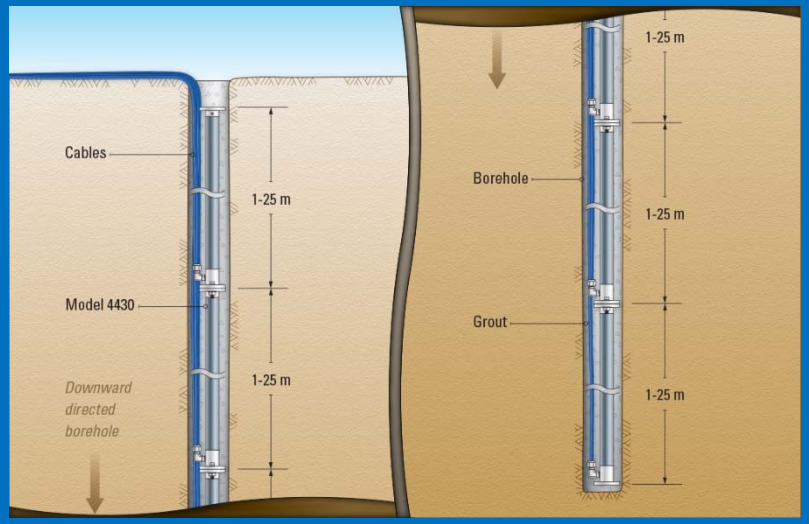
- These will show how the frost penetrates the roadway embankment

Piezometers

- With piezometers we can determine the depth of the groundwater at each location

- With installations at varying depths of groundwater a correlation could be made for a depth of groundwater vs. differential movement at pipe locations

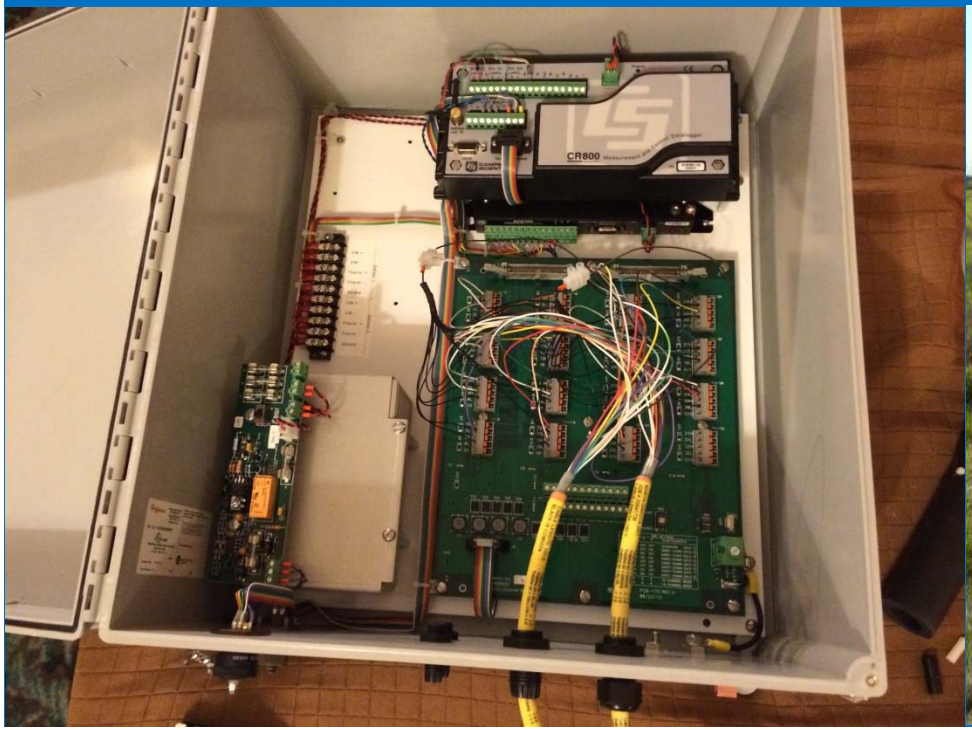
Deformation Meters



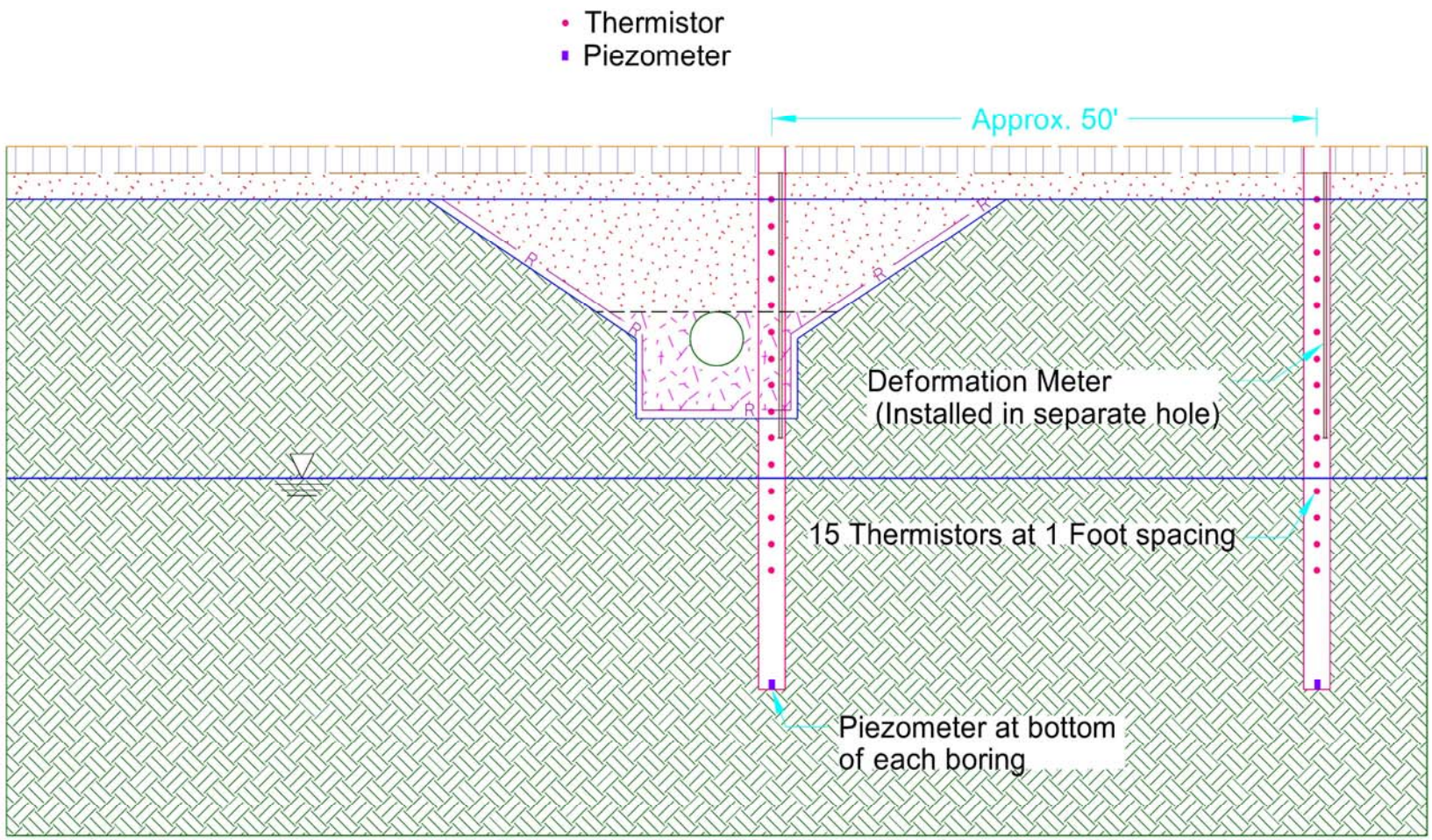
- 10 feet long
- Measures the amount of Vertical Movement in the soil.
- Logging reading at a specified level so it can be correlated to the thermistor data.

Loggers

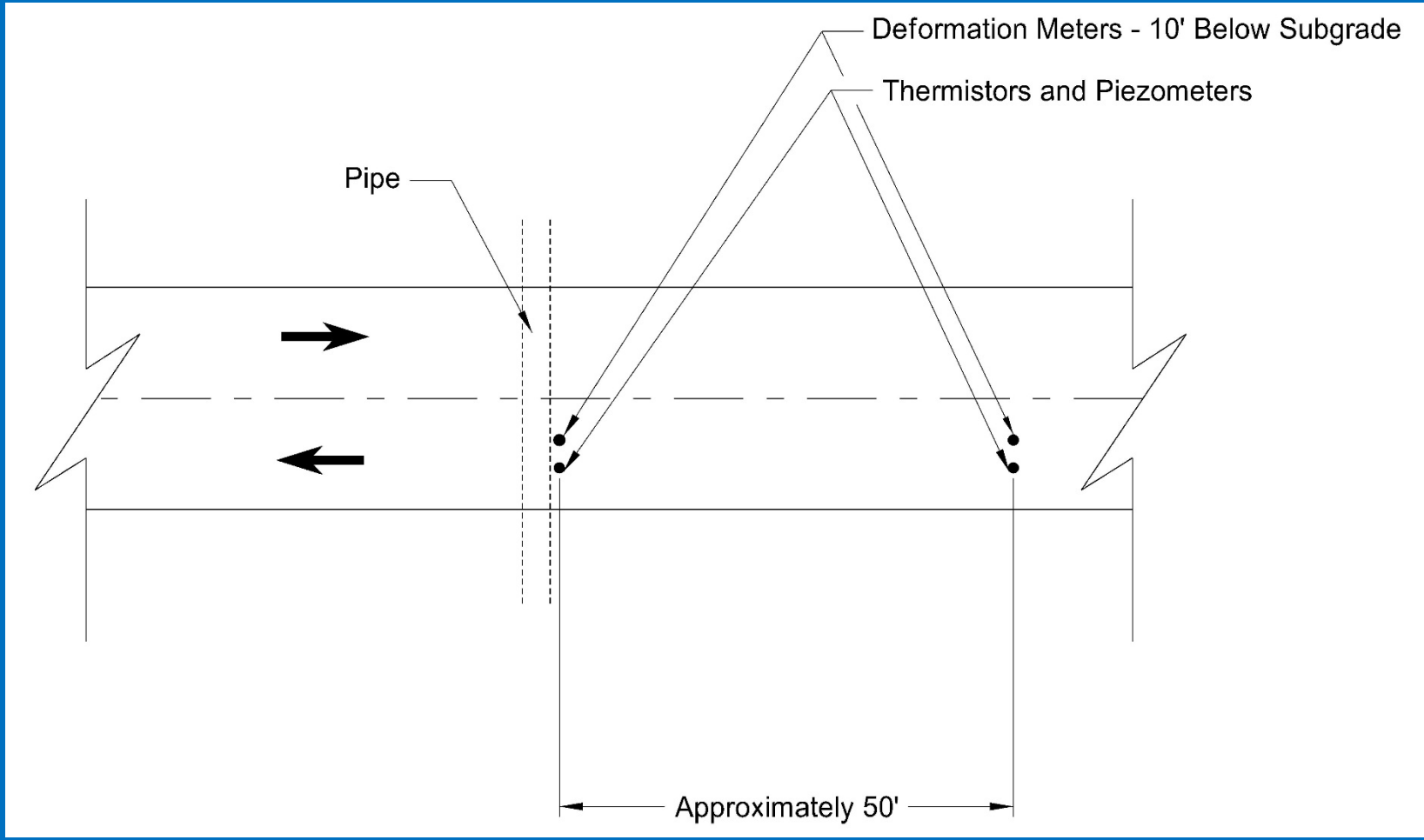
- The Loggers read the piezometers and thermistors at a prescribed interval
- The data is stored until it can be downloaded from the installation via a handheld computer



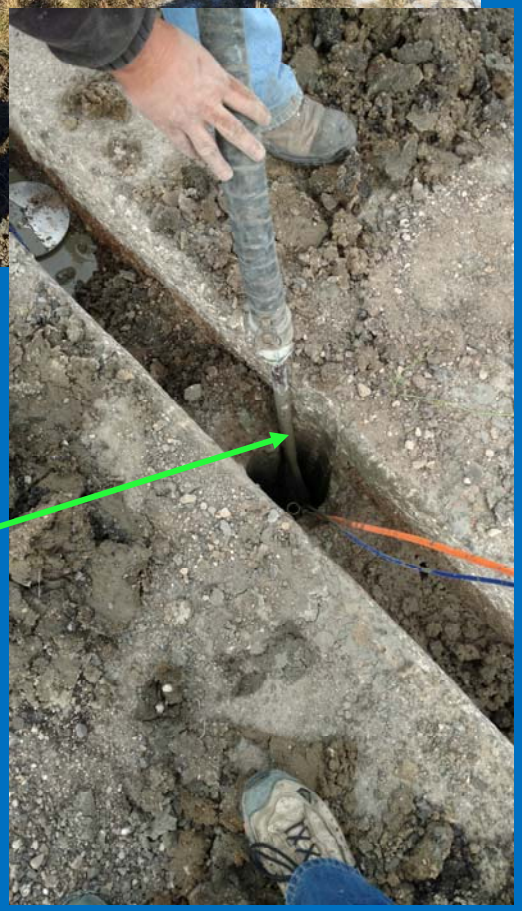
Installation Detail



Plan View Installation



677
S130

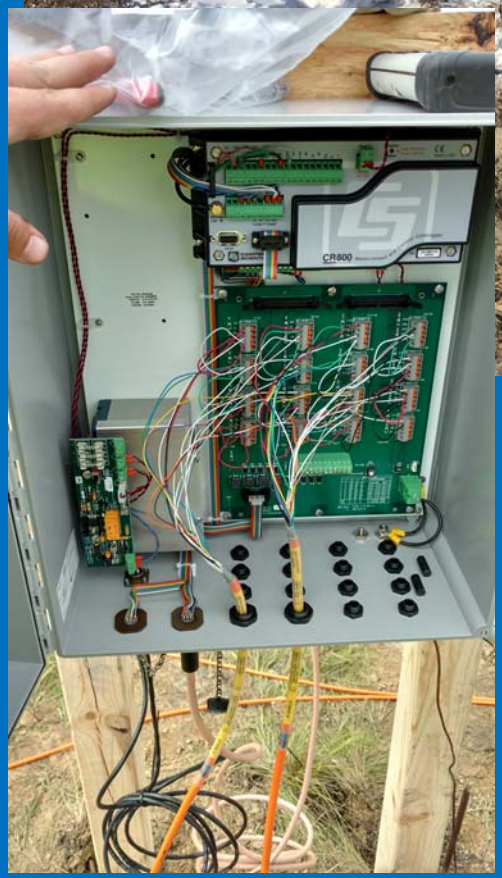


Sacrificial 1” PVC

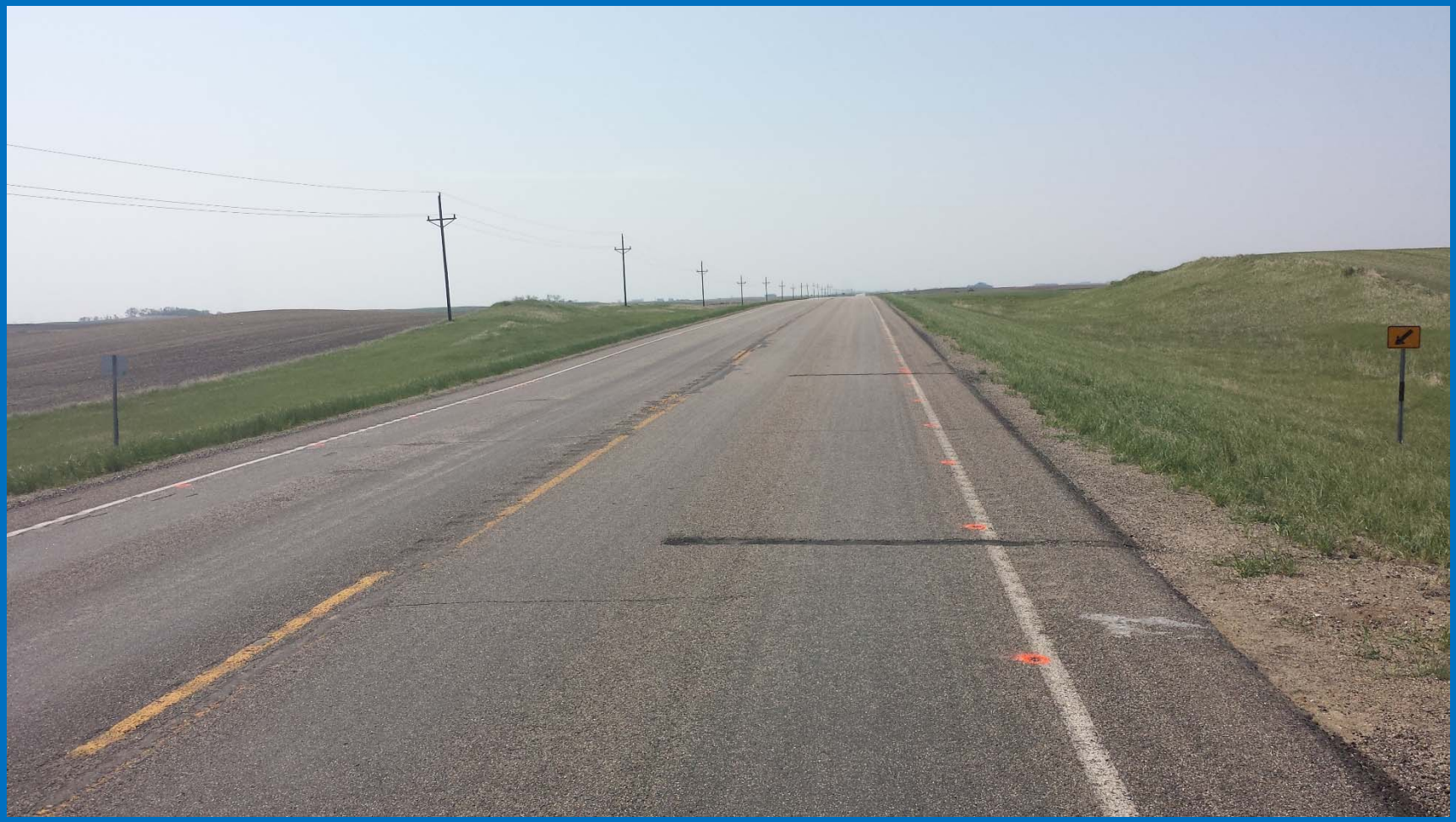
Grout

RENTAL

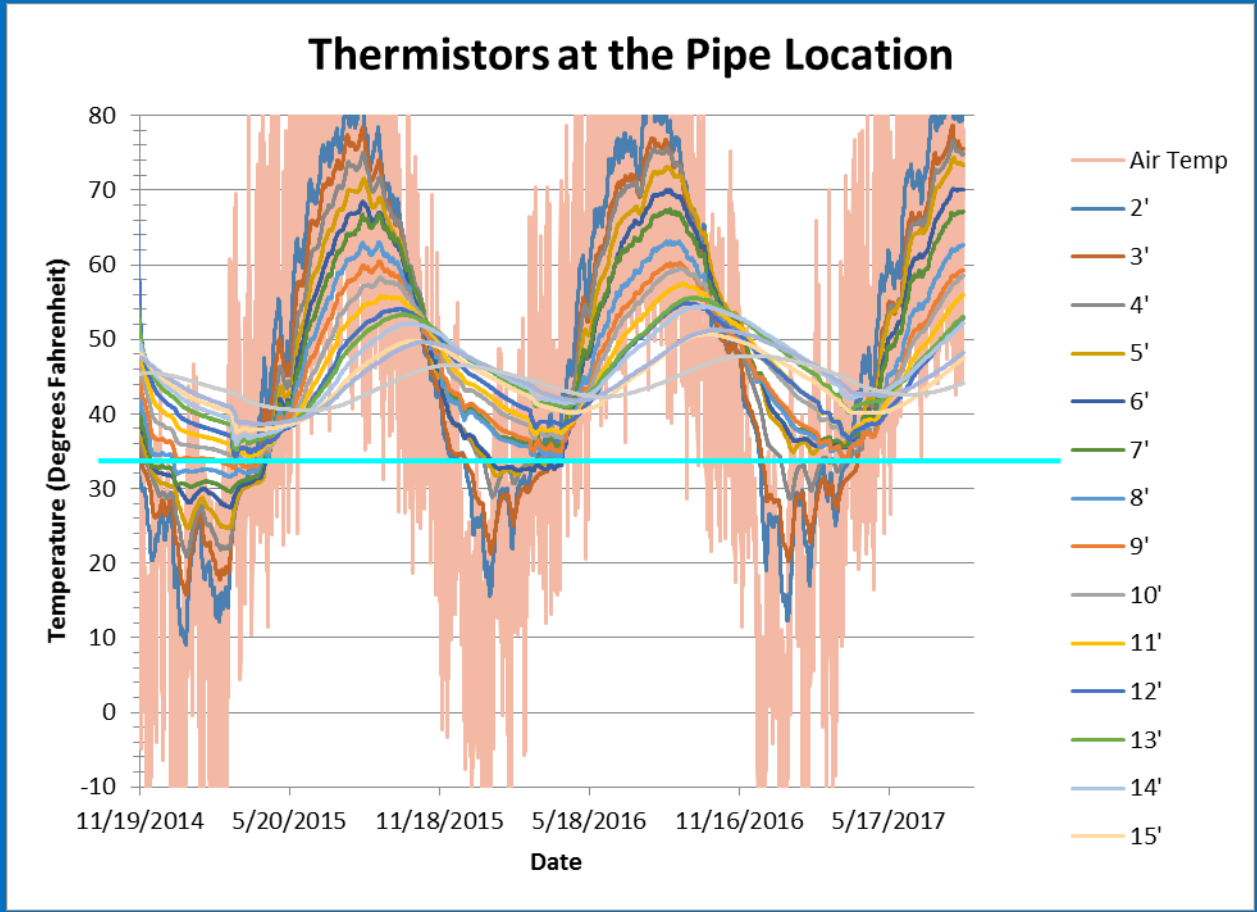
S130


CR800

Installation And Monitoring



Outputs


Thermistors at the Pipe Location
Temperature (Degrees Fahrenheit)
80
70
60
50
40
30
20
10
0
-10
11/19/2014
5/20/2015
11/18/2015
5/18/2016
11/16/2016
5/17/2017
Date
Air Temp
2'
3'
4'
5'
6'
7'
8'
9'
10'
11'
12'
13'
14'
15'

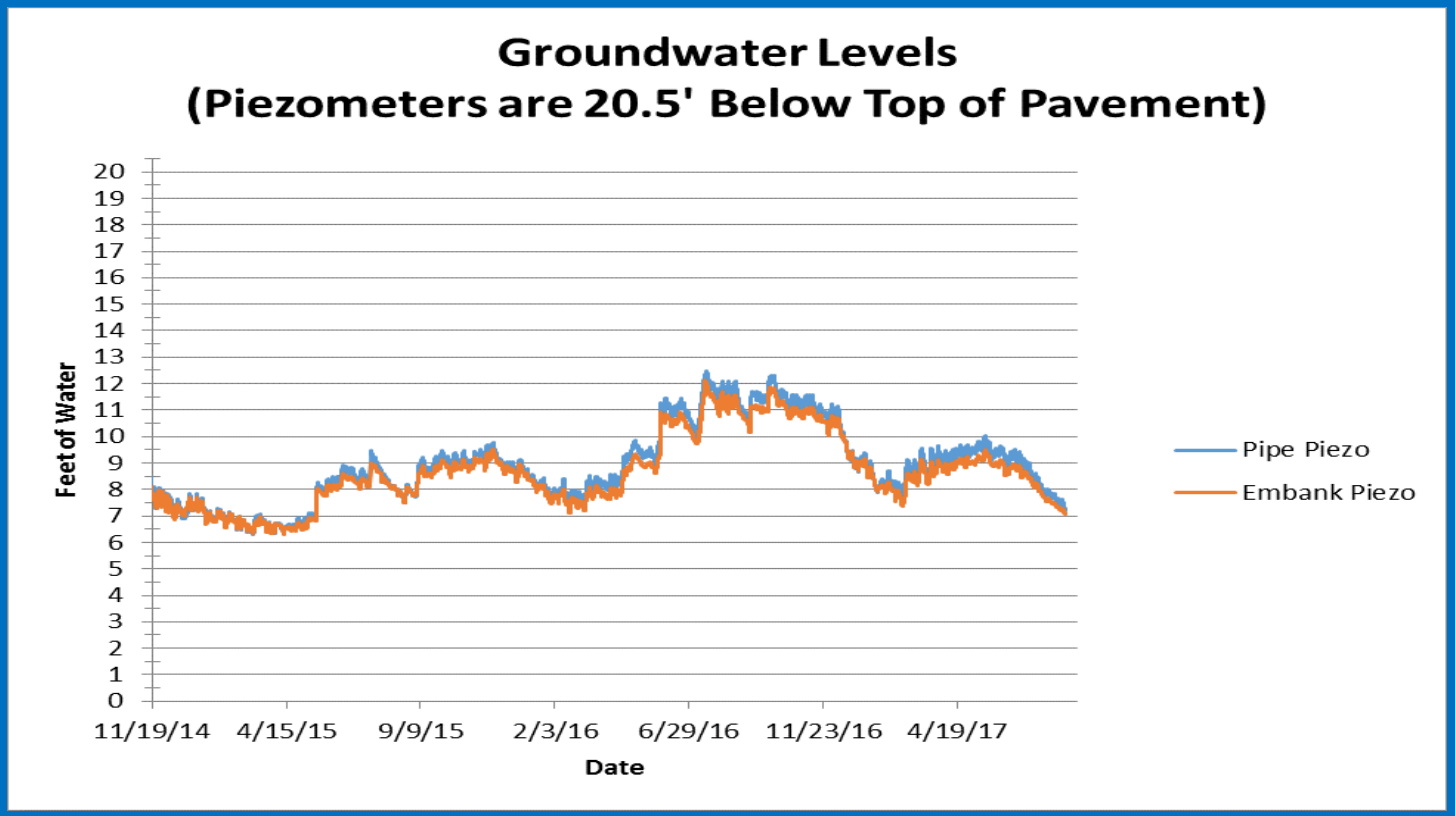
Outputs

Pipe Thermistors

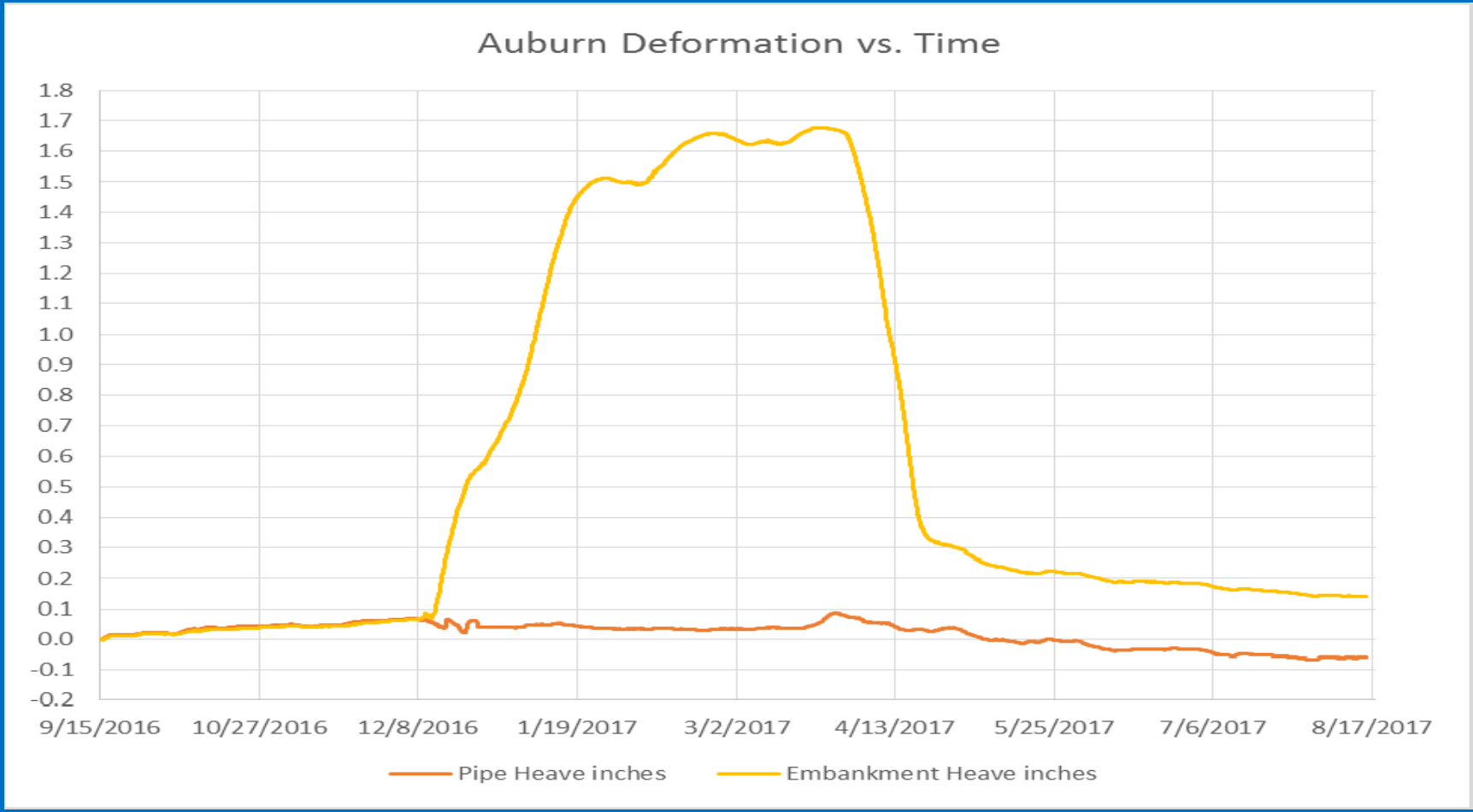
2'	24.1	24.0	23.8	23.7	23.5	23.3	23.2	23.0	22.8
3'	30.5	30.4	30.4	30.4	30.4	30.3	30.3	30.3	30.2
4'	32.3	32.3	32.3	32.3	32.3	32.2	32.2	32.2	32.2
5'	33.5	33.5	33.4	33.4	33.3	33.3	33.3	33.2	33.2
top of pipe at 6.25 6'	34.5	34.4	34.4	34.3	34.3	34.2	34.1	34.1	34.0
7'	34.8	34.7	34.6	34.5	34.4	34.3	34.2	34.1	34.0
invert of pipe at 8.25 8'	36.7	36.6	36.5	36.4	36.3	36.2	36.1	36.0	35.9
9'	39.0	39.0	38.9	38.9	38.8	38.7	38.7	38.6	38.5
10'	41.5	41.5	41.4	41.4	41.3	41.3	41.2	41.2	41.1
11'	43.6	43.5	43.5	43.5	43.4	43.4	43.4	43.3	43.3
12'	45.1	45.1	45.0	45.0	45.0	45.0	45.0	44.9	44.9
13'	46.1	46.1	46.1	46.1	46.1	46.0	46.0	46.0	46.0
14'	46.5	46.5	46.4	46.4	46.4	46.4	46.4	46.4	46.4
15'	46.6	46.6	46.5	46.5	46.5	46.5	46.5	46.5	46.5
16'	46.7	46.7	46.7	46.7	46.7	46.7	46.7	46.6	46.6
20.5'	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5
Embankment Thermistors									
date	11/30/2014	11/30/2014	11/30/2014	12/1/2014	12/1/2014	12/1/2014	12/1/2014	12/1/2014	12/1/2014
air	-6.7	-8.5	-11.6	-13.9	-17.2	-20.2	-20.0	-10.1	3.3
2'	29.0	28.9	28.8	28.6	28.6	28.4	28.3	28.1	27.9
3'	34.1	34.0	34.0	34.0	33.9	33.9	33.9	33.9	33.8
4'	37.2	37.2	37.2	37.1	37.1	37.1	37.1	37.1	37.0
5'	40.2	40.2	40.2	40.1	40.1	40.1	40.1	40.0	40.0
top of pipe at 6.25 6'	42.9	42.9	42.9	42.8	42.8	42.7	42.7	42.7	42.7
7'	45.2	45.1	45.1	45.1	45.1	45.0	45.0	45.0	45.0
invert of pipe at 8.25 8'	46.9	46.8	46.8	46.8	46.8	46.8	46.7	46.7	46.7
9'	48.1	48.1	48.1	48.0	48.1	48.0	48.0	48.0	48.0
10'	48.7	48.7	48.7	48.7	48.6	48.6	48.6	48.6	48.6
11'	48.6	48.6	48.6	48.6	48.6	48.5	48.5	48.5	48.5
12'	49.1	49.1	49.1	49.1	49.0	49.0	49.0	49.0	49.0
13'	48.9	48.9	48.9	48.9	48.8	48.8	48.8	48.8	48.8
14'	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4
15'	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1
16'	47.7	47.7	47.6	47.6	47.7	47.6	47.6	47.6	47.6
20.5'	45.1	45.1	45.1	45.1	45.1	45.1	45.1	45.1	45.1

Embankment Thermistors

Outputs


Groundwater Levels
(Piezometers are 20.5' Below Top of Pavement)
Feet of Water
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
11/19/14
4/15/15
9/9/15
2/3/16
6/29/16
11/23/16
4/19/17
Date
Pipe Piezo
Embank Piezo

Outputs

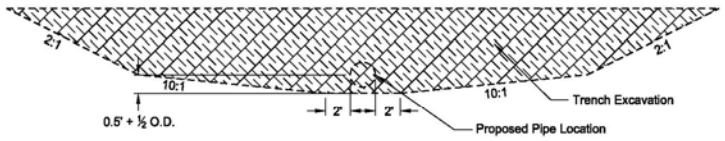

Auburn Deformation vs. Time
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
9/15/2016
10/27/2016
12/8/2016
1/19/2017
3/2/2017
4/13/2017
5/25/2017
7/6/2017
8/17/2017
Pipe Heave inches
Embankment Heave inches

Conclusions

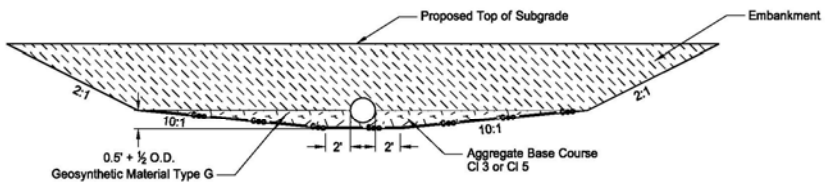
- Minimize Aggregate (More “like” material)
  - Bedding
  - Pipe Envelope
  - Limitations
- Remove Vertical Trench (Transitions)
- Current Standard Drawings Still Works For Most of The State

Alternative Pipe Backfill Detail

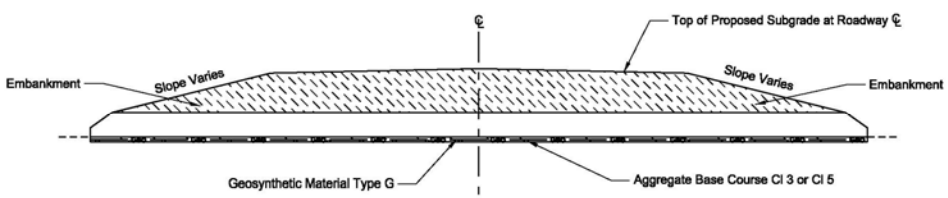
STATE	PROJECT NO.	SECTION NO.	SHEET NO.
ND		20	



EXCAVATION DETAIL



INSTALLATION DETAIL



CROSS SECTION

Pay Items
1) Pipe*
2) Geosynthetic Material Type G
3) Removal of Pipe (if required)

*Included in Pipe Pay Item
1) Pipe
2) Trench Excavation
3) Aggregate Base Course Cl 3 or Cl 5
4) Embankment

NOTES:

1) Embankment may be either Borrow Excavation or Common Excavation - Type A. Borrow Excavation is required to have a Group and Subgroup Classification the same as the excavated material as defined by AASHTO M 145. Common Excavation - Type A is required to be the material excavated during trench excavation.

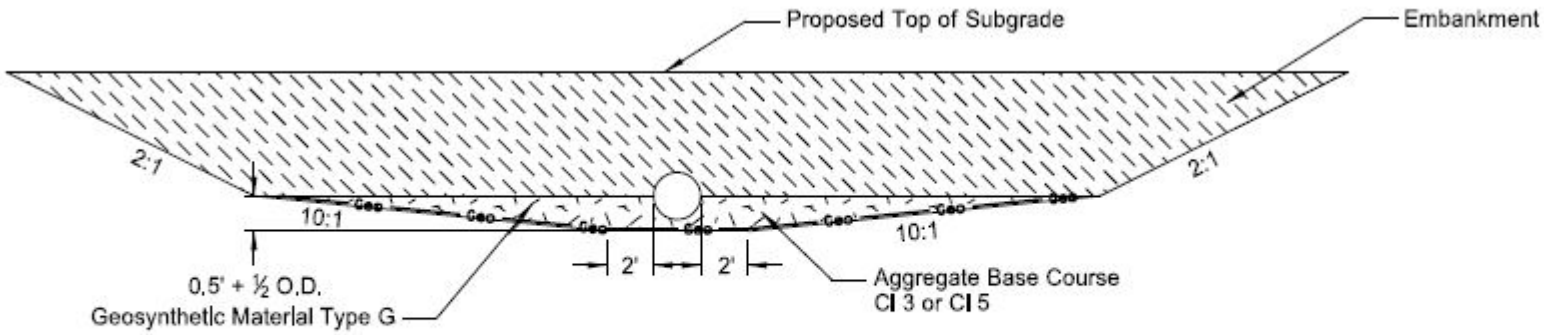
This document is preliminary and not for construction or implementation purposes.

PRELIMINARY

Pipe Backfill Detail
for Centerline Pipes

8/28/2017 7:34:12 AM cschwegler F:\LAB\GEOTECHNICAL\Detail Drawings\Pipe backfill\Alternate Pipe Backfill Detail\Alt Pipe Detail Feb 2017.dgn

Alternative Pipe Backfill Detail



INSTALLATION DETAIL

Future

- Additional modifications to pipe backfill details as we continue to collect and analyze data
- Feedback or ideas from designers and field staff
  - Scoping Meetings
  - Field Reviews
  - Constructability
  - Etc.
- Frost heave inventory app
  - Part of our Geotechnical Asset Management Program

Comments/Questions?

CONTACT

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