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5. Title and Subtitle

Base Reinforcement Using Geogrid

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Work Plan ☐
Construction ☐
Evaluation ☐
Final ☒

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*see supplementary notes

North Dakota DOT
Materials and Research Division
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13. Sponsoring Agency Name and Address

North Dakota DOT
Materials and Research Division
300 Airport Road
Bismarck ND 58504-6005

14. Supplementary Notes

15. Abstract

Purpose and Need

North Dakota's aging highways are being rehabilitated with thicker base sections to improve pavement performance. These bases are being constructed with virgin aggregates and blends of recycled materials to provide adequate drainage and support for the pavement. Most of the aggregate used is a local material that is being depleted and is becoming harder to find. The North Dakota Department of Transportation (NDDOT) is looking at ways to improve the performance of the pavement, decrease future maintenance costs, conserve aggregate resources, and reduce the time needed to rehabilitate the roadway

Objective

The objective of this study is to determine if using Geogrid as a base reinforcement will provide the performance characteristics required, while reducing aggregate use and construction time.

Scope

The experimental feature is on project NH-4-052(044)058 which is located on US Highway 52 from Donnybrook to Carpio. Three different sections were designed and are as follows: **Section 1** (Control) –Length 0.5 miles, Sta 3260+44 to Sta 3286+84; **Section 2** – Length 0.5 miles, Sta 3286+84 to Sta 3313+24; **Section 3** – Length 0.5 miles, Sta 3313+24 to Sta 3339+64. The evaluation period is 10 years or until failure. Every two years the experimental feature will be evaluated and a report generated. The performance of each section will be monitored and evaluated for the following:

- Distresses (e.g., cracks, rutting, etc.) in the different sections.
- Overall pavement condition.
- Maintenance costs.
- FWD Comparisons (after construction and on a biannual basis). The FWD testing will be conducted in the early fall to coincide with the completion of the project.
- Performance of each section. Performance of each section will be judged on the number of distresses, overall pavement condition, maintenance costs, and FWD data.

Summary

From 2004 to 2010, the three experimental sections showed no visual distresses. It was observed in the fourth evaluation in 2012 that Section 3 has rutting in the wheel paths. Section 1 (the control section) has 2 transverse cracks and Section 2 has no visual distresses. In 2013 and 2014 it was observed that rutting was occurring in all of the sections and it was 1/8" to 1/2" over the length of the project. In 2014, there were new cracks in all of the sections which were one transverse shoulder crack in section 1, one transverse crack in Section 2 and one longitudinal crack, four transverse cracks and one transverse shoulder crack in Section 3 during the evaluation in 2014. . From 2015 to 2017, there is no significant difference from previous evaluation. The visual observations and the data that was collected from the three experimental sections are included in this report.

16. Key Words

Base Reinforcement
Geogrid

17. Distribution Statement

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NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION

Experimental Study ND 2002-01

Base Reinforcement Using Geogrid

Fifth Evaluation Report

NH-4-052(044)058

February 2015

Prepared by

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

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Ron Horner

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT	EXPERIMENTAL PROJECT NO. 1 — STATE: ND, YEAR: 2002, NUMBER: 01, SURF:	CONSTRUCTION PROJ NO: NH-4-052(044)058		LOCATION: Ward & Renville Co.
	EVALUATION FUNDING 48: 1 x HP&R; 2 x CONSTRUCTION; 3 DEMONSTRATION; 4 IMPLEMENTATION	NEEP NO. 49		PROPRIETARY FEATURE? 51: x Yes; No
SHORT TITLE	TITLE 52: Base Reinforcement Using Geogrid			
THIS FORM	DATE 140 — MO. 2 -- YR. 09	REPORTING 1 INITIAL; 2 X ANNUAL; 3 FINAL		
KEY WORDS	KEY WORD 1: Base Reinforcement	KEY WORD 2: Geogrid		
	KEY WORD 3:	KEY WORD 4:		
	UNIQUE WORD 233:	PROPRIETARY FEATURE NAME: TENSAR		

CHRONOLOGY	Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:
	277	281 — 7-03	285 — 2013	289	293

QUANTITY AND COST	QUANTITY OF UNITS (ROUNDED TO WHOLE NUMBERS)	UNITS	UNIT COST (*Dollars, Cents*)
	297 — 25,031	305 — 1 LIN. FT; 2 x SY; 3 SY-IN; 4 CY; 5 TON; 6 LBS; 7 EACH; 8 LUMP SUM	306 — $2.78

AVAILABLE EVALUATION REPORTS	CONSTRUCTION	PERFORMANCE	FINAL
315	X	X	

EVALUATION	CONSTRUCTION PROBLEMS	PERFORMANCE
	318 — 1 X NONE; 2 SLIGHT; 3 MODERATE; 4 SIGNIFICANT; 5 SEVERE	319 — 1 EXCELLENT; 2 GOOD; 3 X SATISFACTORY; 4 MARGINAL; 5 UNSATISFACTORY

APPLICATION			
320	1 ADOPTED AS PRIMARY STD.; 2 PERMITTED ALTERNATIVE; 3 ADOPTED CONDITIONALLY	4 X PENDING; 5 REJECTED; 6 NOT CONSTRUCTED	*(Explain in remarks if 3, 4, 5, or 6 is checked)*

REMARKS	
	321 From 2004 to 2010, the three experimental sections showed no visual distresses. It was observed in the fourth evaluation in 2012 that Section 3 has rutting in the wheel paths. Section 1 (the control section) has 2 transverse cracks and Section 2 has no visual distresses. In 2013 and 2014 it was observed that rutting was occurring in all of the sections and it was 1/8" to 1/2" over the length of the project. In 2014, there were new cracks in all of the sections which were one transverse shoulder crack in section 1, one transverse crack in Section 2 and one longitudinal crack, four transverse cracks and one transverse shoulder crack in Section 3 during the evaluation in 2014. The visual observations and the data that was collected from the three experimental sections are included in this report.

Experimental Study ND 2002-01

Base Reinforcement Using Geogrid

Fourth Evaluation Report

NH-4-052(044)058

March 2015

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Disclaimer

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Fifth Evaluation Report

Base Reinforcement Using Geogrid

ND 2002-01

Purpose and Need

North Dakota's aging highways are being rehabilitated with thicker base sections to improve pavement performance. The bases are being constructed with virgin aggregates and blends of recycled materials to provide adequate drainage and support for the pavement. Most of the aggregate used is a local material that is being depleted and is becoming harder to find. In some areas, aggregate is being brought in from surrounding states, which adds substantial costs to rebuilding the roadway.

The North Dakota Department of Transportation (NDDOT) is looking at ways to improve the performance of the pavement, decrease future maintenance costs, conserve aggregate resources, and reduce the time needed to rehabilitate the roadway.

Objective

The objective of this study is to determine if using geogrid as a base reinforcement will provide the performance characteristics required, while reducing aggregate use and construction time.

Scope

The scope of the work was to install geogrid in the base material of a newly constructed roadbed to reinforce the base. The geogrid was placed 6" below the top of the base in two sections having different base thicknesses. These sections will be compared to a standard section for 10 years and will include distresses, pavement condition, maintenance costs, and FWD data.

Location

Geogrid was installed on project NH-4-052(044)058 from RP 61.757 to RP 63.257. The project is on US Highway 52 from Donnybrook to Carpio. This section of highway is northwest of Minot in Ward and Renville counties. Refer to Figure 1 on the next page for the location of the project.

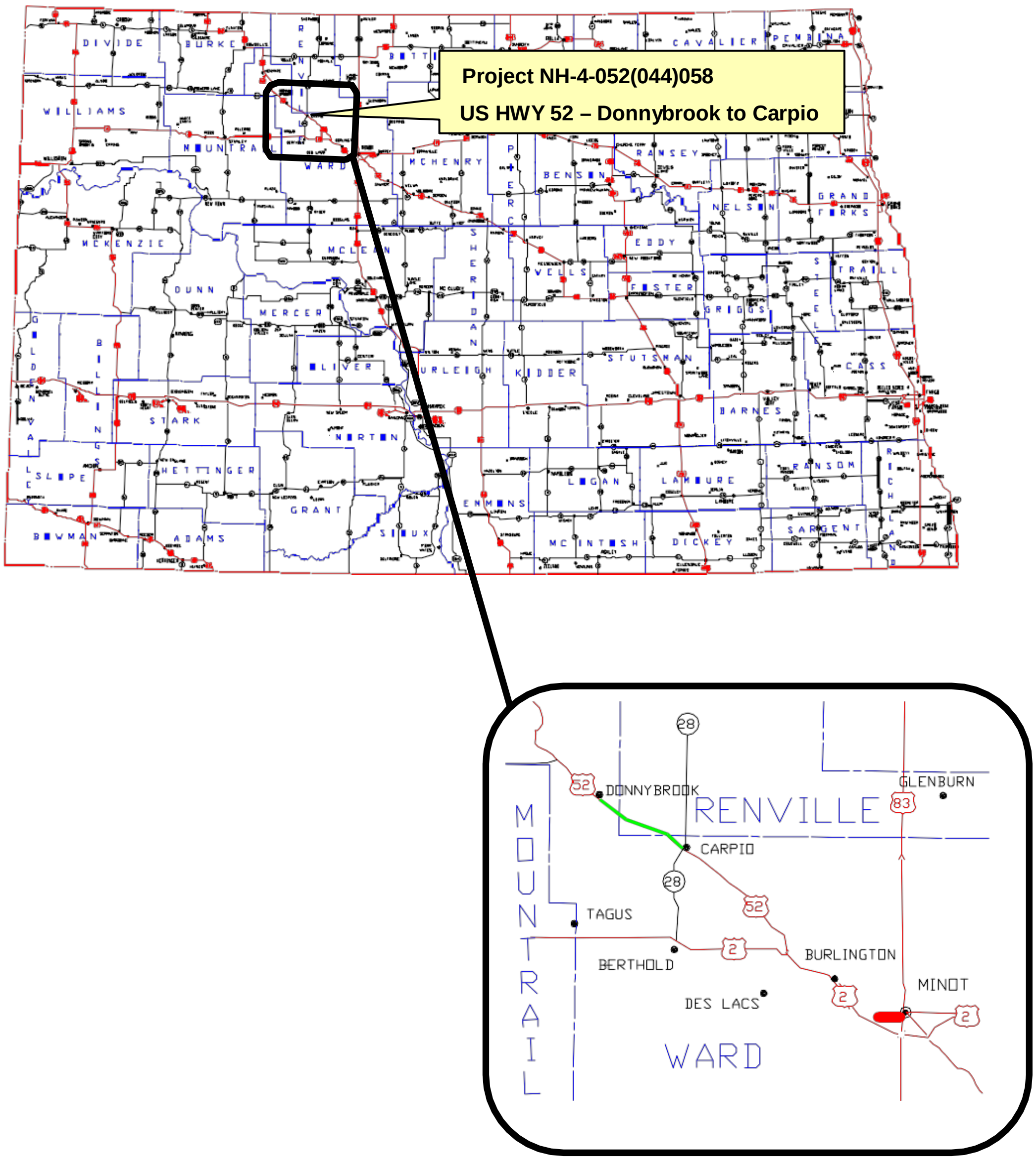


Figure 1 - Project Location.

Design

Three different sections were designed based on the following parameters: 5,500 psi soil modulus; 445 two-way flexible ESALs; 1.3% growth rate; 1,841,393 accumulated one-way flexible ESALs; 80% reliability; 20-year design life; Class 31 HBP; and a blended base (consisting of approximately 50% salvaged HBP and 50% virgin aggregate). Refer to Table 1 for the design sections and Table 2 for the specifications of the blended base.

Section	Blended Base Depth	HBP Class 31 Depth	Depth of Geogrid From Top of Pavement	Width of Geogrid
1 (Control)	18”	5.5”	N/A	N/A
2	18”	5.5”	11.5”	42’-8”
3	12”	5.5”	11.5”	42’-8”

Table 1

Class 3 Modified (Virgin Aggregate Used to Blend with Recycled Asphalt)	
Sieve Size	**Percent Passing**
1”	100
#4	35-85
#30	20-50
#200	4-10
Shale content	12% Maximum
Blended Base Course and Salvaged Base Course Gradation	
Sieve Size	**Percent Passing**
1 1/2”	100
1”	90-100

Table 2

The geogrid comes in two widths, 9.8’ and 13.1’. The manufacturer recommends a one-foot overlap of the material unless the subgrade is extremely weak and then a three-foot overlap is recommended. A one-foot overlap of the material was utilized.

According to the manufacturer, and research conducted by the Federal Aviation Administration (FAA), and the Army Corps of Engineers (COE), utilizing geogrid in the base section has a Traffic Benefit Ratio (TBR) of 3 using Tensar BX1100. The TBR is a multiplier of 3 placed on the design ESALs.

Refer to photos 1 and 2 for a sample of the Tensar BX 1100 Geogrid. Referring to Table 3 below, Section 1 (control) has an expected ESAL life of 1,813,132, Section 2 (using geogrid, with 18” of base depth) has an expected ESAL life of 5,439,396, and Section 3 (using geogrid, with 12” of base depth) has an expected ESAL life of 1,812,314.

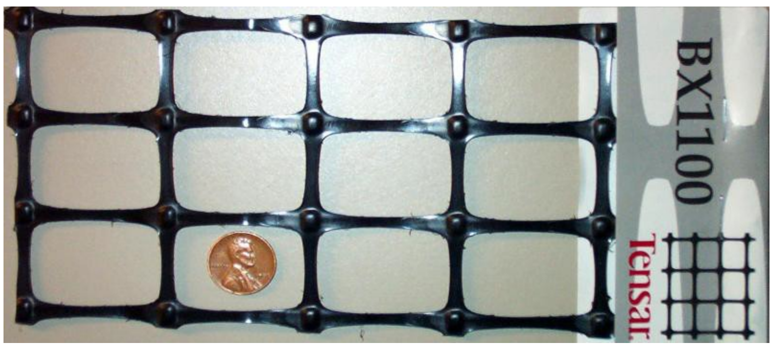


Photo 1 - Tensar BX1100 Geogrid

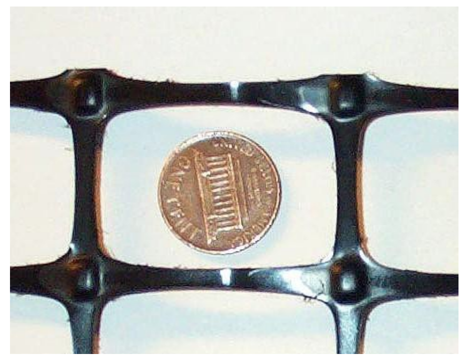


Photo 2- Size of geogrid opening vs. a penny.

Section	Expected ESAL Life	Design ESAL Calculated By
1 (Control)	1,813,132	Darwin 3.01and SpectraPave2
2	5,439,396	SpectraPave2
3	1,812,314	SpectraPave2

Table 3

The pavement thickness design for the test sections utilized DARWIN (1993 AASHTO Design Software) and SpectraPave2 (design software from Tensar, the geogrid manufacturer). Tensar recommends that the geogrid be placed 10” to 13” below the top of the asphalt surface for the best performance. Tensar indicates that by utilizing geogrid in the base, total base depth can be reduced by approximately 6” while carrying the same traffic. Refer to Figure 2 below for the typical sections.

Section 1 (Control)
5.5” Class 31 HBP
18” Blended Base.

Section 2
5.5” Class 31 HBP
18” Blended Base
Geogrid placed 11.5” below top of the pavement.

Section 3
5.5” Class 31 HBP
12” Blended Base
Geogrid placed 11.5” below top of the pavement.

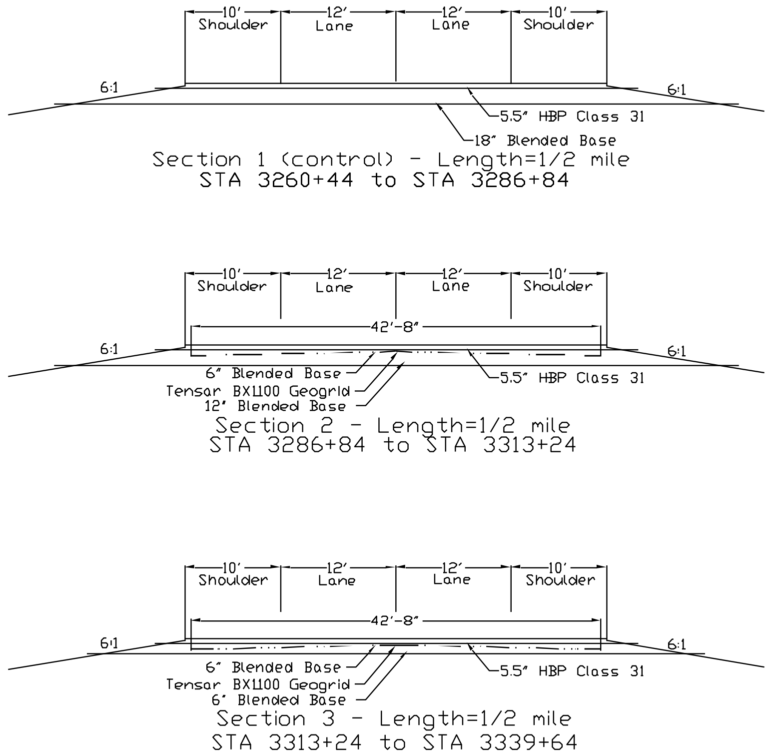


Figure 2 - Typical sections.

Construction

The locations of the three experimental sections were selected in 2002 between RP 61.757 and RP 63.257. They were determined by Materials and Research personnel after studying the project terrain and soil types indicated in the Linear Soils Report. The soils report is found in Appendix E. The area selected for the experimental sections had the most uniform soils.

The Tensar Geogrid BX1100 was sampled and sent to an independent laboratory for testing prior to installation. The geogrid passed the strength requirements of the certification. Copies of the test results are located in Appendix F. The original design called for a blended base (50% salvaged HBP and 50% virgin aggregate). However, to save cost and time, Class 5 was used on the top 8.5” for Section 1 and 2 and blended based was used for the bottom 9.5”. Section 3 used Class 5 for the entire 12.0.” In the original design, the geogrid was supposed to be laid 11.5” below the top of the pavement for Section 2 and 3. Section 3 geogrid was installed properly at 11.5” below the top of pavement but the Section 2 geogrid was installed14.0” below the top of the pavement.

The contractor began spreading the base material in Section 2 on July 28, 2003. Each section was constructed as shown in the typical sections, which are located in the design section of this report.

Steve Madaus of Contech Construction Products, Inc. was on site at the project to direct the geogrid installation. When the required base thickness was laid and compacted, the geogrid was rolled out. The geogrid was overlapped by a minimum of 1 foot. Steve said that it is ok to drive on the geogrid but to avoid stopping, sharp turning, or spinning wheels.

The geogrid rolls were 13.1 feet wide. The stiffness of the geogrid helped to keep the material even and tight. The upper base material was placed on top of the geogrid with belly-dump trucks. The geogrid had a tendency to roll or cause a slight wave ahead of the tires if the truck was moving too fast. The geogrid would then become uneven in these areas. Base material was used in these areas to hold it down. This made it easier for the blade to spread the windrow. There were a few places where the uneven geogrid could not be smoothed out enough and was cut to lay flat and then covered with a geogrid patch. Another method was to fold the material under to take up the slack. The geogrid is supplied in rolls and has a tendency to roll back up. The contractor used large headed nails in some cases to hold down the geogrid. Photo 3 shows a roll of Tensar BX-1100 Geogrid.

Photo 3 – A roll of Tensar Geogrid BX 1100.

The geogrid installation is shown in the following photos.

Photo 4 – Starting new roll of geogrid.

Photo 5 – Nailing down overlap of new roll, rolling out geogrid, and spreading base material.

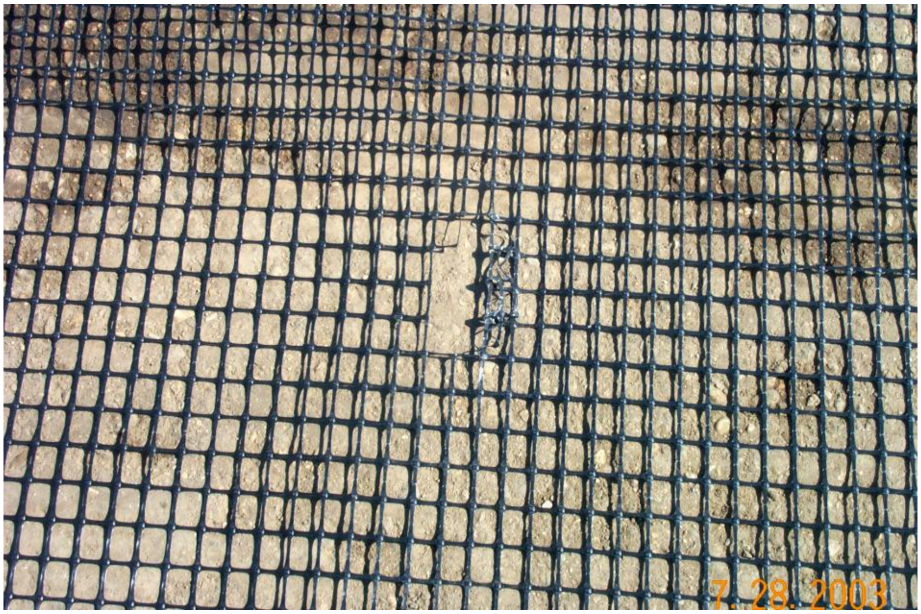


Photo 6 - Damaged areas like this can be repaired by overlaying with a 3'x3' patch.

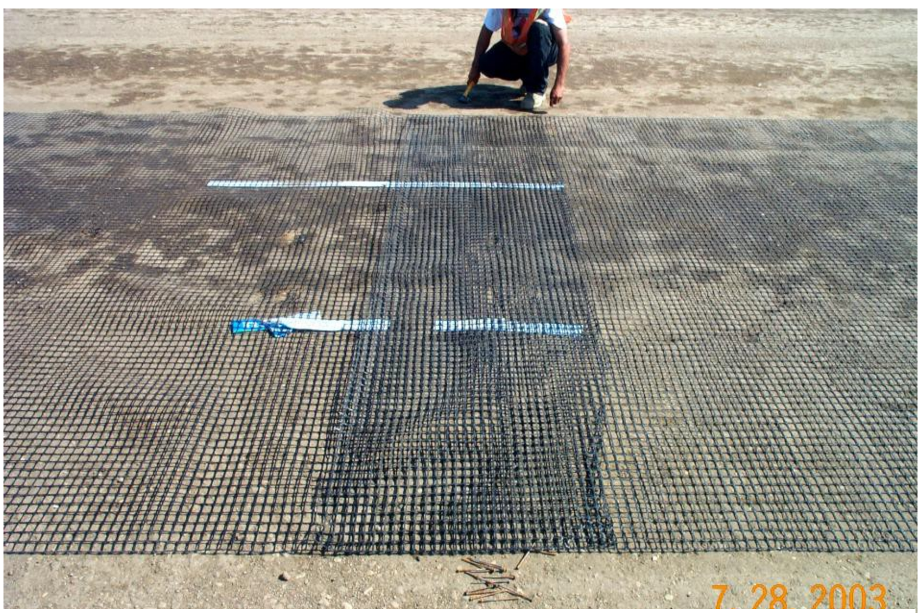


Photo 7 – Overlapping two rolls of geogrid and staking down edges.

Photo 8 – Placing the base material on the geogrid.

Photo 9 – Spreading base – notice the base material on the geogrid. It keeps the ends down so it stays in place.

Photo 10 – Some waves in the geogrid – nailing overlap area.

Photo 11 - Compacting the base material on top of the geogrid.

Costs

The cost of each of the three sections is shown below.

Section 1 (Control):	RP 61.757 to RP 62.257 9.5 inch Blended Base (bottom layer) 8.5 inch Class 5 $90,290.11
Section 2:	RP 62.257 to RP 62.757 9.5 inch Blended Base (bottom layer) 42.67 ft. wide geogrid 8.5 inch Class 5 $121,581.50
Section 3:	RP 62.757 to 63.257 6 inch Class 5 (bottom layer) 42.67 ft. wide geogrid 6 inch Class 5 $82,944.84

Test Section 2 and 3 used 25,037 square yards of geogrid. An additional 780 tons of Class 5 at $4.90 per ton was used on Test Section 3 to fill the slough to the 72 foot graded shoulder. Comparing the Control Section to Section 3, $90,290.11 - $82,944.84 = a savings of $7,345.27 by substituting geogrid for 6" of base material. The geogrid was bid at $2.50 per square yard and included full compensation for all labor, equipment and materials to complete the work.

Plan and Profile Views

Three plan and profile views were drawn and are shown on the next page. The views show the station limits and the layer thicknesses as constructed. Section 3 side view shows how the transitions were constructed. Figure 3 shows a plan view of Section 3 including areas where the geogrid was damaged and repaired. It also shows one area that contains no geogrid. Should any problems show up in the future, this view may help to identify the cause.

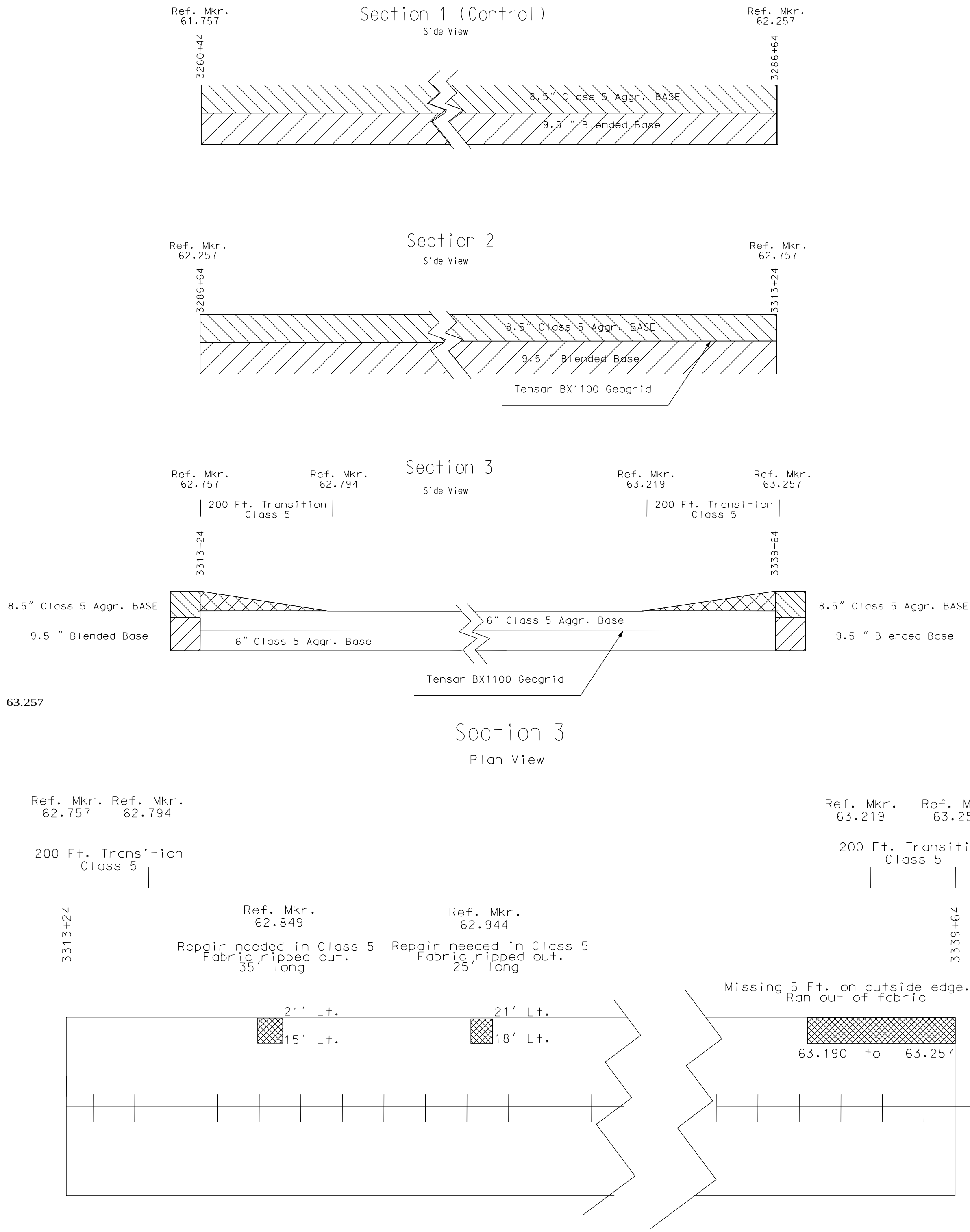


Figure 3- Plan view and cross section view.

Construction Summary

The NDDOT is looking for ways to improve the performance of bases in roadways, conserve aggregates, reduce future maintenance costs, and reduce time needed to rehabilitate the roadway. To meet this objective, geogrid base reinforcement was designed as an experimental feature in two sections on this project.

Three sections each one-half mile in length were constructed. Two sections used geogrid in the base and one was a control section. The three sections were built as shown in Table 4. The original design called for a blended base (50% salvaged HBP and 50% virgin aggregate). However, to save cost and time, Class 5 was used on the top 8.5" and blended base was used for the bottom for Section 1 and 2. Section 3 used Class 5 for the entire 12.0." In the original design, the geogrid was supposed to be laid 11.5" below the top of the pavement for Section 2 and 3. Section 3 geogrid was installed properly at 11.5" below the top of pavement but the Section 2 geogrid was installed 14.0" below the top of the pavement.

	Section Number		
	1	**2**	**3**
HBP	5.5"	5.5"	5.5"
Class 5	8.5"	8.5"	6.0"
Geogrid	none	42.67 ft. wide	42.67 ft. wide
Blend Base	9.5"	9.5"	None
Class 5	None	None	6.0"

Table 4

The geogrid installation was completed with minimal problems. Patches had to be placed in a few areas due to geogrid tears. Waves in the geogrid occurred if aggregate dumping or spreading of the aggregate was placed too fast. Overall the geogrid installation went very well.

A 1½" lift of asphalt was placed on the compacted base and served as the driving surface until the final asphalt lift was placed in 2004. Load testing was conducted with the FWD on these three sections. The base modulus of each section was computed from test data and either met or passed the design value.

Evaluation

Falling Weight Deflectometer

The Falling Weight Deflectometer (FWD) is a tool that is used to help evaluate the strength of roadway sections. It drops a pre-selected load onto the pavement surface. The resulting deflection of the roadway system is measured and stored. The modulus of each layer is calculated from the data using the Elmod 5 program. The FWD is shown in photo 12:

Photo 12 – The FWD operation.

The modulus is an indication of load carrying capacity. The load carrying capacity generally increases with a modulus increase. A base value used for design purposes is 20 ksi.

First Evaluation-2004 to 2005

The FWD data was collected and analyzed from all three sections from 2003 to 2005. The average base modulus in Section 1 was 41,000 psi with a standard deviation of 8,900 psi; the average base modulus was 41,500 psi with a standard deviation of 7,550 psi in Section 2, and in Section 3 the average base modulus was 28,500 psi with a standard deviation of 5,500 psi. Tables and graphs showing the deflection and modulus of the asphalt, base and subgrade layers of each section can be found in Appendix A and Appendix B. The deflection from sensor #1 at the load plate is the highest or total deflection of the load applied.

The roadway had an asphalt thickness of 1½"in 2003 and received an additional 4" of asphalt in 2004. This asphalt thickness will affect the modulus of each layer. The base and subgrade modulus values in Section 3 are lower than in Section 1 and 2.

Section 3 has a 12" base and Section 1 and 2 have an 18" base. The average deflection of Section 3, as shown in Table 5, is higher than Sections 1 and 2. This means Section 3 deflected more and thus results in lower modulus values. As a rule, when the deflections increase the modulus decreases.

Maintenance costs were minimal. Refer to Appendix C.

Second Evaluation-2006 to 2008

The FWD data was collected and analyzed from all three sections from 2006 through 2008. The average base modulus in Section 1 was 38,000 psi with a standard deviation of 9,700 psi; the average base modulus was 32,000 psi with a standard deviation of 6,700 psi in Section 2, and in Section 3 the average base modulus was 32,000 psi with a standard deviation of 8,000 psi. The average base and subbase modulus were similar to the FWD data from the first evaluation completed from 2004 to 2005. Updated tables and graphs showing the average deflection and modulus of the asphalt, base and subgrade layers of each section can be found in Appendix A and Appendix B. The deflection from sensor #1 at the load plate is the highest or total deflection of the load applied.

Maintenance did not do any work to these sections, refer to Appendix C.

Third Evaluation-2009 to 2010

Pathways van data collected show an IRI of 59 for mile point 62, which falls into the good category. The FWD data was collected and analyzed from all three sections in 2009 and 2010. The average base modulus in Section 1 was 37,000 psi with a standard deviation of 11,500 psi; the average base modulus was 29,000 psi with a standard deviation of 6,400 psi in Section 2, and in Section 3 the average base modulus was 23,000 psi with a standard deviation of 5,700 psi. The average base and subbase modulus were similar to the FWD data from the second evaluation completed from 2006 to 2008. Updated tables and graphs showing the average deflection and modulus of the asphalt, base and subgrade layers of each section can be found in Appendix A and Appendix B. The deflection from sensor #1 at the load plate is the highest or total deflection of the load applied.

Maintenance did not do any work to these sections, refer to Appendix C.

Section 1 (control section) has one transverse crack that is sealed and one crack in the control section that is unsealed. Section 2 and Section 3 have no visual distresses.

Fourth Evaluation-2011 to 2012

Materials and Research personnel visually inspected the project on 1/7/2013. 2012 data from the pathways van shows an IRI of 63 at mile point 62, which falls into the good category. FWD data was collected and analyzed from all three sections in both 2011 and 2012. Updated tables and graphs showing the average deflection and modulus of the asphalt, base and subgrade layers of each section can be found in Appendix A and Appendix B. The average deflection of each section is from sensor #1 at the load plate and is the highest or total deflection of the load applied.

The fourth evaluation was the first evaluation completed that had a change between the sections. Section 1 and 2 did not have a change from the last evaluation completed in 2010, but Section 3 had some rutting in the wheel paths. Because of the change in the sections, a comparison of the traffic counts used in the design from 2002 and the current traffic counts was performed to see if increased traffic was a factor in the change.

The original 20-year design completed in 2002 was based on traffic data that predicted an Average Annual Daily Truck Traffic (AADTT) of 555 at the end of the design period. The AADTT in 2012 was 945 which was an increase of 219% from 430 in 2002. This data shows that there is a significant traffic change in traffic over the section. The traffic information can be found in Appendix D.

Maintenance did not do any work in these sections, refer to Appendix C.

Section 1(Control):

There were two transverse cracks in the control section (similar to the third evaluation), one that is sealed and one that is unsealed. There were no other visual distresses found in Section 1 besides the two cracks. The average base modulus in Section 1 was 41,000 psi with a standard deviation of 9,800 psi. The average base and subbase modulus were similar to the FWD data from the third evaluation completed from 2009 to 2010.

Section 2:

There were no visual distresses found in Section 2. The average base modulus was 33,000 psi with a standard deviation of 6,750 psi in Section 2. The average base and subbase modulus were similar to the FWD data from the third evaluation completed from 2009 to 2010.

Section 3:

Rutting was found from the visual inspection in Section 3. The rutting ranged from 1/8” to 1/4” over the length of the whole section and was found in the left wheel path. There were no other visual distresses found in Section 3 besides the rutting. The average base modulus was 29,500 psi with a standard deviation of 6,000 psi in Section 3. The average base and subbase modulus were similar to the FWD data from the third evaluation completed from 2009 to 2010. The similarities in the base and subbase modulus imply that there might be other factors that are causing this section to rut. The traffic counts show that there is a significant increase in traffic from construction in 2002 to the recent traffic counts collected in 2012.

Fifth Evaluation-2013 to 2014

Materials and Research personnel visually inspected the project on 11/26/2013 and 09/04/2014. The 2013 data from the pathways van shows an IRI of 66 at mile point 62, which falls into the good category. FWD data was collected and analyzed from all three sections in both 2013 and 2014. Updated tables and graphs showing the average deflection and modulus of the asphalt, base and subgrade layers of each section can be found in Appendix A and Appendix B. The average deflection of each section is from sensor #1 at the load plate and is the highest or total deflection of the load applied.

All of the sections have increased rutting from the last evaluation completed in 2012 and there were new cracks throughout sections in 2014 evaluation.

Maintenance did not do any work in these sections, refer to Appendix C.

Section 1(Control)

Pavement Condition

There were two transverse cracks in the control section, one that is sealed and one that is unsealed, and there was one transverse shoulder crack which extends to the driving lane. It was also observed that rutting was occurring throughout this section in both wheel paths which was a change from no rutting from the fourth evaluation. The rutting was between 1/8" to 1/4", and can be seen the photo below.

Photo 4, Rutting in Section 1

Soil Modulus

The average base modulus in Section 1 was 34,500 psi with a standard deviation of 7,900 psi. The average base and subbase modulus were similar to the FWD data from the fourth evaluation completed from 2011 to 2012.

<u>Section 2</u>

Pavement Condition

There was one transverse crack found in Section 2 which was a change from the fourth evaluation. It was observed that rutting was occurring throughout this section in both wheel paths which was a change from no rutting from the fourth evaluation. The rutting was between 1/8” to 1/4”, and can be seen in the photo below.

Photo 5, Rutting in Section 2

Soil Modulus

The average base modulus was 28,800 psi with a standard deviation of 6,600 psi in Section 2. The average base and subbase modulus were similar to the FWD data from the fourth evaluation completed from 2011 to 2012.

Section 3

Pavement Condition

There were one 6' longitudinal crack in the outside wheel path, one transverse shoulder crack, and four transverse cracks approximately 2ft apart found in Section 3 which was a change from the fourth evaluation. Rutting was found from the visual inspection in Section 3. The rutting found was between 1/8" and 1/2", which was similar from the fourth evaluation. The rutting is shown in the photo below:

Photo 6, Rutting in Section 3

Soil Modulus

The average base modulus was 27,800 psi with a standard deviation of 5,500 psi in Section 3. The average base and subbase modulus were similar to the FWD data from the fourth evaluation completed from 2011 to 2012.

Summary

From 2004 until 2010, all three sections were performing well and there was not a significant difference between the different sections. In 2012 it was observed that rutting was starting to occur in Section 1 and rutting was found from the visual inspection in Section 3. In 2013 and 2014 it was observed that rutting was occurring in all of the sections and it was 1/8” to 1/2” over the length of the project. There were new cracks in all of the sections which were one transverse shoulder crack in Section 1, one transverse crack in Section 2 and one longitudinal crack, four transverse cracks and one transverse shoulder crack in Section 3 during the evaluation in 2014.

The similarities in the base and subgrade modulus from year to year show that there might be other factors that are causing the sections to rut. The original 20-year design completed in 2002 was based on traffic data that predicted an Average Annual Daily Truck Traffic (AADTT) of 555 at the end of the design period. The AADTT in 2014 was 925 which was an increase of 215% from 430 in 2002. This data shows that there is a significant change in traffic over the sections since construction in 2002.

The chip seal that was placed in 2007 over the whole project does have noticeable wear in the wheel tracks. Pathways van 2013 data for mile point 62 shows an IRI of 66 which falls into the good category. The ride has gotten slightly worse since the 2012 evaluation, which had an IRI of 63. There hasn’t been any maintenance work performed on these sections other than sealing one crack since the 2007 chip seal.

Materials and Research personnel will continue to monitor this project and another evaluation will be completed in 2016.

Appendix A: Average FWD results for each section

Section	Average Deflection (Mils)										
	2003*	2004	2005	2006	2007	2008	2010	2011	2012	2013	2014
1 (Control)	15.77	10.99	10.09	12.44	13.11	12.54	13.10	10.09	12.34	13.65	11.19
2	18.02	10.89	9.97	14.02	14.62	15.12	15.15	11.22	14.01	16.45	12.12
3	26.21	15	14.21	17.99	18.4	18.83	19.51	15.65	18.70	20.34	16.08

Table 5: Average deflections for each section

*1.5 in. of HBP was placed in 2003 with the remainder 4.0 in. laid in 2004.

Section	Average Modulus (ksi) Asphalt										
	2003*	2004	2005	2006	2007	2008	2010	2011	2012	2013	2014
1 (Control)	1154	446	593	276	310	300	326	675	336	349	564
2	1105	435	588	234	271	244	288	619	325	278	571
3	1331	337	406	187	171	193	213	353	222	203	368

Table 6: Average asphalt modulus for each section

*1.5 in. of HBP was placed in 2003 with the remainder 4.0 in. laid in 2004.

Section	Average Modulus (ksi) Base										
	2003*	2004	2005	2006	2007	2008	2010	2011	2012	2013	2014
1 (Control)	45	40	42	40	36	39	37	41	41	33	36
2	31	41	42	35	31	30	29	49	31	27	31
3	22	28	29	30	39	27	23	33	26	27	29

Table 7: Average base modulus for each section

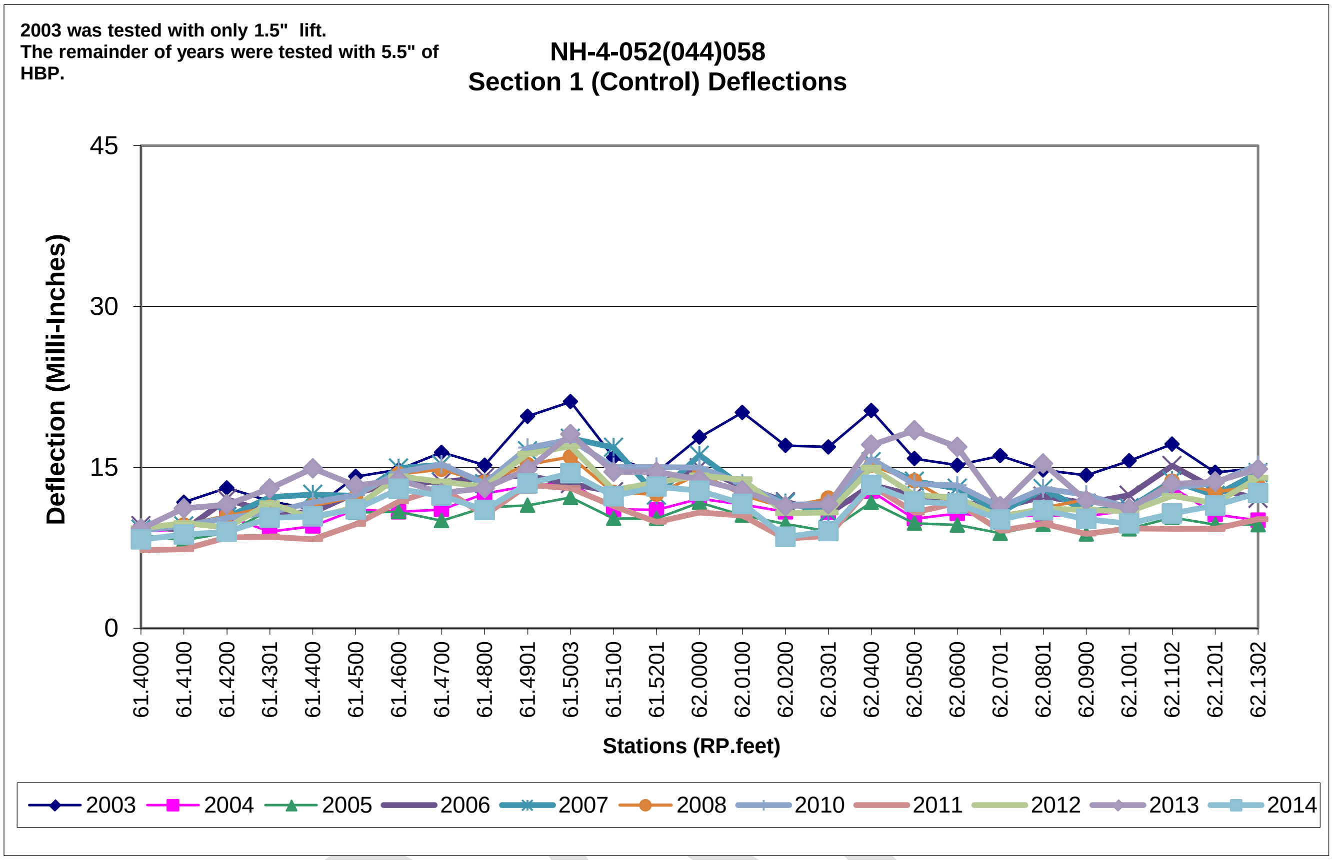
*1.5 in. of HBP was placed in 2003 with the remainder 4.0 in. laid in 2004.

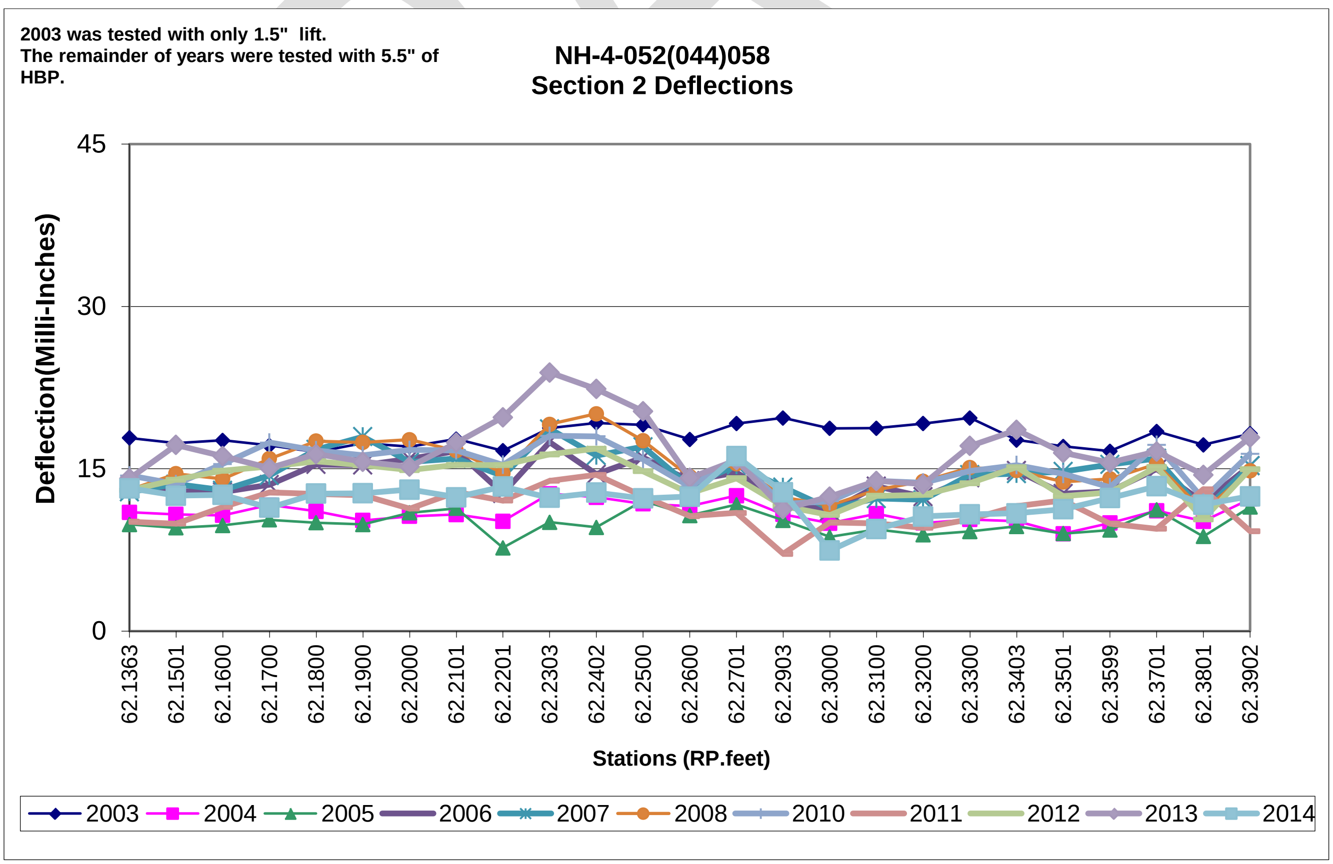
Section	Average Modulus (ksi) Subgrade										
	2003*	2004	2005	2006	2007	2008	2010	2011	2012	2013	2014
1 (Control)	28	25	23	27	24	25	25	25	27	24	24
2	28	25	25	26	23	24	23	21	24	22	21
3	16	22	21	21	14	20	20	12	20	17	17

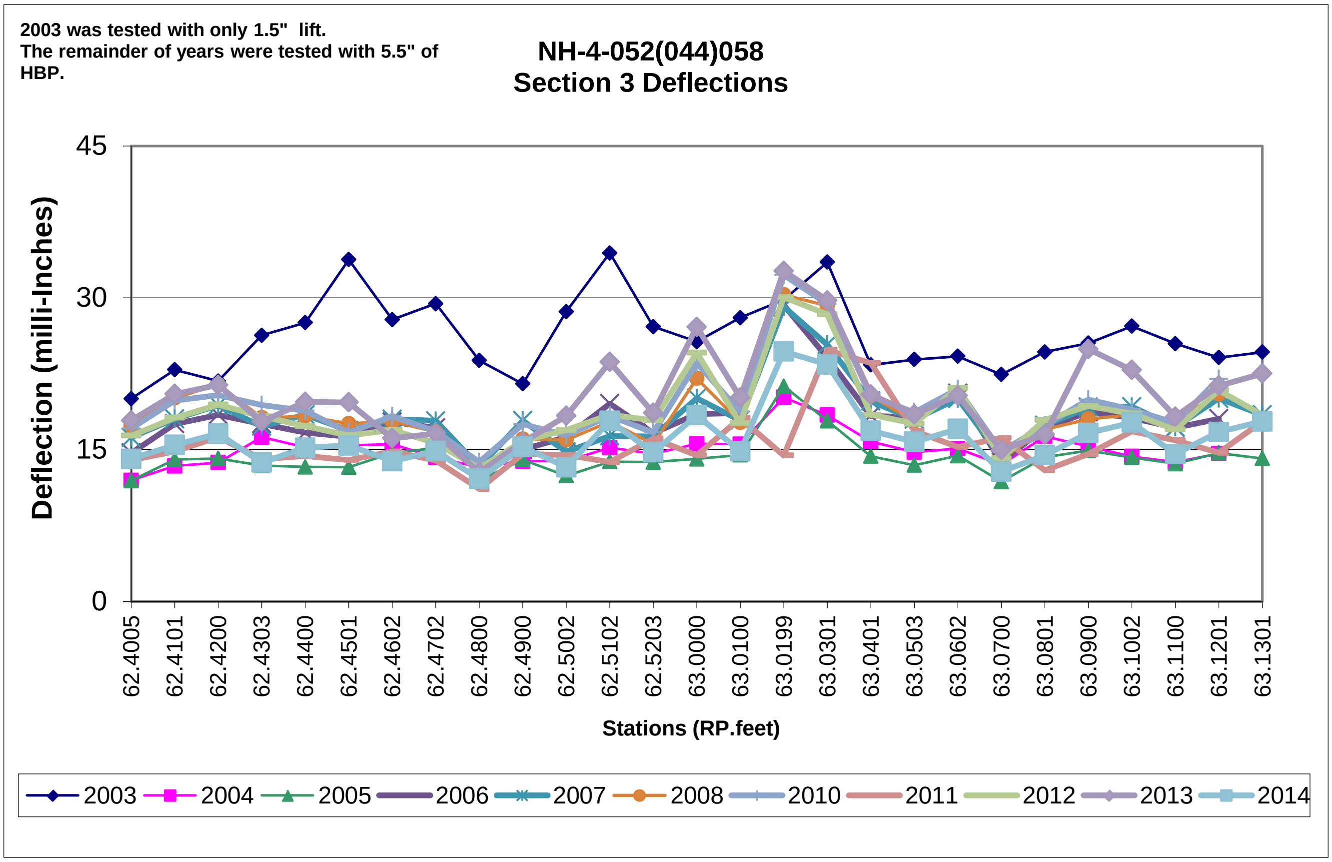
Table 8: Average subgrade modulus for each section

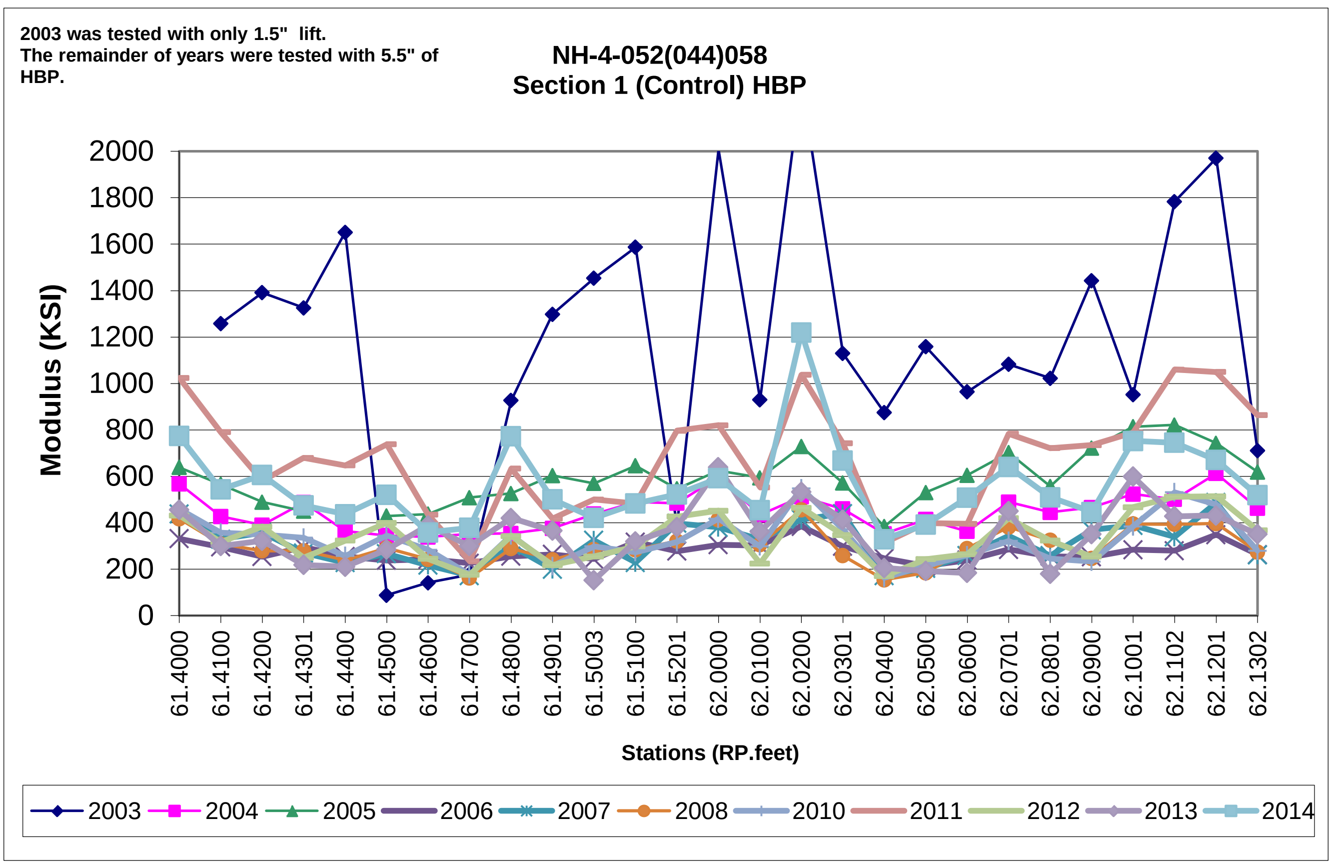
*1.5 in. of HBP was placed in 2003 with the remainder 4.0 in. laid in 2004.

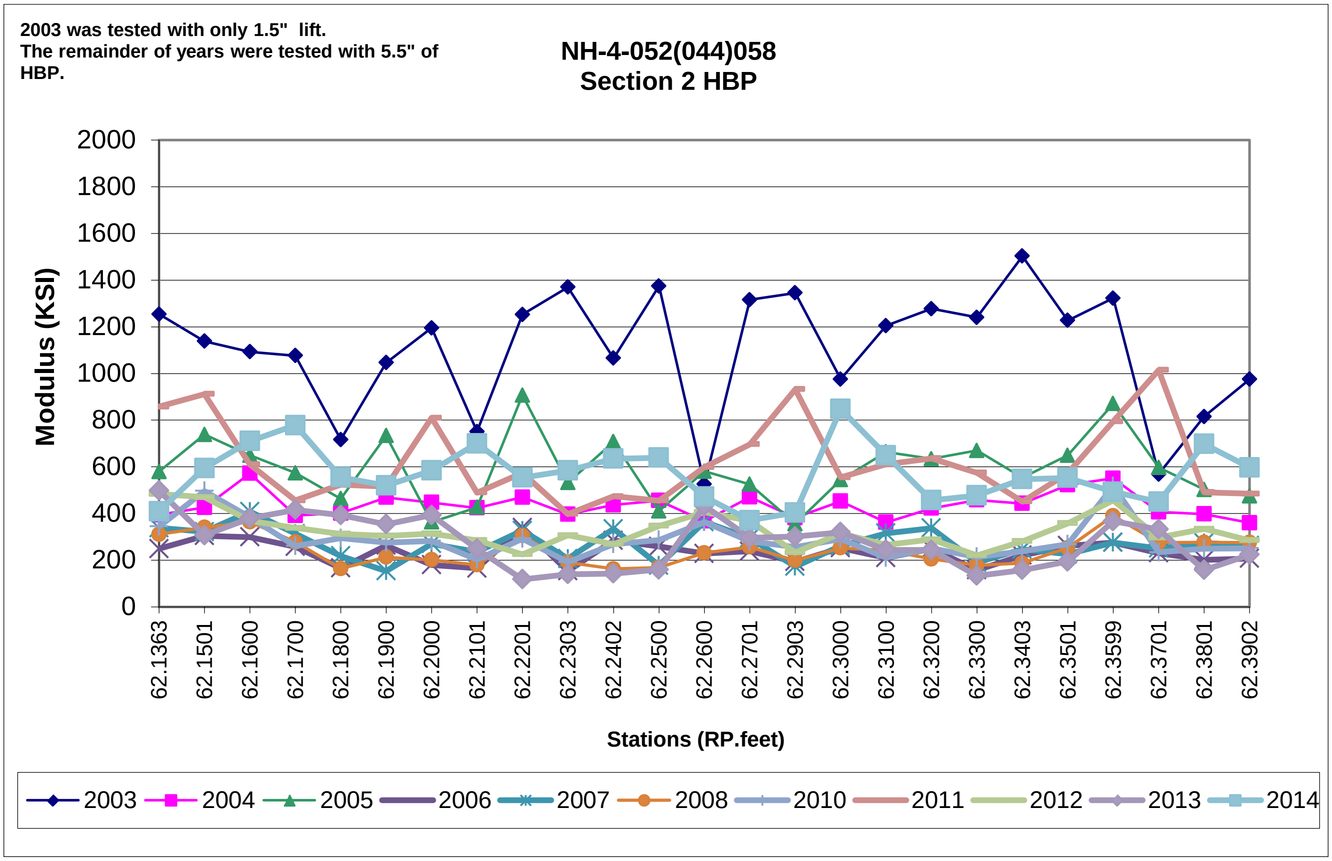
Appendix B: FWD Graphs


2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 1 (Control) Deflections
Deflection (Milli-Inches)
45
30
15
0
61.4000
61.4100
61.4200
61.4301
61.4400
61.4500
61.4600
61.4700
61.4800
61.4901
61.5003
61.5100
61.5201
62.0000
62.0100
62.0200
62.0301
62.0400
62.0500
62.0600
62.0701
62.0801
62.0900
62.1001
62.1102
62.1201
62.1302
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014

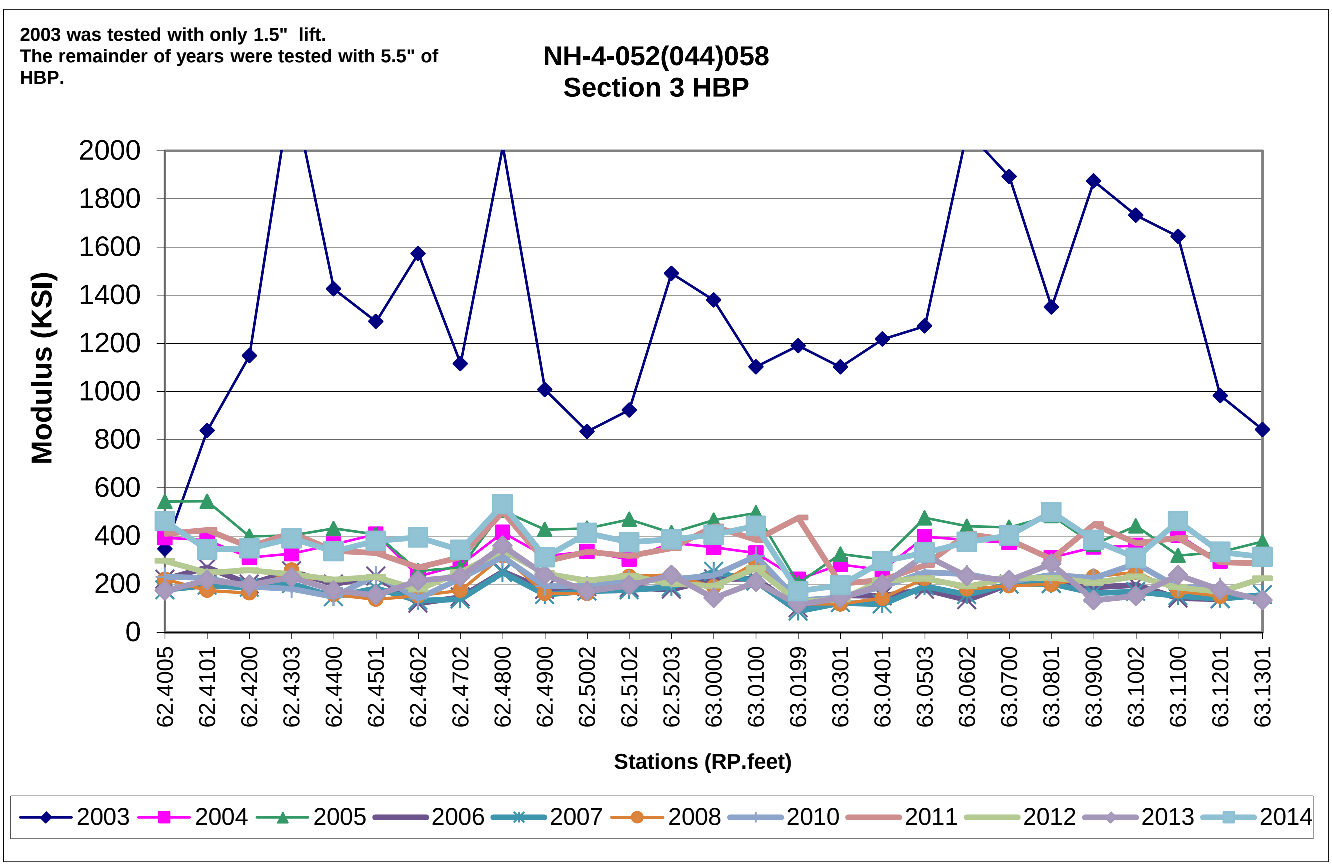

2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 2 Deflections
Deflection(Milli-Inches)
45
30
15
0
62.1363
62.1501
62.1600
62.1700
62.1800
62.1900
62.2000
62.2101
62.2201
62.2303
62.2402
62.2500
62.2600
62.2701
62.2903
62.3000
62.3100
62.3200
62.3300
62.3403
62.3501
62.3599
62.3701
62.3801
62.3902
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014


2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 3 Deflections
Deflection (milli-Inches)
0
15
30
45
62.4005
62.4101
62.4200
62.4303
62.4400
62.4501
62.4602
62.4702
62.4800
62.4900
62.5002
62.5102
62.5203
63.0000
63.0100
63.0199
63.0301
63.0401
63.0503
63.0602
63.0700
63.0801
63.0900
63.1002
63.1100
63.1201
63.1301
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014

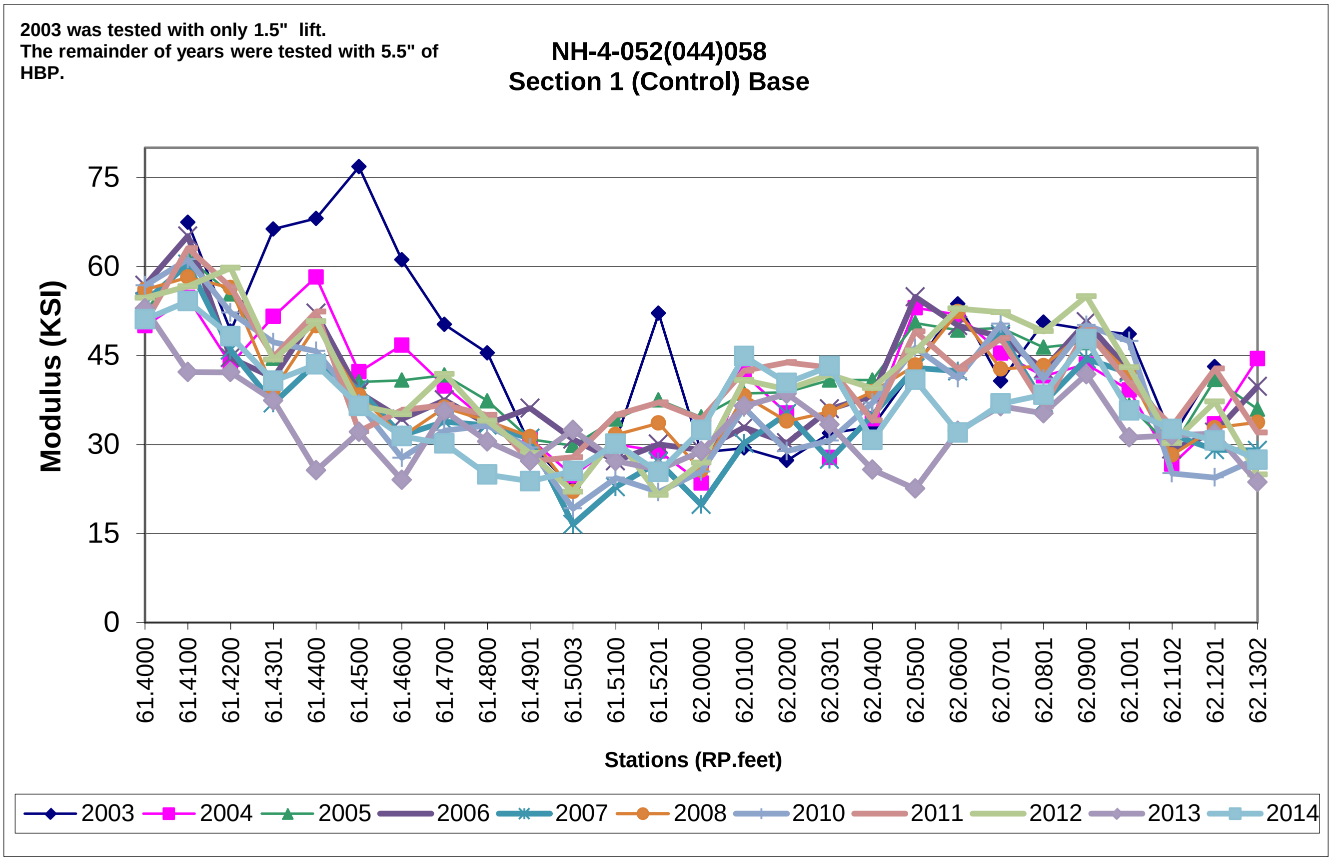

2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 1 (Control) HBP
Modulus (KSI)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
61.4000
61.4100
61.4200
61.4301
61.4400
61.4500
61.4600
61.4700
61.4800
61.4901
61.5003
61.5100
61.5201
62.0000
62.0100
62.0200
62.0301
62.0400
62.0500
62.0600
62.0701
62.0801
62.0900
62.1001
62.1102
62.1201
62.1302
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014

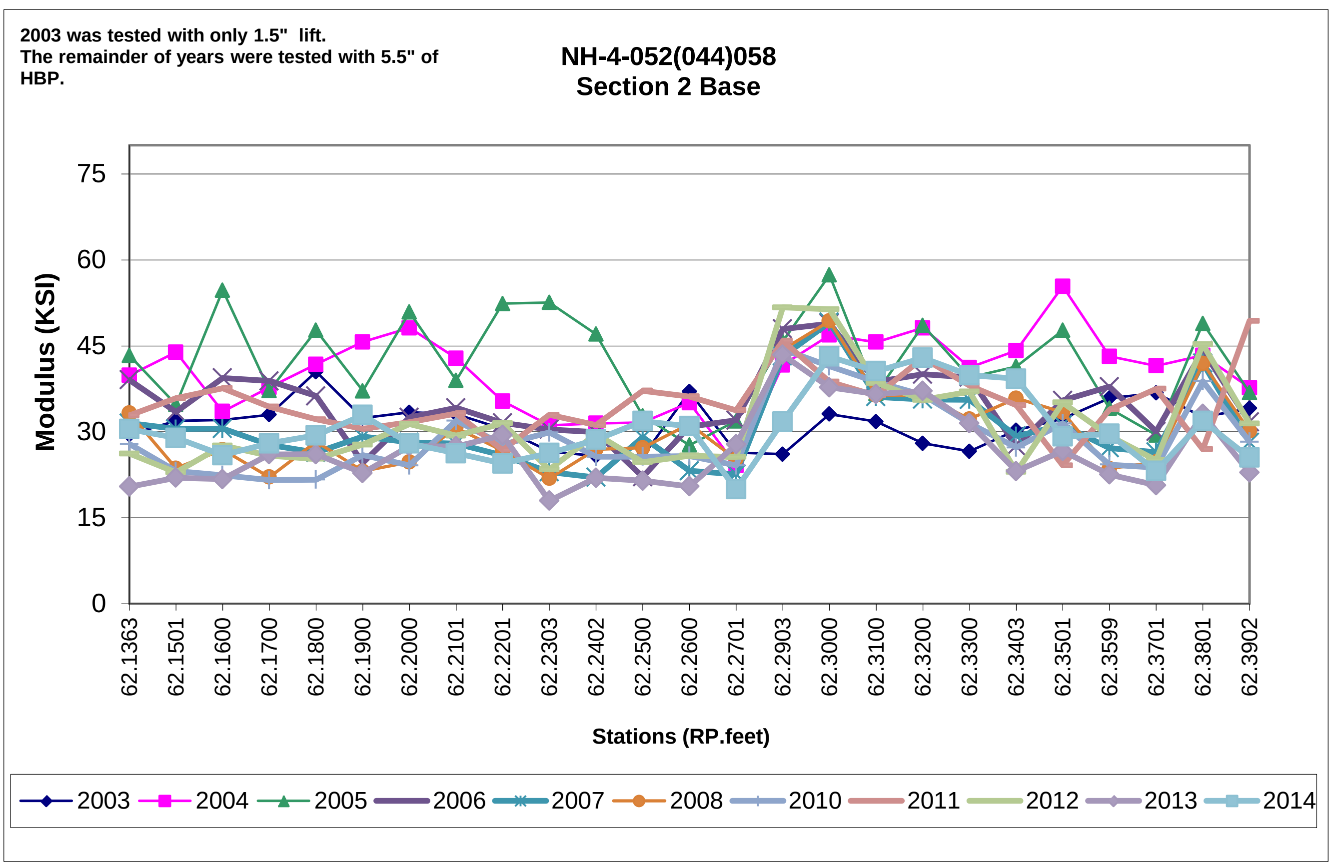


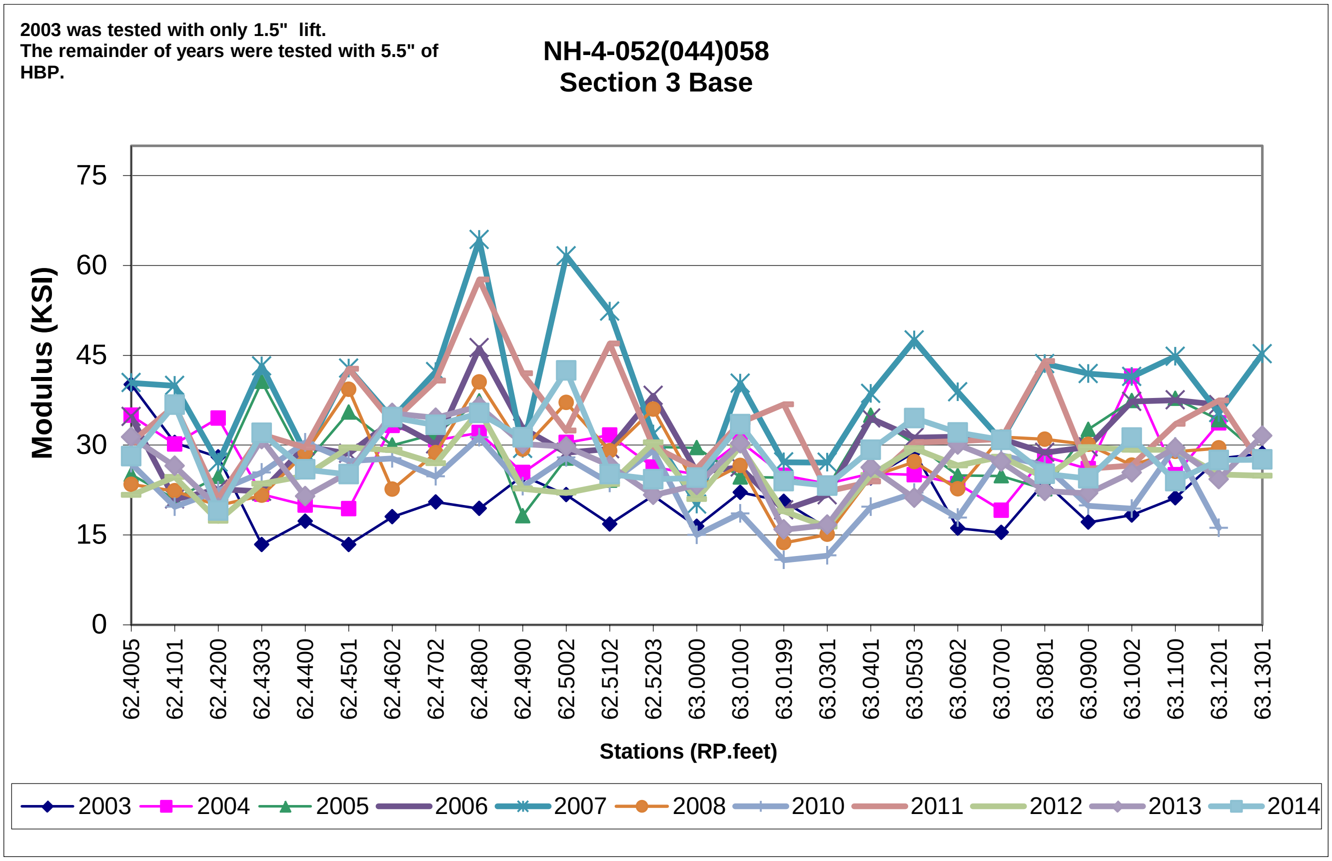
2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 2 HBP
Modulus (KSI)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
62.1363
62.1501
62.1600
62.1700
62.1800
62.1900
62.2000
62.2101
62.2201
62.2303
62.2402
62.2500
62.2600
62.2701
62.2903
62.3000
62.3100
62.3200
62.3300
62.3403
62.3501
62.3599
62.3701
62.3801
62.3902
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014

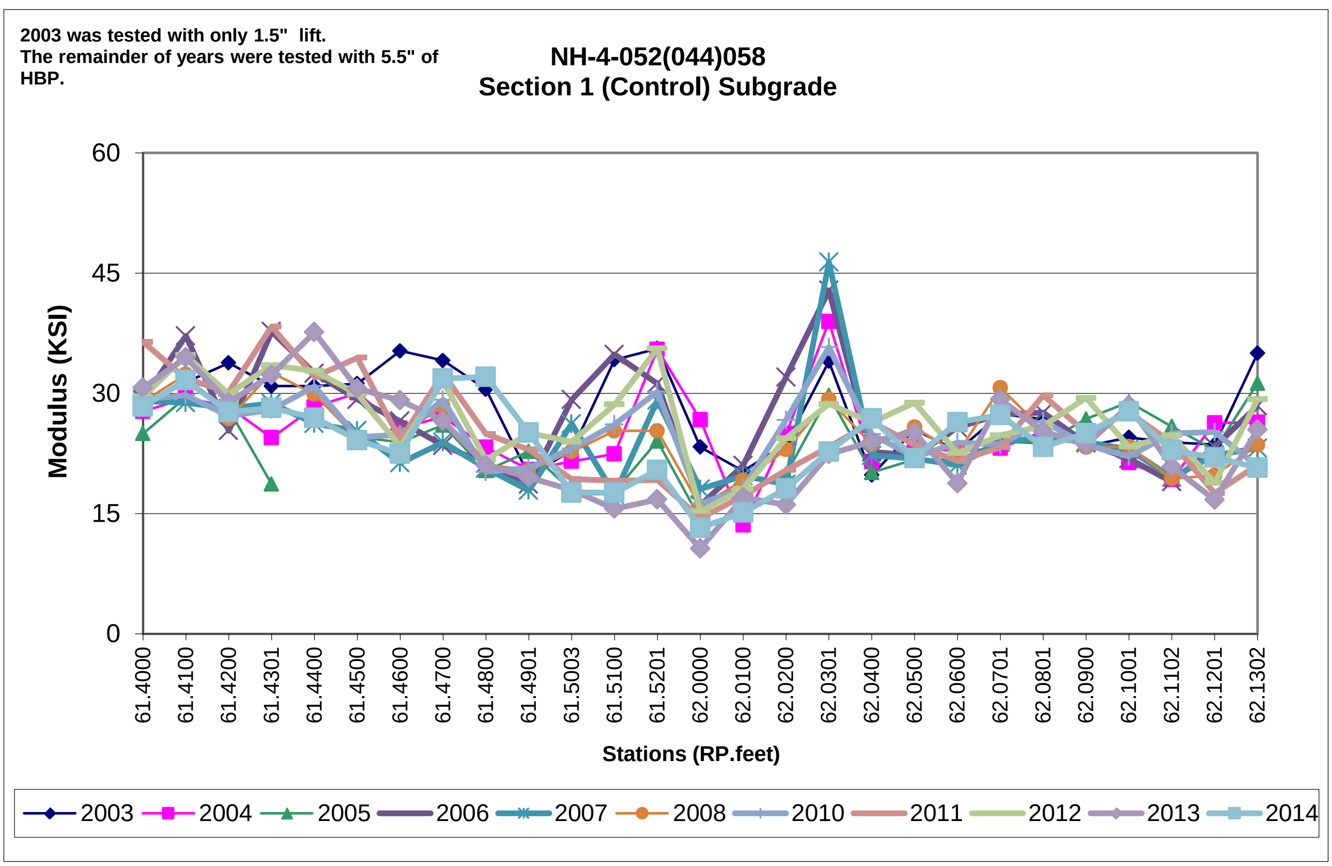


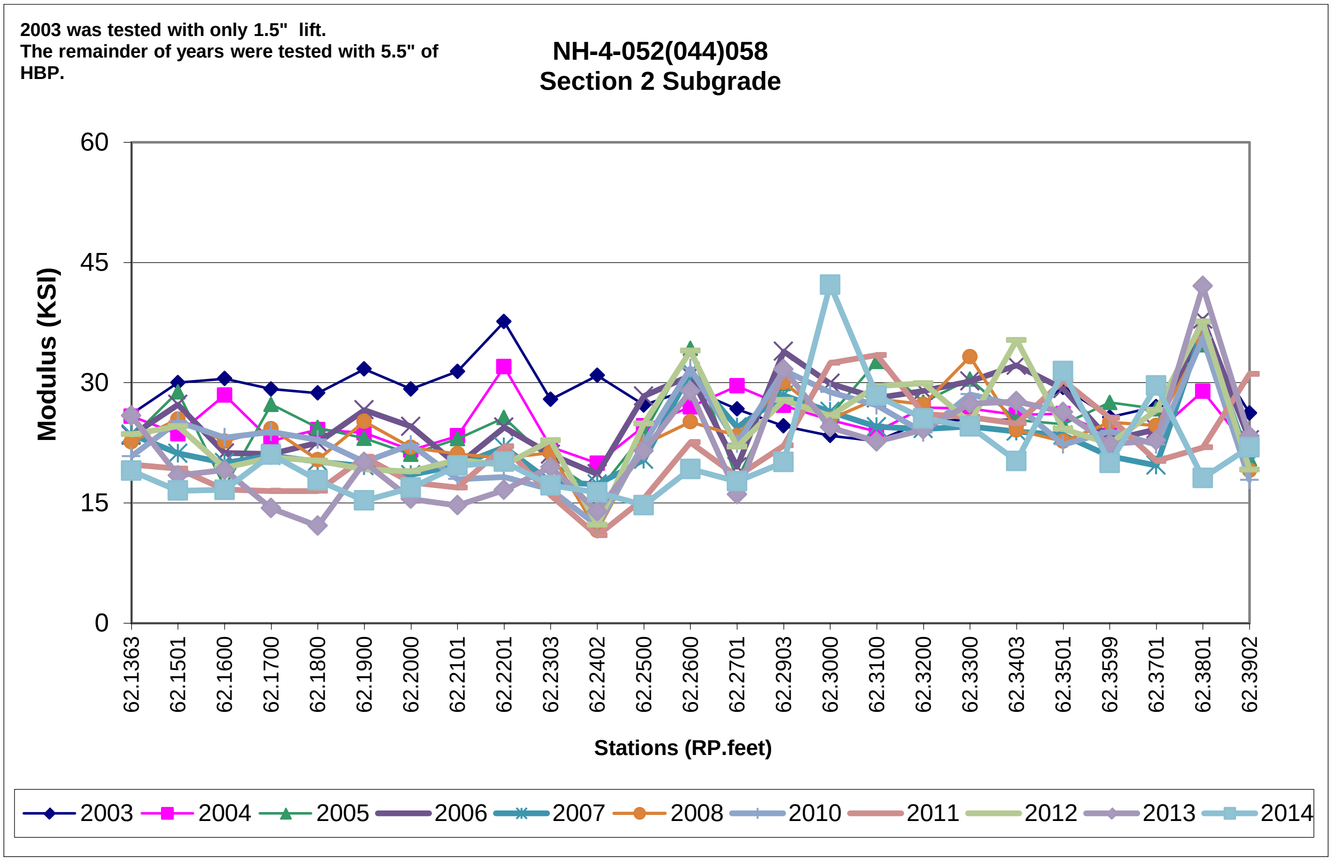
2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 3 HBP
Modulus (KSI)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
62.4005
62.4101
62.4200
62.4303
62.4400
62.4501
62.4602
62.4702
62.4800
62.4900
62.5002
62.5102
62.5203
63.0000
63.0100
63.0199
63.0301
63.0401
63.0503
63.0602
63.0700
63.0801
63.0900
63.1002
63.1100
63.1201
63.1301
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014

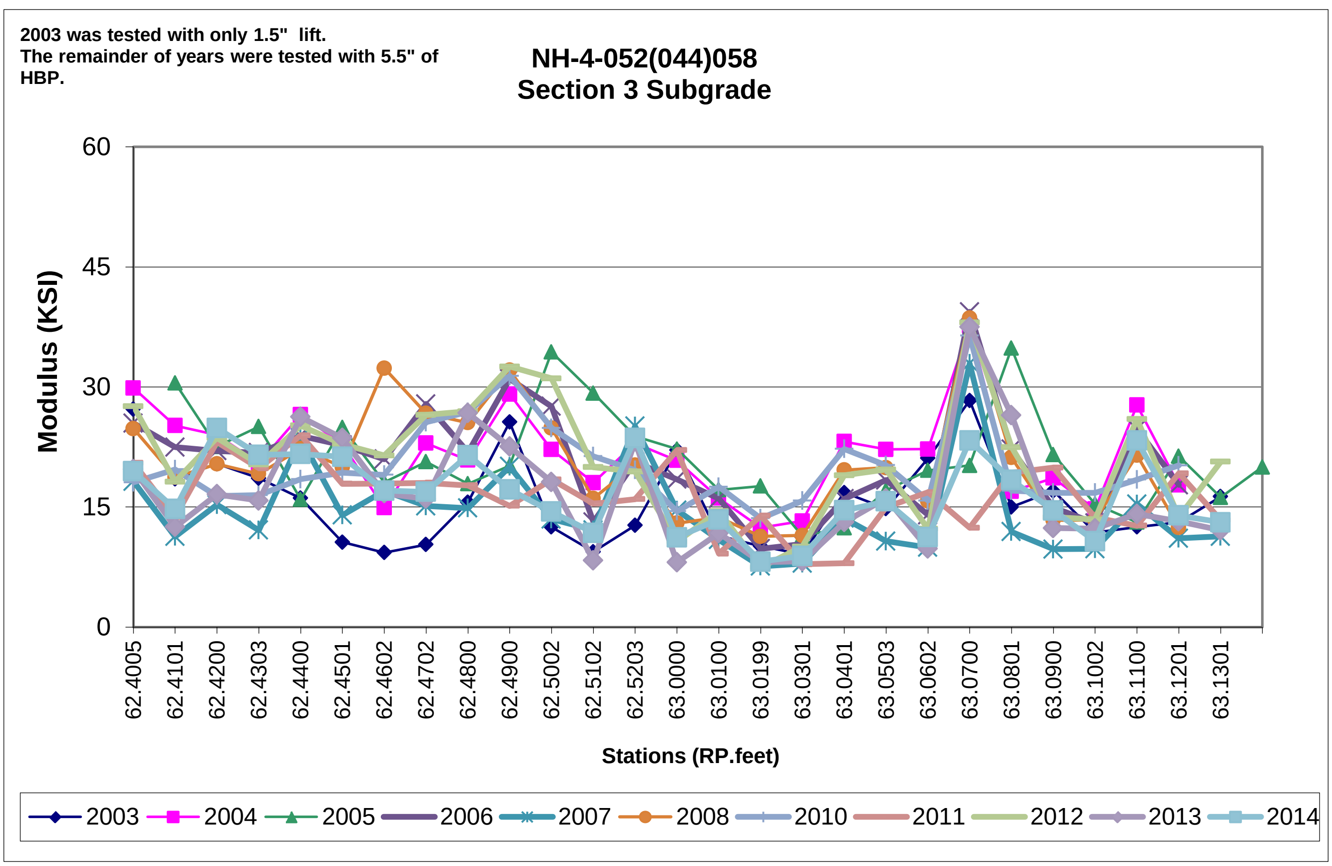

2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 1 (Control) Base
Modulus (KSI)
75
60
45
30
15
0
61.4000
61.4100
61.4200
61.4301
61.4400
61.4500
61.4600
61.4700
61.4800
61.4901
61.5003
61.5100
61.5201
62.0000
62.0100
62.0200
62.0301
62.0400
62.0500
62.0600
62.0701
62.0801
62.0900
62.1001
62.1102
62.1201
62.1302
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014


2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 2 Base
Modulus (KSI)
75
60
45
30
15
0
62.1363
62.1501
62.1600
62.1700
62.1800
62.1900
62.2000
62.2101
62.2201
62.2303
62.2402
62.2500
62.2600
62.2701
62.2903
62.3000
62.3100
62.3200
62.3300
62.3403
62.3501
62.3599
62.3701
62.3801
62.3902
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014


2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 3 Base
Modulus (KSI)
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014


2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 1 (Control) Subgrade
Modulus (KSI)
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014


2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 2 Subgrade
Modulus (KSI)
60
45
30
15
0
62.1363
62.1501
62.1600
62.1700
62.1800
62.1900
62.2000
62.2101
62.2201
62.2303
62.2402
62.2500
62.2600
62.2701
62.2903
62.3000
62.3100
62.3200
62.3300
62.3403
62.3501
62.3599
62.3701
62.3801
62.3902
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014


2003 was tested with only 1.5" lift.
The remainder of years were tested with 5.5" of HBP.
NH-4-052(044)058
Section 3 Subgrade
Modulus (KSI)
60
45
30
15
0
62.4005
62.4101
62.4200
62.4303
62.4400
62.4501
62.4602
62.4702
62.4800
62.4900
62.5002
62.5102
62.5203
63.0000
63.0100
63.0199
63.0301
63.0401
63.0503
63.0602
63.0700
63.0801
63.0900
63.1002
63.1100
63.1201
63.1301
Stations (RP.feet)
2003
2004
2005
2006
2007
2008
2010
2011
2012
2013
2014

Appendix C: Maintenance Costs

Section	Maintenance Costs (dollars/lane mile)											
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1 (Control)	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0

Table 9

On 12/16/2008, 5/8/2011, 1/8/2013 and 2/10/2015 Materials and Research personal spoke to Monte Lee (Minot District Maintenance Foreman). He stated that there has not been any maintenance performed on the three research sections near Donnybrook.

Appendix D: 2002 and 2012 Traffic Counts

2002 Traffic

ESTIMATE OF CURRENT AND FUTURE TRAFFIC
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
(PLANNING DIV. TRAFFIC INFO. SECTION)

RECNO: 8745		***PCN:***	
DATE PRINTED OR REPRINTED: 1/30/2013		***PROJECT NO:***	
DATE PREPARED: 1/10/2013		***COUNTY:***	***ROUTE ID:*** 0
HIGHWAY NO: 52	***HWY SUFFIX:***		
REF PT: 60.000	***FR OFFSET:*** 0.0000	***LENGTH:***	
PASS EXPANSION FACTOR: 1.29		***TRUCK EXPANSION FACTOR:*** 1.29	
TRAFFIC'S ANNUAL % OF GROWTH: 1.3		***ESALS ANNUAL % OF GROWTH:*** 1.3	
LOCATION: RP 60.00 TO RP 64.00(2002)			

******** ***ALL AADT'S ESALS, ARE AT THE HIGHEST POINT OF THE PROJECT SEGMENT*** ********

	YEAR	***PASS***	***TRUCKS***	***TOTAL***	**30TH MAX HR**	**E.S.A.L.'S** ***FLEX***	***RIGID***
CURRENT	2002	1,170	430	1,600	160	350	555
FORECAST	2022	1,510	555	2,065	210	450	720

****

PAVEMENT EQUIVALENCY FACTORS: FLEXIBLE AT SN 4 ***RIGID AT 9 INCHES***

WAS CLASS WIM DATA AVAILABLE FOR THIS PARTICULAR LOCATION? N

IS THIS A REVISED ESTIMATE? N ***SUPERCEDES EST. OF***

REQUESTED BY: JARED LOEGERING- M & R

REMARKS:

TRAFFIC FORECAST ESTIMATE IS BASED ON 2002 TRAFFIC COUNTS. TRAFFIC FOR BOTH DIRECTIONS. COMPLETED BY NR.

$$\text{Acc. ESAL's} = \frac{T}{2} \times 365 \times \left[\left(\frac{(1+i)^n - 1}{i}\right)\right] = \frac{350}{2} \times 365 \times \left[\left(\frac{(1+.013)^{20} - 1}{.013}\right)\right] =$$

$T = 350$
$i = 1.3\%$
$n = 20$ years

1,448,287 ESALs

2002 Traffic

2012 Traffic

ESTIMATE OF CURRENT AND FUTURE TRAFFIC
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
(PLANNING DIV. TRAFFIC INFO. SECTION)

RECNO: 8746	***PCN:***	
DATE PRINTED OR REPRINTED: 1/30/2013	***PROJECT NO:***	
DATE PREPARED: 1/10/2013	***COUNTY:***	***ROUTE ID:*** 0
HIGHWAY NO: 52 ***HWY SUFFIX:***		
REF PT: 60.000 ***FR OFFSET:*** 0.0000	***LENGTH:***	
PASS EXPANSION FACTOR: 1.49	***TRUCK EXPANSION FACTOR:*** 1.64	
TRAFFIC'S ANNUAL % OF GROWTH: 2.0	***ESALS ANNUAL % OF GROWTH:*** 2.5	
LOCATION: RP 60.00 TO RP 64.00 (2012)		

******** ***ALL AADT'S ESALS, ARE AT THE HIGHEST POINT OF THE PROJECT SEGMENT*** ********

	YEAR	*PASS*	*TRUCKS*	*TOTAL*	30TH MAX HR	E.S.A.L.'S *FLEX*	E.S.A.L.'S *RIGID*
CURRENT	2013	1,965	945	2,910	295	765	1,220
FORECAST	2033	2,930	1,550	4,480	450	1,260	2,000

****

PAVEMENT EQUIVALENCY FACTORS: FLEXIBLE AT SN 4 ***RIGID AT 9 INCHES***

WAS CLASS WIM DATA AVAILABLE FOR THIS PARTICULAR LOCATION? N

IS THIS A REVISED ESTIMATE? N ***SUPERCEDES EST. OF***

REQUESTED BY: JARED LOEFERING- M & R

REMARKS:

TRAFFIC FORECAST ESTIMATE IS BASED ON 2012 TRAFFIC COUNTS. TRAFFIC FOR BOTH DIRECTIONS. COMPLETED BY NR.

Acc. $ESAL's = \frac{T}{2} \times 365 \times \left[\left(\frac{(1+i)^n - 1}{i}\right)\right] = \frac{765}{2} \times 365 \times \left[\left(\frac{(1+.025)^{20} - 1}{.025}\right)\right] =$

$T = 765$
$i = 2.5\%$
$n = 20$ years

3,566,354 ESALs

2012 Traffic

2014 Traffic

ESTIMATE OF CURRENT AND FUTURE TRAFFIC
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
(PLANNING DIV. TRAFFIC INFO. SECTION)

RECNO: 9517

DATE PRINTED OR REPRINTED: 9/3/2014

DATE PREPARED: 8/13/2014

HIGHWAY NO: 52 ***HWY SUFFIX:***

REF PT: 59.000 ***FR OFFSET:*** 0.0000

PASS EXPANSION FACTOR: 1.49

TRAFFIC'S ANNUAL % OF GROWTH: 2.0

LOCATION: RP 59.00 TO RP 67.90

PCN:

PROJECT NO:

COUNTY: ***ROUTE ID:*** 0

LENGTH:

TRUCK EXPANSION FACTOR: 1.49

ESALS ANNUAL % OF GROWTH: 2.0

******** ***ALL AADT'S ESALS, ARE AT THE HIGHEST POINT OF THE PROJECT SEGMENT*** ********

					30TH	E.S.A.L.'S	
	YEAR	***PASS***	***TRUCKS***	***TOTAL***	**MAX HR**	***FLEX***	***RIGID***
CURRENT	2014	2,025	925	2,950	295	725	1,150
FORECAST	2034	3,020	1,380	4,400	440	1,080	1,715

****

PAVEMENT EQUIVALENCY FACTORS: FLEXIBLE AT SN 4 RIGID AT 9 INCHES

WAS CLASS WIM DATA AVAILABLE FOR THIS PARTICULAR LOCATION? N

IS THIS A REVISED ESTIMATE? N ***SUPERCEDES EST. OF***

REQUESTED BY: TOM BOLD- M & R

REMARKS:

TRAFFIC FORECAST ESTIMATE IS BASED ON 2014 TRAFFIC COUNTS. TRAFFIC FOR BOTH DIRECTIONS. COMPLETED BY NR.

$$\frac{725}{2} \times 365 \times \left[\frac{(1+0.02)^{20}-1}{0.02}\right] = 3,214,846$$

Appendix E: Linear Soils Report

Linear Soil Report and Recommendation
Project: HPP-4-052(044)058

Donnybrook to Carpio
Project Length: 9.2 Miles
Project Limits: 59.6 to 68.8

Borings are from RP 58+4000 feet to 68+1270 feet
Ward/Renville County

June 5, 2002

*The beginning project limit of 59.6 was given to us by Kadrmas, Lee & Jackson. This does not match up with reference point 58 in the project number. The beginning limit of this project is the ending limit of the HPP-4-052(042)050 project.

SOIL CLASSIFICATION AND COMMENTS

A total of 64 samples were analyzed from the above-mentioned location at depths ranging from 1.5 to 9.0 feet below the pavement surface. The results are as follows:

Quantity	AASHTO Class	In-Place Moisture Range (%)	In-Place Moisture Average (%)	T-180 Optimum Moisture Average (%)	Plastic Limit Range (%)	Plastic Limit Average (%)
1	A-2-4	NA	8.5	11.0	NA	16
6	A-4	8.2-13.6	10.4	9.5	16-20	18
41	A-6	8.2-22.1	16.3	10.8	15-20	17
16	A-7-6	13.2-23.5	17.9	11.9	15-22	18

AASHTO Class	Plastic Index Range (%)	Plastic Index Average (%)	Liquid Limit Range (%)	Liquid limit Average (%)
A-6	10-21	16	27-39	33
A-7-6	21-30	25	40-50	43

Note: Moisture Contents provided in this report have been obtained from samples taken on 6/12/01 and 4/16/02.

SOIL CLASSIFICATION AND COMMENTS (Cont.)

Comparison of the In-Place Moisture Contents to the Plastic Limits at the 2, 3, and 4 foot depths are shown below:

	Quantity	Below Plastic Limit	Plastic Limit to 5% Above	More than 5% Above Plastic Limit
2 Foot	50	76%	24%	None
3 Foot	55	62%	34%	4% (2 samples)
4 Foot	58	45%	50%	5% (3 samples)
5 Foot	9	67%	22%	11% (1 sample)
6 Foot	6	67%	33%	None
7 Foot	4	75%	25%	None
8 Foot	3	67%	33%	None
9 Foot	1	None	100%	None

The Plastic Index values ranged from 6 to 30. The swell potential, based on the Plastic Index (PI) results, is shown below:

Swell Potential		
Low (PI<25)	**Marginal** (25<PI<35)	**High** (PI>35)
86%	14% (9 samples)	None

Frost Susceptibility:
None of the samples were classified as F4 soils (Highly Frost Susceptible).

Group Index:
The A-6 and A-7-6 Group Indexes ranged from a low of 0 to a high of 23 with an average of 8. A group index of 20 or greater indicates a very poor sub-grade material. Only two samples from this project were above 20.

SOIL CLASSIFICATION AND COMMENTS (Cont.)

Moisture samples were taken at all boring locations. The results are as follows:

Depth	Quantity	In-Place Moisture Range (%)	In-Place Moisture Average (%)
2 Foot	105	2.1-16.0	9.7
3 Foot	114	2.2-22.9	11.2
4 Foot	117	1.8-28.6	11.7
5 Foot	10	10.0-21.7	15.3
6 Foot	7	6.3-17.6	12.5
7 Foot	5	12.1-17.4	14.8
8 Foot	3	16.5-19.4	17.5
9 Foot	1	NA	17.1

Moisture content at the 2, 3, and 4 foot depths were determined using analyzed samples and have been compared to the optimum moisture content as determined by the AASHTO T-180 specifications. In-Place Moisture vs. Optimum Moisture results are shown in the following table.

In-Place Moisture vs. Optimum Moisture						
Quantity	**AASHTO Class.**	**Below Optimum**	**Optimum to Moderate** (0 to 6% over optimum)	**Moderate to High** (6 to 10% over optimum)	**High** (10 to 16% over optimum)	**Very High** (>16% over optimum)
1	A-2-4	None	100%	None	None	None
6	A-4	33%	67%	None	None	None
41	A-6	2%	56%	39%	2% (1 sample)	None
16	A-7-6	None	38%	62%	None	None

SOIL CLASSIFICATION AND COMMENTS (Cont.)

Summary of Findings:
Four percent of the 3 foot, 5% of the 4 foot, and 11% (1 sample) of the 5 foot samples had a moisture content in the More than 5% Above the Plastic Limit range.

Eighty-six percent of the sample had low swell potential. The remaining samples possessed marginal swell potential.

The In-Place moisture contents at the two, three, and four foot depths were 11.2%, 11.7%, and 15.3%, respectively.

One A-6 sample had a moisture content in the High (10%-16% over optimum) category.

Maintenance Problem Areas:
On June 12th, 2001, Monte Babeck, Drill Crew Chief, and Monte Lee, Minot District Maintenance Coordinator, met and reviewed the project. A general observation of the pavement revealed several depressed, transverse cracks. The following areas were mentioned by Mr. Lee as problem areas.

-RP 63+0500 to RP 63+0700: This area has been blade patched multiple times because of settlement and a dip forming over a culvert.
-RP 63+2800 to RP 63+3200: A blade patch and chip seal have been placed in this area. The main types of distress were alligator cracking and secondary cracking. Pieces of asphalt have broken away in some area.
-RP 66+2500 to RP 67+0000: This area is located on the backside of a hill. Blade patching and scotch patching have been performed here. Alligator cracking was part of the reason for the patching.
-RP 67+0000 to RP 68+0000: This area has multiple blade patches due to rutting, shoving, and depressed cracks.

Water was found adjacent to the roadway in the following areas.

-RP 60+0700 to RP 60+1700: Water present South of the roadway 7-8 feet below road grade.
-RP 65+0000 to RP 65+1300: Water present South of the roadway 7-8 feet below road grade.
-RP 65+3400 to RP 65+4100: Water present South of the roadway 7-8 feet below road grade.
-RP 67+1100 to RP 67+1800: Water present North of the roadway 5-6 feet below road grade.

SOIL CLASSIFICATION AND COMMENTS (Cont.)

Roadway Pavement Section:
This section of roadway was originally graded in 1947. In 1947, 2.0 inches of asphalt was placed on 5.0 inches of stabilized base. Since then four 1.5 inch overlays have been placed from the years of 1956 to 1986. A contract sand seal was placed in 1988 and a 1.0 inch intermittent contract patch was placed in 1994.

This is to be a grade/aggregate base project. The proposed pavement section is 5.5 inches of HBP, placed upon 18 inches of dense graded base.

Maintenance costs totaled $74,568 from RP 59 to 68, during the years of 1992 through 2000. The average cost per mile per year was $828. The most work was performed in miles 66 and 67. In mile 66 $19,158 was spent over the 9 years, averaging $2,129 of maintenance per year. Mile 67 had $14,914 in maintenance, with an average of $1,657 per year. The majority of the work performed in these miles were in the form of bituminous overlays/blade patching.

DESIGN RECOMMENDATIONS

Subcut Recommendations:

We recommend subcutting the first area due to the presence of organics and high moisture content at the three foot depth. The remaining 18" subcuts are recommended because of past maintenance problems, poor soil properties uncovered during the soil analysis, or a combination of the the two.

Note: To account for unforseen poor subgrade conditions we recommend allowing an additional 1,000 feet of 18" subcut to be used at the discretion of the Project Engineer.

Note: We recommend that subcuts be performed with a backhoe using a smooth cutting edge to minimize disturbance to underlying soils. In addition, we recommend that construction equipment with heavy tire pressures traveling over the following soft subgrade areas be kept to a minimum to prevent additional moisture from pumping up.

RP + Feet	to	RP + Feet	Remarks
60+3250		60+3750	Subcut to a depth of 36" below the newly proposed grade. Place Reinforcement fabric (R1) at the bottom of all subcut excavations and backfill with Class 3, Class 5, or salvaged aggregate. Place a minimum of 12" of aggregate on the fabric prior to compacting. Do not scarify the bottom of the subcut.
Total 36" Subcut Length=500 feet			
63+2800		63+3200	Subcut to a depth of 18" below the newly proposed grade. Place Reinforcement fabric (R1) at the bottom of all subcut excavations and backfill with Class 3, Class 5, or salvaged aggregate. Place a minimum of 12" of aggregate on the fabric prior to compacting. Do not scarify the bottom of the subcut.
68+0600		68+1000	
Proposed 18" Subcut Length=800 feet			
Additional 18" Subcut Length=1000 feet			
Total 18" Subcut Length=1800 feet			

Notes: A 20:1 transition must be constructed prior to entering and on exiting subcut and culvert or box culvert sections to avoid differential heave.

Compaction of aggregate for subgrade repair should comply with NDDOT Standard Specification 302.04 E.

If areas of free water are encountered during construction drainage must be provided. Materials and Research can be contacted for drainage design.

DESIGN RECOMMENDATIONS (Cont.)

Subgrade Preparation:
We recommend 12" Subgrade Preparation on this project. Subgrade Preparation should comply with NDDOT Standard Specification 230.02 B.5, **Type C (12")**. Compaction control should be in accordance with NDDOT Specification 203.02 G, Type A, and also with AASHTO T-180.

Pipe Installation:
The culvert located within the area of RP 63+0500 to RP 63+0700 should be rebuilt according the current pipe detail. Attached is a copy of the pipe installation detail that should be followed for all pipe replacements.

If the vertical profile or horizontal alignment is changed in either the conceptual phase or the design phase, Materials and Research must be notified as soon as possible to ensure that there is adequate geotechnical information addressing these areas.

The information in this report is based on the grading/aggregate base option. If the proposed improvement changes, reassessment of our recommendations will be necessary.

Please contact me at 328-6907 or Jon Ketterling at 328-6908 if there are any questions or modifications to the plans for rehabilitation of this roadway.

Benjie Foss
Geotechnical Section

Appendix F: Geogrid Tensile Strength Test Results

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INTEGRITY IN TESTING

TENSILE STRENGTH TEST RESULTS

ASTM D-6637

CLIENT: NORTH DAKOTA D.O.T.
CLIENT PROJECT: AC-HPP-4-052(044)058
PROJECT NO.: L03127-08
LAB IDNO.: L03127-08-01
.MATERIAL: TENSAR BX1100 GEOGRID
SAMPLE: #1
LOT NO.: 071

TEST	UNITS	SPECIMEN NO. 1	2	3	4	5	AVG	STD
RIB COUNT	MD Ribs/ft.	7.94						
	CD Ribs/ft.	10.67						
WIDE WIDTH STRENGTH MD	2%-MD lbs./ft.	253	313	301	297	287	290	22.66
	5%-MD lbs./ft.	663	710	707	712	689	696	20.74
	Ult.-MD lbs./ft.	941	944	946	961	966	952	11.09
	Elong at Peak-%	10	8	8	8	9	9	0.64
WIDE WIDTH STRENGTH CD	2%-CD lbs./ft.	424	427	410	423	421	421	6.74
	5%-CD lbs./ft.	1,033	1,027	1,015	1,028	1,024	1,025	6.55
	Ult.-CD lbs./ft.	1,628	1,608	1,618	1,620	1,509	1,597	49.37
	Elong at Peak-%	12	12	13	12	9	12	1.37
RETEST WIDE WIDTH STRENGTH CD	2%-CD lbs./ft.	440	439	441	418	446	437	11.10
	5%-CD lbs./ft.	1,044	1,044	1,030	1,025	1,063	1,041	15.01
	Ult.-CD lbs./ft.	1,593	1,650	1,525	1.498	1,649	1,583	69.74
		11	12	10	9	11	11	1.25

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LAB IDNO.: L03127-08"02
MATERIAL: TENSAR BX1100 GEOGRID
SAMPLE: #2
LOT NO.: 080

TEST	UNITS	SPECIMEN NO.					AVG	STD
		1	2	3	4	5		
RIB COUNT	MD Ribs/It CD Ribs/It	7.94 10.63						
WIDE WIDTH STRENGTH MD	2%-MD lbs./ft. 5%-MD lbs./ft. Ult.-MD lbs./ft. Elong at Peak-%	302 710 897 7	289 691 875 7	299 693 975 10	304 704 756 6	276 689 995 10	294 698 900 8	11.51 9.09 94.63 2.05
WIDE WIDTH STRENGTH CD	2%-CD Ibslft 5%-CD lbs./ft. Ult.-CD lbs./ft. Elong at Peak-%	439 1'125 1,605 9	485 1'158 1,661 11	490 1'167 1,637 9	469 1'132 1,454 7	534 .1'197 1,624 10	484 1,156 1,596 9	34.75 29.14 82.12 1.43

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INTEGRITY IN TESTING

TENSILE STRENGTH TEST RESULTS

ASTM D-6637

CLIENT: NORTH DAKOTA D.O.T.
CLIENT PROJECT: AC-HPP-4-052(044)058
PROJECT NO.: L03127-08
LAB IDNO.: L03127-08-04
MATERIAL: TENSAR BX1100 GEOGRID
SAMPLE: #3
LOT NO.: 084

TEST	UNITS	SPECIMEN NO. 1	2	3	4	5	AVG	STD
RIB COUNT	MD Ribs/ft.	7.94						
	CD Ribs/ft.	10.33						
WIDE WIDTH STRENGTH MD	2%-MD lbs./ft.	292	295	312	290	288	295	9.78
	5%-MD lbs./ft.	706	705	717	708	691	705	9.28
	Ult.-MD lbs./ft.	1,058	979	900	922	855	943	78.36
	Elong at Peak-%	17	9	7	8	7	9	4.09
WIDE WIDTH STRENGTH CO	2%-CD lbs./ft.	504	476	446	471	490	478	21.73
	5%-CD lbs./ft.	1'161	1,133	1'115	1,087	1'125	**1,124**	26.93
	Ult.-CD Ibslft	1,587	1,505	1,532	1,537	1,475	1,527	41.69
		10	9	8	10	8	9	0.97

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DATE: 6-25-03

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INTEGRITY IN TESTING

TENSILE STRENGTH TEST RESULTS

ASTM D-6637

CLIENT: NORTH DAKOTA D.O.T.
CLIENT PROJECT: AC-HPP-4-052(044)058
PROJECT NO.: L03127-08
LAB IDNO.: L03127-08-04
MATERIAL: TENSAR BX1100 GEOGRID
SAMPLE: #4
LOT NO.: 093

TEST	UNITS	SPECIMEN NO. 1	2	3	4	5	AVG	STD
RIB COUNT	MD Ribs/ft.	7.94						
	CD Ribs/ft.	10.38						
WIDE WIDTH STRENGTH MD	2%-MD lbs./ft.	299	293	293	302	286	294	6.17
	5%-MD lbs./ft.	708	700	698	708	689	701	7.85
	Ult.-MD lbs./ft.	875	1,025	926	941	904	934	56.74
	Elong at Peak-%	7	11	8	8	8	8	1.58
WIDE WIDTH STRENGTH CD	2%-CD Ibslft	477	479	480	447	438	464	19.95
	5%-CD lbs./ft.	1,123	1,141	1,126	1,091	1,097	1,115	21.01
	Ult.-CD lbs./ft.	1,566	1,414	1,564	1,551	1,576	1,534	67.88
	Elong at Peak-%	10	7	10	10	11	10	1.36

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TENSILE STRENGTH TEST RESULTS

ASTM D-6637

CLIENT: NORTH DAKOTA D.O.T.
CLIENT PROJECT: AC-HPP-4-052(044)058
PROJECT NO.: L03127-13
LAB IDNO.: L03127-13-01
MATERIAL: TENSAR BX1100 GEOGRID
SAMPLE:# 5
LOT NO.: 013

TEST	UNITS	SPECIMEN NO. 1	2	3	4	5	AVG	STD
RIB COUNT	MD Ribslft	7.95						
	CD Ribslft	10.63						
WIDE WIDTH STRENGTH MD	2%-MD lbs./ft.	406	427	431	423	418	421	9.86
	5%-MD lbs./ft.	731	761	771	772	764	760	16.87
	Ult.-MD Ibslft	883	914	915	977	957	929	37.64
	Elong at Peak-%	7	8	7	8	8	8	0.57
WIDE WIDTH STRENGTH CD	2%-CD Ibslft	674	664	659	574	683	651	43.98
	5%-CD Ibslft	1,261	1,246	1,251	1,204	1,266	1,246	24.57
	Ult.-CD lbs./ft.	1,538	1,559	1,610	1,612	1,508	1,565	45.51
	Elong at Peak-%	8	8	9	10	7	9	1.26

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