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ND 2007-02	December 2013	N/A	SHE-1-094(114)154

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14. Supplementary Notes

15. Abstract

Objective

The North Dakota Department of Transportation is always looking to improve driving conditions on state roadways for the public. Snow and ice on bridge decks and pavement surfaces can lead to hazardous driving conditions. The objective of this research is to evaluate the effectiveness of both overlay systems in reducing crash statistics. The research will observe the deicing capabilities of the SafeLane™ product. The durability of both products will be evaluated, with a focus on their ability to resist snow plow damage.

Scope

Highway safety projects SHE-7-002(081)018 and SHE-1-094(114)154 will include experimental features to evaluate the performance of the SafeLane™ product and highway safety project SHE-8-094(065)337 will include an experimental feature to evaluate the performance of the FLEXOGRID™ product. All three projects will be evaluated bi-annually with a focus on the durability of the products along with how the products resist snow plow damage.

Summary

The SafeLane™ product on the Sand Creek Bridge near Williston is showing signs of failure. In the wheel paths, the angularity of the aggregate has continued to deteriorate since installation. Vehicle traffic continues to polish the aggregate and reduce the surface friction. Also, the asphalt portion of this project is in rough shape with some material completely gone and the asphalt itself rutting. Evaluating the deicing capabilities of the SafeLane™ product is difficult because the districts treat the bridge with chemicals the same as other bridges in the district. Since installation two accidents have been attributed to ice build-up on the bridge.

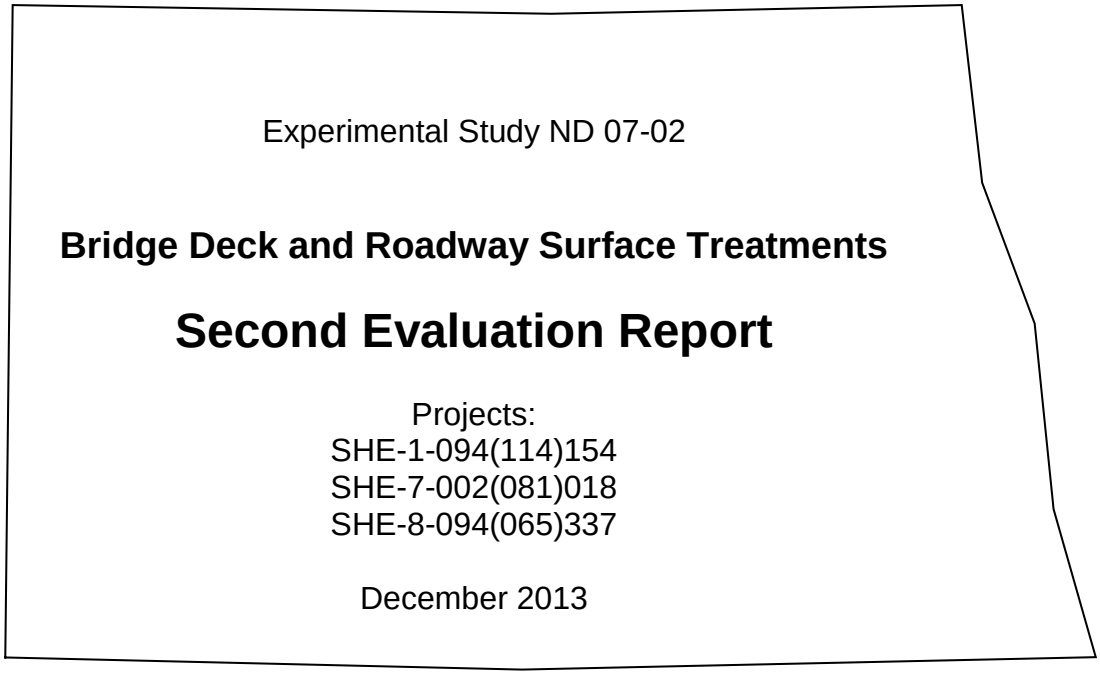
The SafeLane™ product on the Missouri Road Bridge near Mandan is showing signs of fatigue. A large area that was terminated due to panels being replaced on the end of the bridge is continuing to deteriorate. In the wheel paths, the angularity of the aggregate has continued to decrease since installation. Vehicle traffic continues to polish the aggregate and reduce the surface friction. Evaluating the deicing capabilities of the SafeLane™ product is difficult because the districts treat the bridge with chemicals the same as the other bridges in the district. Since installation one accident has been attributed to ice build-up on the bridge.

The FLEXOGRID™ product on the Maple River Bridge on I-94 is overall performing well after four years. There is a minimal amount of material that has been removed from traffic or snow plows at the beginning of the bridge, but the rest of the material is intact. The epoxy and aggregate is still intact on the main part of the bridge, and most of the angularity of the aggregate is still present. The surface friction has diminished some but does not appear to be completely depleted. Since installation two accidents have been attributed to ice build-up on the bridge.

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NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION



Experimental Study ND 07-02

Bridge Deck and Roadway Surface Treatments

Second Evaluation Report

Projects:
SHE-1-094(114)154
SHE-7-002(081)018
SHE-8-094(065)337

December 2013

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO.

1	STATE	YEAR		NUMBER	SURF
	ND	2007	-	02	

CONSTRUCTION PROJ NO
SHE-1-094(114)154
SHE-7-002(081)018
SHE-8-094(065)337

LOCATION
Morton, Williams, and Cass
28 County

EVALUATION FUNDING
48
1 HP&R
2 x CONSTRUCTION
3 DEMONSTRATION
4 IMPLEMENTATION

NEEP NO.
49

PROPRIETARY FEATURE?
51 X Yes
No

SHORT TITLE

TITLE
52 Bridge Deck and Roadway Surface Treatments

THIS FORM

DATE
140 MO. March -- YR. 2013

REPORTING
1 INITIAL 2 X ANNUAL 3 FINAL

KEY WORDS

KEY WORD 1
145 SafeLaneTM

KEY WORD 2
167 Epoxy Overlay

KEY WORD 3
189 Flexogrid

KEY WORD 4
211 Cargill

UNIQUE WORD
233

PROPRIETARY FEATURE NAME
255

CHRONOLOGY

Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:
3/2008	Summer 2008	Summer 2018		
277	281	285	289	293

QUANTITY AND COST

QUANTITY OF UNITS (ROUNDED TO WHOLE NUMBERS)	UNITS		UNIT COST (*Dollars, Cents*)
$7-$10/square foot	1 LIN. FT 2 x SF 3 SY-IN 4 CY	5 TON 6 LBS 7 EACH 8 LUMP SUM	
297	305		306

AVAILABLE EVALUATION REPORTS

CONSTRUCTION	PERFORMANCE	FINAL
315 X		

EVALUATION

CONSTRUCTION PROBLEMS
318
1 NONE
2 x SLIGHT
3 MODERATE
4 SIGNIFICANT
5 SEVERE

PERFORMANCE
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 Two SafeLane™ systems were installed during the 2008 construction season. One installation near Williston and the other near Mandan. One FLEXOGRID™ system was installed near Fargo during the 2009 construction season. The SafeLane products on both bridge decks have a reduced skid resistance most likely from snow plow activity. Also, some the Safelane is deteriorating at the beginning and ends of the bridge decks. The Flexogrid is holding up well after four years with a small amount of material coming off at the beginning of the bridge. The aggregate angularity of the Flexogrid product is still intact which allows the surface friction to still be present, although this has diminished since construction.

Experimental Study ND 07-02

Bridge Deck and Roadway Surface Treatments

Second Evaluation Report

Projects:

SHE-1-094(114)154
SHE-7-002(081)018
SHE-8-094(065)337

December 2013

Written by

Jared Loegering

Andrew Mastel

Disclaimer

The contents of this report reflect the views of the author or authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not reflect the official views of the North Dakota Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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ND 07-02

Bridge Deck and Roadway Surface Treatments

Second Evaluation

Purpose and Need

The North Dakota Department of Transportation is always looking to improve driving conditions on state roadways for the public. Snow and ice on bridge decks and pavement surfaces can lead to hazardous driving conditions.

Bridge decks are susceptible to snow and ice conditions that may differ from the adjacent pavement. Bridge decks are exposed to the atmospheric temperature on all sides of the bridge whereas a typical roadway section has geothermal heat that will help to raise the pavement temperature.

Under certain environmental conditions, the differential temperature can lead to a buildup of frost on the bridge deck. Bridge frost occurs when two things happen:

1) When the bridge deck temperature is at or below the dew point temperature, and
2) When the bridge deck temperature is below freezing.

Black ice is another icing condition that occurs. Black ice forms when snow melts and freezes again. The pavement looks darker and duller in color. Bridge frost and black ice are hard to see presenting a potential hazard to motorists. When possible, NDDOT maintenance forces take proactive measures by pre-applying deicing materials to bridge decks and roadways prior to snow and ice events.

Research is needed to evaluate products that can be applied to bridge decks and roadway surfaces to improve surface friction and help to keep them clear of snow, ice, and frost. This project proposes to evaluate an overlay system called SafeLane™ that is distributed by Cargill and an overlay system called FLEXOGRID™ which is a POLY-CARB product.

These products are epoxy based with aggregate spread into the epoxy during installation. Both products act as a deck sealant and improve surface friction. The SafeLane™ uses special porous aggregate developed through research at Michigan Tech University. The SafeLane™ aggregate is reported to retain deicing chemicals and

release the residual during future precipitation events, thereby reducing the total amount and frequency of deicing chemical application. The manufacturer recommends pretreating the SafeLane™ aggregate with a liquid deicer to lower the freezing temperature of the roadway or bridge deck.

The FLEXOGRID™ manufacturer specifies a durable aggregate with 100 percent fractured faces, with a specific gradation and minimum Mohs scale hardness of 6.5. The recommended aggregate is "Washington Stone." FLEXOGRID™ improves surface friction and is not advertised to have a deicing benefit.

Objective

The objective of this research is to evaluate the effectiveness of both overlay systems in reducing crash statistics. The research will observe the deicing capabilities of the SafeLane™ product. The durability of both products will be evaluated, with a focus on their ability to resist snow plow damage.

SafeLane™ Scope

Highway safety projects SHE-7-002(081)018 and SHE-1-094(114)154 will include experimental features to evaluate the performance of the SafeLane™ product. The projects are scheduled for construction during the summer of 2008. The manufacturer estimates construction will be completed in three to five days.

A contractor that is sublicensed through Cargill and a representative from the manufacturer will be present to ensure proper installation. The cost for the SafeLane™ material is estimated to be $2.50 to $3.00/sq. ft. Based on previous projects, the manufacturer estimates the installed price of their product at approximately $9.00/sq. ft.

SHE-7-002(081)018 Project History

The two-way traffic for the Sand Creek Bridge is shown in Table 1.

Year	Passenger Car	Trucks	Total	30TH Max Hr.	Flex. E.S.A.L'S	Rigid E.S.A.L.'S
2007	5,660	1,240	6,900	690	810	1,240

Table 1: Traffic for Sand Creek Bridge

This highway safety project is west of Williston, North Dakota, on US

Highway 2. The eastbound bridge number 02-018.351 R (Sand Creek Bridge) will be used as the test bridge.

The project begins at reference point 18.303 and ends at 18.384. SafeLane™ will be applied to the full width and length of the bridge deck surface and a portion of the HBP pavement following the bridge. This bridge is on a super elevated curve in a 55 mph zone. The speed limit reduces to 40 mph just after the bridge, as the eastbound traffic approaches Williston. The bridge is shown below in Photo 1.

The Williston District indicated that the crash statistics do not show an accurate number of incidents occurring on the bridge. The incidents usually start on the bridge and the vehicle hits the three cable guard rail. The accidents are not always reported by the motorist. Refer to Appendix A for crash statistics.

The westbound comparison bridge number is 02-018.346 L. This bridge does not have a safety concern, mainly because traffic is just getting up to speed leaving Williston.

The NDDOT Design Division estimated a cost of $121,288 to install approximately 11,700 square feet of SafeLane™, which is a cost of $10.36/ft^2. This area includes the bridge deck and 300' of HBP pavement. Included in the cost is surface preparation, traffic control, material, and labor. A map showing the location of the two bridges is shown in Figure 1.



Photo 1: Sand Creek Bridge Eastbound

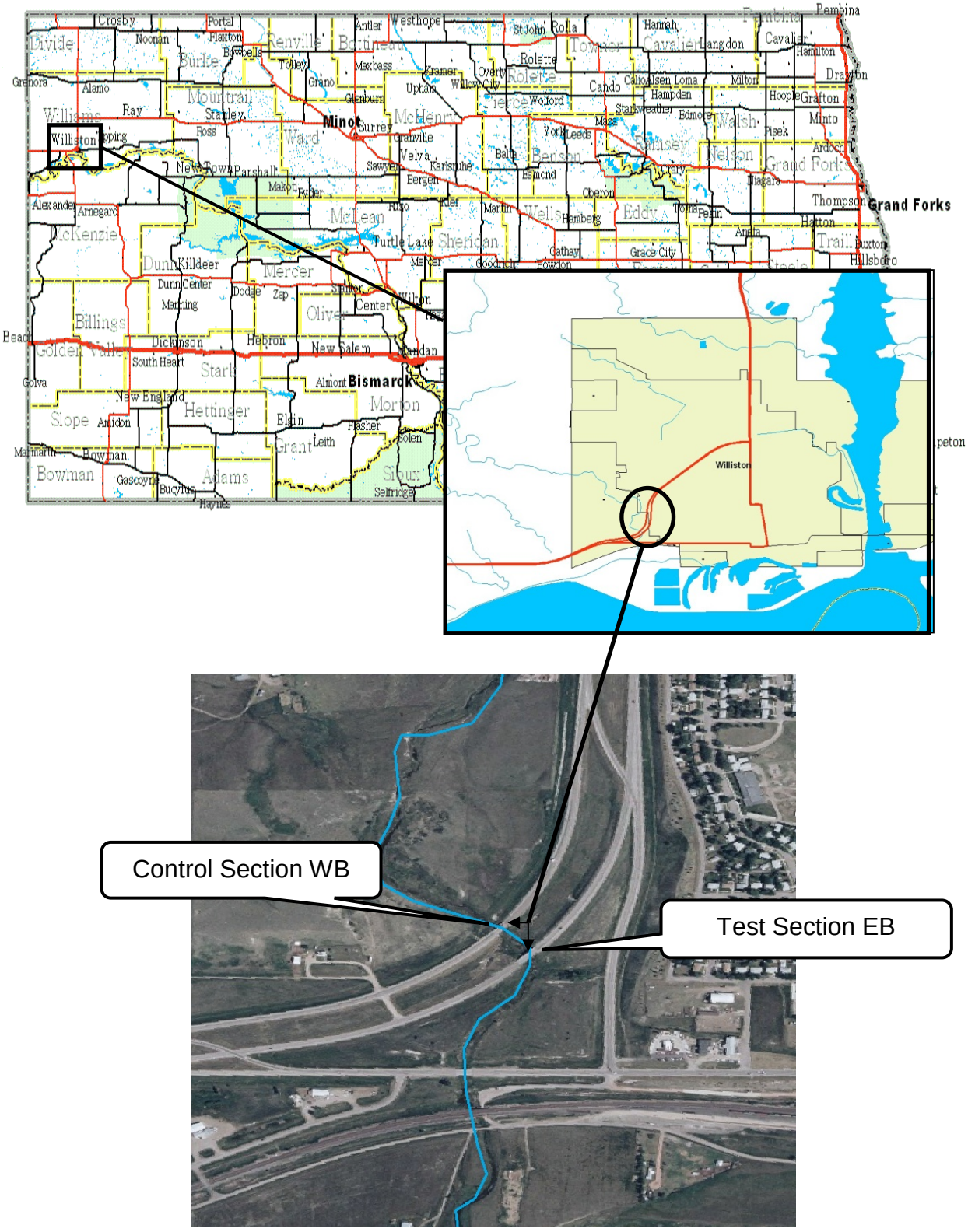


Figure 1: Sand Creek Bridges on US Highway 2 RP 18.303

SHE-1-094(114)154 Road Project History

The one way traffic for the BNRR and Missouri Road Bridge is shown in Table 2.

Year	Passenger Car	Trucks	Total	30TH Max Hr.	Flex. E.S.A.L'S	Rigid E.S.A.L.'S
2007	8,220	730	8,950	895	530	880

Table 2: Traffic for BNRR and Missouri Road Bridge

This highway safety project is located near Mandan at Reference Point 154.337 on I-94. The westbound bridge number 0094.154.232 L (BNRR and Missouri Road) will be used as the test bridge. SafeLane™ will be applied to the full width and length of bridge deck surface and a portion of the preceding approach slab. The bridge is located in a 60 mph zone. The westbound bridge is located just east of the Mandan Ave Exit number 153.

NDDOT Design's Division estimate cost is $81,177.82 to install 7,600 square feet of SafeLane™, which is a cost of $10.68/ft^2. This cost includes the BNRR and Missouri Road westbound bridge to the bridge deck and the preceding 10 ft. of the approach slab. The two bridges are shown in Figure 2 on the next page.

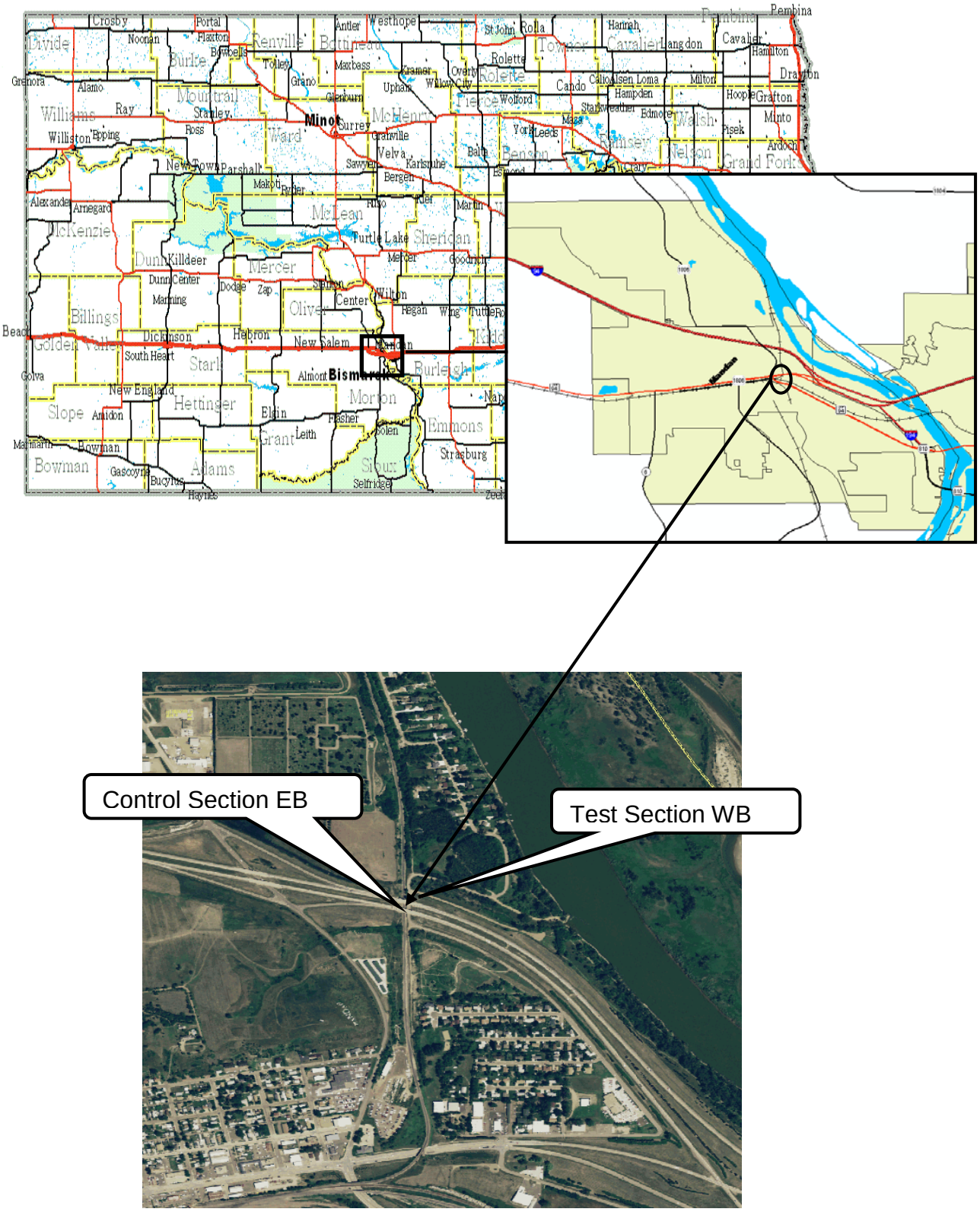


Figure 2: BNRR and Missouri Road Bridges on I-94 RP 154.232

A crash review of westbound I-94 between Reference Point 154.275

(approximately 150 feet west of bridge) to Reference Point 154.337 (east end of bridge) indicated no reportable crashes between January 1, 2003 through October 31, 2007. This bridge is located around a curve. The exit ramp for Exit 153 begins prior to the bridge. Traffic begins to decelerate or brake as they approach or reach the bridge. A picture of the westbound bridge is shown in Photo 2.

The eastbound side has a higher rate of incidents however the eastbound structure was widened in 2010. The 2010 construction project would have interfered with evaluating the performance of a surface treatment.



Photo 2: BNRR and Missouri Road Bridge Eastbound

SafeLane™ Evaluation

The SafeLane™ product will be observed at each location over a period of 10 years or until failure. The Materials and Research Division will lead the evaluation. Williston and Bismarck District maintenance staff will assist in observations of the SafeLane™ bridge decks and the companion bridges.

The Williston and Bismarck District will assist with reporting deicing maintenance activities, date, time, road and weather conditions. They will also note the condition of the test sections compared to the control sections.

Other factors that will be evaluated are crash statistics, performance of binder, and the performance of aggregate materials. A visual evaluation will be conducted twice a year and a report by Materials and Research will be published every two years.

FLEXOGRID™ Scope

Highway safety project SHE-8-094(065)337 will include an experimental feature to evaluate the performance of the FLEXOGRID™ product. The manufacturer will provide the material and perform the installation. The Fargo District will provide traffic control, one 185 CFM compressor, power or vacuum broom to sweep excess aggregate, forklift, and a secure storage yard.

The project is scheduled for construction during the summer of 2008. The manufacturer estimates that construction will be completed in three to five days. The cost for the FLEXOGRID™ material and installation is estimated to be $5.27/sq. ft.

SHE-8-094(065)337 Project History

The one-way traffic for the Maple River Bridge is shown in Table 4.

Year	Passenger Car	Trucks	Total	30TH Max Hr.	Flex. E.S.A.L'S	Rigid E.S.A.L.'S
2007	5,635	1,115	6,750	675	840	1,320

Table 3: Maple River Bridge Traffic

This highway safety project is located near Fargo at Reference Point 337.335 on I-94. The eastbound bridge number 0094-337.335 (Maple River Bridge) will be used as the test bridge. FLEXOGRID™ will be applied to the full width and length of the bridge deck. The westbound bridge will serve as a control bridge. Maps of the bridges are shown in Figure 3.

POLYCARB estimated the project cost to be $49,548.24. This price includes liquid materials, aggregate materials, application machine, all necessary labor, all surface preparation, and all supplies necessary to complete the project.

This bridge does not have any geometric safety concerns but does have a high crash rate. The crash statistics are shown in appendix C. The bridge is shown in Photo 3.



Photo 3: Maple River Bridge Westbound

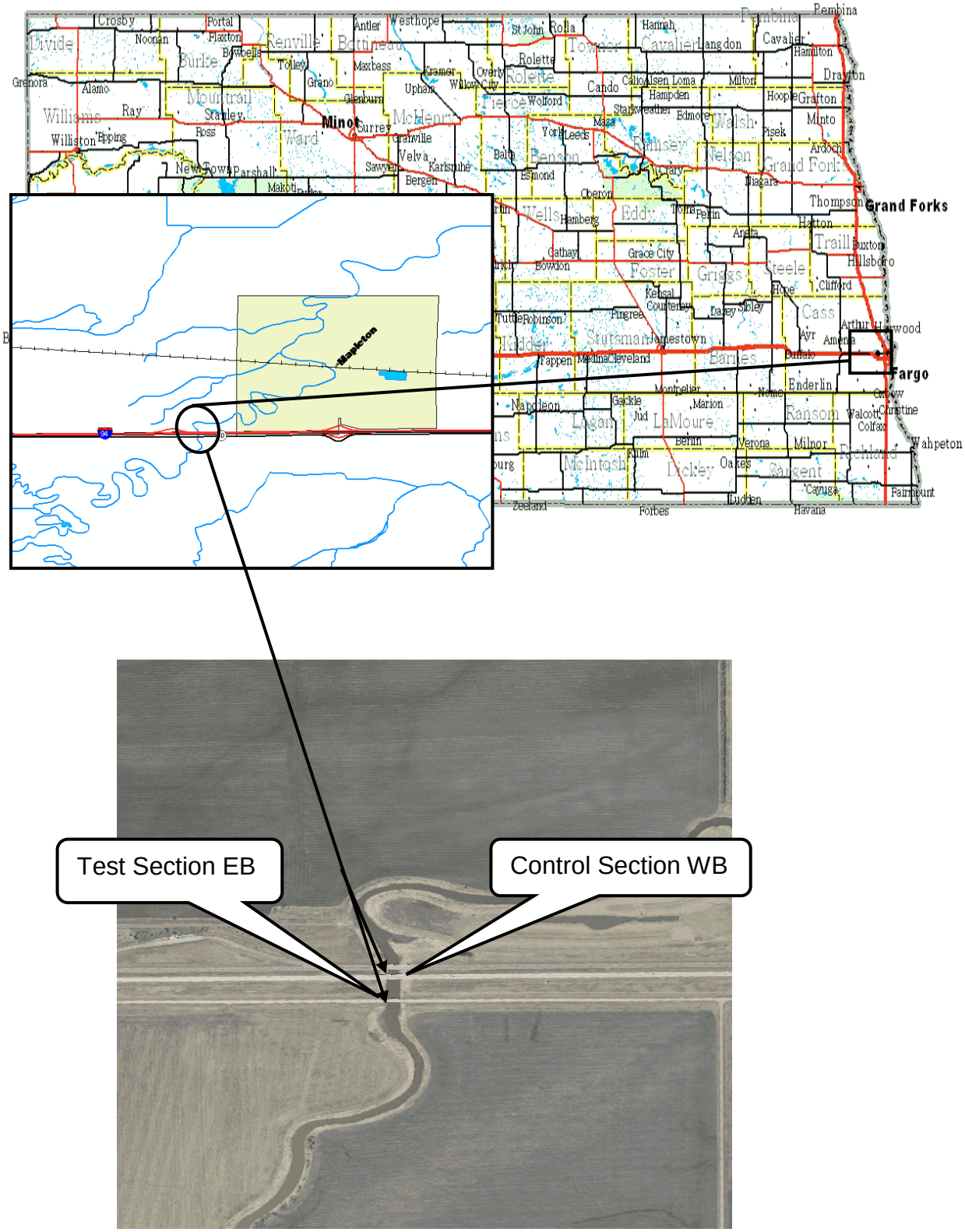


Figure 3: Maple River Bridges on I-94 at RP 337.335

FLEXOGRID™ Evaluation

The FLEXOGRID™ product will be observed over a period of 10 years or until failure. The Materials and Research Division will lead the evaluation. Fargo District maintenance staff will assist in observations of the eastbound SafeLane™ bridge deck and the westbound companion bridge.

Other factors that will be evaluated are crash statistics, performance of binder, and the performance of aggregate. A visual evaluation will be conducted twice a year and a report by Materials and Research will be published every two years.

Construction Report

SafeLane™ Installation Overview

Two SafeLane™ epoxy overlay projects were constructed during the 2008 construction season. Both projects were on four-lane divided roadways and were constructed one lane at a time, leaving one lane open for traffic. The contractors' general construction process is outlined below.

Pavement Preparation

Surface preparation begins by shot blasting concrete pavements and sand blasting asphalt pavements. The pavement surfaces are then blown off with compressed air. Duct tape is placed at the boundaries to ensure straight epoxy lines. The bridge deck would now be ready for the SafeLane™ application.

First Course Application

A two part epoxy called Smartbond (distributed by Unitex) is used. The two-part epoxy is mixed with a variable drill at a one to one ratio for three minutes. The epoxy is then poured on the pavement and spread out with a notched squeegee. The start and stop points of each epoxy batch are kept track of as the product is applied on the pavement surface to monitor the epoxy application rate.

Next, SafeLane™ Aggregate is spread onto the epoxy after a uniform layer of epoxy is established. Workers spreading the epoxy are usually about five feet ahead of the workers spreading the SafeLane™ aggregate. Once the epoxy cures the contractor uses a power broom to remove excess aggregate from the roadway. The first course is then blown off with compressed air, the boundaries and joints are duck taped, and the surface is ready for the second course.

Second Course Application

The second course application is conducted very similar to the first course application. The epoxy is mixed, and then placed on the top of the first course, and aggregate is spread onto the epoxy. The second course takes approximately twice as much epoxy and aggregate as the first course. A flat profile squeegee is used rather than a notched squeegee, which was used during the first course, to spread the epoxy.

The second course is then given time to cure. After the second course is cured

the excess aggregate is cleaned off with a power broom and then blown off with compressed air. The SafeLane™ overlay is now complete and ready for traffic permitting safety obligations.

Sand Creek SafeLane™ Installation

Project SHE-7-002(081)018 was constructed in the summer of 2008 in the Williston District, the plan note is included in Appendix D. This was the installation of a bridge deck overlay on structure number 02-018.351 R as well as an overlay on the 300' of adjacent asphalt roadway on the east end of the bridge deck in the eastbound direction. The cost of this project was $143,709.89 or $12.72 per sq. ft.

Progressive Contractors Incorporated (PCI) was the prime contractor with 3D Specialties providing traffic control. PCI's work crew consisted of seven workers. Materials and Research representatives Andrew Mastel and Matt Luger were present during all construction phases of the project. Tom Peterson, representing the Williston District, was the project engineer. Jim Anderson and Joel Kunnari were also present from the SafeLane™ manufacturer (Cargill Inc) to insure proper installation methods were followed. Jim and Joel also helped spread aggregate during the application process.

Driving Lane Construction

Construction in the driving lane began Monday, August 18, 2008. Williston District personnel performed a chain drag survey which indicated that there was no delamination on the bridge deck. The project engineer's notes are shown in Appendix F. The surface preparation on the concrete and asphalt was conducted simultaneously. Progressive Contractors Incorporated (PCI) had two workers on the bridge deck for shot blasting, two workers for sandblasting and another worker driving the sandblaster truck. Sandblasting was permitted along the edge of the bridge deck where the shot blasting equipment was not able to reach. The shot blasting is shown in Photo 3 and the sand blasting is shown in Photo 4. Surface preparation took approximately 55 min/1000 sq. ft.



Photo 4: Progressive Contractors Incorporated (PCI) Shot Blasting a Concrete Bridge Deck



Photo 5: PCI Sand Blasting Operation in Williston, ND

The bridge deck was inspected visually and appeared to be in good condition. The 300’ of asphalt roadway at the end of the bridge had large transverse cracks and extensive rutting. The ruts increased in depth from about 1/2" at the bridge end to 3/4" about 50' from the end of the project.

A slurry seal consisting of Smartbond Epoxy and sand was used to fill in wide or severe cracks as directed by project personnel.



Photo 6: Slurry Seal

The pavement surfaces were visually inspected to make sure the proper surface preparation was conducted by both a Cargill representative and the project engineer before the first courses of epoxy and aggregate were placed on the pavement.

The driving lane installation dimensions were; 13.5’ x 300’ for the asphalt portion and 15’ x 130’ on the concrete bridge deck.

2500 lb. totes of aggregate were staged along the asphalt portion, and for the bridge deck the contractor placed a stockpile at the west end of the project. PCI used a skid steer to bring the stock piled aggregates closer to the laborers for the bridge deck.

The first course was applied in two segments due to time and temperature constraints. NDDOT’s plan note states: “the temperature of the pavement, deck, all epoxy and aggregate components shall be between 60 to 90 degrees Fahrenheit at the time of application. Epoxy shall not be applied if the air temperature is expected to drop below 55 degrees Fahrenheit within eight hours after application.”

At 7:30 PM on Monday, August 18, 2008, PCI began applying epoxy and SafeLane^{TM} aggregate to the asphalt portion of the driving lane. All courses were applied from the east end to the west end of the project. The pavement temperature at

the start of application was 95˚ F. The project engineer, with the assurance of the Cargill representative, allowed the contractor to proceed even though the deck temperature was above 90˚ F. The Cargill representative stated that they have installed SafeLane™ at pavement temperatures up to 115˚ F.

The epoxy was poured from two large plastic containers that had shutoff valves to accurately fill 5 gallon buckets. The epoxy containers are covered to keep the epoxy temperature down.



Photo 7: PCI Pouring Two Part Epoxy into Five Gallon Buckets

This epoxy was then used to make up batches in a 32 gallon garbage barrel. The contractor used a variable drill with a paddle-end to mix the two part epoxy.



Photo 8: PCI Mixing Epoxy with a Drill and Paddle End



Photo 9: PCI Spreading SafeLane™ Aggregate

The Cargill representative had the contractor start with 10 gallon batches due to high temperatures and inexperience. After the contractor became proficient with the SafeLane™ process the contractor switched to 20 gallon batches.

The SafeLane™ aggregate comes in 2500 lb. totes and was staged as close to

where the contractor was placing the epoxy as possible. The contractor used shovels to spread the aggregate onto the epoxy.

At 9:00 p.m. PCI completed overlaying the 300' of asphalt in the driving lane without any notable problems. The overlay was then allowed to cure overnight.

On Tuesday morning construction began on the concrete portion of the first course. The contractor blew off the driving lane of the structure with a leaf blower. The contractor then continued with the first course application. The deck temp was 68˚ F and it took 45 minutes to complete the first course. The driving lane application rate for the first course was 23 minutes/1000 sq. ft.

While cleaning up with a power broom and compressed air to prepare for the second course, some hydraulic fluid from the contractor's equipment leaked onto the first course. M & R noted that these locations were at approximately 28', 31.5', 59', 63', 81', 111', 115', 123', 128', 131', 203', 207', and 276' from the south east corner of the bridge deck. The fluid was between the centerline and left wheel path. The contractor cleaned these spots with acetone as directed by a Cargill Representative. The driving lane first course cleanup took approximately 20 minutes/1000 sq. ft.

The second course in the driving lane was placed on Tuesday morning. Application started at 10:50 AM and the deck temperature was 91˚ F. A change in the shade of the aggregate was apparent and it was evident that some of the aggregate was damp. Cargill representatives told NDDOT personnel that this was okay and construction continued.

The contractor ran out of epoxy in the plastic totes towards the end of the second course. Using a claw truck to lift the metal barrels containing additional epoxy, the contractor poured more epoxy into the plastic totes as pictured in photo 10.



Photo 10: Contractor Refilling Plastic Totes With Epoxy

The contractor had to make two transverse seams in the overlay. This was achieved by placing a piece of duct tape across the lane, placing the epoxy only to that point, and then spreading the aggregate on top of the epoxy. Once the contractor was ready to proceed the loose aggregate was swept back by hand, the duct tape was removed, and the overlay could then continue. The Cargill representative stated that this would not be a performance issue. The second course was finished at 2:40 PM with an application rate of 38 minutes/1000 sq. ft.

After the second course was allowed to cure the contractor used a power sweeper on the front of a skid steer. The power broom swept the aggregate into a bobcat bucket and was placed onto a trailer. Next, the pavement was blown off with compressed air and 3-D Specialties switched traffic to the driving lane in order to begin surface preparation in the passing lane. The second course cleanup time was approximately 25 minutes/1000 sq. ft.



Photo 11: Contractor Using Power Broom

Passing Lane Construction

The bridge deck in the passing lane was in good condition; however, the asphalt roadway had bad transverse and longitudinal cracks and extensive rutting. The rutting was similar to the driving lane. Materials and Research also observed several locations of efflorescence under the bridge deck where moisture and chlorides had been passing through from the top of the bridge deck.

The Passing Lane installation dimensions were; 12’ x 300’ for the asphalt portion and 13’ x 130’ on the concrete bridge deck.

The first course application in the passing lane was placed on Wednesday morning at a rate of 26 minutes/1000 sq. ft. and the pavement temperature was 73˚ F. There were no notable problems during the first course application in the passing lane. After the epoxy cured, the first course excess aggregate was cleaned up at approximately at a rate of 11 min/1000 sq. ft. and the surface was ready for the second course.

Along the asphalt portion the aggregate totes were staged every 40’. For the bridge deck, the contractor staged the aggregate by dumping it into a windrow. During the three previous courses, they had dumped a stockpile at the west end of the project

and transported the aggregate closer to the laborers with a skid steer.



Photo 12: Aggregate Staged for Second Course

The contractor was not allowed to start the second course until Thursday morning because the deck temperature exceeded the plan note recommendation on Wednesday. Refer to Appendix D for the SafeLaneTM plan note. The contractor began the passing lane second course application at 7:15 AM. The deck temperature was 73˚ F. The second course was completed at 9:30 AM. This pass was completed in 2 hours and 15 minutes or 26 minutes/1000 sq. ft. The passing lane's second course application rate was much quicker because the contractor was familiar with the product, the temperature was much lower, and the materials needed were readily available.

The second course cleanup took 23 minutes/1000 sq. ft. The SafeLane^{TM} installation was now complete and ready for pavement markings.

Below are some project details along with the manufacturer's specification for epoxy application rate and aggregate quantities.

Williston SafeLane™	1st course (DL) Completed 8/19/08(*8/18/08)	2nd course (DL) Completed 8/19/08	1st course (PL) Completed 8/20/08	2nd course(PL) Completed 8/21/08
Start	*7:30 p.m. 6:45 a.m.	10:50 a.m.	7:45 a.m.	7:15 a.m.
Stop	*9:00 p.m. 7:30 a.m.	2:40 p.m.	10:00 a.m.	9:30 a.m.
Starting surface temp	*95˚F 68˚F	91˚F	73˚F	73˚F
Ending surface temp	Not Recorded	Not Recorded	82˚F	Not Recorded
Sq. ft. installed	*4050 1950	6000	5290	5290
Gallons of epoxy used for each course	*105 52	418	158	427
Total epoxy (gal/100 sq. ft.) for each course	2.6	7.0	3.0	8.1
Epoxy (gal/100 sq. ft.) specification	2 to 3.5	7 to 9	2 to 3.5	7 to 9
Aggregate used for each course	7,500 lbs.	25,000 lbs.	7,500 lbs.	20,000 lbs.
Total aggregate (lbs./sq. ft.) for each course	1.25	4.17	1.42	3.78
Aggregate (lbs. /sq. ft.) specification	1 to 2	3 to 4	1 to 2	3 to 4

Table 4: Sand Creek Bridge and Asphalt SafeLaneTM Field Summary

Williston SafeLane™ Construction	Minutes /1000 Square Feet
Avg. Surface Prep and Material Staging	45
Avg. 1st Course Application Rate	24
Avg. 1st Course Cleanup Rate	15.5
Avg. 2nd Course Application Rate	32*
Avg. 2nd Course Cleanup Time	24

Table 5: Time for Construction

* During application of the driving lane second pass the contractor was delayed because they ran out of epoxy and had to go to town for more epoxy.

BNRR and Missouri Road SafeLane™ Installation



Photo 13: BNRR and Missouri Road Structure With the SafeLane™ Application

Project SHE-1-094(114)154 was constructed in the summer of 2008 in the Bismarck District, the plan note is included in Appendix A. The cost of this project was $83,540.59 or $10.96 per sq. ft.

Traffic Safety Services (TSS) was the prime contractor, with PCI performing the shot blasting. TSS provided a work crew of 8-12 people throughout the project. Materials and Research representatives Andy Mastel and Matt Luger were present during most of the construction of this project. Bernie Southam, representing the Bismarck District, was the project engineer. Cargill representative Joel Kunnari was present to insure proper installation. Chain dragging results are shown in Appendix F.

Construction began on the north section (20' of the north half of the bridge deck including the north shoulder) on August 25, 2008 at 8:00 a.m. The bridge was constructed with the north section covering 3960 sq. ft. and the south section (20' of the south half of the bridge deck including the shoulder) covering 3660 sq. ft. First, PCI performed shot blasting with a one man crew. TSS was required to sandblast the edge of the bridge deck, where the shot blaster was not able to reach, and any asphalt and patching. The sand blasting equipment that TSS used was much smaller than what PCI

used in Williston. It took the contractor a significant amount of time to sandblast with a small canister sand blasting setup. The Cargill representative told TSS to go over some areas again with their sand blaster to achieve the proper texture. The north portion surface preparation rate was approximately 99 minutes/1000 sq. ft.

The bridge deck was visually inspected by the Cargill representative and the project engineer to insure proper pavement preparation before the application of the first course. TSS had no previous experience with the SafeLane™ application.

Driving Lane Construction

All courses were installed from the west end to the east end of the project. The epoxy was poured from two large plastic totes that had shutoff valves to accurately fill 5 gallon buckets. This epoxy was then used to make up batches in a 32 gallon garbage barrel. The contractor used a variable drill with a paddle-end to mix the two part epoxy. The Cargill representative had the contractor start with 10 gallon batches due to temperature and inexperience. After the contractor became proficient with the SafeLane™ process the contractor switched to 20 gallon batches.

The SafeLane™ aggregate comes in 2500 lb. totes and was staged on the bridge deck while the contractor was performing surface preparation. The contractor used shovels to spread the aggregate onto the epoxy.

The driving lane or north section of the first course application began Monday at 6:30 PM. The deck temperature was 92˚ F and falling. There were no notable errors. The first course was completed at 7:20 PM. The ending bridge deck temperature was 89˚ F and the application time for the 1st course was 13 minutes/1000 sq. ft. TSS was able to clean the north portion of the 1st course in approximately 23 minutes/1000 sq. ft. The contractor had a power broom similar to PCI's pictured in photo 10 for cleanup.

The second course of the north section started on Tuesday morning at 8:45 AM. The deck temperature was 65˚F throughout the second course installation. The second course application was completed at 10:00 AM with an application rate of 19 minutes/1000 sq. ft.

The contractor hand mixed the first batch on the north section of the second course by hand. Areas of the hand mixed batch did not fully cure by 1:30 PM. The rest

of the course was fully cured. The project engineer decided to continue construction and call this area of the overlay a blemish. He inspected the area the next day and decided that no remedial action would need to be taken. Aggregate did not adhere to some spots of this batch, see photo 14.



Photo 14: Project Engineer Inspecting Hand Mixed Portion

The contractor completed the north portion of the second course clean up in approximately 15 minutes/1000 sq. ft.

Traffic was switched to the north portion at 2:30 PM on Tuesday afternoon. Surface preparation of the south portion was performed at a rate of approximately 98 minutes/1000 sq. ft.

Passing Lane Construction

The first course of the passing lane or south portion started on Tuesday evening at 7:30 PM. The bridge deck temperature was 82˚ F throughout the first course application. The south portion first course application was finished at 8:20 PM at a rate of 14 minutes/1000 sq. ft.

On Wednesday morning the first course was cleaned off (16 minutes/1000 sq. ft.) and the south portion second course application began at 8:55 AM. The bridge deck temperature was 56˚ F at the start of the second course. The application was

completed at 10:20 AM with an ending bridge deck temperature of 68˚ F. The south portion second course application rate was 23 min/1000 sq. ft. and the cleanup rate was approximately 25 minutes/1000 sq. ft.



Photo 15: Traffic Safety Services Applying Second Course

In the tables below are some project details for the Mandan SafeLane™ project.

Mandan SafeLane™	1st Course North Section	2nd Course North Section	1st Course South Section	2nd Course South Section
Date	8/25/08	8/26/08	8/26/08	8/27/08
Surface Preparation	240 minutes	No Data	No Data	No Data
Epoxy and Aggregate Start Time	6:30 p.m.	8:45 a.m.	7:30 p.m.	8:55 a.m.
Epoxy and Aggregate Stop Time	7:20 p.m.	10:00 a.m.	8:20 p.m.	10:20 a.m.
Cleanup	No Data	No Data	No Data	No Data
Beginning deck temp	92 F	65 F	82 F	56 F
Ending deck temp	89 F	65 F	80 F	68 F
Sq. ft. installed	3960	3960	3660	3660
Gallons of epoxy used for each course	103	315	120	287
Total epoxy (gal/100 sq. ft.) for each course	2.6	8.0	3.3	7.8
Epoxy (gal/100 sq. ft.) specification	2 to 3.5	7 to 9	2 to 3.5	7 to 9
Aggregate used/course	7200 lbs.	13,750 lbs.	7500 lbs.	15,000 lbs.
Total aggregate (lbs./sq. ft.) for each course	1.82	3.47	2.05	4.10
Aggregate (lbs./sq.) specification	1 to 2	3 to 4	1 to 2	3 to 4

Table 6: BNRR and Missouri Road SafeLane™ Facts

Mandan SafeLane™ Construction	Minutes /1000 Square Feet
Avg. 1st Course Application Rate	14
Avg. 1st Course Cleanup Rate	20
Avg. 2nd Course Application Rate	21
Avg. 2nd Course Cleanup Time	20

Table 7: Time for Construction

SafeLane™ Installation Summary

A Cargill representative was present during construction of both SafeLane™ projects to insure their product was installed correctly. District personnel supervised the projects and M & R were present to observe the construction process.

Pavement temperature was a factor in both installations. NDDOT's plan note stated that the deck temperature was supposed to be between 60˚ F and 90˚ F. This temperature restriction was exceeded with reassurance from the Cargill Representative that the overlay would still be able to be installed correctly. The contractor was not allowed to proceed if the pavement temperature was above 95˚ F.

In Williston the contractor allowed their workers to walk in the epoxy during the installation. After seeing the mess this created the Cargill representative told TSS, the contractor for the Mandan SafeLane™ project, that they were not allowed to walk in the epoxy. This kept the Mandan project much cleaner.

The surface preparation time per square foot was significantly slower in Mandan because of the canister type sandblaster used as opposed to the industrial sandblasting equipment used by PCI in Williston. The rest of the equipment was very similar.

Both crews were new to the SafeLane™ process. They were both able to become proficient with the process in a short time.

The NDDOT Materials and Research laboratory performed the sodium sulfate soundness test and L.A. Abrasion test on the SafeLane™ aggregate. The results are summarized below and are also included in Appendix H along with an aggregate gradation.

Test	SafeLane™ Aggregate Specification	NDDOT Lab Test Results
Five Cycle Sodium Sulfate Soundness (ASTM C 88)	<5%	1.8%
L.A. Abrasion	29-35	29.4%

Table 8: Lab Results

FLEXOGRID™ Installation Overview



Photo 15: FLEXOGRID™ Installation Semi-Trailer

Pavement Preparation

Surface preparation began by shot blasting the concrete. Sandblasting was used where the shot blaster could not reach and to remove the pavement markings. The pavement surfaces were then blown off. Duct tape was placed at the boundaries to ensure straight epoxy lines. The bridge deck was now ready for the FLEXOGRID™ application.

First Course Application

Preceding the installation a crack sealer called MARK – 135 Penetrating Crack Sealer was sprayed onto the pavement surface. More material was applied when the operator could see a visible crack in the pavement. This was applied with a hand held wand type sprayer.

Then a two part epoxy called MARK – 163 Polymer Overlay was dispensed out of a hose at the back of the installation semi. The epoxy material was mechanically mixed at a 2:1 ratio onsite in the POLYCARB semi-trailer. The epoxy was spread out with a notched squeegee.

Next, Oklahoma Flint Aggregate was spread onto the epoxy. This was

performed with a broadcaster that is mounted on the back of the installation semi-trailer. The aggregate was kept in a hopper at the front of the trailer and went through a series of conveyor belts and eventually was placed into the aggregate spreader. The operator is able to adjust the engine RPMs of the spreader to achieve the proper broadcasting diameter. Once the epoxy cures the contractor used a power broom to remove excess aggregate from the roadway. The first course was then complete, the boundaries and joints were duck taped, and the surface was ready for the second course.

Second Course Application

The second course application was installed very similar to the first course application. The epoxy was mixed, placed on the top of the first course, and aggregate was spread onto the epoxy. A flat profile squeegee is used rather than a notched squeegee, which was used during the first course, to spread the epoxy. The excess aggregate is then cleaned up after the epoxy is fully cured and the roadway is ready for traffic permitting safety obligations.

FLEXOGRID™ Installation



Photo 16: Maple River Bridge Deck Prior to Installation

Project SHE-8-094(065)337 was constructed in July 2009 in the Fargo District, the special provision is included in Appendix E. The cost of the project was $86,930.48 or $9.25/ sq. ft.

The FLEXOGRID™ installation began on Tuesday July 7, 2009 at 7:00 a.m. and the last coat of epoxy was finished on Friday July 10, 2009 at 4:30 p.m. Materials and Research representatives Andy Mastel and Kyle Evert were onsite to observe the passing lane installation and the surface preparation in the driving lane. Materials and Research did a crack survey after the passing lane had been shot blasted. A crack survey was not conducted in the driving lane or shoulder. The crack survey can be found in Appendix G. Chain dragging was not conducted on this bridge deck.

Swanston Equipment Company was the general contractor. SURF PREP, INC performed the shot blasting. Swanston Equipment Company performed the sandblasting, taping the epoxy lines, sweeping the excess aggregate, and provided POLY-CARB with labor as needed. POLY-CARB's representatives were John Taylor and Bruce Roeder (project engineer) who supervised the FLEXOGRID™ installation.

POLY-CARB also provided an operator and a driver for their installation semi.

The bridge deck passing lane installation was conducted first. Traffic was then changed to the passing lane. Construction on the driving lane and shoulder area was performed together.



Photo 17: SURF-PREP INC. Shot Blasting

The surface preparation in the passing lane took about two hours to shot blast and another two hours to sandblast, blow off the surface, and tape boundaries of the passing lane on the structure. This work was complete by about 12:00 p.m. on July 7, 2009. The contractor could not proceed because there was a 60% chance of rain for the afternoon and the special provision prohibits installation when rain is forecasted greater than 50% within 8 hours following application.

The contractor started their first pass at 9:30 a.m. on July 8. The first pass took the contractor one hour to install the material. Then it had to cure for at least two hours before it could be cleaned off. The sweeping started around 1:30 p.m. the contractor used a sweeper that did not have any capability to pick up the aggregate. Sweeping and second course preparation was completed in two hours. This included getting the deck cleaned up and the joints re-taped for the second pass.



Photo 18: Contractor Applying Crack Sealer During First Pass of Passing Lane



Photo 19: Contractor Applying First Pass Application

The second pass material installation was conducted in one hour. The second pass was finished by 4:00 p.m. on Wednesday afternoon. The epoxy had to dry for another two hours and then the contractor cleaned off the bridge deck. Traffic was not switched until Thursday morning.

There was a significant moisture event early Thursday morning which delayed construction. The shot blasting operation was not able to begin until about 12:00 p.m. on Thursday. The contractor blew off the bridge deck in the morning to dry it off to expedite the drying process. Due to the special provision stating "The application of the system shall not be made when it has rained 24 hours before application or rain is forecast (greater than 50%) within eight hours after application" the application did not take place until Friday.

Materials and Research representatives were not able to watch the actual driving lane installation due to so many weather delays already incurred. With the quality control and POLYCARB's expertise Materials and Research felt comfortable that the manufacturer specifications would be followed during the installation. In the table below are some details for the I-94 FLEXOGRID™ installation.

POLY-CARB FLEXOGRID™ I-94 RP 337.335	**Left Lane (2 coats)**	**Right Lane and Shoulder (2 coats)**
Date	7/8/2009	7/10/2009
MARK - 135 Penetrating Crack Sealer	25 gallons	56 gallons
MARK - 163 Polymer Overlay	285 gallons	442 gallons
Oklahoma Flint Aggregate	18,000 lbs.	25,000 lbs.
Sq. ft. installed	3466.75	5933.75
Surface Prep (min/100 sq. ft.)	6.92	no data
1st pass Overlay Installation (min/100 sq. ft.)	1.76	1.38
2nd pass Overlay Installation (min/100 sq. ft.)	1.3	0.81
Total gal of epoxy/100 sq. ft. for each lane	8.22	7.45
Total aggregate lbs./100 sq. ft. for each lane	519	421
1st pass deck temperature degrees F	79	73
2nd pass deck temperature degrees F	93	90

Table 9: Installation Details

The NDDOT Materials and Research laboratory performed the sodium sulfate soundness test and an L.A. Abrasion test on the FLEXOGRID™ aggregate. The results are summarized below.

Test	FLEXOGRID™ Aggregate Specification	NDDOT Lab Test Results
Five Cycle Sodium Sulfate Soundness (ASTM C 88)	No specification	4.65%
L.A. Abrasion	No specification	17.6%

Table 10: Lab Results

First Evaluation-2010

Project SHE-7-002(081)018 (SafeLane™)

Product Performance



Photo 20: SafeLane™ Facing West

SafeLane™ was installed on the ND 2 Sand Creek Structure in the Williston District and was last visually inspected on November 15, 2010. All of the epoxy and most of the aggregates remain in place on the concrete portion of the installation. On the asphalt portion there is rutting. Because of the rutting, some of the road profile is higher and at these locations most of the material has been removed, which is most likely from snow plow activity. In the wheel paths, the angularity of the aggregate has reduced since installation. Vehicle traffic has polished the aggregate and reduced the surface friction.

Crash Statistics

There have not been any reportable accidents near this structure since the time of installation.

Materials and Research sent out a survey to the Williston District and the responses are provided on the following pages:



Photo 21: Small Pockets Were Evident in the Aggregate

Williston District Responses (December 2010)

SafeLane™ questions ((W) Williston District questions were answered by Walt Peterson.)

1. How has SafeLane™ affected your winter maintenance activities at this location?

(W) There is not a lot of change.

2. Have you noticed if SafeLane™ has the ability to retain deicing chemicals? If it has please explain.

(W) Yes, sand and chemical will stay longer (possibly due to course texture).

3. Has the SafeLane™ remained clear of frost, ice, or snow when the control structure was not? If it has please explain.

(W) We have not had a problem with frost and ice. Snow will collect on it. We have not had a lot of frost or ice since the installation. We have had colder winters and typically do not experience melting in months of mid-December to Mid-March. So snow just blows across and collects at the barriers.

4. Has SafeLane™ made the location of the installation safer? If so how do you quantify that?

(W) We have not had an accident from frost or compact snow on this curve section since SafeLane™; prior to that, had a couple of accidents/winter, from sliding off the curve.

5. Has SafeLane™ performed up to your districts expectations? Please explain yes and no responses.

(W) Yes, based on no accidents. This bridge is located on a curve section. No accidents since placement.

6. Would you recommend SafeLane™ at other locations in your district?

(W) Especially in curves where more skid resistance is needed.

Additional district Comments:

(W) It is very hard to wash the sand and salt chemical off the deck in the spring. Still has course texture.

Project SHE-1-094(114)154 (SafeLane™)

Product Performance



Photo 22: BNRR and Missouri Road SafeLane™ Looking West

The SafeLane™ on the I-94 Structure was visually inspected on November 12, 2010. All of the epoxy and most of the aggregate from the epoxy overlay remains in place. In the wheel paths, the angularity of the aggregate has reduced since installation. Vehicle traffic has polished the aggregate and reduced the surface friction.

During the 2010 construction season the approach and exit slabs were replaced along with some concrete repair on the west end of the structure. A portion of the SafeLane™ was removed on the approach slab as well as a portion on the west end of the structure. These repairs were tied into the replacement of the adjacent eastbound structure.

Crash Statistics

Four crashes have been reported near this structure. None of the accidents were directly associated with the structure. Crash statistics for this project are available in Appendix B Page 2.

Materials and Research sent out a survey to the Bismarck District and the responses are provided below:



Photo 23: Obliteration Occurred on Part of Installation on the West End

Bismarck District Responses (December 2010)

SafeLane™ questions ((B) Bismarck District questions were answered by maintenance staff and Kevin Levi.)

1. How has SafeLane™ affected your winter maintenance activities at this location?
(B) It hasn't, we continue to treat the deck the same as the others. Since the SafeLane™ was applied there hasn't been any deck spalling. To quantify the ice control a bit more, we feel as we pass over the deck we should treat it with chemicals rather than take the chance of it becoming slippery.

2. Have you noticed if SafeLane™ has the ability to retain deicing chemicals? If it has please explain.
(B) We think it does retain chemicals because of the coarse surface but are not sure if it is the aggregate or how much chemical is being retained.

3. Has the SafeLane™ remained clear of frost, ice, or snow when the control structure was not? If it has please explain.

(B). We have always treated the deck with chemicals as we do the others. We have noticed frost but the deck does not seem to be as slippery as the other decks without the SafeLane™.

4. Has SafeLane™ made the location of the installation safer? If so how do you quantify that?

(B) With our observations we think it has made the deck safer. It does not seem to be as slippery as the other decks without the SafeLane™.

5. Has SafeLane™ performed up to your districts expectations? Please explain yes and no responses.

(B) Somewhat, it seems to help with snow/ice control and deck spalling issues.

6. Would you recommend SafeLane™ at other locations in your district?

(B) No, but only because of the cost. There should be other epoxies and aggregate that could be used that would cost less?

Additional district Comments:

(B) Kevin Levi's comments: Because of the location and size of the bridge with the SafeLane™ it is difficult to notice the benefits of the product for anti-icing. If the SafeLane™ would have been used in a more remote area I think we would have a better idea regarding its performance and if it would be a benefit on other structures.

Project SHE-8-094(065)337 (FLEXOGRID™)

Project Performance



Photo 24: FLEXOGRID™ Installation Looking East

Materials and Research visited the I-94 Maple River Structure with FLEXOGRID™ on November 5, 2010. This FLEXOGRID™ system appears to be performing well after one year. The epoxy and aggregate is still intact. The skid resistance may have gone down some but does not appear to be significantly changed.

Crash Statistics

Two accidents have been reported on this structure since installation. Both of them have been associated with drifting snow on or near the bridge deck. The full report is available in Appendix C Page 2.

Materials and Research sent out a survey to the Fargo District and the district responses are provided on the following two pages:



Photo 25: FLEXOGRID™ Installation Looking West

FLEXOGRID™ questions answered by Troy Gilbertson ((F) Fargo District December 2010)

1. How has FLEXOGRID™ affected your winter maintenance activities?

(F) Guardrail repairs due to winter time crashes at Mapleton appear to be less.

2. Has FLEXOGRID™ performed up to your districts expectations? Please explain yes and no responses.

(F) The FLEXOGRID™ *seems to be performing well, the adhesion of the aggregate to the bridge deck is good. We also believe that it helps seal and preserve the bridge deck concrete.*

3. Has FLEXOGRID™ made the location of the installation safer? If so how do you quantify that?

(F) We believe it has made the location safer. We do not have crash numbers to quantify that. We are coming to this conclusion as it does not appear that we are having as many crashes. We do not seem to be getting as many requests to apply salt

sand due to a slippery surface as compared to the requests we used to get.

4. Would you recommend FLEXOGRID™ at other locations in your district?

(F) Yes

Additional district Comments

(F) *While the hardness/gradation specification for the rock was met for the Mapleton Bridge and Red River Bridges on I-94 I like the flint rock that was used on the Mapleton bridge better that the granite that was used on the Red River Bridge. The Flint rock is sharper and appears to have better skid resistance. The* FLEXOGRID™ *project on the Red River Bridge seems to have left a slight lip at the ends of the bridge which you can feel when you drive over it.*

Second Evaluation-2013

Project SHE-7-002(081)018 (SafeLane™)

Product Performance



Photo 26: SafeLane™ Facing West

The SafeLane™ product on the ND 2 Sand Creek Structure in the Williston District was evaluated in the fall of 2012 and spring of 2013. This was completed to find if the winter activities of snow plows caused damage to the product. It was observed that the friction qualities of the product continued to deteriorate over the winter, most likely from snow plow activity. Most of the epoxy and aggregate seems to be intact on the concrete bridge deck but the asphalt portion is rutting and in poor condition with a lot of the product gone most likely scraped off from snow removal. Some of the asphalt portion is shown below:



Photo 27: SafeLane™ Asphalt Portion

The aggregate continues to lose its angularity, and is smooth in the wheel paths. Vehicles continue to polish the aggregate on both the asphalt and concrete portions and this greatly reduces the surface friction of the product. There also seems to be some damage to the material from a mill machine or plow, as if something went onto the bridge a little bit and scarred the material. This damage is shown in the next photo:



Photo 28: SafeLane™ Bridge Damage

Crash Statistics

Since installation, there have been four accidents near this structure. Two of the accidents were attributed to ice build-up on the bridge and from this the vehicles lost control. The other two accidents were from losing control of the vehicle prior to the bridge because of ice on the roadway. Crash statistics for this structure can be found in Appendix A.

Project SHE-1-094(114)154 (SafeLane™)

Product Performance



Photo 29: BNRR and Missouri Road SafeLane™ Looking West

The SafeLane™ on the I-94 Structure was visually inspected in the fall of 2012 and spring of 2013. This was completed to find if the winter activities of snow plows caused damage to the product. In the wheel paths, the angularity of the aggregate has continued to deteriorate since installation. Vehicle traffic continues to polish the aggregate and reduce the surface friction. The decrease in the angularity of the aggregate is most likely from snow plow activities.

The portion of the SafeLane™ that was removed on the approach slab as well as a portion on the west end of the structure in 2010 continues to deteriorate and expand. This is shown in the photo below.



Photo 29: Obliteration Occurring on Part of Installation on the West End of Bridge

Crash Statistics

Four accidents have been reported near this structure since construction. One of the accidents was attributed to ice on the bridge and from that the vehicle lost control. Two of the other accidents were from ice on the roadway and the other accident was attributed to some standing water on the bridge that the vehicle struck and then lost control. Crash statistics for this project are available in Appendix B.

Project SHE-8-094(065)337 (FLEXOGRID™)

Product Performance



Photo 30: FLEXOGRID™ Installation Looking East

Materials and Research visited the I-94 Maple River Structure with FLEXOGRID™ in the fall of 2012 and spring of 2013. The product showed no difference between the fall and spring. Some of the material is coming off right at the beginning of the bridge, as shown below:



Photo 30: Beginning of the Bridge

Besides for the small area that is coming off at the beginning of the bridge, the FLEXOGRID™ system appears to be performing well after four years. The epoxy and aggregate is still intact on the main part of the bridge, and most of the angularity of the aggregate is still present. The surface friction has diminished since the first evaluation but does not appear to be completely depleted.

Crash Statistics

Four accidents have been reported on this structure since installation. Two of the accidents were attributed to ice on the bridge and from that the vehicles lost control. The two other accidents were associated with drifting snow on or near the bridge deck. Crash statistics for this structure are available in Appendix C.

Summary

Product Performance

SafeLane™ was installed on the ND 2 Sand Creek Structure in the Williston District and was visually inspected by Materials and Research personnel during the fall of 2012 and spring of 2013. All of the epoxy and most of the aggregates remain in place on the concrete portion of the installation. The asphalt portion is rutting and is in poor condition. Because of the rutting, some of the road profile is higher and at these locations most of the material has been removed, which is most likely from snow plow activity. In the wheel paths, the angularity of the aggregate has continued to deteriorate since installation. Vehicle traffic continues to polish the aggregate and reduce the surface friction.

The SafeLane™ on the I-94 structure near Mandan was last visually inspected during the fall of 2012 and spring of 2013 by Materials and Research personnel. All of the epoxy and most of the aggregate from the epoxy overlay remains in place. In the wheel paths, the angularity of the aggregate has continued to decrease since installation. Vehicle traffic continues to polish the aggregate and reduce the surface friction.

Materials and Research personnel visited the I-94 Maple River Structure with FLEXOGRID™ in the fall of 2012 and spring of 2013. This FLEXOGRID™ system appears to be performing well after four years. The epoxy and aggregate is still intact on the main part of the bridge, and most of the angularity of the aggregate is still present. The surface friction has diminished some but does not appear to be completely depleted.

Crash Statistics

Since installation, there have been four accidents near the Sand Creek Structure since the time of the SafeLane™ installation. Two of the accidents were attributed to ice build-up on the bridge and the other two accidents were from losing control of the vehicle prior to the bridge because of ice on the roadway.

Four accidents have been reported near the Missouri Road Bridge structure since installation of the SafeLane™ system. One of the accidents was attributed to ice

on the bridge and from that the vehicle lost control. Two of the other accidents were from ice on the roadway and the other accident was attributed to some standing water on the bridge that the vehicle struck and then lost control.

Four accidents have been reported on the Maple River Structure since installation of the FLEXOGRID™ system. Two of the accidents were attributed to ice on the bridge and from that the vehicles lost control. The two other accidents were associated with drifting snow on or near the bridge deck.

Traffic

Updated traffic was collected for all three locations of the SafeLane™ and FLEXOGRID™ systems. The traffic can be found in the table below:

Sand Creek Bridge Traffic			BNRR and Missouri Road Bridge Traffic			Maple River Bridge Traffic		
Year	**Flex. E.S.A.L'S**	**Rigid E.S.A.L.'S**	**Year**	**Flex. E.S.A.L'S**	**Rigid E.S.A.L.'S**	**Year**	**Flex. E.S.A.L'S**	**Rigid E.S.A.L.'S**
2007	810	1,240	2007	530	880	2007	840	1,320
2008	505	760	2013	955	1,285	2009	825	1,285
2011	2,220	3,385	-	-	-	2013	1,515	2,435
2012	1,915	3,040	-	-	-	-	-	-

Table 11, Updated Traffic

From this information it can be observed that traffic has increased for all three project locations. This increase in traffic might contribute to the fatigue observed on the SafeLane™ system.

Results from this ongoing study indicate:

- The SafeLane™ product on the Sand Creek Bridge near Williston is showing signs of failure. In the wheel paths, the angularity of the aggregate has continued to deteriorate since installation. Vehicle traffic continues to polish the aggregate and reduce the surface friction. Also, the asphalt portion of this project is in rough shape with some material completely gone and the asphalt itself rutting. Evaluating the deicing capabilities of the SafeLane™ product is difficult because the districts treat the bridge with chemicals the same as other

bridges in the district. Since installation two accidents have been attributed to ice build-up on the bridge.

- The SafeLane™ product on the Missouri Road Bridge near Mandan is showing signs of fatigue. A large area that was terminated due to panels being replaced on the end of the bridge is continuing to deteriorate. In the wheel paths, the angularity of the aggregate has continued to decrease since installation. Vehicle traffic continues to polish the aggregate and reduce the surface friction. Evaluating the deicing capabilities of the SafeLane™ product is difficult because the districts treat the bridge with chemicals the same as the other bridges in the district. Since installation one accident has been attributed to ice build-up on the bridge.

- The FLEXOGRID™ product on the Maple River Bridge on I-94 is overall performing well after four years. There is a minimal amount of material that has been removed from traffic or snow plows at the beginning of the bridge, but the rest of the material is intact. The epoxy and aggregate is still intact on the main part of the bridge, and most of the angularity of the aggregate is still present. The surface friction has diminished some but does not appear to be completely depleted. Since installation two accidents have been attributed to ice build-up on the bridge.

Both the SafeLane™ and FLEXOGRID™ systems will be evaluated in the fall of 2013 and spring of 2014 to see how the products have performed over the winter. The third evaluation report will be available fall 2014.

Appendices

Appendix A: EB Sand Creek Structure Crash Statistics

EB Sand Creek Structure Crash Statistics

The Williston District indicated that the crash statistics do not show an accurate number of incidents occurring on the bridge. The incidents usually start on the bridge and the vehicle hits the three cable guard rail. The accidents are not always reported by the motorist.

RP	Date	Time	Surface Condition	Vehicle Description	Comments
18.50	4/21/2004	12:30 p.m.	Dry	Passenger Car	Dry. Driver fell asleep. Vehicle hit shoulder guardrail.
18.40	10/18/2004	8:55 a.m.	Ice/Snow	Passenger Car	Icy Bridge. Lost control, hit median shoulder guardrail.
18.40	11/30/2006	6:54 p.m.	Ice/Snow	Pickup-Van-Utility	Ice. Lost control on curve, hit shoulder guardrail.
18.40	7/18/2007	2:50 p.m.	Dry	Pickup-Van-Utility	Dry. Trailer came unhitched, trailer hit shoulder guardrail. 30 mph.
18.40	2/3/2011	8:42 a.m.	Ice/Snow	Pickup-Van-Utility	Vehicle lost control due to ice on the bridge. Entered the ditch and rolled over.
18.40	12/10/2011	1:00 a.m.	Dry	Pickup-Van-Utility	Vehicle (hit and run) lost control near the bridge and entered the ditch.
18.40	12/10/2011	7:47 a.m.	Ice/Snow	Passenger Car	Vehicle lost control due to ice on the bridge. Entered the ditch and rolled over.
18.40	12/10/2011	7:48 a.m.	Frost	Pickup-Van-Utility	Vehicle lost control due to ice on the bridge. Entered the ditch and rolled over.

Appendix B: BNRR and Missouri Road Crash Statistics

BNRR and Missouri Road Crash Statistics

A crash review of westbound I-94 between Reference Point 154.275 (approximately 150 feet west of bridge) to Reference Point 154.337 (east end of bridge) indicated no reportable crashes between January 1, 2003 through October 31, 2007.

Since installation of the Safelane on this structure, 4 accidents have occurred. They are summarized in the table below:

RP	Date	Time	Surface Condition	Vehicle Description	Comments
154.01	3/23/2009	5:24 p.m.	Wet	Passenger Car	Vehicle struck some standing water and struck the guardrail on the bridge
154.01	12/2/2009	6:05 a.m.	Snow	Pickup-Van-Utility	Vehicle lost control due to ice on the roadway and struck the guardrail on the bridge.
154.01	2/26/2012	9:36 a.m.	Ice/Snow	Pickup-Van-Utility	Vehicle lost control due to ice on the roadway and struck the guardrail on the bridge.
154.01	3/18/2013	7:44 a.m.	Ice/Snow	Pickup-Van-Utility	Vehicle lost control due to ice on the bridge and struck the guardrail on the bridge.

Appendix C: EB Maple River Bridge Crash Statistics

EB Maple River Bridge Crash Statistics

Below are the crash statistics for the Maple River Bridge from 2003 to 2007:

Year	Number of Accidents	Surface Condition	Comments
2003	2	1 during snow/ice 1 during dry condition	1 traveling EB and 1 traveling WB.
2004	5	All during snow/ice conditions	3 traveling EB and 2 traveling WB.
2005	4	All during snow/ice conditions	1 involving gusty winds, 2 involving snow drifts, 3 traveling EB and 1 traveling WB.
2006	4	Freezing rain and gusty wind conditions	3 traveling EB and 1 traveling WB. All crashes occurred on the same day.

The table below shows the crash statistics for the Maple River Bridge from 2007 to 2013:

RP	Date	Time	Surface Condition	Vehicle Description	Comments
337.3	4/25/2008	8:06 p.m.	Ice/Snow	Passenger Car	Vehicle lost control due to ice on the bridge and struck the guardrail.
337.3	2/15/2010	1:55 a.m.	Snow	Passenger Car and Truck Tractor	First vehicle lost control while passing a semi on the bridge. There were snow drifts in the left lane which caused the first vehicle to strike the semi and guardrail.
337.3	2/15/2010	8:16 p.m.	Snow	Pickup-Van-Utility	Vehicle attempted to pass another vehicle on the bridge and struck a snow drift in the left lane. The vehicle lost control and struck the bridge guardrail.
337.3	1/2/2011	3:20 p.m.	Ice/Snow	Pickup-Van-Utility	Vehicle lost control due to ice on the bridge, entered median and rolled over.
337.3	1/3/2011	3:39 p.m.	Ice/Snow	Pickup-Van-Utility	Vehicle lost control due to ice on the bridge, entered median and rolled over.

Appendix D: SafeLane™ Plan Note

SafeLane™ Plan Note

950-PO1 Anti-Icing Surface Overlay Experimental Feature: SafeLane™, an epoxy overlay manufactured by Cargill Incorporated, will be applied by a contractor with an appropriate license from Cargill. The contractor must purchase materials for the overlay system from or through Cargill (www.cargillsafelane.com or 866-900-7258). Cargill will provide liquid and aggregate materials, have a company representative to oversee installation of the product, and coordinate with the contractor as well as the NDDOT to insure installation practices follow manufacturer specifications. A copy of the manufacturer's specifications shall be submitted to the project engineer seven days prior to start of work.

The contractor shall provide an application machine and all necessary labor, all surface preparation, and traffic control. The installation process must be performed according to manufacturer specifications. The contractor must give the NDDOT a two week notice prior to beginning construction.

The temperature of the pavement, deck, all epoxy and aggregate components shall be between 60 to 90 degrees Fahrenheit at the time of application. Epoxy shall not be applied if the air temperature is expected to drop below 55 degrees Fahrenheit within eight hours after application.

Concrete surfaces need to be thoroughly cleaned by steel shot blasting to ensure proper bonding between the epoxy and concrete substrate. Asphalt surfaces need to be cleaned by sandblasting. A bond breaker such as duct tape is to be used on all expansion joints: And to tape off the longitudinal joints of the overlay to achieve a clean straight joint and eliminate overlap when the adjacent lane is constructed. The tape should be removed prior to the epoxy curing. The pavement markings will need to be obliterated prior to installation. After surfaces have been properly cleaned, moisture and oil free compressed air shall be used to remove dust and other loose material. Mechanical brooms, without water, may be used after the surface has been blown off with compressed air. The surface must then be blown again with compressed air after

brooming to remove all loose residual dust.

District personnel shall chain drag bridge deck and report the results to Materials and Research prior to installation.

Epoxy and aggregate is applied in a double pass method. Each pass of epoxy overlay shall be cured before commencing removal of the loose rock so as to not tear or damage the surface. Removal can be done by oil and moisture-free compressed air, vacuuming or mechanical brooming. After all loose aggregate and any remaining dust has been removed from the first course, the application of the second course of epoxy and aggregate can begin. If the engineer in the field observes that there are areas where the top surface of the stone has been coated with epoxy, the epoxy must be removed by a light shot blasting.

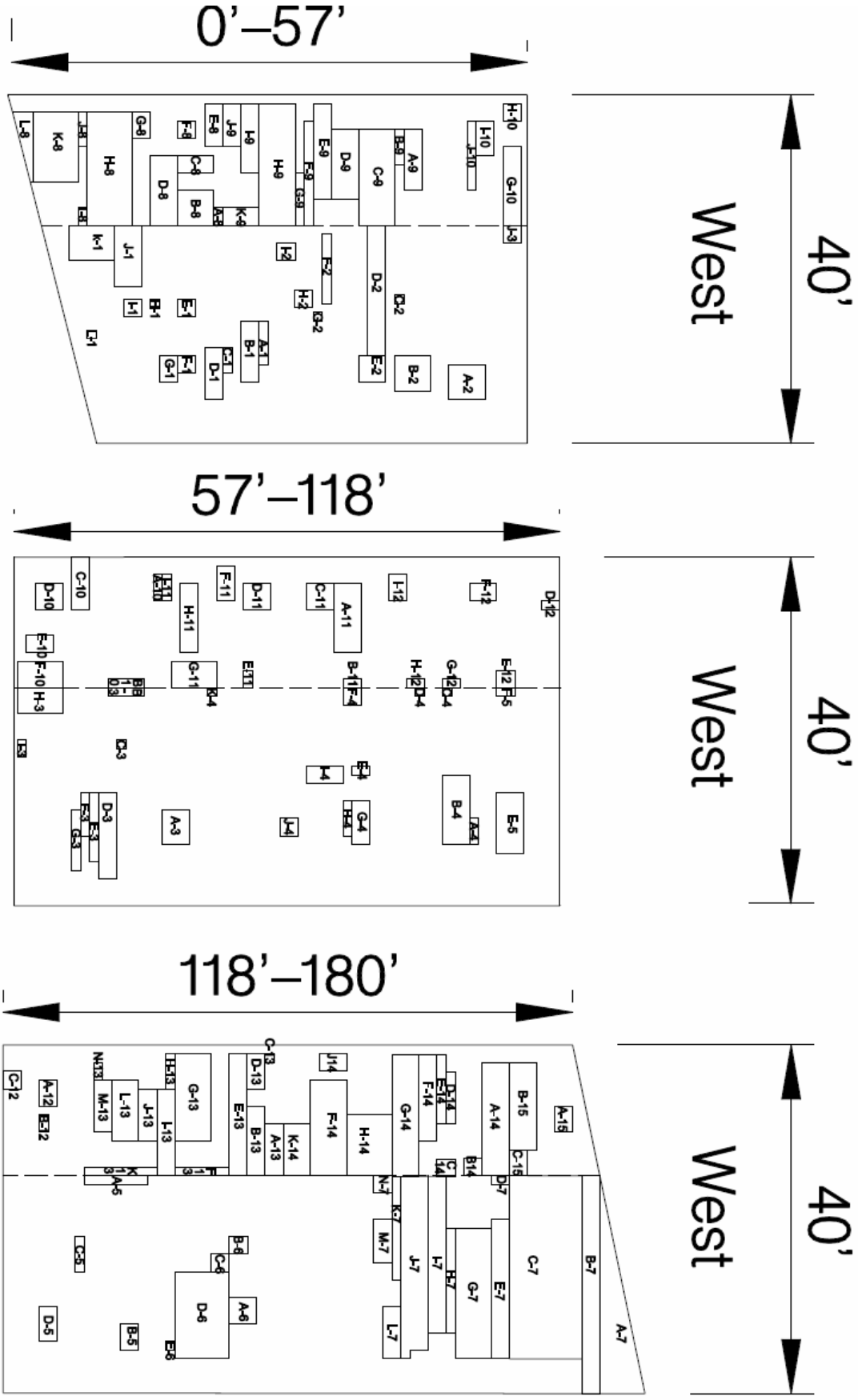
Obliteration of pavement markings shall be paid for separately as “OBLITERATION OF PVMT MK.” All labor, equipment, and materials required to perform this described work shall be included in the price bid for “Anti-Icing Surface Overlay” (SF).

Appendix E: FLEXOGRID™ Plan Note

Appendix F: BNRR and Missouri Road Structure and Sand Creek Structure chain drag results

BNRR and Missouri Road Structure chain drag results

#	Area(sq. ft.)	#	Area(sq. ft.)	#	Area(sq. ft.)	#	Area(sq. ft.)
A-1	5	I-4	8	L-8	8	I-12	6
B-1	14	J-4	4	A-9	14	A-13	12
C-1	3	K-4	1	B-9	4	B-13	16
D-1	12	A-5	7	C-9	44	C-13	1
E-1	4	B-5	6	D-9	24	D-13	8
F-1	4	C-5	4	E-9	22	E-13	28
G-1	6	D-5	8	F-9	12	F-13	6
H-1	1	E-5	21	G-9	6	G-13	40
I-1	4	F-5	2	H-9	56	H-13	4
J-1	21	A-6	9	I-9	16	I-13	20
K-1	20	B-6	4	J-9	10	J-13	12
L-1	1	C-6	4	K-9	8	K-13	8
A-2	16	D-6	60	A-10	3	L-13	21
B-2	16	E-6	1	B-10	4	M-13	12
C-2	1	A-7	63	C-10	12	N-13	2
D-2	30	B-7	50	D-10	9	A-14	39
E-2	9	C-7	168	E-10	6	B-14	4
F-2	8	D-7	2	F-10	15	C-14	4
G-2	1	E-7	32	H-10	4	D-14	6
H-2	4	F-7	60	G-10	18	E-14	8
I-2	4	G-7	12	I-10	8	F-14	20
A-3	12	H-7	36	J-10	8	G-14	42
B-3	4	I-7	40	A-11	24	H-14	35
C-3	1	J-7	21	B-11	2	I-14	44
D-3	20	K-7	12	C-11	9	J-14	6
E-3	8	L-7	12	D-11	9	K-14	18
F-3	5	M-7	10	E-11	2	A-15	6
G-3	7	N-7	4	F-11	8	B-15	30
H-3	15	A-8	2	G-11	15	C-15	6
I-3	2	B-8	16	H-11	16		
J-3	4	C-8	8	I-11	3		
A-4	3	D-8	24	A-12	6		
B-4	24	E-8	10	B-12	2		
C-4	1	F-8	4	C-12	4		
D-4	1	G-8	6	D-12	2		
E-4	2	H-8	65	E-12	4		
F-4	4	I-8	2	F-12	6		
G-4	10	J-8	4	G-12	2		
H-4	4	K-8	40	H-12	2		


0’–57’
40’
West
57’–118’
40’
West
118’–180’
40’
West

Sand Creek Structure chain drag results

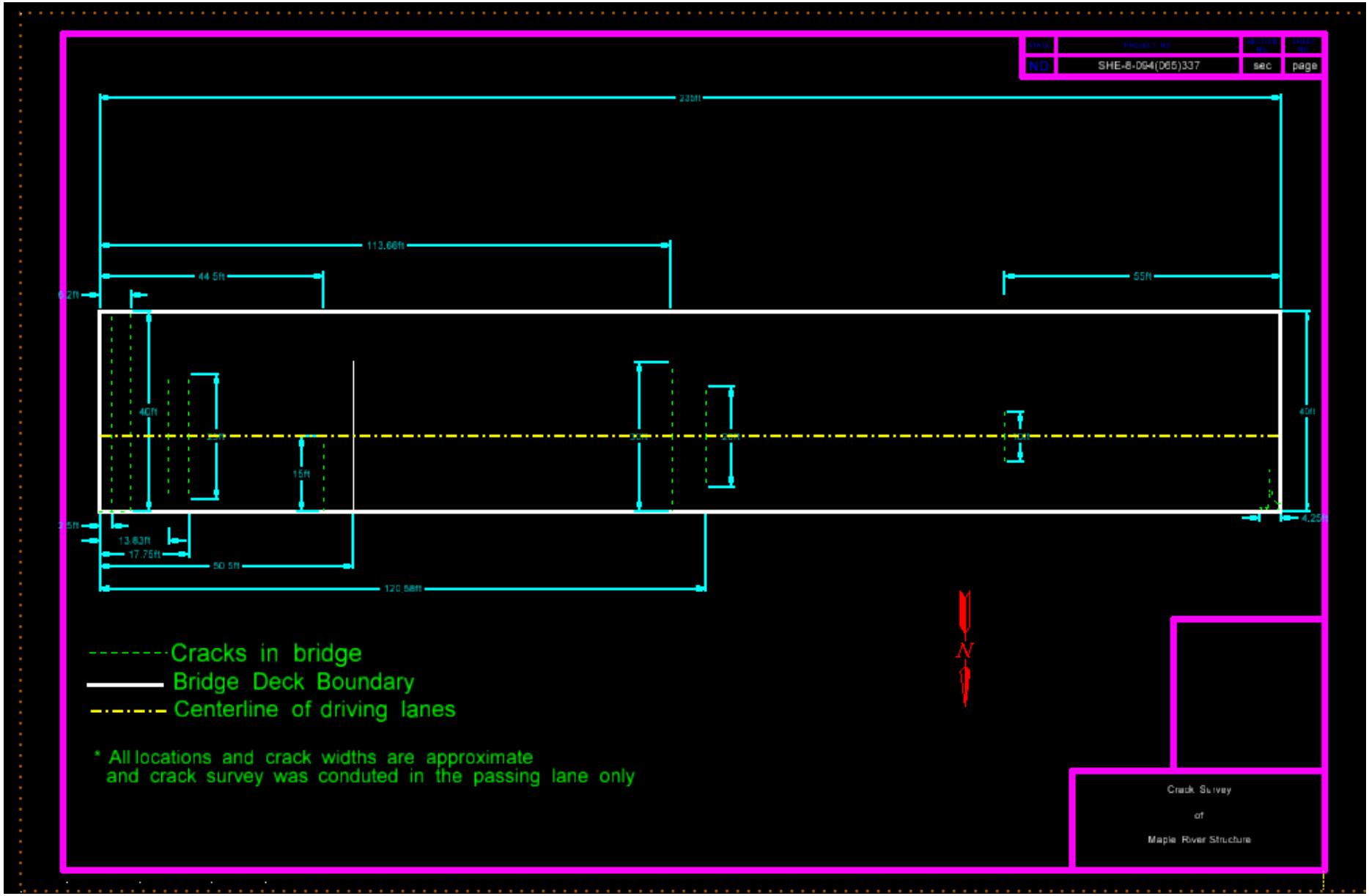
Comments from Tom Peterson(project engineer) are as follows:

August 18, 2008 completed delamination survey using chain drag method for right half of deck working from begin bridge to end bridge. No delamination’s noted.

August 19, 2008 completed delamination survey using chain drag method for left half of deck working from begin bridge to end bridge. No delamination’s noted.

Thomas E. Peterson - Project Manager

Appendix G: Maple River Structure Crack Survey


STATE
PROJECT NO
SECTION NO
SHEET NO
ND
SHE-8-064(065)337
sec
page
238ft
113.66ft
44.5ft
55ft
40ft
40ft
15ft
13.63ft
17.75ft
50.5ft
120.58ft
4.25ft
Cracks in bridge
Bridge Deck Boundary
Centerline of driving lanes
* All locations and crack widths are approximate
and crack survey was conduted in the passing lane only
N
Crack Survey
of
Maple River Structure