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NDDOT M+R ☒ NDDOT OTHER* ☐ NDSU ☐ UND ☐ UGPTI ☐ OTHER* ☐ *see supplementary notes North Dakota DOT Materials and Research Division 300 Airport Road Bismarck ND 58504-6005	North Dakota DOT Materials and Research Division 300 Airport Road Bismarck ND 58504-6005

14. Supplementary Notes

15. Abstract

Purpose and Need

While striving to meet EPA guidelines, the North Dakota Department of Transportation must find a pavement marking system that will also withstand our severe winters, snow plow operations, high traffic volume, and maintain an effective reflectivity over time.

Objective

The objective of this experimental project is to evaluate the effectiveness, durability, and reflectance over time of Polycarb's "MARK-55 Series" epoxy pavement marking.

Scope

The marking system was place on I-29 in Fargo, North Dakota. This location represents a high traffic area and an ideal location to evaluate the MARK-55 series marking system. There were two types of glass beads used on this project, "Visibeads", a trademark of Potters Industries, and Minnesota Specification Epoxy Beads. The markings were evaluated annually. This evaluation included a nighttime visual inspection, a daytime visual inspection, and a "Retroreflectivity Inspection".

Summary

During the following two years the marking system has lost some of its effectiveness due to snow plow damage. Exposure to merging traffic and lane switching caused wear to the marking system.

The sections of roadway where the "Visibeads" are used were registering a larger retroreflectivity reading throughout the evaluation period and also appeared brighter in all hours of the day from a driver's point of view.

The differences between the retroreflectivity readings for the first and second annual evaluations are not appreciable.

During the two year evaluation period the "MARK-55 Series" epoxy marking system has performed to an acceptable standard.

Recommendation

The "MARK-55 Series" epoxy marking system is more expensive to apply. The current price for Polycarb's MARK 55.1 formulation is approximately $22.50 per gallon, which equates to approximately 7¢ per linear foot. The current price for Polycarb's MARK 55.4 formulation is approximately $35.00 per gallon, which equates to approximately 11¢ per linear foot. These prices are for leaded material and will increase approximately 35% if unleaded material is specified. These prices reflect the cost of the material only and are based on the application of a 4" strip laid 15 mils thick and 320 feet long.

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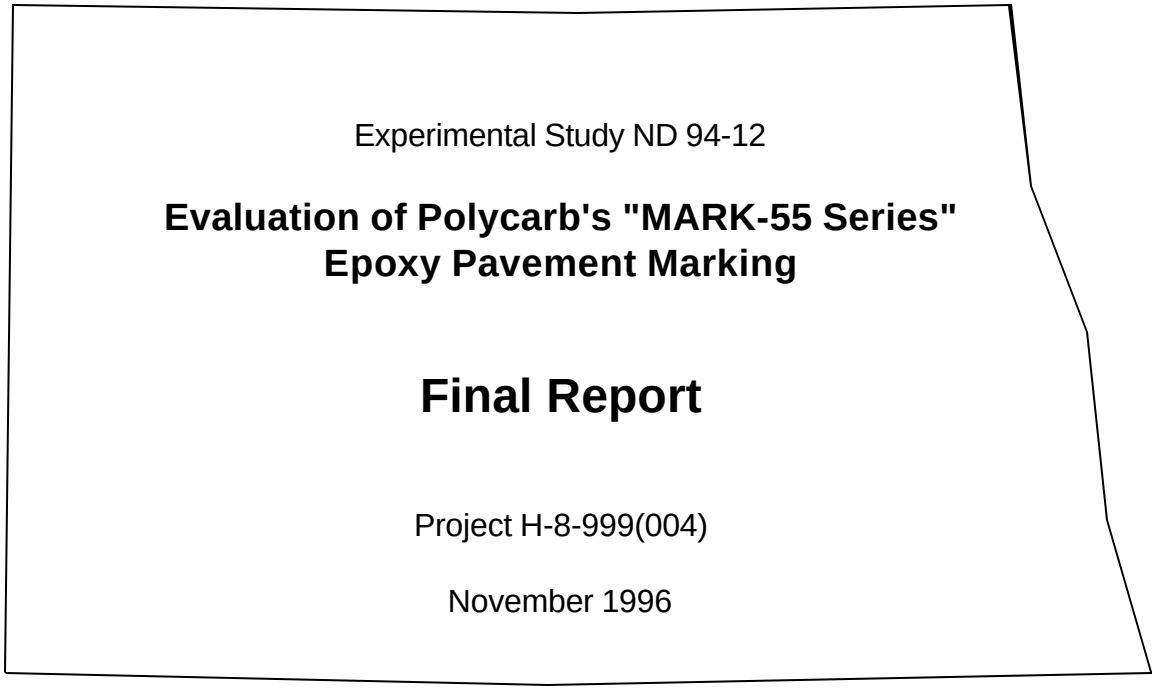
NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION



Experimental Study ND 94-12

Evaluation of Polycarb's "MARK-55 Series" Epoxy Pavement Marking

Final Report

Project H-8-999(004)

November 1996

Prepared by

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO. [1]: STATE ND | YEAR 94 | NUMBER 12 | SUF. —
CONSTRUCTION PROJ. NO. [8]: H-8-999(004)
LOCATION [25]: I-29 Fargo, ND

EVALUATION FUNDING [48]: 1 [X] HPR 2 [ ] CONSTRUCTION 3 [ ] DEMONSTRATION 4 [ ] IMPLEMENTATION
NEEP NO. [49]:
PROPRIETARY FEATURE? [51]: [X] YES [ ] NO

SHORT TITLE

TITLE [52]: Evaluation of PolyCarb's "MARK-55 Series" Epoxy Pavement Marking

THIS FORM

DATE [140]: MO. 06 | YR. 95
REPORTING [144]: 1 [X] INITIAL 2 [ ] ANNUAL 3 [ ] FINAL

KEY WORDS

KEY WORD 1 [145]: TRAFFIC
KEY WORD 2 [167]: CONTROL
KEY WORD 3 [189]: LANELINES
KEY WORD 4 [211]: EPOXY
UNIQUE WORD [233]:
PROPRIETARY FEATURE NAME [255]: PolyCarb's MARK-55 Series

CHRONOLOGY

Date Work Plan Approved: MO. / YR. [277]	Date Feature Constructed: MO. / YR. [281]	Evaluation Scheduled Until: MO. / YR. [285]	Evaluation Extended Until: MO. / YR. [289]	Date Evaluation Terminated: MO. / YR. [293]
07 / 94	08 / 94	06 / 99		

QUANTITY AND COST

QUANTITY OF UNITS (Rounded to whole numbers) [297]: 2,0,0,0,0
UNITS [305]: 1 [ ] LIN. FT. 2 [ ] S.Y. 3 [ ] S.Y.-IN. 4 [ ] C.Y. 5 [ ] TON 6 [ ] LBS. 7 [ ] EACH 8 [X] LUMP SUM
UNIT COST (Dollars, Cents) [306]:

AVAILABLE EVALUATION REPORTS

[X] CONSTRUCTION [315] [ ] PERFORMANCE [ ] FINAL

EVALUATION

CONSTRUCTION PROBLEMS [318]: 1 [ ] NONE 2 [X] SLIGHT 3 [ ] MODERATE 4 [ ] SIGNIFICANT 5 [ ] SEVERE
PERFORMANCE [319]: 1 [ ] EXCELLENT 2 [ ] GOOD 3 [ ] SATISFACTORY 4 [ ] MARGINAL 5 [ ] UNSATISFACTORY

APPLICATION

[320]: 1 [ ] ADOPTED AS PRIMARY STD. 2 [ ] PERMITTED ALTERNATIVE 3 [ ] ADOPTED CONDITIONALLY 4 [ ] PENDING 5 [ ] REJECTED 6 [ ] NOT CONSTRUCTED
(Explain in Remarks if 3, 4, 5 or 6 is checked)

REMARKS

[321]

[7001]

FORM FHWA 1467 Previous Editions are Obsolete

Experimental Study ND 94-12

Evaluation of Polycarb's "MARK-55 Series" Epoxy Pavement Marking

FINAL REPORT

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Written by
Curt Dunn

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EVALUATION OF POLYCARB'S
MARK-55 SERIES EPOXY MARKING

Objective

The objective of this experimental project is to evaluate the effectiveness, durability, and reflectance over time of Polycarb's "MARK-55 Series" epoxy pavement marking.

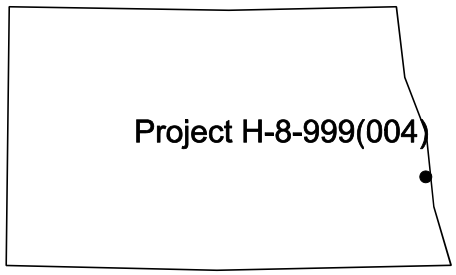
Scope

While striving to meet EPA guidelines, the North Dakota Department of Transportation must find a pavement marking system that will also withstand our severe winters, snow plow operations, high traffic volume, and maintain an effective reflectivity over time.

Polycarb's "MARK-55 Series" epoxy pavement marking will be evaluated for its ability to withstand high traffic wear and snow plowing operations, its reflectivity, and its ease of application and repair.

Location

It was decided to place the marking system on I-29 in Fargo, North Dakota. This location represents a high traffic area and an ideal location to evaluate the MARK-55 series marking system. Table 1 on the following page shows a listing of the beginning and ending locations:



DIRECTION	COLOR & LINE TYPE	STARTING STATIONS	ENDING STATIONS
Northbound	White Edge	500	263+30
Northbound	White Skip	477+55	263+30
Northbound	Yellow Edge	472+22	263+30
Southbound	White Edge	470+00	263+30
Southbound	White Skip	477+41	263+30
Southbound	Yellow Edge	471+97	263+30

Table 1

Traffic

Traffic data for the test sections is presented in Table 2.

SECTION	YEAR	PASS>CAR	TRUCKS	TOTAL	DHV	EASLS
I-94 Ave. to 13th Ave. S (NB)	1996	18,935	1,715	20,650	2,065	2,280
	2016	29,225	2,545	31,770	3,175	3,380
13th Ave. S to Main Ave. (NB)	1996	15,605	1,545	17,150	1,715	2,055
	2016	23,185	2,265	25,450	2,545	3,010
Main Ave. to 12th Ave. N (NB)	1996	16,655	1,295	17,950	1,795	1,720
	2016	22,085	1,665	23,750	2,375	2,210
12th Ave. N to 19th Ave. N (NB)	1996	10,130	1,020	11,150	1,115	1,360
	2016	14,995	1,605	16,600	1,660	2,130
I-94 Ave. to 13th Ave. S (SB)	1996	17,455	1,895	19,350	1,935	2,520
	2016	27,890	3,020	30,910	3,090	4,020
13th Ave. S to Main Ave. (SB)	1996	15,770	1,380	17,150	1,715	1,835
	2016	24,240	2,360	26,600	2,660	3,140
Main Ave. to 12th Ave. N (SB)	1996	16,320	1,230	17,550	1,755	1,635
	2016	21,450	1,500	22,950	2,295	1,995
12th Ave. N to 19th Ave. N (SB)	1996	10,145	1,005	11,150	1,115	1,340
	2016	14,735	1,465	16,200	1,620	1,950
I-94 NE Ramp	1996	9,250	750	10,000	1,000	1,000
	2016	12,425	975	13,400	1,340	1,300
13th Ave. S SE Ramp	1996	9,600	300	9,900	990	400
	2016	13,440	420	13,860	1,390	560
19th Ave. N SW Ramp	1996	5,500	100	5,600	560	130
	2016	6,240	110	6,350	635	140

Table 2

Design

PolyCarb's "MARK-55 Series" epoxy pavement marking system is categorized into two categories: short life and long life. The long life formulations are identified as MARK 55 and MARK 55.4. The short life formulations are identified as MARK 55.1, MARK 55.1W and MARK 55.3.

PolyCarb claims the long life formulation will give the state approximately 4 years of service on concrete and 6 years of service on asphalt. The short life formulation should give the state 1 ½ years of service on concrete and 2 to 2 ½ years on asphalt.

On this experimental project the MARK 55.4 formulation was used for the white edge lines and the white skip lines on both lanes of I-29. The MARK 55.1 formulation was used for the yellow edge lines in both lanes and the MARK 55 formulation was used for the white edge lines on the various ramp sections of the project.

The epoxy marking material consisted of a 100% solid two-part system formulated and designed to provide a simple volumetric mixing ratio of two components (e.g. two volumes of Part A to one volume Part B).

There were two types of glass beads used on this project, "Visibeads", a trademark of Potters Industries, and Minnesota Specification Epoxy Beads. Table 3 depicts the "Visibeads" gradation.

"VISIBEADS" GRADATION	
Sieve Size	**Percent Passing**
No. 10	100.0
No. 16	23.1
No. 20	1.3
No. 30	1.1
No. 50	0.6
No. 100	0.1

Table 3

The Minnesota gradation specification, (table 4), is similar to North Dakota's specification. Minnesota's specification also requires that the beads meet the requirements stated in AASHTO

M247. This is also similar to North Dakota's Specification requirements. For moisture resistance the beads have to be silicone treated to meet the requirements of section 4.4.2 of AASHTO M247. This Minnesota specification was recommended by Potter's Industries, the supplier.

Sieve Size	MINNESOTA's BEAD GRADATION	NORTH DAKOTA'S BEAD GRADATION
	Percent Passing	Percent Passing
No. 20	100	100
No. 30	75 - 95	75 - 95
No. 40	-	-
No. 50	15 - 35	15 - 35
No. 80	-	-
No. 100	0 - 0	0 - 5

Table 4

By looking at the gradation tables, the "Visibeads" are larger than Minnesota's bead gradation. With larger beads we should get larger retroreflectivity readings.

Construction

The prime contractor on this project was Swanston Equipment Company based in Fargo, North Dakota.

All ramps were striped except the 12th Avenue North interchange, part of the 13th Avenue South interchange, and the Texas Turn portion. Detailed drawings showing the different types of formulations and their locations are found in appendix A.

The test sections between the I-94 and the I-29 interchange and the 12th Avenue North interchange were installed with Minnesota specified glass beads. The test sections between the 12th Avenue North interchange and the 19th Avenue North interchange were installed with "Visibeads".

Evaluation

Materials and Research conducted the second and final evaluation of the "MARK-55 Series" epoxy marking system on 7/23-24/96. This evaluation included a nighttime visual inspection, a daytime visual inspection, and a "Retroreflectivity Inspection".

The evaluation of the "MARK-55 Series" epoxy marking system was to be a five year study. However the experimental sections in question were accidentally striped during a recent pavement marking project on August 5, 1996.

On the afternoon of the 23rd, the daytime inspection was conducted. This inspection also included the retroreflectivity inspection. Photos 1 through 4 show a general overview of the condition of the northbound test sections between the I-94 interchange and the 12th Avenue North interchange.

As previously mentioned this area was installed with Minnesota specified glass beads. Photo1 shows isolated damage encountered on the white edge line. Photo 2 shows a view of the marking system near the overpass of 13th Avenue South. Photo 3 shows a typical section between 13th Avenue South and Main Avenue.

Photo 1. View of damaged white edge line in the northbound test section between the I-94 interchange and the 13th Avenue South interchange.

Photo 2. View of the northbound test section near the overpass of 13th Avenue South.

Photo 3. View of the northbound section between 13th Avenue South and Main Avenue.

Photo 4 depicts some damage encountered on a centerline skip just south of the 12th Avenue North interchange.

Photo 4. View of the centerline skip in the northbound section just south of the 12th Avenue North interchange.

Photos 5 through 8 show a general overview of the condition of the northbound test sections between the 12th Avenue North interchange and the 19th Avenue North interchange. As previously mentioned, these test sections will installed with Visibeads".

Photos 5 and 6 show a view of the edge lines (white and yellow) and the centerline skips.

Photo 5. Overview of the northbound test section between 12th Avenue North and 19th Avenue North.

Photo 6. View of the northbound test section between 12th Avenue North and 19th Avenue North.

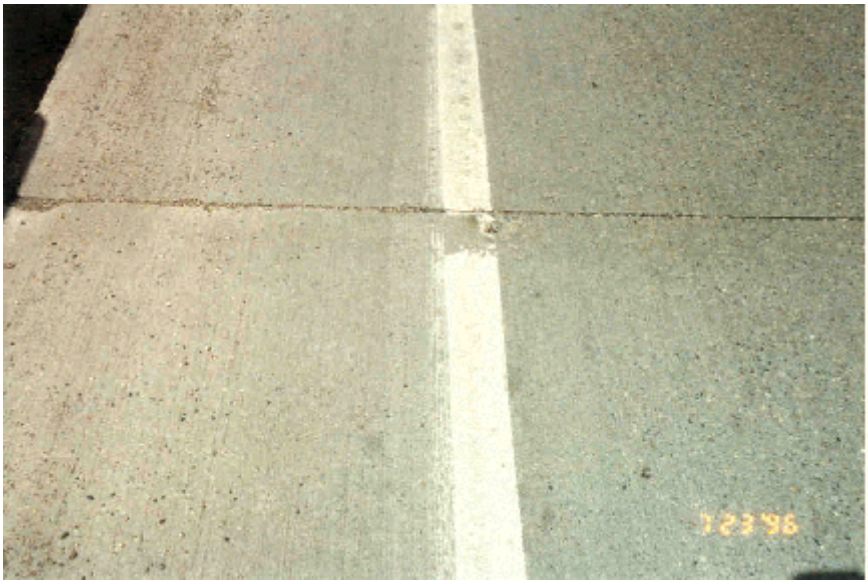


Photo 7. View of the isolated damage on the white edge line in the northbound test section between the 12th Avenue North interchange and the 19th Avenue North interchange.

Photos 7 and 8 depict isolated areas in which the white and yellow edge lines are damaged.

Photo 8. View of the isolated damage on the yellow edge line in the northbound test section between the 12th Avenue North enterchange and the 19th Avenue North interchange.

Photos 9 and 10 depict the white edge lines on the northbound on-ramp from I-94 to I-29. This stretch of roadway has Type 55 pavement marking installed on it. This pavement marking was epoxied over the existing paint.

Photo 9. Damaged areas encountered on the northbound on-ramp from I-94 to I-29.

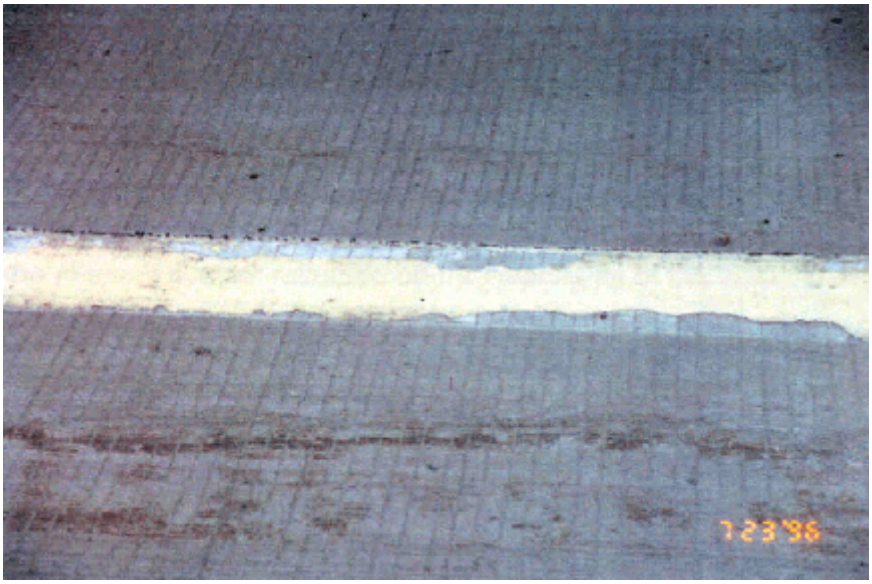


Photo 10. Damaged areas encountered on the northbound on-ramp from I-94 to I-29.

Photo 11. A typical section in the southbound lane of I-94.

Photo 11 depicts a typical section in the southbound lane. This particular section has Minnesota specified glass beads applied on it.

As was portrayed in the photos, there are several areas in the test sections that have limited damage. This can be attributed to either snowplow damage or damage due to traffic.

On the evening of the 23rd, the nighttime inspection was conducted. This inspection was performed by driving through the sections in question and determining how well the marking system reflected off the headlights of the vehicle.

- The yellow edge lines appeared brighter than the white edge lines in both lanes.
- The marking system containing the "Visibeads' appeared brighter than the area containing the Minnesota specified beads.

For the retroreflectivity readings, an apparatus called a retroreflectometer is used. This instrument is useful for testing highway traffic markings for luminous reflectorance using directions of illumination and observation similar to those occurring during night traffic. For this project, a portable unit termed the "Mirolux 12" was used. This unit is made by Miro-Bran Assemblers, Inc.. It is battery powered. The dimensions are 18 inch long, 6 inch wide and 9 inch high. It can be handled and operated easily by one person.

Readings are taken by setting the instrument directly over the edge or skip line in question and reading the digital scale. An average of several readings are taken rather than a single reading. This is to ensure that the readings taken may reflect a more accurate depiction of the condition of the marking system.

The retroreflectivity readings were taken during the daytime. The readings were concentrated along the entire length of the northbound lane as well as the corresponding ramps.

Table 5 on the following page compares the results of the average readings taken for the both the "Visibeads" and the Minnesota specification beads from 1994 to1996.

	"VISIBEADS"			MINNESOTA'S SPEC. BEAD		
Year	1994	1995	1996	1994	1995	1996
White edge lines	320	232	204	275	136	131
Yellow edge lines	-----	153	174	-----	127	130
Center line skips	328	214	176	172	93	113

Table 5

The retroreflectivity readings from the 1996 annual evaluation were not that much different from the 1995 annual evaluation. The readings for the 1996 annual evaluation were taken in the same general area where the 1995 annual evaluation was done.

As was shown in the daytime and nighttime evaluations, the retroreflectivity readings in the area where the "Visibeads" are located were significantly better for the entire marking system than in the area containing the Minnesota specification beads. Keep in mind also that the traffic may be slightly more in the area where the Minnesota specification beads are located which may correspond to more lane switching.

The on-ramp sections containing the Type 55 epoxy pavement marking showed an average retroreflectivity reading of 135. There were some signs of damage to the Type 55 epoxy pavement marking where it was epoxied over the existing paint as shown in photos 9 and 10.

Summary

During the following two years the marking system has lost some of its effectiveness due to snow plow damage. Exposure to merging traffic and lane switching caused wear to the marking system.

The sections of roadway where the "Visibeads" are used were registering a larger retroreflectivity reading throughout the evaluation period and also appeared brighter in all hours of the day from a drivers point of view.

The difference between the retroreflectivity readings for the first and second annual evaluations are not appreciable.

During the two year evaluation period the "MARK-55 Series" epoxy marking system has performed to an acceptable standard.

Recommendations

The short life formulation of the"MARK-55 Series" epoxy marking system identified as MARK 55.1 has a manufacturer's design life of approximately 1-1/2 years on concrete pavements and approximately 2-1/2 years on asphalt pavements. The MARK 55.1 formulation was used on all of the yellow edge lines in our concrete pavement test sections. During the two years of service, this formulation has performed to acceptable standards considering the heavy traffic and harsh winters.

The MARK 55.4 and the MARK 55 formulations are long life formulations which have a design life of approximately four years on concrete pavements and approximately six years on asphalt pavements. The MARK 55.4 and the MARK 55 formulations were used on all the white edge lines and ramp sections in our concrete pavement test sections. These formulations also were performing to acceptable standards after two years. Due to the experimental project being shortened from five years to two years, it is impossible to assess the performance of these two formulations beyond this point.

The Polycarb "MARK-55 Series" epoxy marking system is used by many other states. Some states are obtaining good performance even after three or four years of snow plowing and are requiring that it be used on all resurfacing projects (concrete and asphalt).

The "MARK-55 Series" epoxy marking system is more expensive to apply. The current price for Polycarb's MARK 55.1 formulation is approximately $22.50 per gallon which equates to approximately 7¢ per linear foot. The current price for Polycarb's MARK 55.4 formulation is approximately $35.00 per gallon which equates to approximately 11¢ per linear foot. These prices are for leaded material and will increase approximately 35% if unleaded material is specified. These prices reflect the cost of the material only and are based on the application of a 4" strip laid 15 mils thick and 320 feet long.

In the past, the North Dakota Department of Transportation (NDDOT) used alkyd paints for pavement marking and recently used waterborne paints on projects. The NDDOT expects to receive at least 1 year of acceptable service on centerline skip lines

for both alkyd and waterborne paint systems and 2 years of acceptable service on edge lines.

The current price for yellow alkyd paint (leaded) is $4.78 per gallon or approximately 1.5¢ per linear foot. Yellow waterborne paint (leaded) is approximately $5.00 per gallon or approximately 1.6¢ per linear foot. The current price for white alkyd paint (unleaded) is approximately $4.64 per gallon or approximately 1.5¢ per linear foot. White waterborne paint (unleaded) is approximately $4.15 per gallon or approximately 1.3¢ per linear foot. These prices reflect the cost of the material only and are based on the application of a 4" strip laid 15 mils thick and 320 feet long.

Polycarb encourages the use of 20 to 25 pounds of glass beads with the "MARK-55 Series" epoxy marking system, which is considerably more than the 6 pounds currently used by the NDDOT. The cost of "Visibeads" is approximately 85¢ per pound compared to 25¢ per pound for normal beads.

It is encouraged by Polycarb and its users that the "MARK-55 Series" epoxy marking system be applied to surfaces that are free from existing pavement marking systems unlike itself. In the evaluation of the ramp test sections there were some problems encountered involving the epoxy system breaking away from the existing paint.

Other benefits to offset the high cost of the "MARK-55 Series" epoxy marking system may be the cost savings incurred by having fewer bidding projects and fewer lane closures for traffic control. The "MARK-55 Series" epoxy marking system is also free of flammable and toxic solvents, thus does not emit any toxic fumes into the environment during application.

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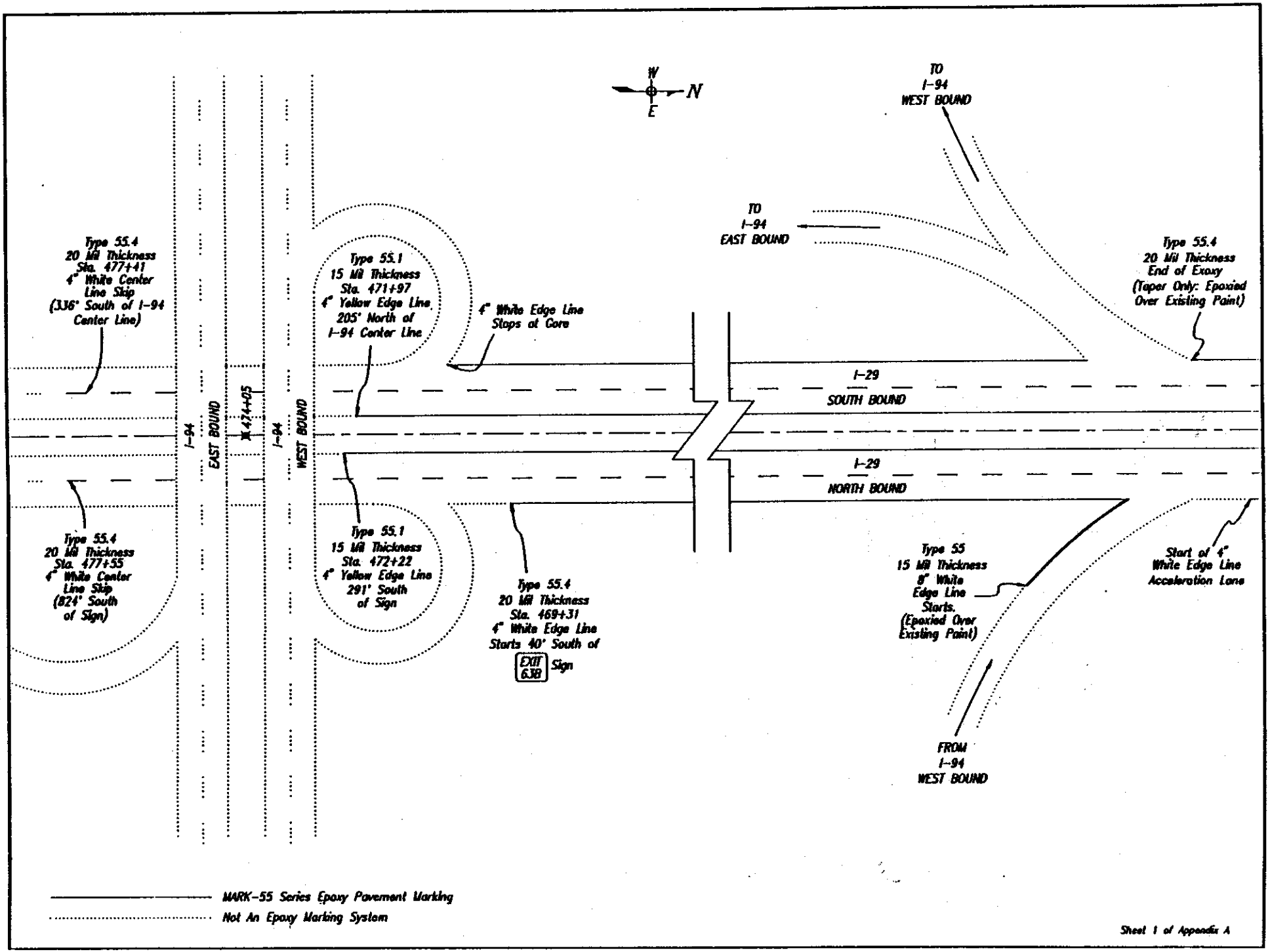
Appendix A


W
N
E
TO
I-94
WEST BOUND
TO
I-94
EAST BOUND
Type 55.4
20 Mil Thickness
Sta. 477+41
4" White Center
Line Skip
(336' South of I-94
Center Line)
Type 55.1
15 Mil Thickness
Sta. 471+97
4" Yellow Edge Line
205' North of
I-94 Center Line
4" White Edge Line
Stops at Core
Type 55.4
20 Mil Thickness
End of Exoxy
(Taper Only: Epoxied
Over Existing Paint)
I-29
SOUTH BOUND
I-94
EAST BOUND
474+05
I-94
WEST BOUND
I-29
NORTH BOUND
Type 55.4
20 Mil Thickness
Sta. 477+55
4" White Center
Line Skip
(824' South
of Sign)
Type 55.1
15 Mil Thickness
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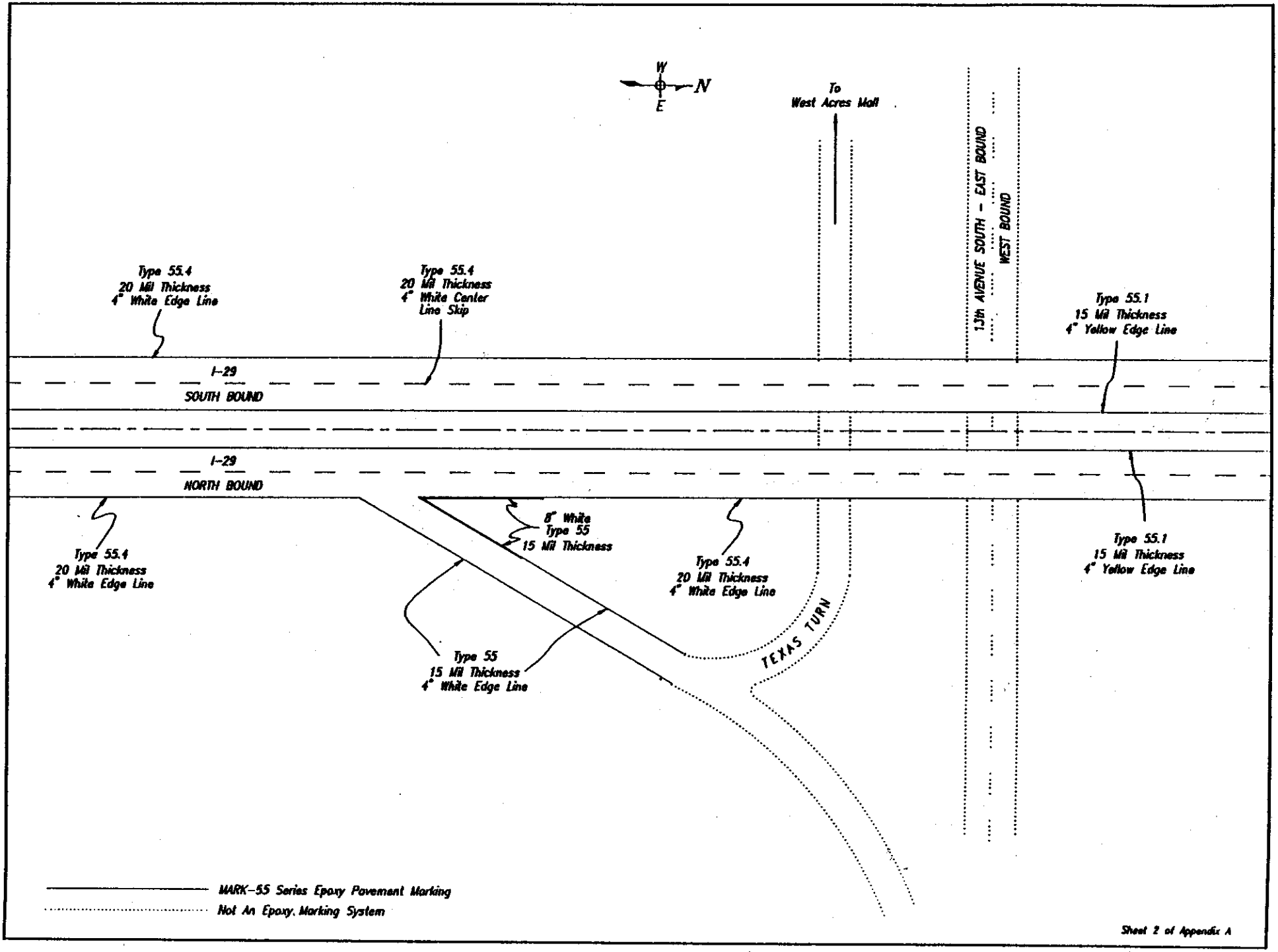
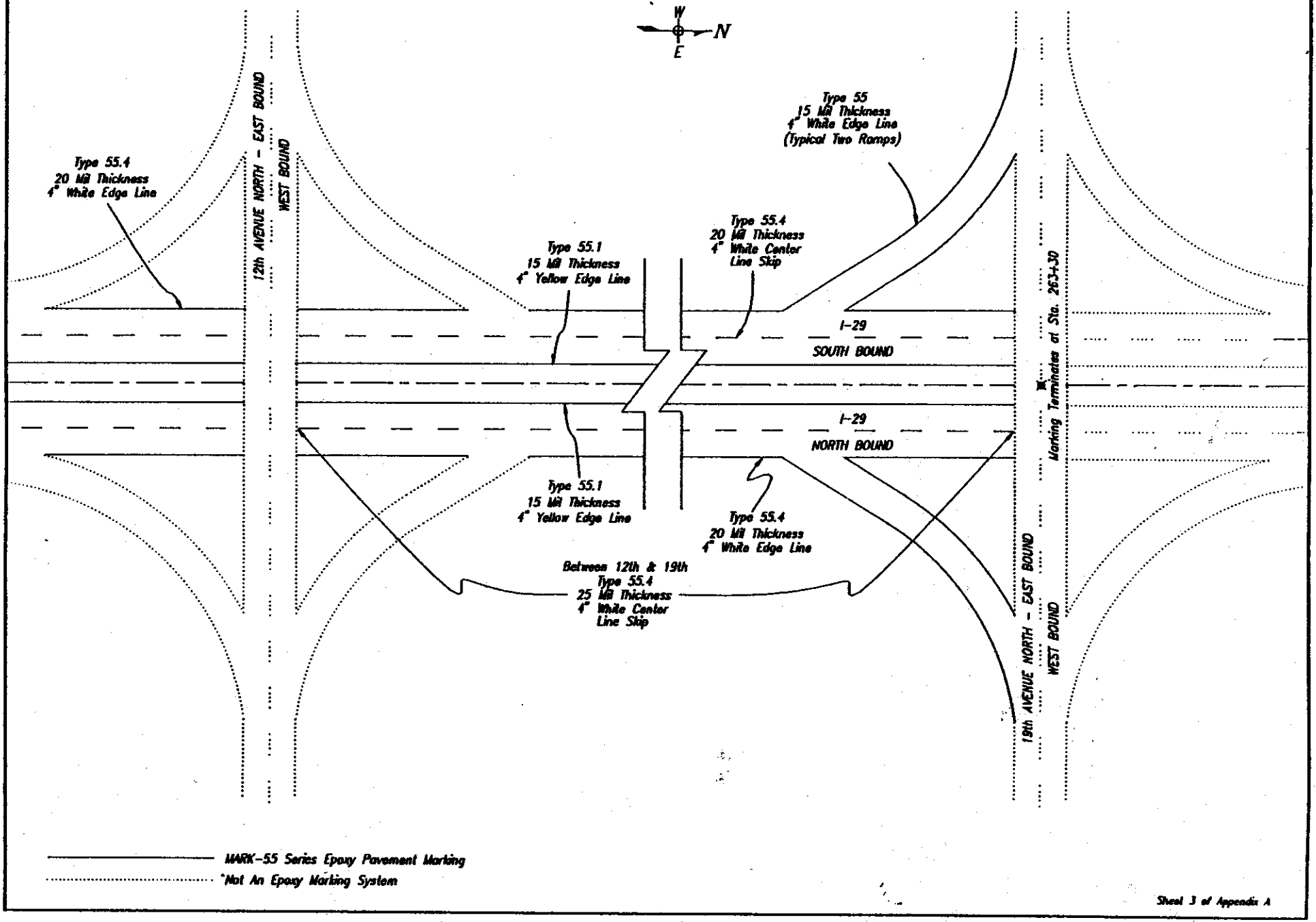
4" Yellow Edge Line
291' South
of Sign
Type 55.4
20 Mil Thickness
Sta. 469+31
4" White Edge Line
Starts 40' South of
EXIT
63B
Sign
Type 55
15 Mil Thickness
8" White
Edge Line
Starts.
(Epoxied Over
Existing Paint)
Start of 4"
White Edge Line
Acceleration Lane
FROM
I-94
WEST BOUND
MARK-55 Series Epoxy Pavement Marking
Not An Epoxy Marking System
Sheet 1 of Appendix A



Sheet 2 of Appendix A



Sheet 3 of Appendix A