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Microsurfacing Performance Evaluation

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*see supplementary notes

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

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15. Abstract

Purpose and Need

Microsurfacing is a polymer modified cold mix paving system that can remedy a broad range of pavement distresses. It can be used to repair; rutting and shoving, improve surface friction, and restore the road profile with minimal surface preparation.

Objective

This study will evaluate the performance and cost effectiveness of microsurfacing as a method to fix rutting and depressed transverse cracks in a rural highway segment.

Scope

The physical characteristics the two sections will be compared to are; distresses, overall surface condition, performance, ride, and skid resistance. These physical characteristics will be evaluated by the pathways van annually. The evaluation period for this project will be 7-years or until failure. The project location is located on Highway 85 near Amidon.

Construction

The construction of this project had a problem with the paving of the second lift of the microsurfacing section. The paving operation could not get a uniform product from the paver. The cause of this problem was due to operator error. The problem was corrected and the rest of the microsurfacing for the project was continued as planned. The project was completed on time and has improved the pavement surface.

Conclusion

The microsurfacing section of this research project did not perform as expected. It may have failed because it appears the pavement is continuing to rut. This makes it difficult to make a valid decision on the effectiveness of the microsurfacing slurry product. The objective of this project was not met because the pavement was still rutting. Due to the pavement continuing to rut it is difficult to determine if the poor performance of the microsurfacing section was caused by the microsurfacing slurry of the rutting of the pavement.

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Emulsion
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NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION

Experimental Study MR 02-01

Microsurfacing Performance Evaluation

Final Evaluation Report

NH-5-085(041)041

April 2007

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Disclaimer

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Microsurfacing Performance Evaluation

Purpose and Need

Microsurfacing is a polymer modified cold mix paving system that can remedy a broad range of pavement distresses. It can be used to repair; rutting and shoving, improve surface friction, and restore the road profile with minimal surface preparation. Traffic can be reopened to the public within hours as well.

The current practice of the North Dakota Department of Transportation (NDDOT) to repair rutting or shoving in existing flexible pavements is to either mill and overlay these roads or to place a leveling course and then overlay the roadway.

The NDDOT has used microsurfacing to rehabilitate flexible pavements on several projects. The project numbers for the previous microsurfacing projects are UNH-1-810(012)002, SNH-1-083(066)090, and SS-1-200(040)169.

Project UNH-1-810(012)002 was part of experimental project ND 92-01. It was located on Bismarck Expressway approximately 1,500' west of Washington St. to Airport Road in all lanes. The results indicated that microsurfacing can be used to repair rutted Hot Bituminous Pavement (HBP). However, at busy intersections, rutting had returned due to start and stop traffic. Project SNH-1-083(066)090 was constructed between Bismarck and Wilton at RP 90.453 to RP 90.953. Project SS-1-200(040)169 was constructed between the Jct. at 1806 N to N Jct. of US 83, from Reference Point (RP) 169.942 to Reference Point (RP) 188.892. These projects were intended to correct rutting and depressed cracks in the existing surface. The ruts were leveled with microsurfacing and then a final layer of microsurfacing was placed over the roadway.

Microsurfacing requires a high quality of aggregate that is not readily available in vast parts of the state. In certain areas, aggregate has to be hauled into the state at a substantial cost. The bid prices for the aggregate ranged from $20/ton to $105/ton in the past projects. In certain areas, microsurfacing may not be a cost effect measure.

This research project was needed in order to evaluate the performance and cost effectiveness of microsurfacing.

Objective

This study will evaluate the performance and cost effectiveness of microsurfacing as a method to fix rutting and depressed transverse cracks in a rural highway segment.

Scope

A microsurfacing section and a typical overlay section were compared for this research project. The physical characteristics of the two sections that were compared are; distresses, overall surface condition, performance, rut, International Ride Index (IRI), and skid resistance. These physical characteristics will be evaluated by the Pathways van annually. The evaluation period for this project was to be 7-years or until failure. The price was being incorporated with the physical properties to compare the microsurfacing and typical overlay section.

Location

The project selected for evaluation was NH-5-085(041)041. The project was located in Slope County on US Highway 85 from RP 41.057 to RP 57.055 (Stark/Slope County Line). The project starts in Amidon and proceeds to the east and then to the north. The typical overlay section began in Amidon at RP 41.057 and proceeded east and then north to RP 51.098 for a length of 10.041 miles. The microsurfacing section was the north section of the project and began at RP 51.098 and proceeded to RP 57.005 for a length of 5.957 miles. The location is shown in Figure 1.

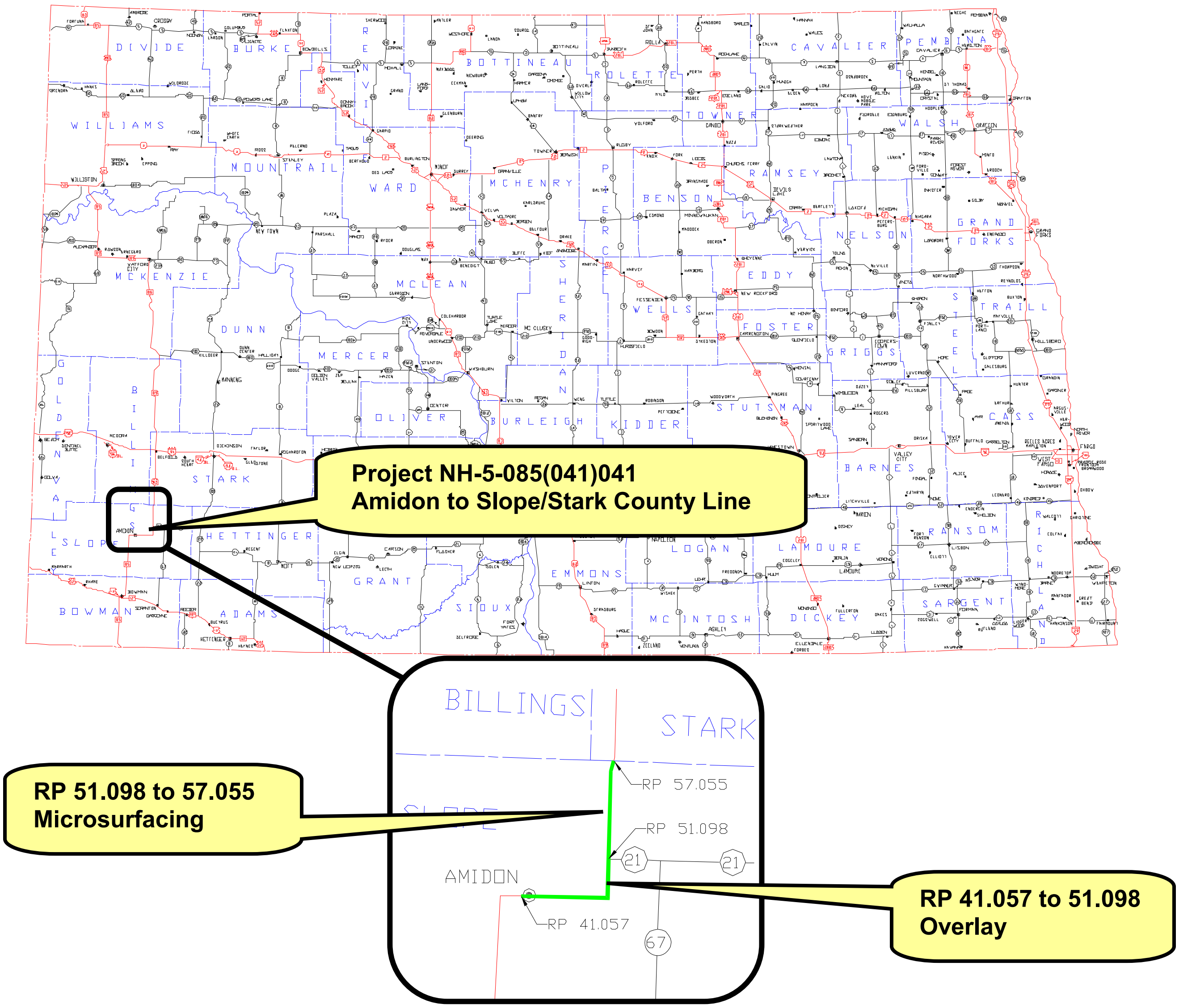


Figure 1 - Project Location.

Project Historical Information

RIMS Data

Reference Point 41.108 to Reference Point 41.378						
Components	Year	Depth (in)	Left Shldr. Width (ft)	Roadway Width (ft)	Right Shldr. Width (ft)	Oil
Curb and Gutter	1964	-	-	44.0	-	-
Aggregate Base	1964	5.0	-	41.0	-	-
HBP	1964	3.0	-	41.0	-	120-150
HBP	1964	2.0	-	41.0	-	120-150
HBP	1975	2.0	-	37.0	-	200-300
HBP-Large Stone	1991	2.0	-	41.0	-	120-150
Milling	1991	-2.8	-	41.0	-	
HBP	1991	1.5	-	41.0	-	120-150
Contract Chip Seal	1993	-	-	41.0	-	MC-3000
Milling	2002	-2.5	-	41.0	-	-
HBP	2002	2.5	8.5	24.0	8.5	PG 58-28

Table 1

Reference Point 41.378 to Reference Point 51.098						
Components	Year	Depth (in)	Left Shldr. Width (ft)	Roadway Width (ft)	Right Shldr. Width (ft)	Oil
Grade	1963	-	-	46	-	-
Traffic Service Gravel	1963	1	-	43	-	-
Aggregate Base	1964	4	-	43	-	-
HBP	1964	2	-	43	-	120-150
HBP	1964	1.5	-	24	-	120-150
HBP	1975	1.5	-	24	-	200-300
Drive Slope Flattening	1985	-	-	-	-	-
HBP-Large Stone	1991	2.5	-	27	-	120-150
Milling	1991	-2.8	-	27	-	
HBP	1991	1.5	-	27	-	120-150
Safety Project	1991	-	-	-	-	-
Salvaged Aggr. Base	1991	3	5	-	5	-
Contract Chip Seal	1993	-	-	27	-	MC-3000

Table 2

Reference Point 51.098 to Reference Point 57.055						
Components	Year	Depth (in)	Left Shldr. Width (ft)	Width (ft)	Right Shldr. Width (ft)	Oil
Grade	1963	-	-	46	-	-
Drive Slope Flattening	1985	-	-	-	-	-
Stabilized Base	1991	3	-	43	-	-
Aggregate Base	1991	5	-	40	-	-
Recycled Bituminous Base	1991	6	-	36	-	-
HBP-Large Stone	1991	3	-	30	-	120-150
HBP	1991	1.5	-	27	-	120-150
Salvaged Aggr. Base	1991	3	3.5	-	3.5	-
Safety Project	1991	-	-	-	-	-
Contract Chip Seal	1993	-	-	27	-	MC-3000

Table 3

Traffic

Reference Point 41.378 to Reference Point 51.098				
Year	Passenger Vehicle AADT	Truck AADT	Total	Flex ESALs
2005	1,281	273	1,554	184
2004	1,281	273	1,554	184
2003	1,281	273	1,554	184
2002	766	236	1002	163
2001	766	236	1002	163
2000	834	186	1020	131

Table 4

Reference Point 51.098 to Reference Point 57.055				
Year	Passenger Vehicle AADT	Truck AADT	Total	Flex ESALs
2005	850	300	1,150	201
2004	850	300	1,150	201
2003	850	300	1,150	201
2002	575	200	775	136
2001	575	200	775	136
2000	688	235	923	161

Table 5

Design

Three inches of Class 29 HBP was overlaid from RP 41.057 to 51.098 and the remaining project was microsurfaced from RP 51.098 to RP 57.055. Typical sections can be found in Appendix A.

Microsurfacing began with the selection of high quality materials; asphalt, aggregate, emulsifiers, water and additives. Portland cement, hydrated lime that is free of lumps, or other approved mineral additive can be combined with asphalt, and water to form a three-part asphalt emulsion. These components combined together serve as a binder, holding the crushed aggregate together and adhering the new slurry surfacing to the existing surface over which it is being applied. Special Provision 394(97) provides the necessary specifications that need to be followed for material properties and can be found in Appendix B. The mix design for the microsurfacing can be found in Appendix C.

Microsurfacing categorizes the aggregate it uses into three classes. Type I uses a fine aggregate mixture with a maximum sieve size of 1/8”. Type I is used for maximum crack penetration and sealing in low-density/low-wear traffic areas. Type II uses maximum sieve size of 1/4” and it is used on moderate to heavy traffic. Type II is used for sealing, correcting moderate to severe raveling, improving oxidation, and improving skid resistance. Type III uses a maximum sieve size of 3/8” and it is used under heavy traffic loads. Type III corrects severe rutting and provides skid resistance for roadways. Type III aggregate for the microsurfacing was selected for this project. Table 6 provides the required gradation for a Type III aggregate.

Microsurfacing Aggregate Gradation Required for Type III	
Sieve Size	**Percent Passing**
3/8”	100
#4	70-90
#8	45-70
#16	28-50
#30	19-34
#50	12-25
#100	7-18
#200	5-15

Table 6

The ruts in each wheel path will receive one pass to fill in the rutting with varying depths. Each lane will then receive a ½” lift of microsurfacing to provide a uniform texture and profile across the width of the road.

The design life for the microsurfacing is 7 years. The design life for the conventional overlay is for 20 years.

Construction

Project NH-5-085(041)041 was constructed in 2002. Robert Dvorak from the Dickinson district of the North Dakota Department of Transportation was the field engineer for the project. Northern Improvement Inc. from Dickinson ND was the prime contractor. Northern Improvement Inc. subcontracted the microsurfacing portion of the project out for $316,000.00 to Monarch Oil. The bid price for the entire project was $1,617,918.90.

Using the bid prices for the project, the calculated price for microsurfacing was $4.08 per SY ($64,627.20 per mile) and the price for the overlay was $3.62 per SY ($85,184.00 per mile). The overlay price per mile is more expensive because the width of the overlay was 40’ and the microsurfacing width was 27’. The unit price, estimated cost, and total cost for the project can be seen in Table 7. The initial cost of the overlay and microsurfacing will be compared to the cost of the future maintenance and rehabilitation between the two sections.

Spec No.	Code No.	Description	Unit	Estimated Quantity	Unit Cost	Total Cost
230	0125	Shoulder Preparation	Mile	31	$350.00	$11,165.00
401	0150	Emulsified Asphalt	Gal	6990	$0.85	$5,941.50
409	0229	Hot Bituminous Pavement CL 29	Ton	37,905	$13.00	$492,765.00
409	0445	PG 58-28 Asphalt Cement	Ton	2,198	$155.00	$340,690.00
409	0900	Testing	Ton	37,905	$0.20	$7,581.00
409	0910	Cored Sample	EA	225	$17.00	$3,876.00
950	9720	Aggregate For Microsurfacing	Ton	3,336	$82.00	$273,552.00
950	9721	Asphalt Emulsion for Microsurfacing	Gal	88,959	$1.25	$111,198.75

Table 7

1st Evaluation

Overlay

This first evaluation took place on September 15, 2003. The overlaid section did not have many distresses. There were some transverse cracks beginning to appear. The cracks were sealed in the spring of 2003. The ride was good. The overall condition of the asphalt was very good. An overall view can be seen in photo 1.

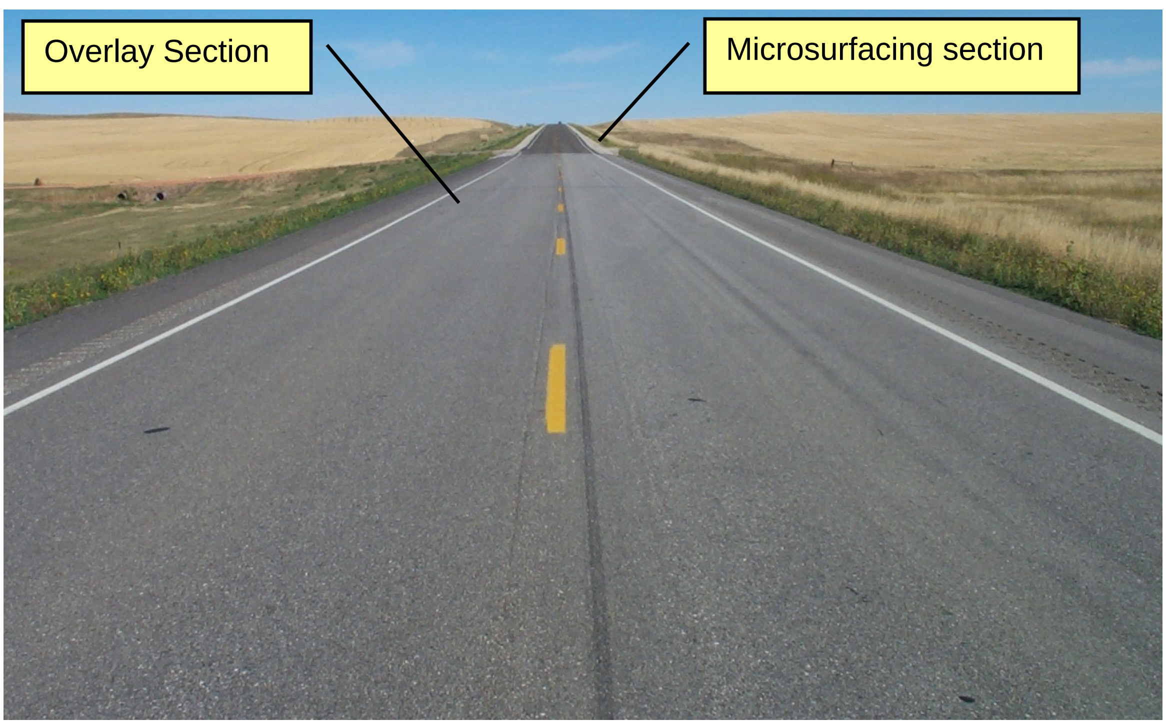


Photo 1 – An overall photo of the overlay section.

The maintenance cost for the overlay section in 2003 can be seen in Table 8. Most of the costs were Crack Pour Costs. These costs were to repair transverse cracking. The crack spacing was estimated at 80 to 150 feet. The average maintenance cost per mile for the overlay was $654.00.

Maintenance Cost - Overlay Section				
Ref. Pt.	**Total**	**Blade Patching Cost**	**Crack Pour Cost**	**Routine Roadway Operations Cost**
42	623	34	572	17
43	598	9	572	17
44	736	8	711	17
45	728	0	711	17
46	728	0	711	17
47	728	0	711	17
48	589	0	572	17
49	573	0	556	17
50	583	0	566	17
Total	5,886	51	5,682	153

Table 8

There was no skid resistance data for 2003. Montana Department of Transportation was not available to do any skid resistance testing for the NDDOT this year. The only skid resistance data available is from 2002. This data was also available in the construction report and can be found in Appendix E.

The Pathways van was used to determine the IRI and rut depth. The Overlay Road Profile Report displays the IRI broken down into the percentage good, fair, and poor. It also has the rut depth broken down in the same manner. This report can be seen in Appendix D.

Microsurfacing

The first evaluation of the microsurfacing section took place on September 15, 2003. The microsurfacing section did not have many distresses. There were some transverse cracks beginning to appear. The cracks were sealed in the spring of 2003. The microsurfaced pavement rode rougher then the overlaid section. This section also had some patches on the pavement. There were two patches within RP 52 to RP 53, one for approximately 184' and the other was approximately 1,167'. There was also a patch within RP 56 to RP 57 for about 961'.

The pathways van was used to determine the International Roughness Index (IRI), ride score, and rut depth. The Microsurfacing Road Profile Report, which can be seen in Appendix D, displays the IRI broken down into the percentage good, fair, and poor. It also has the rut broken down in the same manner.

The maintenance cost for the overlay section from 2003 can be seen in Table 9. Most of the costs were Crack Pour Costs. These costs were to repair transverse cracking. The average maintenance cost per mile for the microsurfacing was $569.86.

Maintenance Cost - Microsurfacing Section				
Ref. Pt.	**Total**	**Blade Patching Cost**	**Crack Pour Cost**	**Routine Roadway Operations Cost**
51	571	0	554	17
52	571	0	554	17
53	569	0	552	17
54	569	0	552	17
55	569	0	552	17
56	569	0	552	17
57	571	0	554	17
Total	3,989	0	3,870	119

Table 9

There is no skid resistance testing data for 2003. The Montana Department of Transportation was not available to do any skid resistance testing for the NDDOT that year.

Final Evaluation

Overlay

This final evaluation took place on November 18, 2004. The overlaid section did not have many distresses on it. The transverse crack spacing was approximately 75'. The ride appeared to be good and the overall condition of the asphalt was very good. An over all view can be seen in photo 3.

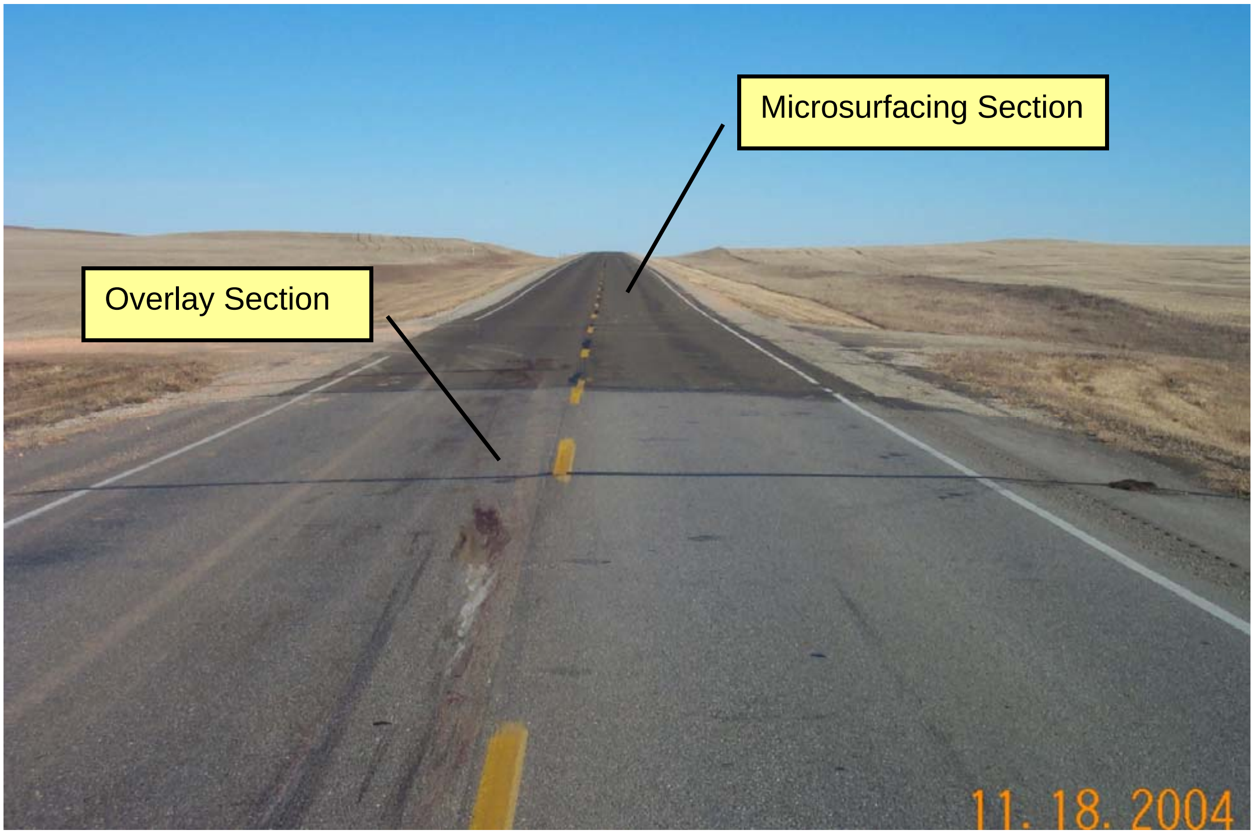


Photo 3

The maintenance cost for the overlay section in 2005 can be seen in Table 10. The majority of the costs are for crack sealing. The average maintenance cost per mile for the overlay was $2,362.

2005 Maintenance Cost – Overlay Section									
Ref. Pt.	**Total**	Blade Patching	Hand Patching	Scotch Patching	Crack Pour	Seal Coat	Shoulder Repair	Roadway Milling	Roadway Operation
42	$2,008	$154	$178	$4	$1,153	$11	$122	$0	$386
43	1,955	129	161	4	1,153	0	122	0	386
44	2,123	137	163	4	1,303	0	122	0	394
45	2,117	128	163	4	1,306	0	122	0	394
46	3,556	128	163	4	1,306	0	1,561	0	394
47	3,552	128	163	4	1,302	0	1,561	0	394
48	1,966	128	163	4	1,155	0	122	0	394
49	1,950	128	163	4	1,139	0	122	0	394
50	2,026	128	163	4	1,149	0	122	59	401
Total	$21,253	$1,188	$1,480	$36	$10,966	$11	$3,976	$59	$3,537

Table 10

The skid resistance was measured by the Montana Department of Transportation. The average skid resistance for the overlay section was 46.4; this is a decrease from 51.9 measured in 2002. In Appendix E the test results can be seen for the years of 2002 and 2004.

The rut depth and IRI are two very important factors for the evaluation of this project. Chart 1 through Chart 4, shows the IRI and rut depth for overlay and microsurfacing section in the northbound and southbound direction. The Overlay Road Profile Report displays the IRI broken down into the percentage good, fair, and poor. It also has the rut depth broken down in the same manner. This report can be seen in Appendix D.

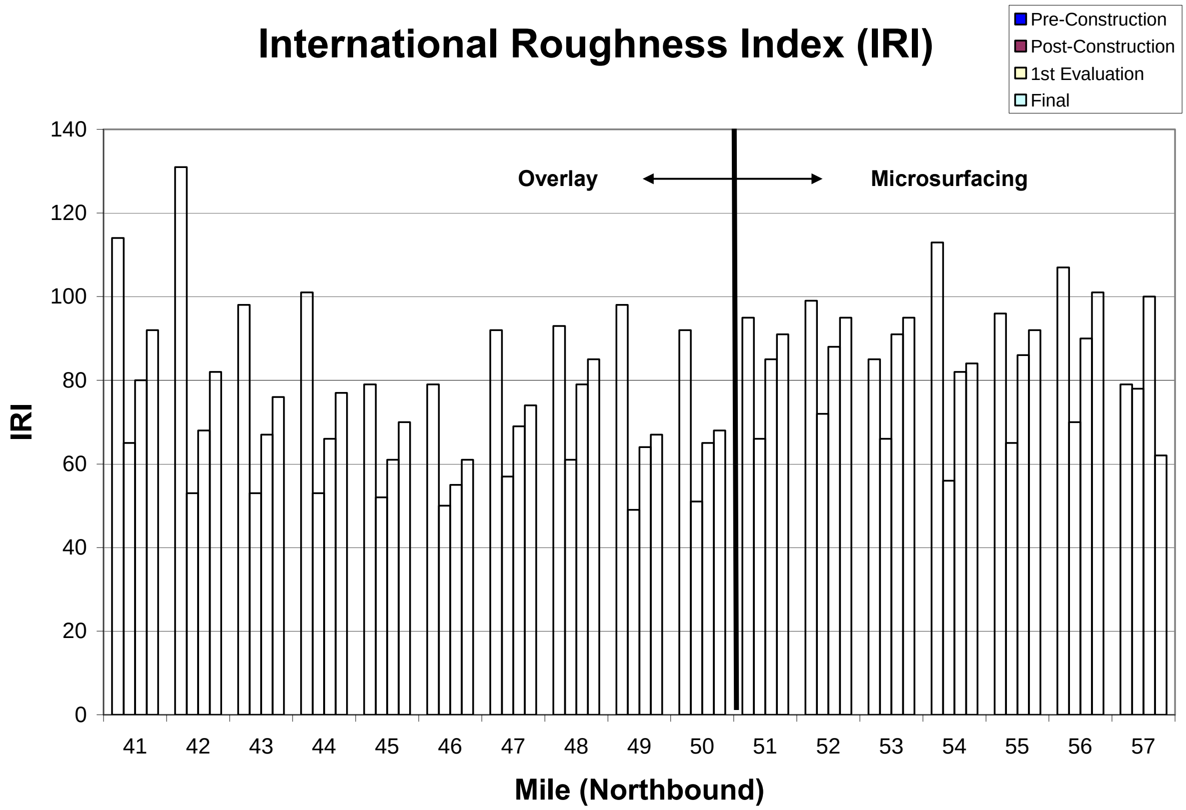


Chart 1

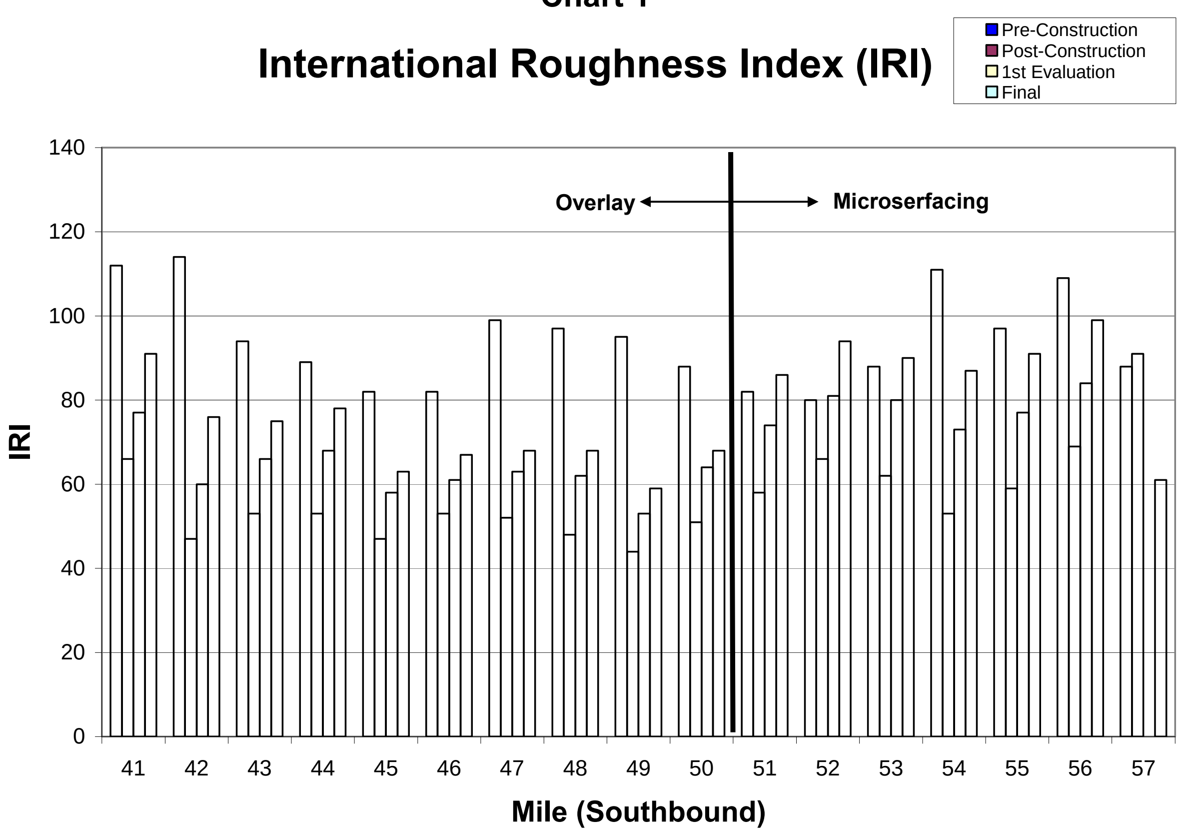


Chart 2

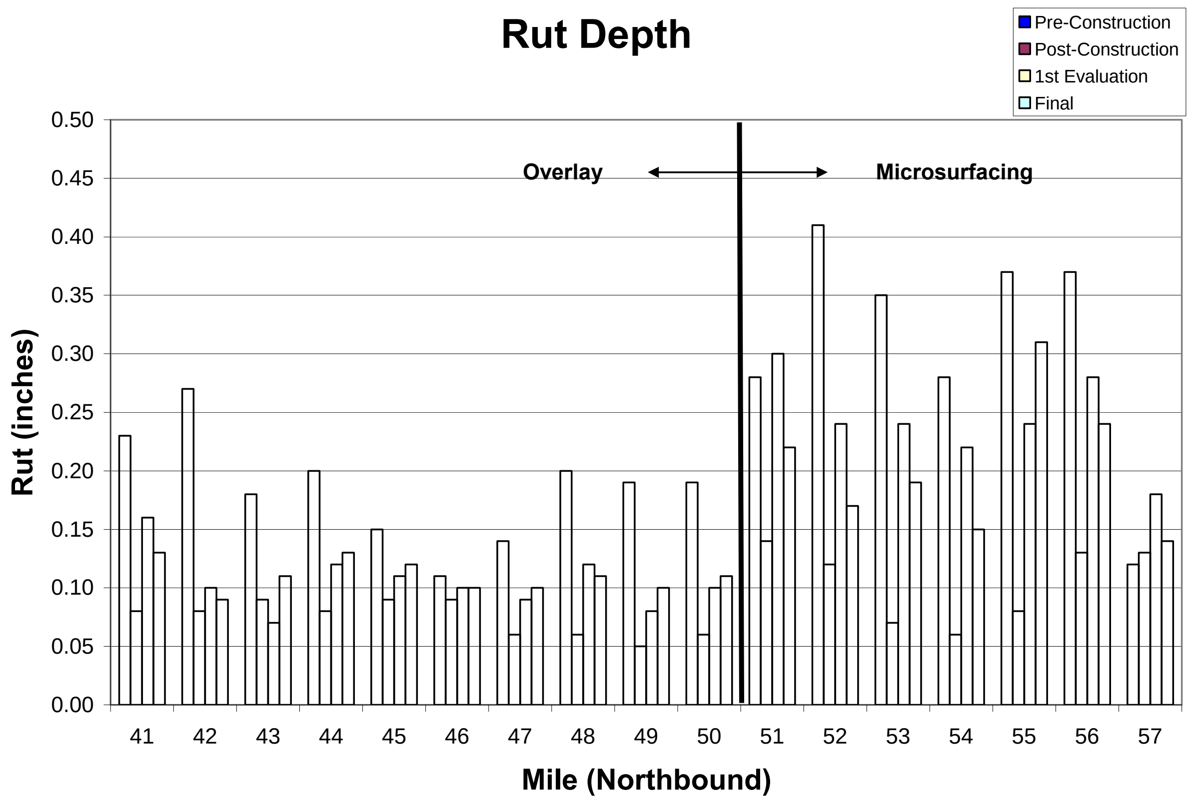


Chart 3

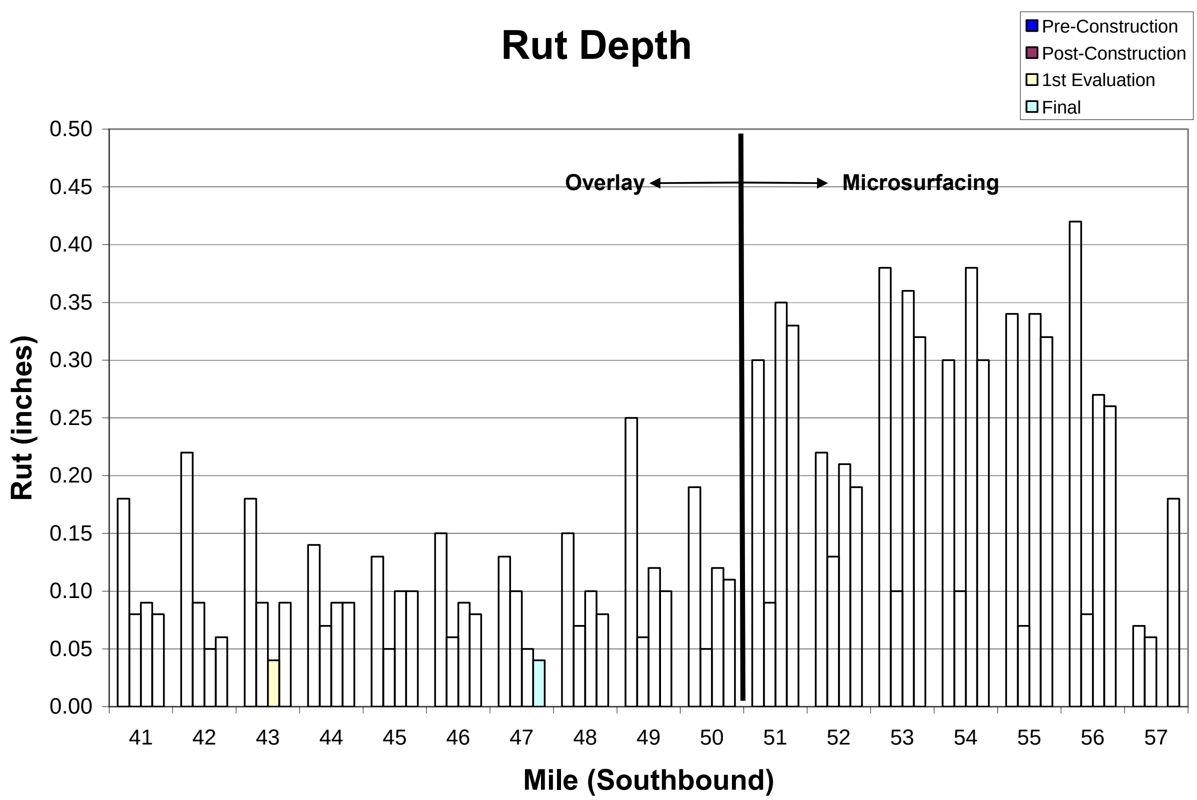


Chart 4

Microsurfacing

The Microsurfacing section was evaluated on November 18, 2004 and also again on May 9, 2006. The microsurfacing section had depressed cracks and a crack spacing of approximately 40'. The microsurfacing section did not ride as smoothly as the overlay section. There was also some alligator cracking in the wheel paths.

The maintenance cost for the overlay section in 2005 can be seen in Table 11. The majority of the costs are for blade patching. The average maintenance cost per mile for the overlay was $14,621.

2005 Maintenance Cost – Microsurfacing Section								
Ref. Pt.	**Total**	Blade Patching	Hand Patching	Scotch Patching	Crack Pour	Shoulder Repair	Roadway Milling	Roadway Operation
51	$5,644	$1,799	$163	$4	$1,138	$1,862	$277	$401
52	12,391	7,982	461	4	1,138	2,128	277	401
53	17,480	13,026	483	4	1,135	2,152	277	403
54	20,442	15,377	1,094	4	1,135	2,152	277	403
55	17,775	12,057	333	4	1,135	3,567	277	402
56	17,694	11,997	312	4	1,135	3,567	277	402
57	10,924	4,743	885	20	2,582	2,151	59	484
Total	$102,350	$66,981	$3,731	$44	$9,398	$17,579	$1,721	$2,896

Table 11

The average skid resistance for the microsurfacing was 49.4; this is a decrease from 59.5 measured in 2002. In Appendix E the test results can be seen for the years of 2002 and 2004.

The IRI and the rut depth for the whole project can be seen in charts 1 through 4. The microsurfacing section did not perform well compared to the overlay section. The IRI and rut returned to similar scores prier to the rehab. In May 9, 2006 evaluation the roadway appeared to still be rutting. The HBP in between the wheel paths appeared to shoving. This was determined by using a straight edge to show that the lanes were crowned in the center of the lanes.

Summary

The results from the Pathways van indicate that the overlay section is performing better then the microsurfacing. The overlay section also rides better then the microsurfacing section in a typical vehicle. Table 12 displays the average score for the IRI, Ride, and Rut for the entire project. The IRI and RIDE have decreased slightly from the previous evaluation. The IRI increased from 65.3 to 73.3 inches per mile for the overlay section and the microsurfacing section increased from 83.9 to 87.7 inches per mile. The RIDE for the overlay section decreased from 3.9 to 3.72 and the microsurfacing decreased from 3.52 to 3.26. The rut scores remained the same for the overlay section at 0.10 inches and decreased slightly for the microsurfacing section from 0.29 inches to 0.24 inches.

In general Microsurfacing is a fix for a roadway that has rutting, but for the pavement and base need to be done rutting for the Microsurfacing to work. In this project the microsurfacing clearly preformed worse then the overlay. The reason for microsurfacing's poor performance may be caused by the roadway continuing to rut.

Distress		International Roughness Index (IRI)		Ride Score		Rut Depth (inches)	
Section		Overlay	Microsurfacing	Overlay	Microsurfacing	Overlay	Microsurfacing
Before Construction	RIMS score	96.90	94.50	3.22	3.27	0.18	0.29
After Construction	RIMS score	53.00	66.50	4.18	3.87	0.07	0.10
	± % Improvement	45.3%	29.6%	29.8%	18.3%	61.1%	65.5%
First Evaluation	RIMS score	65.30	83.90	3.90	3.52	0.10	0.29
	± % Improvement	-23.2%	-26.2%	-6.7%	-9.0%	-42.9%	-190.0%
Final Evaluation	RIMS score	73.25	87.71	3.72	3.26	0.1	0.24
	± % Improvement	-12.2%	-4.5%	-4.6%	-7.4%	0.0%	17.2%

Table 12

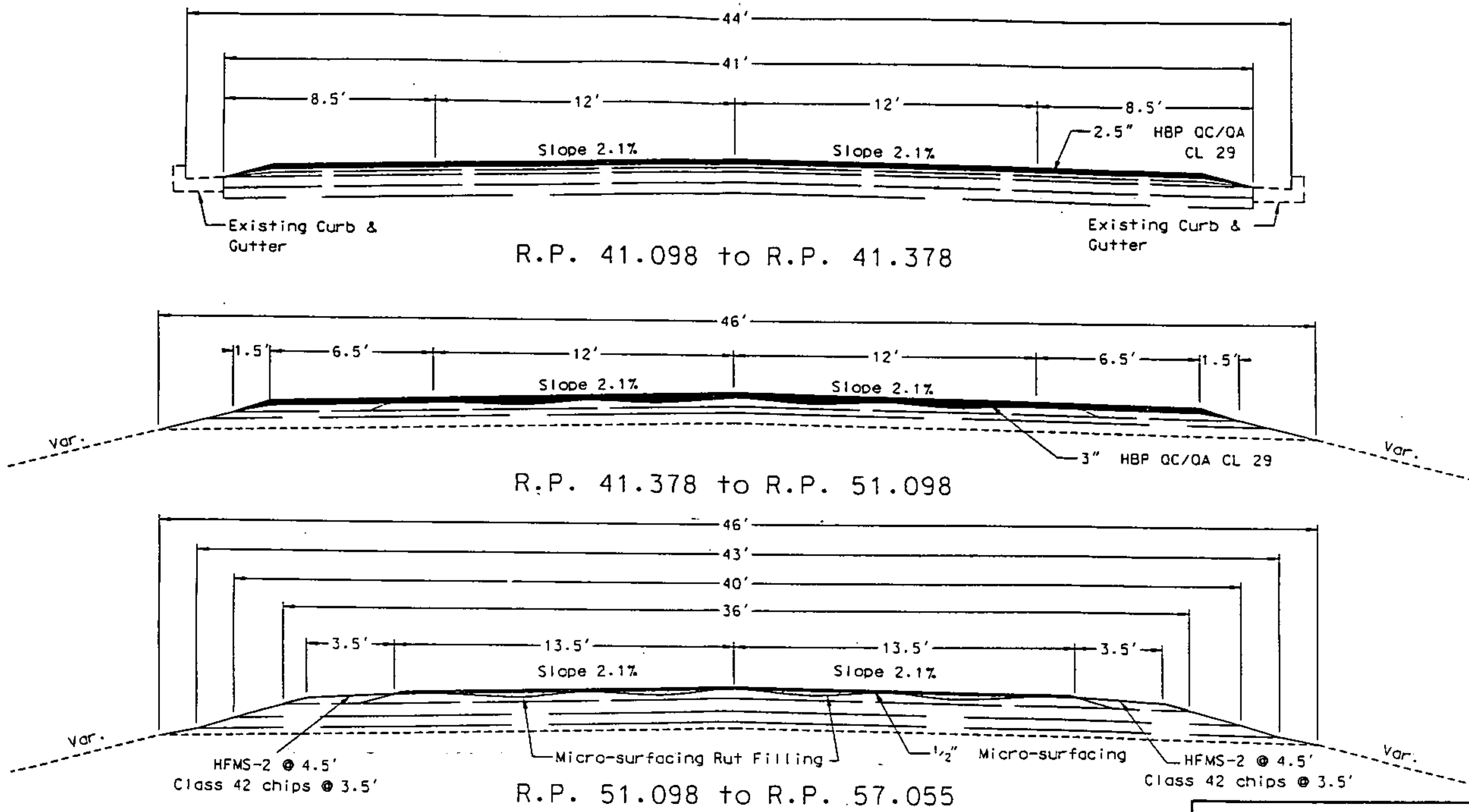
Recommandation

The microsurfacing section of this research project did not perform as expected. It may have failed because it appears the pavement is continuing to rut. This makes it difficult to make a valid decision on the effectiveness of the microsurfacing slurry product. The objective of this project was not met because the pavement was still rutting. Due to the pavement continuing to rut it is difficult to determine if the poor performance of the microsurfacing section was caused by the microsurfacing slurry of the rutting of the pavement. An evaluation of another microsurfacing slurry project would be recommended to provide the proper recommendation of the performance of microsurfacing slurry.

Appendix A

Revised 11/02/01

STATE	PROJECT NO.	SHEET NO.
ND	NH-5-085(041)041	9



Proposed

Typical Sections

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Appendix B

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

MICROSURFACING

NH-5-085(041)041

NOVEMBER 16, 2001

1. DESCRIPTION

Microsurfacing is a tough and durable thin overlay material which can restore the original service properties to worn but structurally sound pavements. Its properties are based on a blend of select crushed aggregate and a sophisticated chemical formulation of asphalt cement, cationic emulsifiers, adhesives, and latex.

2. MATERIALS

2.1 **Emulsified Asphalt.** The emulsified asphalt shall be a quick-set latex modified cationic type CSS-1H emulsion and conform to the requirements specified in AASHTO M208 and ASTM 2397. It shall pass all applicable storage and settlement tests. Have a Minimum residue after distillation of 62%. The latex shall be milled into the emulsion. The cement mixing test shall be waived for this emulsion.

2.1.1 **Special Residue Properties.** Distillation of residue will be at a temperature of 350 degrees F for 20 minutes. Softening point of the residue shall be 140 degrees F minimum, Absolute Viscosity shall be 8,000 poise minimum, ASTM 2171, #13 Canon-Manning viscosity tube, use the average of the two bulbs.

2.2 **Aggregate.** The mineral aggregate used shall be of the type and grade specified for micro-surfacing. The aggregate shall be manufactured crushed stone such as granite, slag, limestone, chat, or other high quality aggregate or combination thereof.

2.2.1 **Aggregate Physical Requirements.**

Grading - The aggregate including natural fines when tested by AASHTO methods T11 or ASTM C117 or C136, should met the referenced gradation requirements.

Deleterious Substances - To limit the permissible amount of clay like fines in an aggregate, a sand equivalent value of 60 or higher is required when tested by ASTM 2419.

Soundness - The aggregate shall have a weighted loss of not more than 15% when the sodium sulfate test is used of 20% when the magnesium sulfate test is used.

Hardness - The aggregate wear, from resistance to abrasion, shall be a maximum of 35% when using AASHTO T96 or ASTM C131 test methods.

2.3 **Water.** The water shall be potable and shall be free of harmful soluble salts.

2.4 **Modifier.** Special quick-setting emulsifier agents shall be milled into the asphalt emulsion. The emulsified asphalt shall be so formulated that when the paving mixture is applied at thickness of one inch with the relative humidity at not more than 59% and the ambient air temperature of at least 75 degrees F. the material will cure sufficiently so that rolling traffic can be allowed in one hour with no damage to the surface, as verified by the Engineer.

2.5 **Additives.** A mineral additive shall be introduced to the mineral aggregate and may be any recognized brand of nonairentrained portland cement or hydrated lime that is free of lumps, or other approved mineral additive. It may be accepted upon visual inspection. The amount of mineral additive needed shall be determined by the laboratory mix design and will be considered as part of the material gradation requirement.

A liquid field control additive is introduced and blended with water to provide effective control of the required quick-set properties. This additive shall be make available by the chemical supplier or emulsion manufacturer and certifiable as being compatible with the mixture.

3. ENGINEERING

3.1 **General.** Before work commences, the contractor shall submit a signed mix design covering the specific material to be used on the project. This design shall be performed by a qualified laboratory. Once the materials are approved, no substitution will be permitted unless first tested and approved by the laboratory preparing the mix design.

3.2 **Mix Design.** The qualified laboratory shall develop the job mix design and present certified test results for the contractors approval. Compatibility of the aggregate and emulsion shall be certified by the emulsion manufacturer in accordance with ASTM D3910, applicable tests. All component material used in the mix design shall be representative of the material proposed by the contractor for use on the project.

3.3 **Specifications.** The Engineer shall approve the design mix and all microsurfacing materials and methods prior to use. The component materials shall be within the following limits.

Residual Asphalt -	5% to 9% by dry weight of aggregate
Mineral Additive -	0.5% to 3% by dry weight of aggregate
Latex Modifier -	As required to provide specified properties
Field Control Additive -	As required to provide the specified properties
Water -	As required to produce consistency

Aggregate Gradations:

Screen Size	Type II - % Passing	Type III - % Passing
3/8"	100	100
#4	90-100	70-90
#8	65-90	45-70
#16	45-70	28-50
#30	30-50	19-34
#50	18-30	12-25
#100	10-21	7-18
#200	5-15	5-15

4. EQUIPMENT

4.1 **General.** All equipment, tools and machines used in the performance of this work shall be maintained in satisfactory working condition at all times to ensure a high quality product.

4.2 **Mixing Equipment.** The material shall be mixed by a self-propelled microsurfacing mixing machine which shall be a continuous flow mixing unit able to accurately deliver and proportion the aggregate, emulsified asphalt, mineral and field control additives, and water to a revolving multi-blade twin shafted mixer and discharge the mixed product on a continuous flow basis. The machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral and field control additives, and water to maintain an adequate supply to the proportioning controls. The machine may be equipped with self-loading devices which provide for the loading of materials while continuing to lay microsurfacing, thereby minimizing construction joints.

4.3 **Proportioning Devices.** Individual volume or weight controls for proportioning each material to be added to the mix, i.e., aggregate, emulsified asphalt, mineral and field control additives, and water shall be provided and properly marked. These proportioning devices are usually revolution counters or similar devices and are used in material calibration and determining the materials output at any time.

4.4 **Emulsion Pump.** The emulsion pump shall be a heated positive displacement type.

4.5 **Spreading Equipment.** The surfacing mixture shall be spread uniformly by means of a mechanical type spreader box attached to the mixer, equipped with paddles to agitate and spread the materials throughout the box. A front seal shall be provided to insure no loss of the mixture at the road contact point. The rear seal shall act as final strike off and shall be adjustable. The mixture shall be spread to fill cracks and minor surface irregularities and leave a uniform skid resistant application of material on the surface. The spreader box and rear strike off shall be so designed and operated that a uniform consistency is achieved to produce a free flow of material to the rear strike off. The longitudinal joint where two passes join shall be neat appearing, uniform and lapped. All excess material shall be removed from the job site prior to opening the road. The spreader box shall have suitable means provided to side shift the box to compensate for variations in pavement width and longitudinal alignment. The spreader box shall also be hinged near the center to compensate for a quarter crown.

A Rut Box shall be available to prefill wheel ruts when necessary prior to overlay to eliminate puddles or runoff interruption. The box shall be a 4' width with hydraulically adjusted strike off screeds to attain maximum grade and profile. The Rut Box shall be capable of an inverted or regular crown.

4.6 **Auxiliary Equipment.** Suitable surface cleaning equipment, traffic control equipment, hand tools and any support equipment shall be provided as necessary to perform the work.

5. **MACHINE CALIBRATION.** Each mixing unit to be used in performance of the work shall be calibrated in the presence of the Engineer prior to construction, or previous calibration documentation covering the exact materials to be used may be acceptable provided they were made during that calendar year. The documentation shall include the individual calibration of each material at various settings, which can be related to the machine metering devices.

6. **WEATHER LIMITATIONS.** The material shall be spread only when the road surface and atmospheric temperatures are at least 45 degrees F and rising and the weather is not rainy and there is no forecast of temperatures below 32 degrees F within 48 hours from the time of placement of the mixture. All work must be completed before September 15th.

7. **TRAFFIC CONTROL.** Suitable methods shall be used by the contractor to protect the microsurface from traffic until the new surface will support traffic without damage. All traffic control methods used shall be in accordance with the plans and specifications and employed in a safe manner.

8. **SURFACE PREPARATION.**

8.1 **General.** The area to be surfaced shall be thoroughly cleaned of vegetation, loose aggregate and soil, particularly soil that is bound to the surface. Manholes, valve boxes and other service entrances will be protected from the surfacing material.

8.2 **Tack Coat.** If required by the plans, the contractor shall apply a tack coat consisting of one part emulsified asphalt and three parts water with a distributor at .10 - .15 gallons per square yard.

9. **STOCKPILE.** Precautions shall be taken to insure that stockpiles do not become contaminated. The mineral aggregate shall be screened prior to being weighed for job site delivery. This weight shall be done by means of a scale approved by the Engineer.

10. APPLICATION.

10.1 GENERAL. The surface should be pre-wetted by fogging ahead of the spreader box when required by local conditions. The rate of application of the fog spray shall be adjusted during the day to suit temperatures, surface texture, humidity and dryness of the pavement surface.

The microsurfacing mixture shall be of the desired consistency upon leaving the mixer and no additional materials should be added. A sufficient amount of material shall be carried in all parts of the spreader at all times so that a complete coverage is obtained. Overloading of the spreader shall be avoided. No lumping, balling, or unmixed aggregate shall be permitted.

No streaks, such as those caused by oversized aggregate, will be left in the finished surface. If excessive oversize develops, the job will be stopped until the contractor proved to the Engineer that the situation has been corrected.

10.2 Joints. No excessive buildup, uncovered areas or unsightly appearances shall not be permitted on longitudinal or transverse joints. The contractor shall provide suitable width spreading equipment to produce a minimum number of longitudinal joints throughout the project. When possible, longitudinal joints shall be placed on lane lines. Half passes and odd widths passes will be used only in minimum amounts. If half passes are used, they shall not be the last pass of any paved areas.

10.3 Mix Stability. The microsurfacing mixture shall possess sufficient stability so that premature breaking of the material in the spreader box does not occur. The mixture shall be homogeneous during and following mixing and spreading. It shall be free of excess water or emulsion and free of segregation of the emulsion and aggregate fines from the coarser aggregate.

10.4 Hand Work. Areas which cannot be reached with the mixing machine shall be surfaced using hand squeegees to provide complete and uniform coverage. The area to be hand worked shall be lightly dampened prior to mix placement. Care shall be exercised to leave no unsightly appearance from handwork.

The same type finish as applied by the spreader box shall be required. Handwork shall be completed at the time of the machine applying process.

10.5 Lines. Care shall be taken to insure straight lines along curbs and shoulders. No runoff on these areas will be permitted. Lines at intersections will be kept straight to provide a good appearance.

11 METHOD OF MEASUREMENT.

11.1 **Aggregate for Microsurfacing:** Aggregate will be paid at the contract unit price per ton. This payment shall be full compensation for furnishing all materials except asphalt emulsion.

11.2 **Asphalt Emulsion for Microsurfacing:** Asphalt emulsion used will be paid at the contract unit price per gallon. This payment shall be full compensation for furnishing the asphalt emulsion.

Appendix C

Monarch Oil Inc.

P. O. BOX 3189, OMAHA, NE 68103-0189 • E. 22ND AND AVE. H., EAST OMAHA, NE 68110 • (402) 341-5254 • FAX (402) 341-5256

June 14, 2002

Northern Improvement Company
Keith Reiss

Re: Mix Design for Project No. NH-5-085(041) 041, I-5-J005-1200, I-5-J005-2100 Bowman, Hettinger Slope County

As requested, here is a microsurfacing system evaluation using crushed aggregate from Fisher Sand and Gravel, Newton Pit, Sec. 1 & 12 T16 R56, Sec. 6 T16 R55, Type I Portland cement, polymer modified CSS-1H and field additive supplied by Monarch Oil, Inc., Omaha, NE. The microsurfacing system was completed in accordance with applicable specifications, such as American Society for Testing & Materials (ASTM), International Slurry Surfacing Association (ISSA), American Association of State Highway Transportation Officials (AASHTO), or as required by state or federal specifications.

Based on the trial mixes and mix design test results, the following microsurfacing system is indicated:

Job Mix Formula

Proportions	Percent Of Dry Aggregate
Crushed aggregate	100%
Type I Portland cement	1 ± 0.5%
CSS-1H polymer modified (Monarch Oil, Inc.)	12 ± 0.5%
Residual asphalt	7.68 ± 0.3%
Water	8 ± 2
Field additive	.1 ± .1%

The results of the test (Table 1) completed on the aggregate indicate that it meets the specifications for Micro Surfacing aggregate. The polymer-modified

CSS-1H emulsion test results (Table 2) meet the AASHTO M-208 specification "Cationic Emulsified Asphalt" for CSS-1H.

Based on these results, the materials submitted can be used for microsurfacing application.

Monarch Oil Inc.
P. O. BOX 3189, OMAHA, NE 68103-0189 • E. 22ND AND AVE. H., EAST OMAHA, NE 68110 • (402) 341-6254 • FAX (402) 341-5256

CSS-1H emulsion test results (Table 2) meet the AASHTO M-208 specification "Cationic Emulsified Asphalt" for CSS-1H.

Based on these results, the materials submitted can be used for microsurfacing application.

Monarch Oil, Inc.

Steve Walenz
President

Monarch Oil Inc.

P. O. BOX 3189, OMAHA, NE 68103-0189 • E. 22ND AND AVE. H., EAST OMAHA, NE 68110 • (402) 341-6294 • FAX (402) 341-5256

Microsurfacing System
Monarch Oil, Inc.
Materials Testing Results

Table 1
Crushed Aggregate

Aggregate from Fisher Sand and Gravel Newton Pit

Gradation

Sieve Size	% Passing	Specification
3/8	100	100
#4	81	70-90
#8	52	45-70
#16	35	28-50
#30	25	18-34
#50	18	12-25
#100	12	7-18
#200	7	5-15

Test	Result	Specification	Method
1. Sand Equivalent, pct.	79	60.0 Min.	AASHTO T176
2. Methylele Blue Value, ml/gm sample	1.5	None	ISSA TB 145

Monarch Oil Inc.
P. O. BOX 3108, OMAHA, NE 68103-0188 • E. 22ND AND AVE. H., EAST OMAHA, NE 68110 • (402) 341-5254 • FAX (402) 341-6259

Microsurfacing System
Monarch Oil, Inc.
Materials Testing Results

Table 2
Polymer Modified CSS-1H Emulsion
from Monarch Oil, Inc.

Test	Result	Specification	Method
1. Residual asphalt, pct	64.0	62.0 Min	AASHTO T59
2. Storage Stability Test 1 day, pct	0.1	1.0 Max.	AASHTO T59
3. Particle Change Test	Positive	Positive	AASHTO T59
4. Viscosity, Saybolt Furol @ 77° F, sec.	28	20-100	AASHTO T59
5. Sieve Test, pct	Nil	0.1 Max.	AASHTO T59
	Test on	Residue	
6. Penetration, 25° C, dmm	67	40-90	AASHTO T49
7. Softening Point, °F	140° (60°)C	135 Min. (57°C)	AASHTO T53
8. Absolute Viscosity at 140°F Pa•S	1100	800Pa•s	ASTM-D 2171

Appendix D

NDDOT US Highway 85

Road Profile Report of 03/14/2002

From	To	Dir	IRI LWP in/mile	IRI RWP in/mile	IRI Avg	% of Mile with Good IRI	% Fair IRI	% Poor IRI	Average Rut Depth Inches	% of mile with Rut .25 to .37	% Rut .38 to .49	% Rut > .50"	Ride Index
41	42	N	98	130	114	42.1	11.8	20.5	0.23	26.6	5.2	1.8	2.86
42	43	N	100	163	131	40.0	17.2	25.1	0.27	39.4	7.2	2.6	2.52
43	44	N	78	119	98	44.8	16.6	14.3	0.18	11.4	1.3	0.0	3.18
44	45	N	81	122	101	46.4	17.0	14.1	0.20	19.4	4.7	2.2	3.12
45	46	N	71	87	79	50.9	13.1	7.7	0.15	4.3	0.0	0.0	3.60
46	47	N	77	82	79	52.6	15.8	7.1	0.11	1.8	0.0	0.0	3.59
47	48	N	85	99	92	53.7	19.9	11.2	0.14	8.6	0.2	0.2	3.32
48	49	N	84	102	93	52.6	16.8	12.4	0.20	26.1	2.0	0.2	3.30
49	50	N	92	105	98	51.8	15.4	15.2	0.19	16.5	0.8	0.0	3.18
50	51	N	89	95	92	50.4	17.7	10.6	0.19	19.1	8.4	5.2	3.32
51	52	N	91	99	95	53.9	20.5	12.0	0.28	4.7	7.0	23.3	3.26
52	53	N	94	104	99	48.0	20.9	12.2	0.41	3.4	6.4	39.8	3.17
53	54	N	77	94	85	51.7	17.3	8.3	0.35	14.4	17.2	27.9	3.46
54	55	N	101	125	113	47.0	16.8	21.5	0.28	42.8	12.7	3.3	2.88
55	56	N	91	102	96	52.8	18.1	12.2	0.37	6.3	16.6	35.4	3.23
56	57	N	100	114	107	48.3	23.4	18.6	0.37	15.6	19.9	33.0	3.01
57	58	N	76	82	79	53.6	9.3	10.2	0.12	6.4	0.0	0.0	3.60
58	57	S	82	94	88	48.9	9.9	12.4	0.07	3.6	0.0	0.0	3.41
57	56	S	94	125	109	52.3	21.6	16.2	0.42	21.4	21.5	33.5	2.95
56	55	S	91	103	97	44.5	21.5	13.0	0.34	23.5	12.8	23.6	3.21
55	54	S	94	128	111	49.3	15.7	21.2	0.30	60.3	12.3	2.2	2.92
54	53	S	86	91	88	48.9	19.9	10.7	0.38	12.2	9.0	36.1	3.40
53	52	S	73	87	80	44.5	11.1	10.7	0.22	10.8	13.8	14.0	3.58
52	51	S	82	82	82	54.0	15.8	7.0	0.30	7.8	8.0	23.2	3.54
51	50	S	85	91	88	56.0	16.2	10.2	0.19	20.5	5.4	2.1	3.41
50	49	S	79	111	95	47.9	21.4	9.8	0.25	38.5	3.7	0.2	3.26
49	48	S	82	112	97	50.0	18.6	12.3	0.15	6.3	0.0	0.0	3.21
48	47	S	95	103	99	47.6	21.3	14.3	0.13	1.9	0.4	0.0	3.17
47	46	S	80	84	82	49.9	17.9	8.0	0.15	3.4	0.4	0.2	3.54
46	45	S	77	87	82	52.8	13.9	8.5	0.13	0.8	0.0	0.0	3.54
45	44	S	81	97	89	49.8	13.2	12.6	0.14	3.7	0.9	0.0	3.38
44	43	S	82	106	94	49.9	11.7	13.3	0.18	7.8	0.4	0.0	3.28
43	42	S	93	135	114	43.5	12.4	21.0	0.22	24.7	3.0	1.1	2.86
42	41	S	101	123	112	48.1	14.7	20.1	0.18	20.2	2.1	1.0	2.90
		Average	86.53	105.38	95.82				0.23				3.24
		Std. Dev.	8.57	18.33	12.44				0.09				0.26

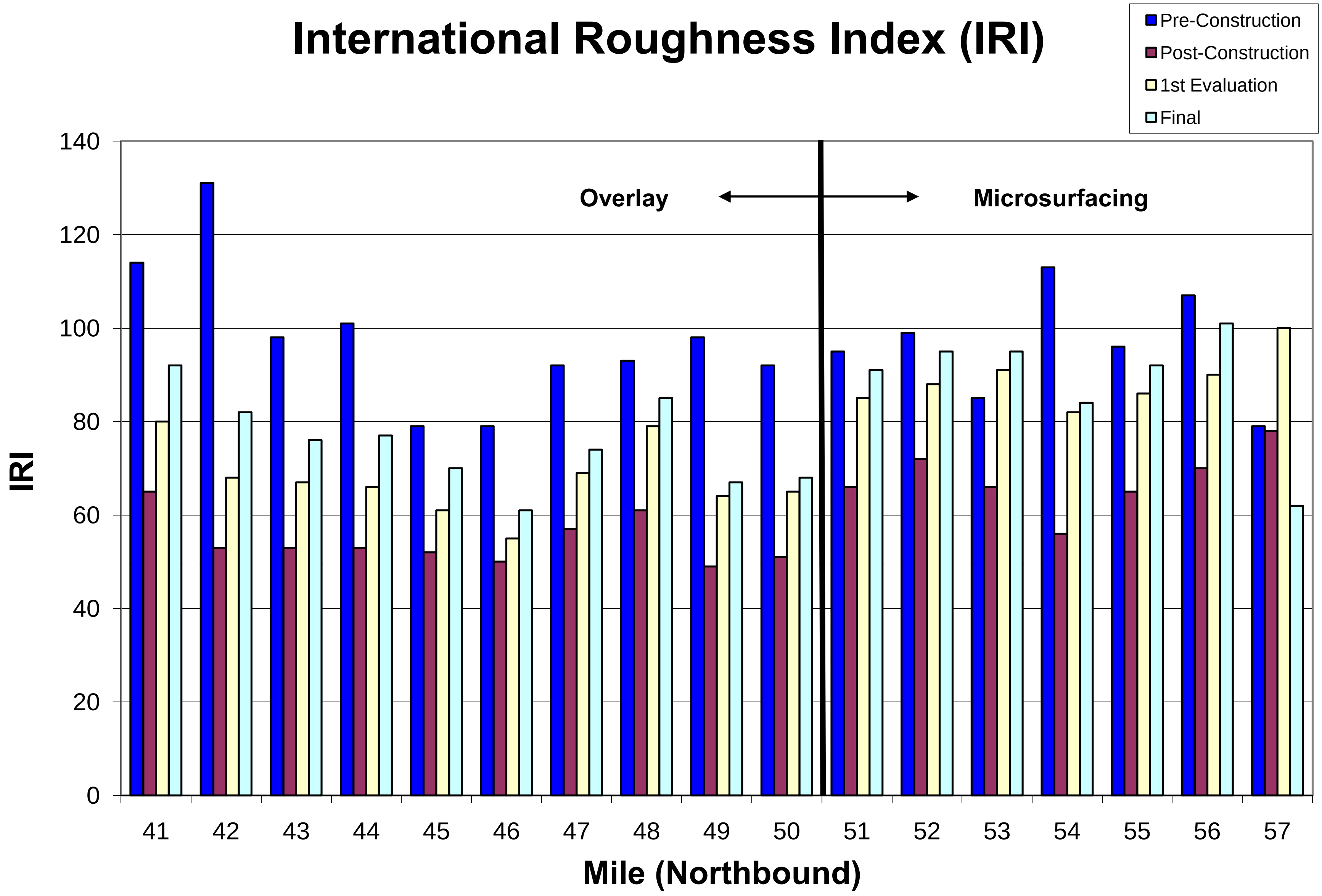
NDDOT US Highway 85

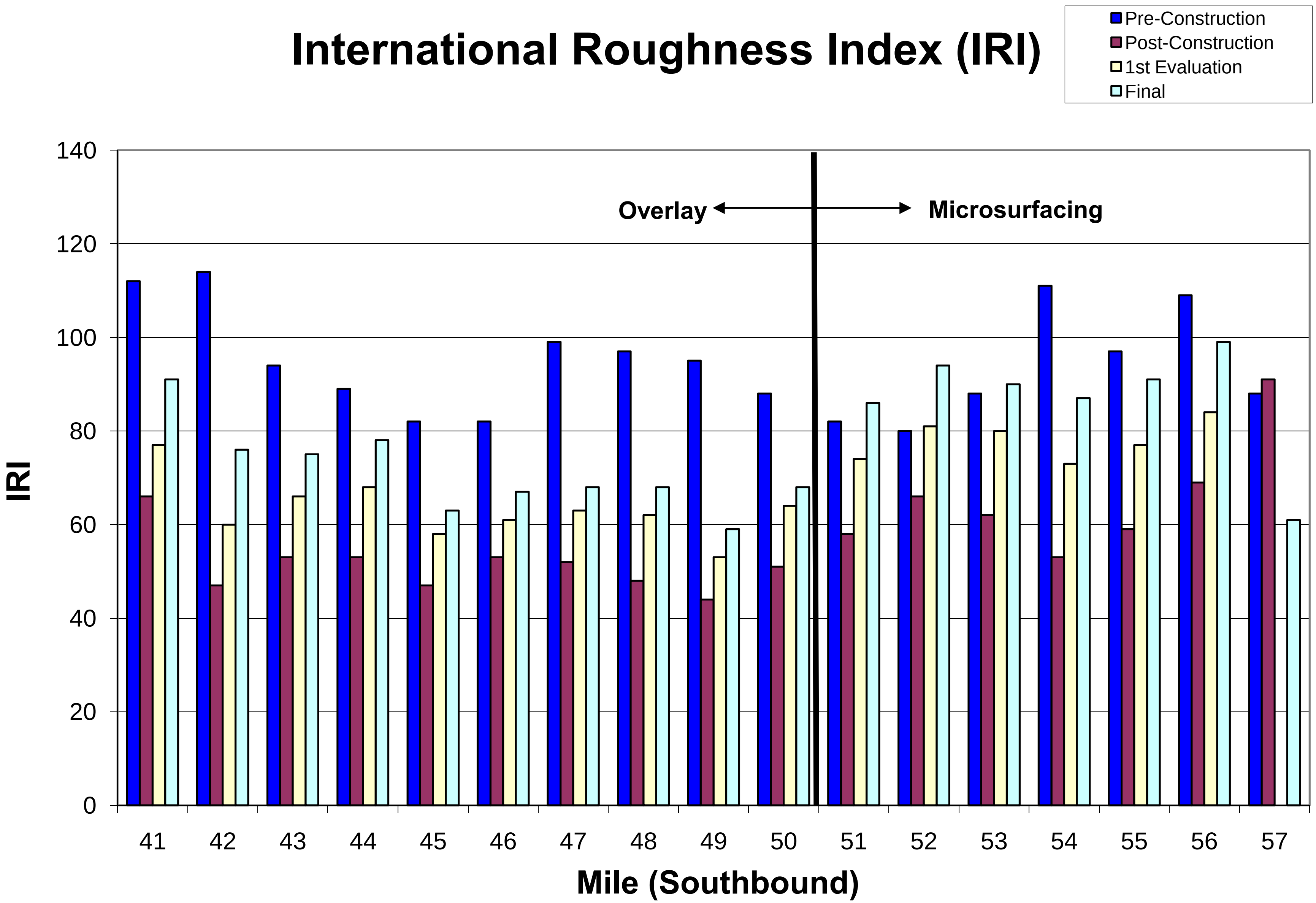
Road Profile Report of 09/16/2002

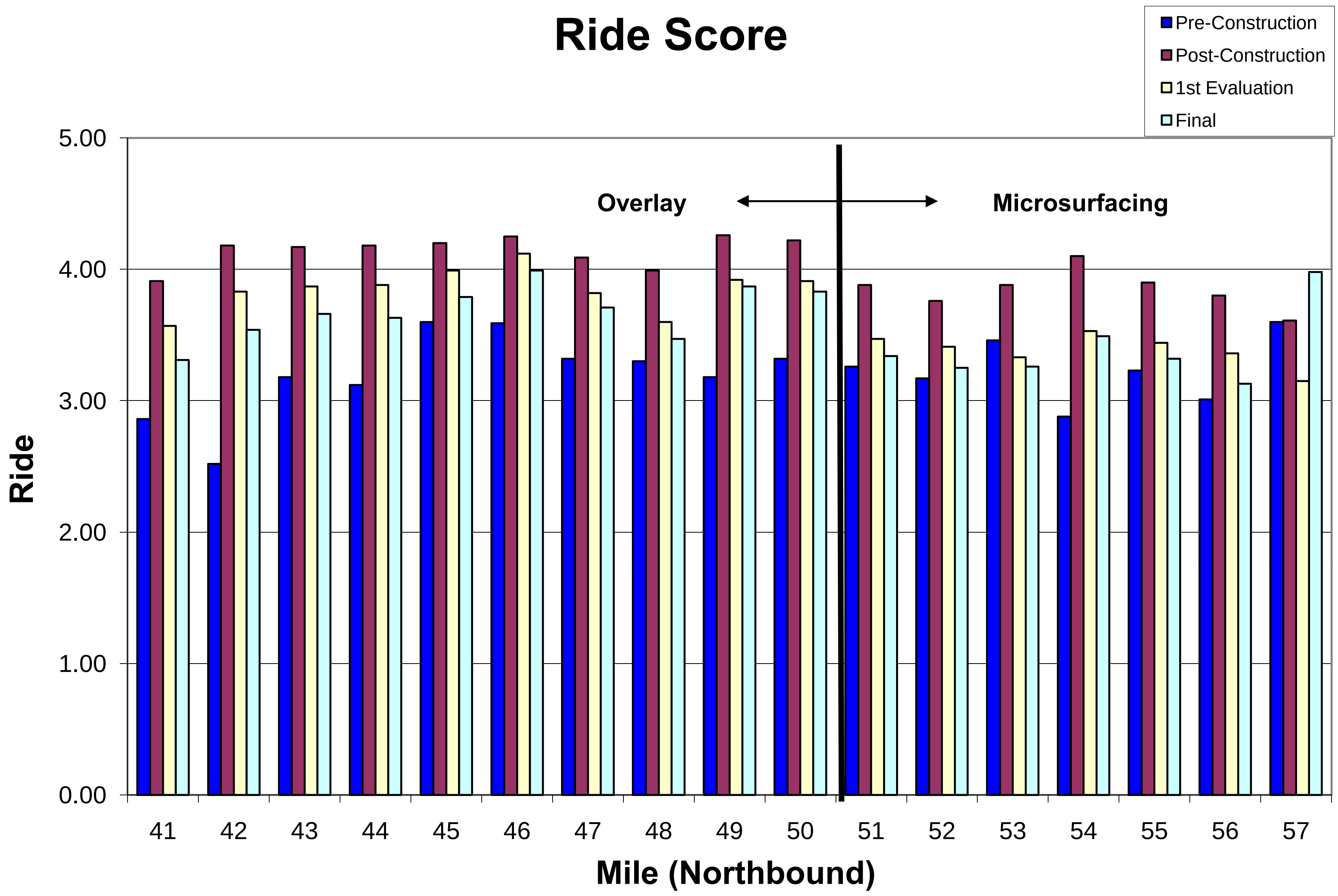
From	To	Dir	IRI LWP in/mile	IRI RWP in/mile	IRI Avg	% of Mile with Good IRI	% Fair IRI	% Poor IRI	Average Rut Depth Inches	% of mile with Rut .25 to .37	% Rut .38 to .49	% Rut > .50"	Ride Index
41	42	N	61	69	65	44.8	7.9	4.3	0.08	1.1	0.0	0.0	3.91
42	43	N	47	59	53	43.1	3.6	0.1	0.08	0.0	0.0	0.0	4.18
43	44	N	48	59	53	40.6	4.3	0.2	0.09	0.0	0.0	0.0	4.17
44	45	N	48	58	53	43.3	3.4	0.5	0.08	0.0	0.0	0.0	4.18
45	46	N	47	57	52	41.9	3.7	0.2	0.09	0.0	0.0	0.0	4.20
46	47	N	46	54	50	39.3	3.0	0.2	0.09	0.0	0.0	0.0	4.25
47	48	N	53	61	57	50.3	5.3	0.2	0.06	0.0	0.0	0.0	4.09
48	49	N	56	67	61	49.3	5.5	2.4	0.06	0.0	0.0	0.0	3.99
49	50	N	46	53	49	39.3	1.5	0.2	0.05	0.0	0.0	0.0	4.26
50	51	N	48	54	51	10.2	3.4	0.0	0.06	0.0	0.0	0.0	4.22
51	52	N	65	68	66	54.1	7.7	3.3	0.14	15.4	4.5	0.0	3.88
52	53	N	66	78	72	56.1	10.6	5.1	0.12	7.0	0.6	0.0	3.76
53	54	N	65	68	66	58.0	8.8	3.4	0.07	0.4	0.2	0.0	3.88
54	55	N	54	59	56	44.8	5.4	0.8	0.06	0.0	0.0	0.0	4.10
55	56	N	60	71	65	54.7	8.6	2.3	0.08	1.3	0.0	0.0	3.90
56	57	N	68	72	70	59.8	9.4	3.3	0.13	8.4	2.3	0.2	3.80
57	58	N	80	77	78	57.6	6.0	8.2	0.13	5.7	0.0	0.0	3.61
58	57	S	90	93	91	51.3	11.3	11.4	0.06	0.0	0.0	0.0	3.33
57	56	S	68	71	69	59.8	9.7	3.5	0.08	0.6	0.2	0.0	3.81
56	55	S	56	63	59	51.6	5.4	1.5	0.07	0.4	0.0	0.0	4.03
55	54	S	49	58	53	36.7	4.9	0.7	0.10	2.7	0.0	0.0	4.17
54	53	S	59	66	62	54.4	7.0	2.5	0.10	3.4	0.2	0.0	3.97
53	52	S	64	69	66	56.1	10.4	2.2	0.13	7.9	2.6	0.0	3.88
52	51	S	55	61	58	43.9	6.1	1.9	0.09	2.3	1.2	0.0	4.07
51	50	S	46	56	51	39.7	4.5	0.2	0.05	0.0	0.0	0.0	4.22
50	49	S	40	48	44	27.3	0.8	0.0	0.06	0.0	0.0	0.0	4.38
49	48	S	46	51	48	29.5	1.8	1.5	0.07	0.0	0.0	0.0	4.28
48	47	S	51	54	52	37.4	2.7	1.0	0.10	0.0	0.0	0.0	4.19
47	46	S	53	54	53	42.7	4.5	0.7	0.06	0.0	0.0	0.0	4.17
46	45	S	45	49	47	30.5	2.2	0.0	0.05	0.0	0.0	0.0	4.32
45	44	S	51	55	53	44.4	3.2	0.4	0.07	0.0	0.0	0.0	4.18
44	43	S	50	56	53	46.0	3.1	0.3	0.09	0.0	0.0	0.0	4.18
43	42	S	45	50	47	32.7	2.4	0.0	0.09	0.0	0.0	0.0	4.30
42	41	S	65	68	66	48.0	6.5	4.3	0.08	0.6	0.0	0.0	3.88
		Average	55.62	61.94	58.50				0.08				4.05
		Std. Dev.	10.85	9.73	10.08				0.02				0.23

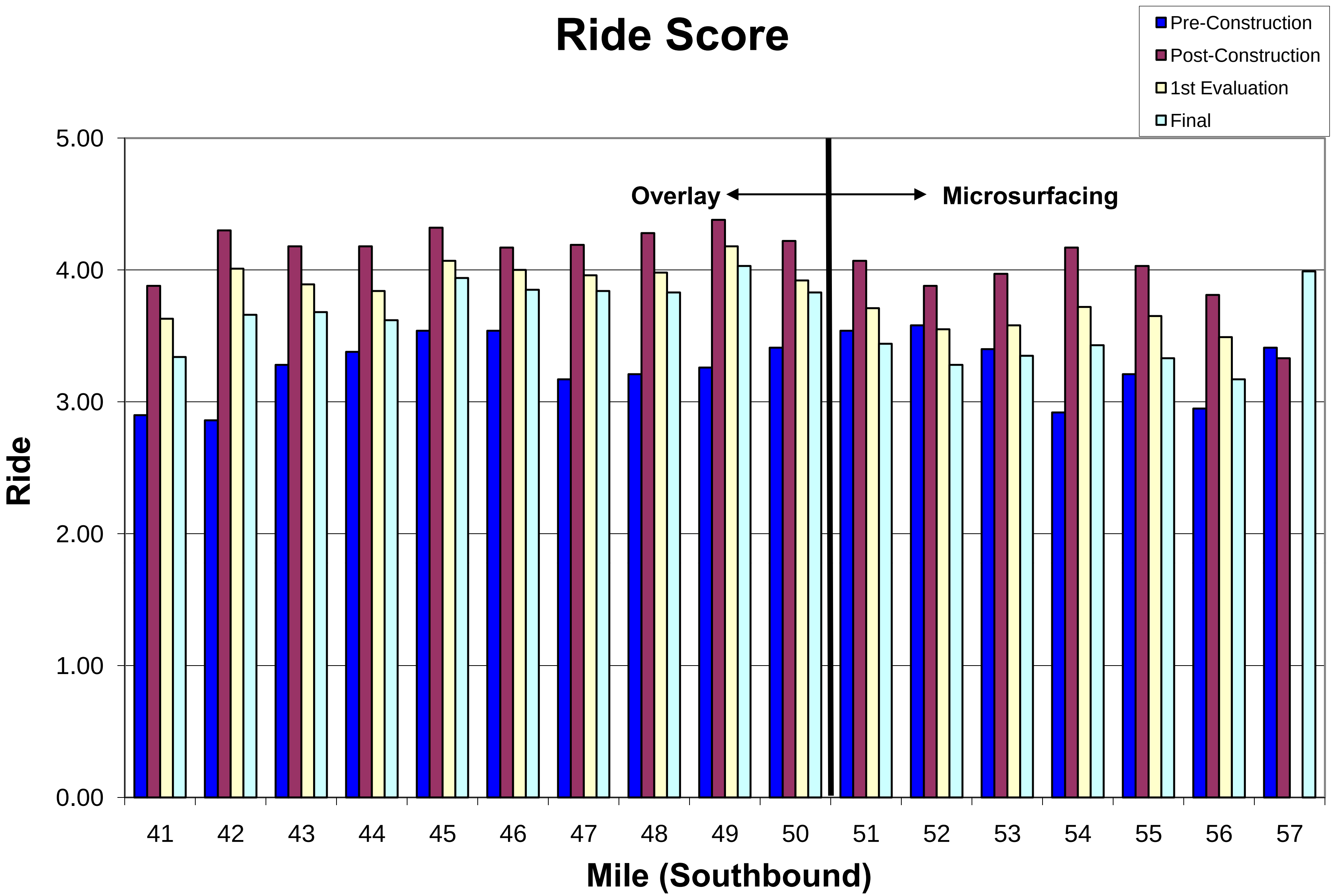
NDDOT US Highway 85													
Road Profile Report of 6/28/2004													
From Ref Pt	To Ref Pt	Direction	IRI LWP in/mile	IRI RWP in/mile	IRI AVG in/mile	% of Mile With Good IRI	% of Mile With Fair IRI	% of Mile With Poor IRI	Average Rut Depth Inches	% of Mile With Rut .25 to .37	% of Mile With Rut >38 to .49	% of Mile with Rut ≥ .50	Ride Score
41	42	N	80	81	80	59.4	7.9	6	0.16	9.6	0.9	0.3	3.57
42	43	N	62	75	68	64.4	4.7	0	0.1	1.2	0	0	3.83
43	44	N	63	71	67	61.4	5.7	0	0.07	0	0	0	3.87
44	45	N	63	70	66	54.1	6.8	1.2	0.12	0	0	0	3.88
45	46	N	59	64	61	55.4	1.9	0.9	0.11	0	0	0	3.99
46	47	N	54	57	55	47.6	1.8	0	0.1	0	0	0	4.12
47	48	N	65	73	69	66	6.2	0.3	0.09	0	0	0	3.82
48	49	N	72	86	79	61.8	9.5	3.3	0.12	3.5	0	0	3.6
49	50	N	60	69	64	65.5	3	0.3	0.08	1.8	0	0	3.92
50	51	N	62	68	65	65.8	2.5	0.9	0.1	0	0	0	3.91
51	52	N	81	89	85	68.2	10.2	4.7	0.3	47.6	17.3	7.3	3.47
52	53	N	81	95	88	64.7	9.3	6	0.24	38.9	7.1	1.7	3.41
53	54	N	87	96	91	69.7	12.6	7.2	0.24	43.4	0.6	0	3.33
54	55	N	77	88	82	65.5	12.9	3.4	0.22	35.7	1.5	0	3.53
55	56	N	84	89	86	67.8	15.3	5	0.24	55.1	5.2	0	3.44
56	57	N	87	93	90	66.5	18.3	4.9	0.28	37.7	17.1	7.1	3.36
57	58	N	100	100	100	62.1	6.8	14.6	0.18	18.4	4	0	3.15
57	56	S	79	89	84	67.1	15.3	4.8	0.27	44.6	16.7	0.6	3.49
56	55	S	70	84	77	69.4	10.1	1.5	0.34	62.3	21.4	1.2	3.65
55	54	S	66	81	73	70.3	7.5	1.6	0.38	40.8	47.7	0.3	3.72
54	53	S	74	86	80	67.2	10.1	4.1	0.36	71.7	11	0.8	3.58
53	52	S	80	83	81	58.8	7.8	6.4	0.21	16.8	4.7	3.9	3.55
52	51	S	72	76	74	56.5	8.8	3.7	0.35	52.9	20	5.1	3.71
51	50	S	56	73	64	64.5	5	0	0.12	0	0	0	3.92
50	49	S	48	58	53	45	2.8	0	0.12	0	0	0	4.18
49	48	S	57	67	62	50.9	3.1	2.3	0.1	0	0	0	3.98
48	47	S	60	66	63	60.7	2.2	0.3	0.05	0	0	0	3.96
47	46	S	61	61	61	58.9	3.8	0	0.09	3.8	1.2	0	4
46	45	S	57	59	58	50.7	3.6	0.6	0.1	0	0	0	4.07
45	44	S	65	71	68	61.3	5.3	0.9	0.09	0	0	0	3.84
44	43	S	60	72	66	62	5.2	0	0.04	0	0	0	3.89
43	42	S	56	65	60	55.8	2.9	0.3	0.05	0	0	0	4.01
42	41	S	74	81	77	60.5	5.7	5.6	0.09	6.8	0	0	3.63
		Average	68.85	76.85	72.64				0.17				3.74
		Std. Dev.	11.87	11.89	11.67				0.10				0.26

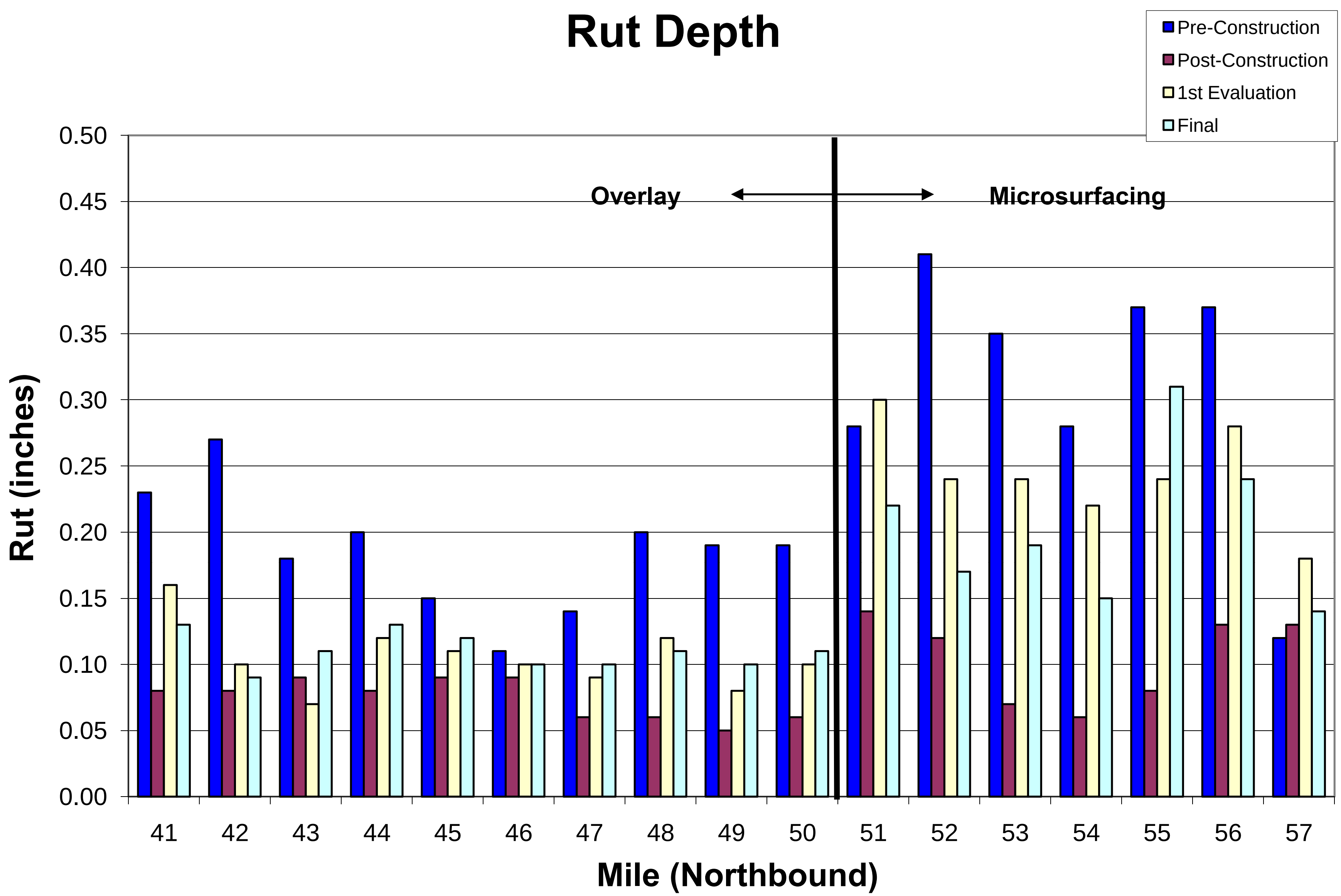
NDDOT US Highway 85 Road Profile Report of 10/18/2005													
From Ref Pt	To Ref Pt	Direction	IRI LWP in/mile	IRI RWP in/mile	IRI AVG in/mile	% of Mile With Good IRI	% of Mile With Fair IRI	% of Mile With Poor IRI	Average Rut Depth Inches	% of Mile With Rut .25 to .37	% of Mile With Rut >38 to .49	% of Mile with Rut ≥ .50	Ride Score
41	42	N	92	93	92	47.6	5.8	2.6	0.13	8.1	0.9	0.0	3.31
42	43	N	76	88	82	51.7	1.6	0.9	0.09	1.0	0.0	0.0	3.54
43	44	N	73	80	76	48.7	1.6	0.3	0.11	0.3	0.0	0.0	3.66
44	45	N	74	81	77	45.6	3.8	0.9	0.13	3.7	0.0	0.0	3.63
45	46	N	68	73	70	39.2	2.4	0.6	0.12	1.7	0.0	0.0	3.79
46	47	N	59	64	61	27.3	0.8	0.0	0.10	0.0	0.0	0.0	3.99
47	48	N	72	76	74	46.2	1.8	0.0	0.10	0.0	0.0	0.0	3.71
48	49	N	79	91	85	48.5	3.8	1.5	0.11	1.8	0.0	0.0	3.47
49	50	N	65	69	67	35.3	1.2	0.0	0.10	0.0	0.0	0.0	3.87
50	51	N	65	72	68	32.9	2.4	0.0	0.11	0.0	0.0	0.0	3.83
51	52	N	85	97	91	57.6	6.8	1.9	0.22	40.6	5.1	0.0	3.34
52	53	N	90	101	95	55.0	6.7	4.0	0.17	20.5	5.2	0.5	3.25
53	54	N	93	97	95	62.8	7.7	2.3	0.19	21.4	1.9	0.0	3.26
54	55	N	76	92	84	52.5	3.9	1.6	0.15	13.8	0.3	0.0	3.49
55	56	N	86	98	92	63.5	6.0	1.3	0.31	63.2	9.7	0.0	3.32
56	57	N	96	106	101	67.5	6.3	3.8	0.24	36.5	10.1	3.1	3.13
57	58	N	62	62	62	26.5	1.5	0.5	0.14	3.1	1.8	0.0	3.98
58	57	S	59	64	61	19.0	2.6	1.9	0.18	4.1	0.0	0.0	3.99
57	56	S	96	102	99	59.4	12.2	2.0	0.26	54.0	11.6	0.0	3.17
56	55	S	82	101	91	59.9	6.7	2.0	0.32	61.3	15.5	2.0	3.33
55	54	S	79	95	87	47.1	9.1	1.4	0.30	53.6	17.9	0.3	3.43
54	53	S	85	96	90	61.8	7.6	1.8	0.32	66.3	10.0	0.9	3.35
53	52	S	92	96	94	47.8	6.8	5.5	0.19	15.9	2.7	5.9	3.28
52	51	S	83	90	86	46.0	6.5	3.3	0.33	55.1	14.2	3.0	3.44
51	50	S	62	75	68	35.6	3.7	0.6	0.11	0.0	0.0	0.0	3.83
50	49	S	56	63	59	23.2	1.2	0.6	0.10	0.0	0.0	0.0	4.03
49	48	S	64	73	68	29.8	1.9	1.8	0.08	0.0	0.0	0.0	3.83
48	47	S	70	66	68	36.1	3.1	0.6	0.04	0.0	0.0	0.0	3.84
47	46	S	70	65	67	31.5	3.0	0.6	0.08	0.0	0.0	0.0	3.85
46	45	S	63	64	63	25.7	1.6	0.3	0.10	0.0	0.0	0.0	3.94
45	44	S	75	81	78	45.0	4.5	0.9	0.09	0.0	0.0	0.0	3.62
44	43	S	72	79	75	44.3	4.0	0.8	0.09	0.0	0.0	0.0	3.68
43	42	S	75	78	76	44.1	7.0	0.9	0.06	0.0	0.0	0.0	3.66
42	41	S	89	93	91	47.5	5.8	5.0	0.08	2.7	0.0	0.0	3.34
		Average	75.97	82.97	79.21				0.15				3.59
		Std. Dev.	11.60	13.80	12.56				0.08				0.27

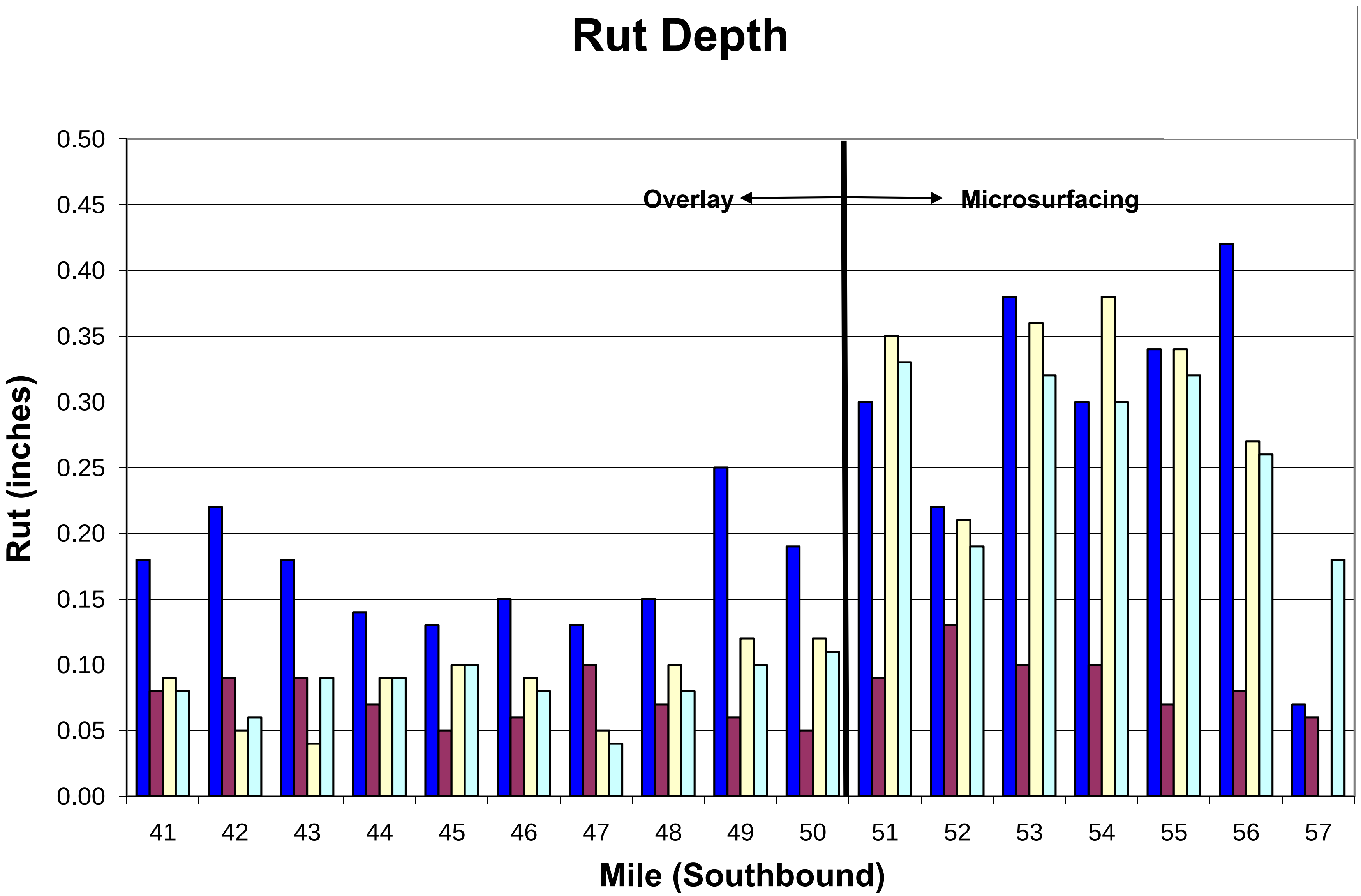

International Roughness Index (IRI)
Pre-Construction
Post-Construction
1st Evaluation
Final
Overlay
Microsurfacing
IRI
140
120
100
80
60
40
20
0
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
Mile (Northbound)


International Roughness Index (IRI)
Pre-Construction
Post-Construction
1st Evaluation
Final
Overlay
Microsurfacing
IRI
0
20
40
60
80
100
120
140
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
Mile (Southbound)


Ride Score
Pre-Construction
Post-Construction
1st Evaluation
Final
Overlay
Microsurfacing
Ride
5.00
4.00
3.00
2.00
1.00
0.00
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
Mile (Northbound)


Ride Score
Pre-Construction
Post-Construction
1st Evaluation
Final
Overlay
Microsurfacing
5.00
4.00
3.00
2.00
1.00
0.00
Ride
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
Mile (Southbound)


Rut Depth
Pre-Construction
Post-Construction
1st Evaluation
Final
Overlay
Microsurfacing
Rut (inches)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
Mile (Northbound)


Rut Depth
Rut (inches)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Overlay
Microsurfacing
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
Mile (Southbound)

Appendix E

Skid Number in Northbound Driving Lane