FEDERAL HIGHWAY ADMINISTRATION
Long Term Pavement Performance (LTPP)
Specific Pavement Studies

MONTANA SPS-9A CONSTRUCTION REPORT

DRAFT

Prepared for:

Montana Department of Transportation

August 2001

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I. INTRODUCTION

The Strategic Highway Research Program (SHRP) Specific Pavement Study 9 (SPS-9) experiment was designed to provide field validation of the Superpave asphalt binder specification and Superpave Level I asphalt concrete mix procedures. To accomplish this, the SPS-9 study was split into two related experiments, SPS-9A and SPS-9B. SPS-9A is focused towards the study of Superpave performance graded (PG) binders. The SPS-9B was to focus on pavement structural factors and Superpave performance prediction models.

This report covers the construction of the SPS-9A test sections on the northbound lanes of I-15 near Great Falls, Montana. Section II of this report gives the project location, description, and other attributes of the project. Section III describes the materials and construction procedures for each layer and then continues to detail construction sequence and operations. The test section construction is summarized in section IV and finally, the key observations are documented in section V.

SPS-9A OBJECTIVES

The primary objectives of the Superpave Asphalt Binder Study experiment are:

- To evaluate and improve the practical aspects of implementing the Superpave program through hands-on field trials by highway agencies.
- Compare the performance of the Superpave mixes with mixes designed with current highway agency practices.
- Provide long-term performance data for evaluation and refinement of the Superpave specifications and design procedures.
- Test the sensitivity of the Superpave asphalt binder specifications for distress factors such as fatigue, low temperature cracking, and permanent deformation.
- Provide highway agencies the opportunity to evaluate the performance of other experimental modifications by the construction of supplemental sections

The SPS-9A experiment requires construction of a minimum of three test sections at each site. These include a highway agency's standard mix, the Superpave Level 1 designed standard mix, and the Superpave mix with an alternate binder. The alternate binder is defined as "a binder with a PG grade higher or lower than the required Superpave binder, such that the performance characteristics of interest may be expected to exhibit distresses earlier than the Superpave section." The pavement structural sections remain the same for all three test sections.

PROJECT BACKGROUND

This report documents the construction of the of the SPS-9A near Great Falls, Montana, site number 300900. The sections are built on top of an existing embankment in the northbound lanes of I-15. The experimental project consists of three test sections, each of which are 500 ft (152.4m) long with 250 ft (76m) destructive test areas at both ends of the section, and a 200 ft (61m) transition in between. Construction of the surfacing on the test sections occurred October

22-27, 1998. A Superpave PG graded binder, PG 64-34, was used on the Superpave section, a 64-22 was used on the alternate binder section and a Polymer Modified AC in a Montana "grade D" mix was used for the agency standard mixture.

II. SPS-9A PROJECT DESCRIPTION

This section of the report describes in detail the geographical location, section layout, climatic zone, subgrade and structural attributes, and construction of individual sections.

LOCATION AND LAYOUT

This SPS-9A project is located on the northbound outer lane of I-15 between km posts 426 and 429 (mileposts 266.5 and 268.1), about 15 mi (24km) south of Great Falls in Cascade County, Montana. Table 1 presents the experimental design of the LTPP SPS-9 project. The project consisted of the construction of three asphalt concrete sections of identical thickness having different PG binders. The location, layout, stationing order, and structural attributes of individual sections are presented in table 2 and figures 1 and 2.

Table 1. Study design.

Moisture		Wet > 635 mm/year of precipitation				Dry < 635 mm/year precipitation			
Average 7 Day Maximum Pavement Design Temperature		<52C	<58C	<64C	<70C	<52C	<58C	<64C	<70C
Minimum Pavement Design Temperature	> -46C								
	> -40C								
	> -34C								
	> -28C								
	> -22C								
	> -16C								
	> -10C								

Notes: Traffic rate should exceed 50,000 ESAL/year in study lane.
Total traffic for design (design life) is agency choice.
The average 7-day maximum pavement design temperature is the aveage of the highest daily pavement temperatures for the seven hottest consecutive days.
The minimum pavement design temperature is the coldest pavement temperature of the year.

CLIMATE

The project is located in the LTPP dry-freeze climatic zone. The average maximum and minimum temperatures during the summer and winter seasons are enumerated below.

	Summer	Winter
Average Maximum Temperature	80.4°F (27°C)	35.5°F (1.9°C)
Average Minimum Temperature	51.8°F (11°C)	15.7°F (-9.0°C)

The average annual precipitation is 15.0 in (381mm).

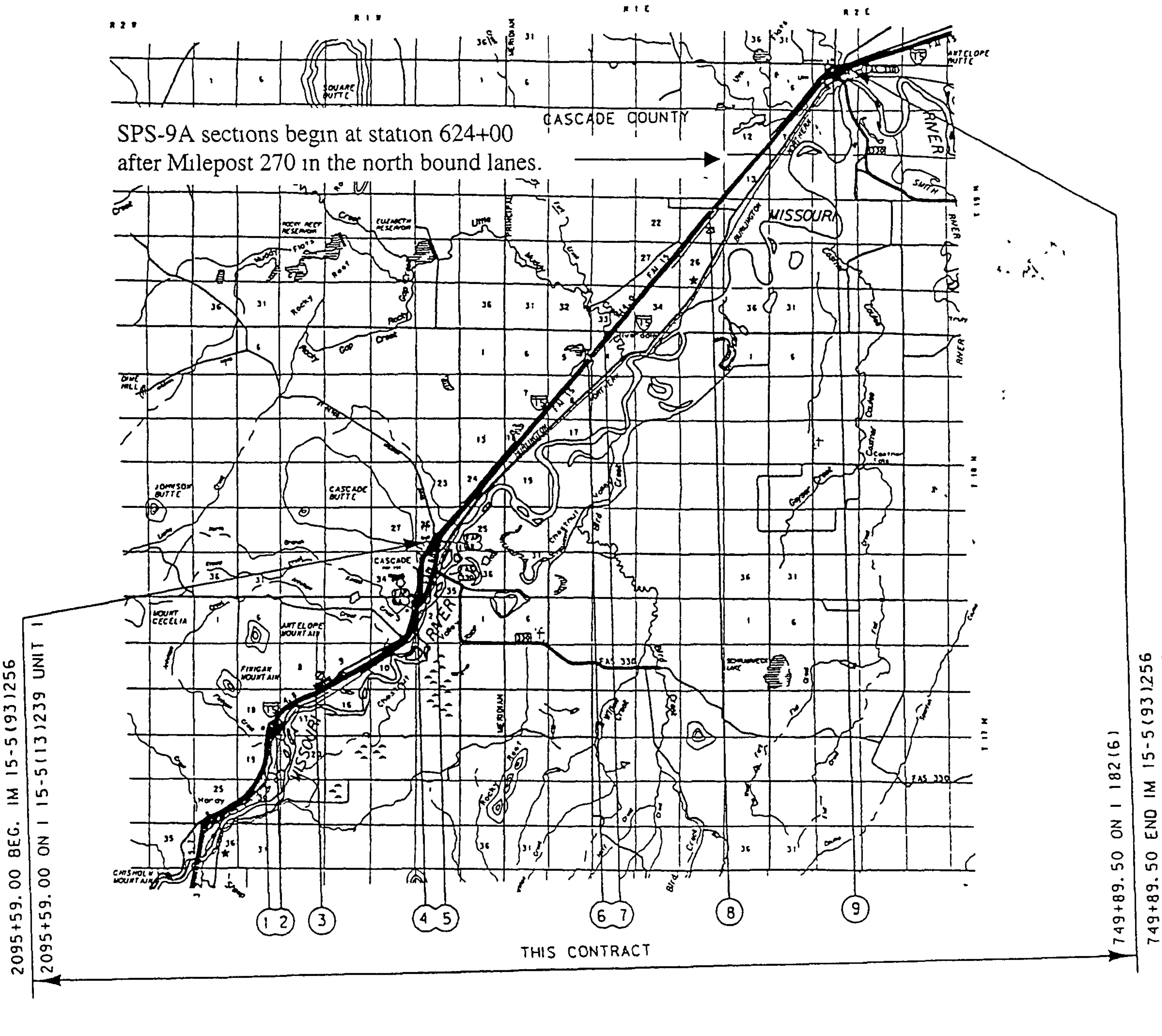


Figure 1. SPS-9A site location.

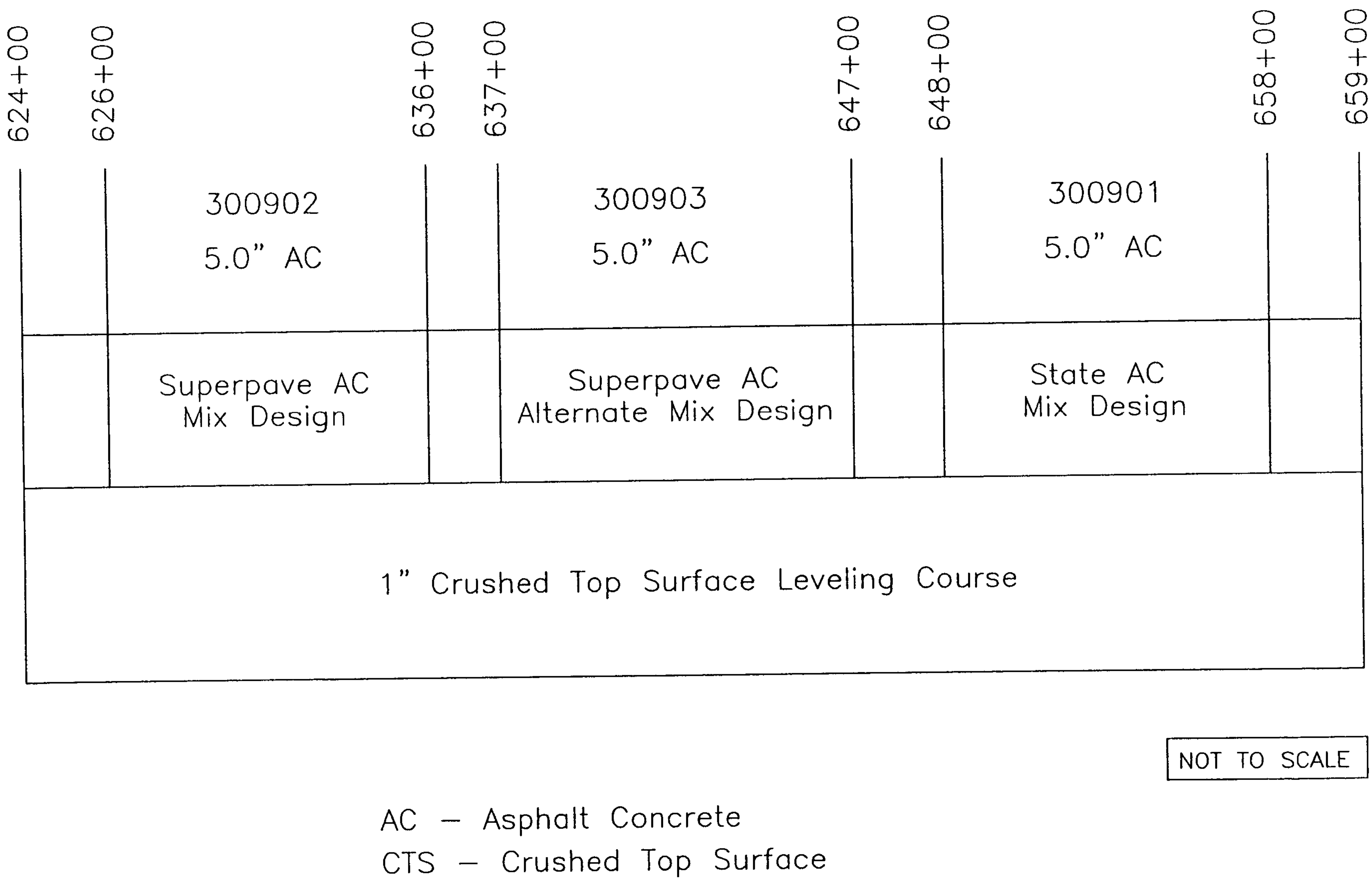


Figure 2. Layout of experimental test sections, Montana SPS-9A project, I-15.

Table 2. Test section layout.

Site	Location	Construction Stationing (ft)	Test Section (ft)	Description
Transition		624+00 to 626+00		200 ft
300902	Begin	626+00	-2+50	5 in Superpave mix with PG64-34 AC
	Begin Monitoring	628+50	0+00	
	End Monitoring	633+50	5+00	
	End	636+00	7+50	
Transition		636+00 to 637+00		100 ft
300903	Begin	637+00	-2+50	5 in Superpave mix with PG64-22 AC
	Begin Monitoring	639+50	0+00	
	End Monitoring	644+50	5+00	
	End	647+00	7+50	
Transition		647+00 to 648+00		100 ft
300901	Begin	648+00	-2+50	5 in Grade D plant mix
	Begin Monitoring	650+50	0+00	
	End Monitoring	655+50	5+00	
	End	658+00	7+50	
Transition		658+00 to 659+00		100 ft

TRAFFIC

The estimated 18K equivalent single axle loads (ESALs) in the study lane is 174,000 per year. For a design period of 20 years, the total design 18K ESALs is estimated to be 3,480,000.

GEOMETRY AND EMBANKMENT

The SPS-9A test sections were built on a straight, flat stretch of northbound I-15 without curves. The test sections are constructed on fill over a coarse grained granular subgrade. A coarse grained subgrade is defined as having less than 50 percent passing the #200 (75 µm) sieve.

AGENCIES AND PERSONNEL

This project was constructed under the supervision of the Montana Department of Transportation (DOT) and Empire Sand and Gravel was the contractor. All LTPP required material sampling was carried out by Montana DOT personnel. The following personnel were involved in the project at various phases of construction:

Montana DOT

Tim Sauer	Tom Roberts
Doug Wilmont	Mike Ostertag
Pat Ernst	Stan Kuntz
Jim Blossom	Brian Stremcha

Empire Sand and Gravel

Bob Marshall	Robert Oberlander
Tom Salverson	Tony Tams

WRCOC

Pete Pradere	Jason Puccinelli
Douglas Frith	Scott Gibson

The Western Region RCOC (NCE) provided on-site coordination to insure that the goals of the experiment were met to the extent possible.

III. CONSTRUCTION

A summary of the complete paving operations is included in this section of the report. The SPS-9A project in Montana was constructed between April 1998 and November 1998. The construction consisted of milling off the existing pavement surface and building the SPS-9A sections directly on the existing embankment. This was a change from the original plans which had included reprocessing the millings with asphalt emulsion for use as a base layer. Instead, a thin leveling course of granular material was used. Detailed below are discussions regarding the pre-paving operations, AC mix designs, summaries of the paving operation, and information concerning the additional materials sampling and testing performed on the test sections.

PRE-PAVING OPERATIONS

Equipment

The following equipment was used in the preparation of the embankment for paving of the SPS-9A test sections on I-15 in Montana:

- Pavement Milling Machine
- CAT 637D Scraper
- CAT CS-563C Steel Drum Roller
- Ingorsoll and Pro Pac Series 150 Steel Drum Rollers
- CAT 14G Blade
- CAT 14H Blade
- Belly Dump Trucks
- Water Truck

Existing Embankment Preparation

Work on the existing embankment began on July 29, 1998, and was completed on July 31, 1998. The existing pavement was milled off of the existing embankment. In some areas there was a very thin layer of the surfacing left behind (photos 1 and 2, appendix A). No additional working or compaction of the existing embankment was done. The top layer of the existing embankment consisted of pit run, a well-graded granular material that met AASHTO (A-1-A) criteria. The average depth of this material according to borings done prior to the construction was 30 in (762mm).

Bulk Sampling of the Existing Embankment

Bulk sampling of existing embankment material was performed by excavating test pits (photos 3-5, appendix A). The bulk sampling location were also used for compaction testing of underlying layers using a nuclear density gauge. The sampling and density testing locations are indicted in figures 3, 4, and 5. A summary of existing embankment material bulk sample locations, stations,

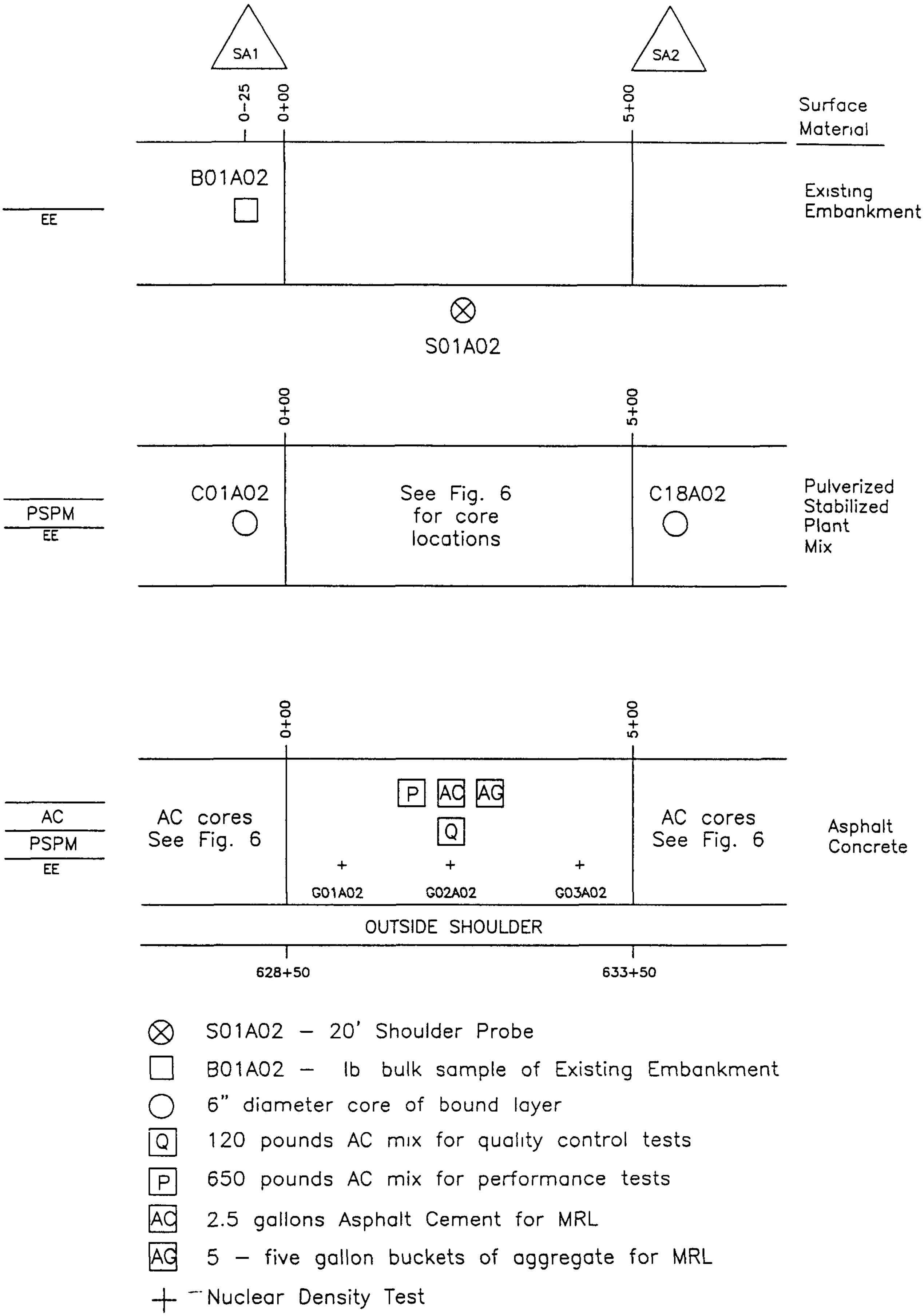


Figure 3. Sampling and testing plan for test section 300902, Montana SPS-9A .

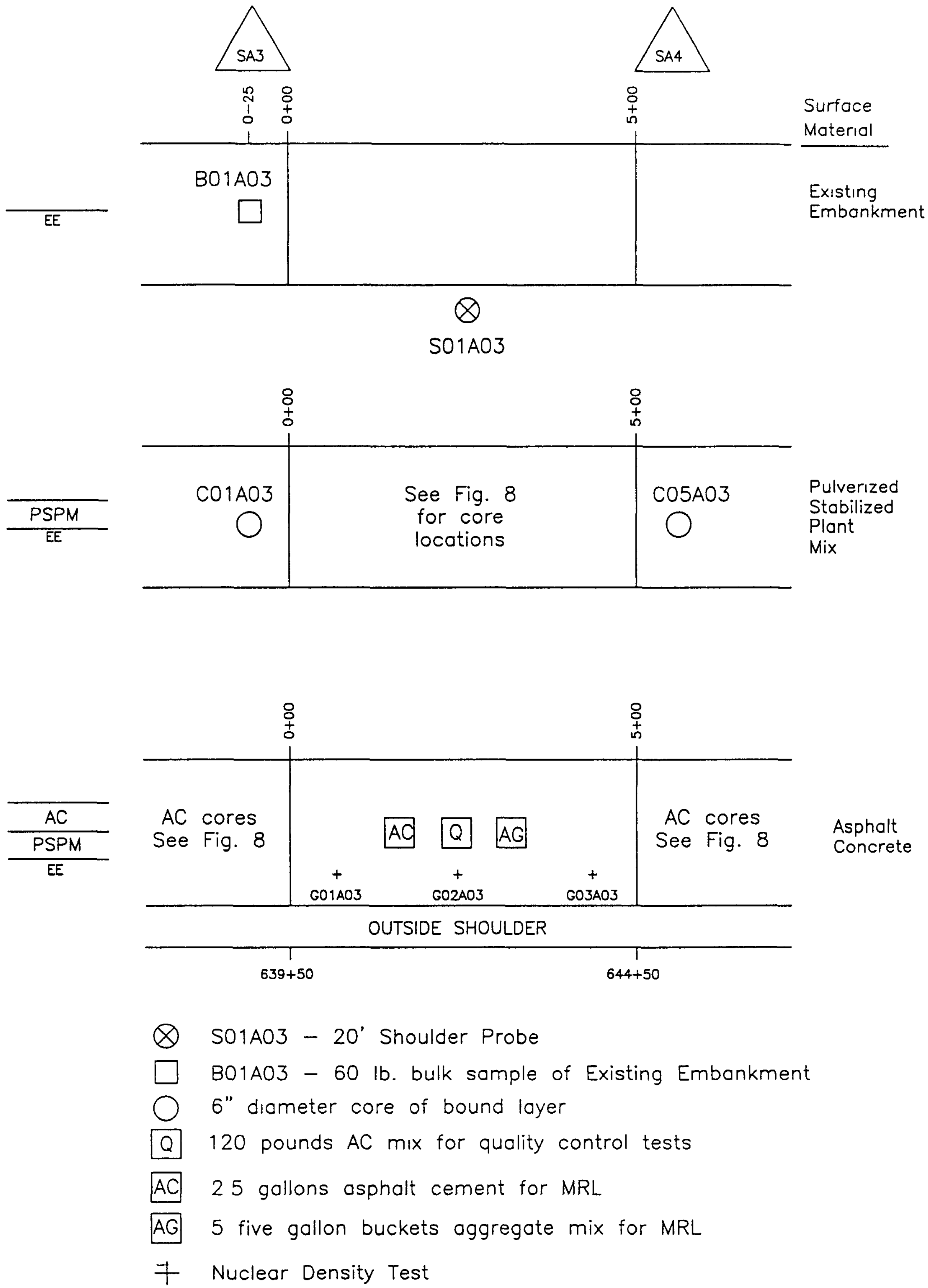


Figure 4. Sampling and testing plan for test section 300903, Montana SPS-9A .

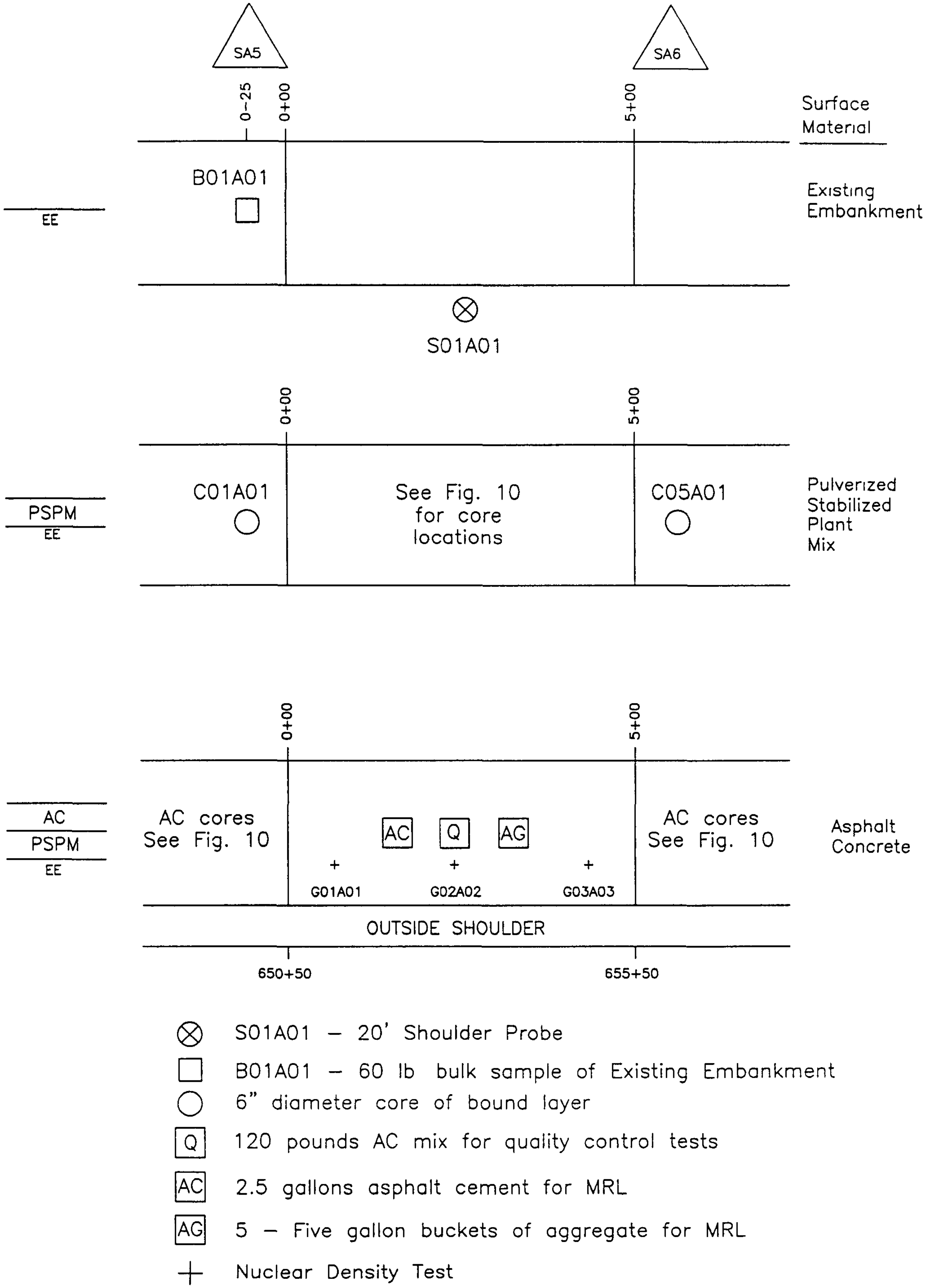


Figure 5. Sampling and testing plan for test section 300901, Montana SPS-9A .

and sample numbers are given in tables 3 and 4, respectively. Note that the samples were taken in the destructive sampling areas outside the 500 ft (152m) test section. Samples of the natural subgrade below the A-1-A material were not taken from the SPS-9 site.

Table 3. Existing embankment bulk sample locations.

Section No	Bulk Sample Designation	Section Station	Project Station	C/L Reference
300902	B01A02	0-25.0	628+25	Right, 6.0 ft
30093	B01A03	0-25.0	639+25	Right, 6.0 ft
300901	B01A01	0-25.0	650+25	Right, 6.0 ft

Table 4. In-situ density and moisture test results on existing embankment.

Test No	Section	Station	Offset	Rod Depth (in)	Depth to Top of Pavement (in)	Avg In-Situ Density (pcf)	Avg. In-Situ Moisture Content (%)
T1A01	300901	629+35	9.5' rt of CL	8	6	135.9	5 9
				4	6	130 3	6.0
T2A01	300901	631+00	9.5' rt of CL	8	6	128.1	6.6
				4	6	123 4	6 9
T3A01	300901	632+65	9 5' rt of CL	8	6	127 0	8 3
				4	6	124 8	8.4
T1A02	300902	640+55	9.5' rt of CL	8	6	136.6	6.5
				4	6	137 1	6 4
T2A02	300902	642+00	9 5' rt of CL	8	6	138.6	5 3
				4	6	137.8	5 6
T3A02	300902	643+65	9.5' rt of CL	8	6	136.0	6.1
				4	6	137 1	6 3
T1A03	300903	651+35	9 5' rt of CL	8	6	137 4	4.2
				4	6	136 8	4 2
T2A03	300903	652+00	9 5' rt of CL	8	6	137 9	6.1
				4	6	136 9	6 0
T3A03	300903	654+65	9 5' rt of CL	8	6	137 3	4 9
				4	6	134 9	5 1

FIELD DENSITY AND FIELD MOISTURE TESTING

Field density and field moisture tests were performed on the existing embankment layers. The density tests were carried out using a Troxler nuclear gauge at locations indicated in figure 6 in accordance with the procedures in AASHTO T239-97. The results of the density tests are

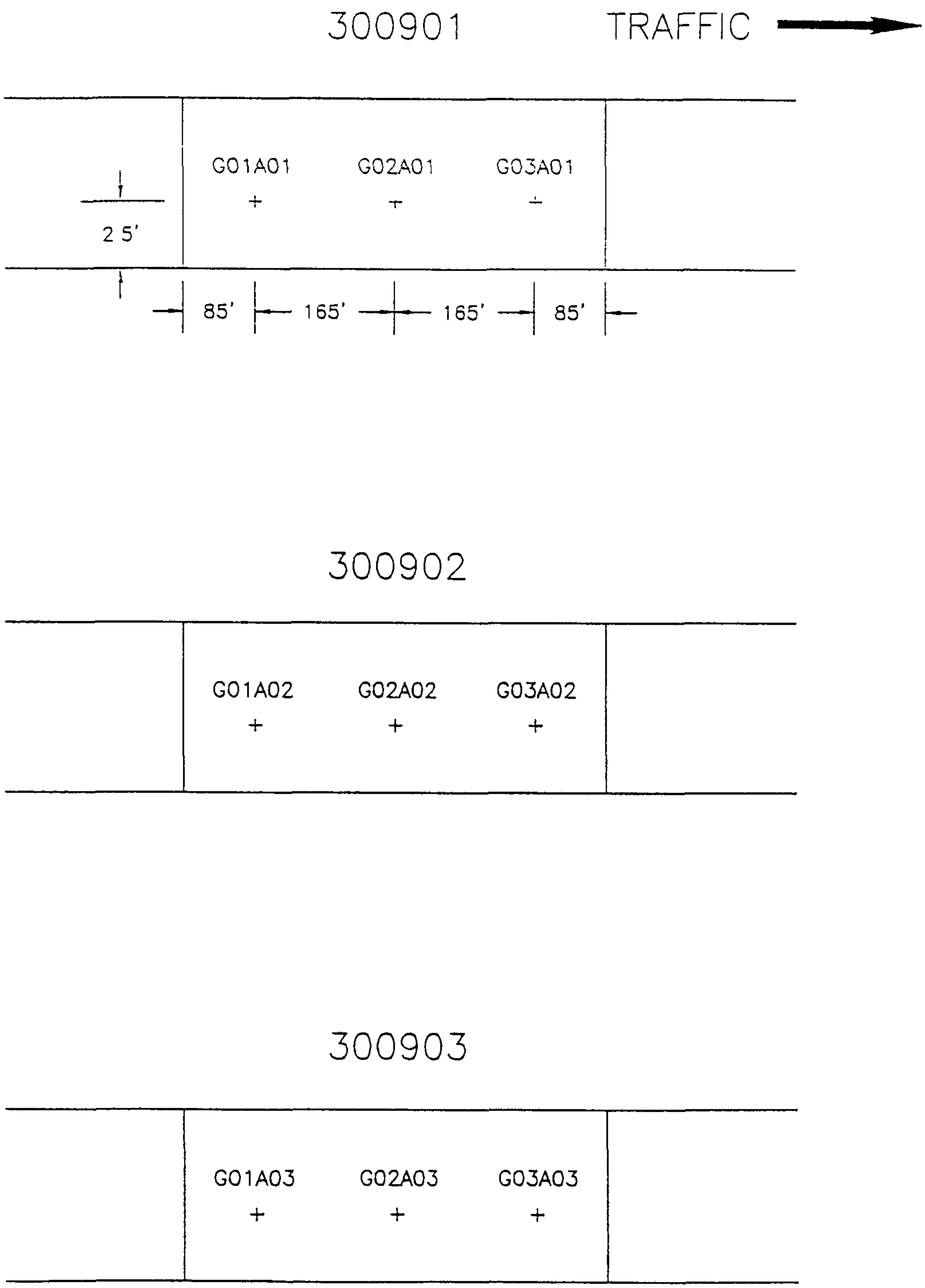


Figure 6   On-site density/moisture measurements using nuclear density/moisture gauge.

tabulated in table 3. Density tests were taken at depths of 4 in (100mm) and 8 in (200mm). In-situ densities range from 123.4 to 137.8 pcf (1977 to 2207 kg/m^3) at the 4 in (100mm) depth and 127.0 to 138.6 pcf (2052 to 2220 kg/m^3) at the 8 in (200mm) depth.

SHOULDER AUGER PROBES

Shoulder auger drilling to a depth of 20 ft (6.1m) was performed to determine the existence of bedrock or any stiff underlying layer within 20 ft (6.1m) of pavement surface. Table 5 lists the section locations and soil types for shoulder probes performed on existing embankment. No rock or other stiff layer, such as a water table, was encountered. Auger probes did confirm granular subgrade type.

Table 5. Auger probes performed on shoulder of existing embankment.

Test No	Section	Station	Offset	Type of Equip Used	Depth of Layer	Material Description
S01A02	300902	631+00	6' rt of CL	SIMCO 4" Drill Rig	0 to 2.5 ft	Sandy gravel
					2.5 to 7 ft	Fine, gray, silty sand
					7 to 12 ft	Light brown silt
					12 ft ↓	Light brown, fine sand
S01A03	300903	642+00	6' rt of CL	SIMCO 4" Drill Rig	0 to 3 ft	Gray, silty gravel w/ sandy gravel
					3 to 12 ft	Light brown, moist silt
					12 ft ↓	Light brown, fine sand w/layers of dark brown sand
S01A01	300901	653+00	6' rt of CL	SIMCO 4" Drill Rig	0 to 2.5 ft	Light brown, silty, sandy gravel
					2.5 to 7 ft	Dark brown sand w/ silt layers
					7 to 14 ft	Fine, moist, sandy silt w/gray and light brown zones
					14 to 20 ft	Gray silt
					20 ft ↓	Clay

PREPARED EMBANKMENT ELEVATIONS

As stated earlier in this section of the report, the Pulverized Stabilized Plant Mix layer indicated on the plans and in the SPS-9 Materials Sampling and Testing Guide was not placed. Instead a 0.1 ft (30mm) thick layer of a 3/8 in (9.5mm) minus material called a crushed top surface (CTS) was used as a leveling course. The CTS was placed and finished between August 3, 1998 and August 6, 1998 (photos 6 and 7, appendix A). The CTS surface was shot with a prime coat of emulsion prior to paving (photos 8 and 9, appendix A).

Baseline elevation surveys on the surface of prepared embankment were carried out at locations indicated in figure 7. The purpose of the elevation surveys was to obtain a profile of the prepared surface and to determine the thickness of subsequent layers. The average surface profile of the prepared embankment for each section are shown in appendix B.

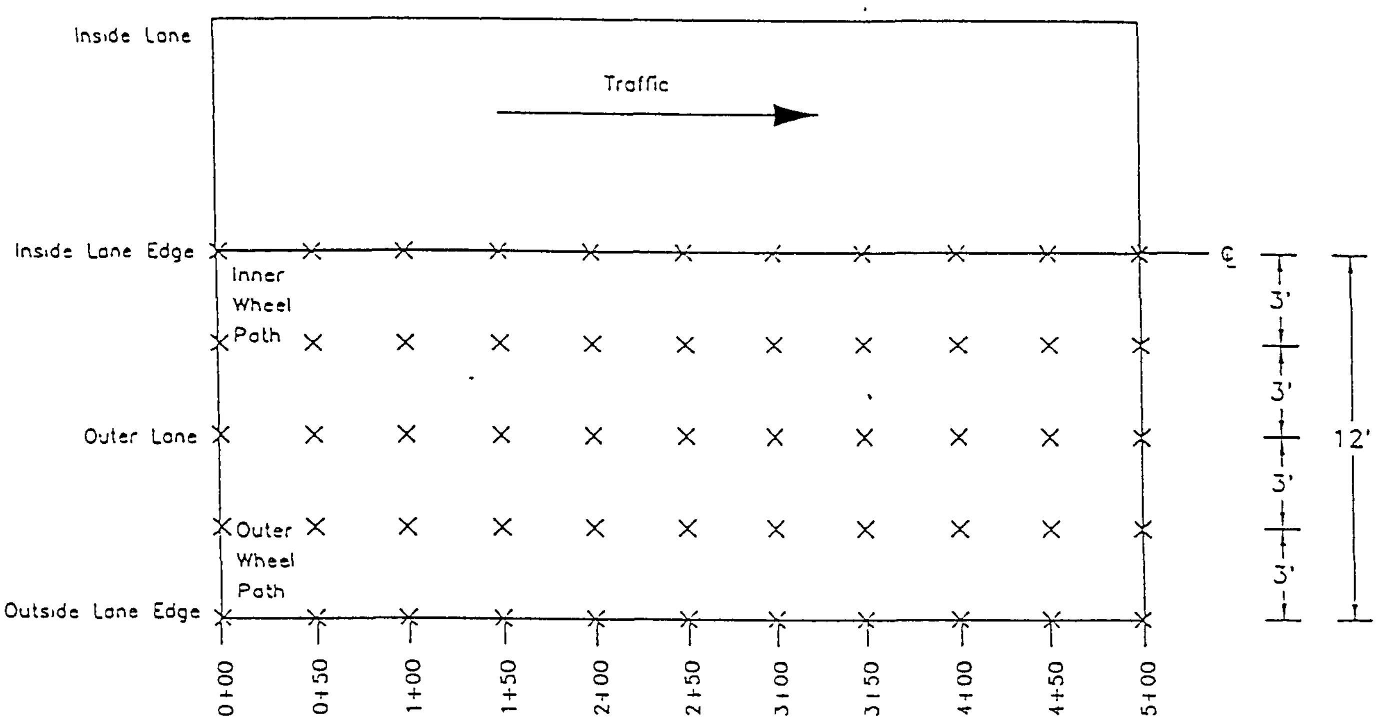


Figure 7. Test section elevation measurement location for Montana SPS-9A.

ASPHALT CONCRETE MIX DESIGN

As per the SPS-9A experimental design, section 300902 was the Superpave Level I AC mix design with PG binder 66-34, section 300903 was Superpave Level I AC mix design with alternate PG binder using PG binder 66-22, and section 300901 was the a standard Marshall "Grade D" mix design using a polymer modified binder.

Table 6 shows the samples required for the mix design development for all sections. It should be noted that the mix design for section 300902 and 300903 was developed using Montana DOT's standard level 1 mix design methodology and not in accordance with SPS-9A requirements. The mix design for the agency standard mix was developed using Montana DOT's conventional Marshall mix design methodology and also did not have the additional testing done required for the SPS-9A. Additional materials in accordance with table 6 were sampled during construction so that additional laboratory mixed samples could be created in order to fulfill the requirements for the LTPP program. At this writing that testing had not yet been performed and the following information was derived from the mix designs provided by Montana DOT.

Table 6. Asphalt concrete bulk sampling requirements.

Material	Quantity/Section			Purpose
	300901	300902	300903	
Asphalt Cement	2.5 gal	2.5 gal	2.5 gal	Mix design asphalt properties tests
Aggregate	550 lb	550 lb	550 lb	Mix design aggregate properties tests
Asphalt Cement/ Aggregate	Note 1	Note 1	Note 1	Mix design-optimum asphalt content
Asphalt Cement/ Aggregate		660 lb		Laboratory mixed performance tests (mold into 40 specimens)
Asphalt Cement/ Aggregate	Note 2		Note 2	Laboratory mixed performance tests (mold into 9 specimens)
HMA Mix	120 lb	120 lb	120 lb	Field mixed quality control tests (mold into 6 specimens)
HMA Mix		550 lb		Field mixed performance tests (mold into 34 specimens)
Asphalt Cement	2.5 gal	2 5 gal	2.5 gal	MRL storage
Combined Aggregate	5 5-gal. buckets	5 5-gal buckets	5 5-gal buckets	MRL storage

Note 1. After the asphalt cement and aggregate have been selected which meet the specifications, a sufficient quantity of asphalt cement and aggregate must be obtained to allow the mix design to be completed

Note 2. Use asphalt and aggregate from rows 1 and 2 for material.

Supervpave Level I Mix Design

Only one Superpave Level 1 mix design was developed for the two sections using the Superpave mixtures. The mix design was developed by Montana DOT laboratory using a gyratory compactor. Asphalt binder was supplied by Montana Refining Company. Aggregate from the Henen & Bogden pit was used in the mix design. Three separate stockpiles were analyzed and combined to obtain the required gradation. The aggregate gradation remained the same for the two Superpave AC paving mixtures. AC binder grade and binder contents were the variable factors. Based on the results of modified Lottman tests, 1 percent hydrated lime was recommended as mineral filler in the mixtures. The number of gyrations used in the mix design are summarized in table 7.

Table 7. Number of gyrations for Level 1 mix design.

N Initial (N_i)	8
N Design (N_d)	96
N Maximum (N_m)	152

The physical properties of aggregates used in the mix design are presented in table 8, and the asphalt concrete mix design used for the Superpave sections are summarized in table 9. The detailed mix designs for both the Superpave and conventional mix designs are enclosed in appendix C.

Table 8. Properties of aggregate used for the Superpave Level 1 mix.

Fractured Faces	92% 1 face, 85% 2 face
Plasticity Index	Non-plastic
Percent Elongated	4%
Percent Wear	18%
Sand Equivalent	55
Volumetric Swell	Coarse-Fraction 4.6% Intermediate-Fraction 2.4%
Absorption (% by wt.)	Coarse-Fraction 1.319 Fine-Fraction 1.488 Agg. Blend 1.390
Bulk Dry Specific Gravity	Coarse Agg. 2.632 Fine Agg. 2.637

Agency Standard Mix Design

Section 300901 was paved with the agency standard mix used on the rest of the project. The mix was produced using a 75 blow Marshall compaction method in accordance with Montana DOT specifications. This test section was meant to act as a control and represent standard mixtures, materials, and construction practices that traditionally have been used in Montana. Montana is currently converting all its mix design to Superpave gyratory-based compaction methods.

Aggregate for this mixture is comprised of coarse aggregate, crushed fines, and chips from the Henen/Bogden pit. The aggregates were blended as follows:

Table 9. Asphalt concrete mix designs used in Montana SPS-9.

<table>
<tr><td colspan="3">Aggregate Stockpile Gradation</td><td colspan="4">Recommended Asphalt Content (% wt)</td><td colspan="3">Asphalt Cement Grade (PG)</td><td colspan="2">Section</td></tr>
<tr><td colspan="3" rowspan="3">Coarse 45%
Intermediate 20%
Fine 35%</td><td colspan="4">5.00</td><td colspan="3">64-34</td><td colspan="2">300902</td></tr>
<tr><td colspan="4">4.80</td><td colspan="3">64-22</td><td colspan="2">300903</td></tr>
<tr><td colspan="4">5.60</td><td colspan="3">Polymer (EVA) modified AC</td><td colspan="2">300901</td></tr>
<tr><td colspan="7">Mineral filler:</td><td colspan="5">1% hydrated lime</td></tr>
<tr><td colspan="7">Air voids</td><td colspan="5">3.8%</td></tr>
<tr><td colspan="7">Voids in Mineral Aggregate:</td><td colspan="5">14 6%</td></tr>
<tr><td colspan="7">Voids Filled with Asphalt:</td><td colspan="5">73 7%</td></tr>
<tr><td colspan="7">Retained Strength:</td><td colspan="5">77%</td></tr>
<tr><td colspan="7">Adhesion:</td><td colspan="5">90%</td></tr>
<tr><td colspan="7">Dust/Effective Asphalt Ratio:</td><td colspan="5">1.0</td></tr>
<tr><td colspan="7">Density @ N(d):</td><td colspan="5">2368 Kg/m³</td></tr>
<tr><td colspan="12">Aggregate Gradation (mm)</td></tr>
<tr><td>Sieve Size</td><td>25</td><td>19</td><td>12.5</td><td>9.5</td><td>4.75</td><td>2.36</td><td>1.18</td><td>0.600</td><td>0.300</td><td>0.150</td><td>0.075</td></tr>
<tr><td>% Passing</td><td>100</td><td>97</td><td>80</td><td>68</td><td>42</td><td>29</td><td>20</td><td>15</td><td>10</td><td>7</td><td>4.5</td></tr>
</table>

1. 54 percent course aggregate
2. 41 percent crushed fines
3. 5 percent chips

Table 10 presents the mineral aggregate properties and the specification values.

Table 10. Mineral aggregate properties and specification values.

Mineral Aggregate Properties	
Property	Results
Coarse Aggregate Angularity, % Fractured Faces	1 face = 96 2 faces = 91
Plasticity Index	NP
L.A. Wear	16
Absorption (Blend)	1 267
Bulk Dry Specific Gravity	Fine = 2 622 Coarse = 2 652

The asphalt cement used on the agency standard section was polymer modified and met a performance grade rating of PG 70-28. Montana Refining Company was the supplier for this material as well.

Mixture properties for the agency standard mix are presented in table 11 and the complete mix design is contained in appendix C.

Table 11. Mixture properties for the agency standard mix.

Marshall Property	Mix Design Results
AC Content %	5.6
Mineral Filler (Hydrated Lime) %	1.4
Rice Gravity	2.450
Unit Wgt. (Kg/m3) Lbs/ft3)	2372 (148.1)
Marshall Stability Kn (lbs)	9.3 (2100)
Flow	11
Air Voids %	3.0
VMA	15.1
VFA	80.1
Asphalt Ratio	0.89

PAVING OPERATION

Asphalt concrete construction work began on October 22, 1998 and was completed on October 24, 1998. The following equipment were used in the AC paving operations:

- Blaw Knox PF 220 Paver with an Omni 2 Screed and 20 ft ski
- Two 20 ton DynaPac Double Drum 50 Series Steel Drum Vibratory Rollers
- Caterpillar 9.3 tonne (10.5 ton) vibratory roller
- Windrow Elevator
- Belly Dump Trucks

The design thickness of the AC layers was 5 in (130mm) for all three test sections and the materials were placed in two equal layers.

AC PAVEMENT CONSTRUCTION

The first lift of material was placed on section 300902 with the PG 64-34 binder on October 22, 1998. The final lift was placed and compacted on October 23, 1998. The first lifts for sections 300903 and 300901 were placed on October 23, 1998, and the final lifts were placed on October 24, 1998 (photo 10, appendix A). During the construction of the first lift of section 300902, the mix temperature was relatively high, about 330°F (166°C), but the mix looked good, with little apparent segregation, well coated aggregates, and no excess binder. Density tests revealed that the air voids in the compacted mix were on the low side (3 percent to 4 percent). Because of low air voids, the contractor reduced the AC content by 0.1 percent on the 2nd lift of material. This small reduction in AC content resulted in a dramatic increase of air voids of about 2 percent to 3 percent, indicating an asphalt sensitive mix.

The hot-mix was delivered to the site in belly dump trucks and placed in a windrow in front of the paver. The windrow material was delivered to the paver using a windrow elevator. The paver would pull two lanes of width (approximately 24 ft) at a time starting from the outside shoulder. The centerline joint was offset 1 ft between lifts.

Compaction of the Superpave sections 300902 and 300903 was not achieved to specification. The specifications called for 94 percent of Rice density as the density requirement. Field in-situ nuclear density tests indicated an average max density of 90 percent Rice. On section 300902, roller marks could be seen for quite some time, indicating a tender and temperature-sensitive mix. The roller marks were removed by another pass of the roller more than an hour after initial rolling. Both Superpave sections exhibited some movement (lateral spreading) after placement; this may have been due to the underlying CTS layer or due to a tender mix. The final lift of section 300903 did not show as much movement, but still could not be compacted to the specifications.

ROLLING PATTERN

The rolling pattern was established by compacting AC material placed on the outside shoulder. As discussed above, additional rolling after the pattern shown below resulted in displacement of material but no additional density. The resulting pattern used for each lift was:

Breakdown: DynaPac 20.2 tonne (22.3 ton) double drum roller in vibratory mode, single coverage
Caterpillar 9.3 tonne (10.5 ton) vibratory roller in vibratory mode, single coverage

Finish: DynaPac 15.1 tonne (16.6 ton) steel wheel tandem roller, single coverage

This rolling pattern was used for all the lifts.

FIELD DENSITY TESTING

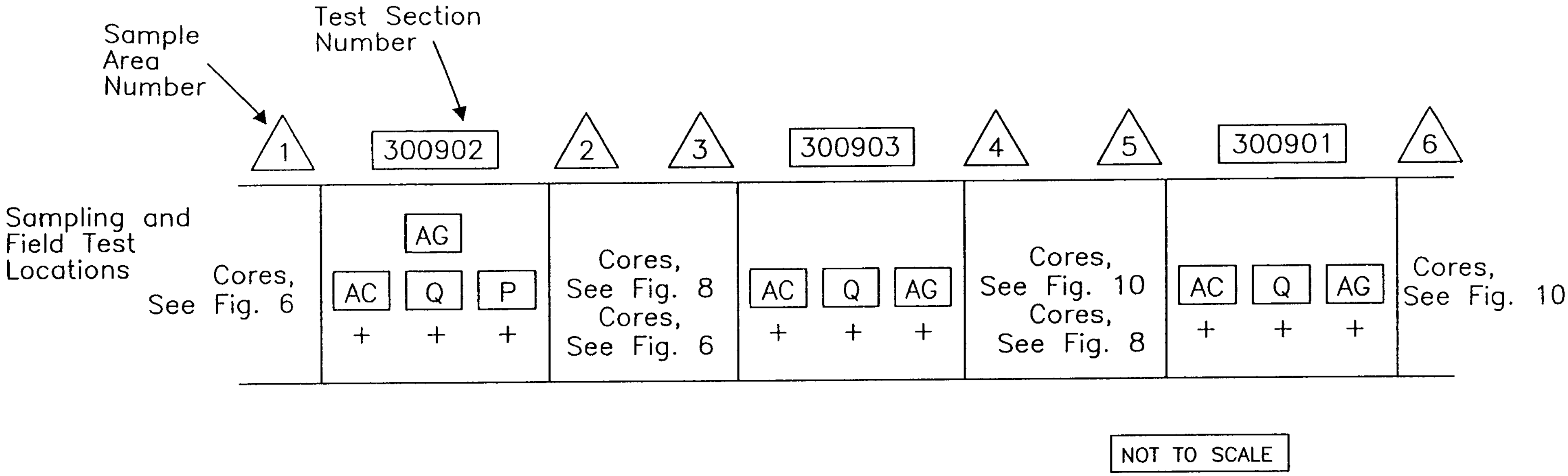
Field density tests on asphalt concrete layers were performed to determine field compaction at locations indicated in figure 8. The test locations and density test results are presented in table 12.

Table 12. In-situ density test results on AC.

Test No.	Section	Station	Offset	Avg. In-Situ Density (pcf)	% Compaction*
T1A01	300901	629+35	6' rt of CL	137.7	89.6
T2A01	300901	631+00	6' rt of CL	139.7	91.0
T3A01	300901	632+65	6' rt of CL	139.4	90.8
T1A02	300902	640+35	6' rt of CL	139.2	90.6
T2A02	300902	642+00	6' rt of CL	139.1	90.6
T3A02	300902	643+65	6' rt of CL	139.8	91.0
T1A03	300901	651+35	6' rt of CL	141.1	92.4
T2A03	300901	653+00	6' rt of CL	142.7	93.5
T3A03	300901	545+50	6' rt of CL	144.4	94.6

* % Compaction based on N design or Marshall design maximum theoretical densities.

As can be seen from the table, the agency standard mix achieved higher compaction values based on a theoretical density computed from the mix design data shown in appendix C.



Q	120 pounds of AC mixture for quality control tests
P	650 pound AC mixture for Performance Tests
AC	2.5 gallons asphalt cement for MRL
AG	5 5-gallon buckets of aggregate for MRL
+	Location of Nuclear Density Test

Figure 8. Overview of material sampling and testing on asphalt concrete, Montana SPS-9A.

MATERIAL SAMPLING AND TESTING

All samples required by the materials sampling and testing plan were obtained. Bulk samples of aggregate and binder were taken from the plant, as well as bulk samples from the field. Many samples were collected by the contractor for quality control purposes, other samples were collected by Montana DOT for quality assurance, and still others were collected solely for experimental testing purposes. The sampling and testing described in this section pertains only to those additional samples that were required for the SPS-9 testing. All the materials sampling locations are shown in figure 8.

The required tests can be divided into five categories:

- material verification
- mixture design confirmation
- quality control tests
- as-built tests
- performance prediction tests

These tests are listed in tables 13 through 17.

Table 13 shows the binder and aggregate testing to be performed on the AC surface layer materials from all test sections. Table 14 shows the mix design tests that need to be performed on the alternate Superpave section and the agency standard mix. It should be noted that the agency standard mix was developed using the Marshall mix design method, but that a gyratory compaction regime must be developed for performance comparison purposes. Table 15 shows the tests to be performed on compacted mixtures prepared both in the laboratory during the mix desgin process and plant mixed samples taken in the field from section 300902. Table 16 shows quality control tests to be performed on compacted gyratory specimens from sections 300901 and 300903 produced from plant mixed bulk samples in the field.

Two portable gyratory compactors were delivered to the Great Falls District lab to mold the compacted specimens from the bulk mixtures for the testing in tables 15 and 16. Unfortunately, they did not arrive on the day of sampling so all bulk samples had to be reheated to achieve compaction temperature the day after sampling.

Figure 9 shows the core locations and time schedule for core sampling section 300902. Figure 10 shows the core locations and time schedule for core sampling on section 300901 and 300903. All cores are 6 in. (150mm) in diameter. Table 17 shows the testing to be done on core samples taken from 399092 at time interval A. Thirty four cores are sampled at that time. Table 18 shows the testing to be performed on cores from section 300901 and 300903 at all time intervals and the testıng to be done on section 300902 for time intervals B-F.

At this writing, cores from interval A-E have been sampled, but no testing has been performed.

Table 13. Superpave aggregate and binder tests to be performed by participating highway agency on AC surface layer materials from all test sections.

Test Name	Test Designation	Protocol	No. of Tests per Section	Material Source
Aggregate Tests				
Aggregate Gradation	AG04	LTPP P14	1	BU10A01 BU10A01 BU10A03
Specific Gravity of Coarse Agg	AG01	LTPP P11	1	
Specific Gravity of Fine Agg.	AG02	LTPP P12	1	
Specific Gravity of -200 Material		AASHTO T100	1	
Coarse Aggregate Angularity		PennDOT TM 621	1	
Fine Aggregate Angularity		ASTM C1252	1	
Toughess		AASHTO T96	1	
Soundness		AASHTO T104	1	
Deleterious Materials		AASHTO T112	1	
Clay Content		AASHTO T176	1	
Thin, Elongated Particles		ASTM D4791	1	
Asphalt Cement				
Penetration @ 5°C		AASHTO T49	1[e]	BC01A01 BC01A02 BC01A03
Penetration @ 25° & 46°C	AE02	LTPP P22	1[e]	
Viscosity @ 60° & 135°C	AE05	LTPP P25	2	
Specific Gravity @ 16°C	AE03	LTPP P23	2	
Dynamic Shear @ 3 temperatures		AASHTO TP5	2	
Brookfield Viscosity @135° & 165°C		ASTM D4402	1	
Rolling Thin Film Oven Test (RTFOT)		AASHTO T240	B	
Dynamic Shear on RTFOT residue @ 3 temperatures[d]		AASHTO TP5	3	
Pressure Aging (PAV) of RTFOT res		AASHTO PP1	B	
Creep Stiffness of RTFOT-PAV residue @ 2 temps-24h conditioning[c d]		AASHTO TP1	2	
Creep Stiffness of RTFOT-PAV residue @ 2 temperatures[d]		AASHTO TP1	2	
Dynamic Shear on RTFOT-PAV residue @ 3 temperatures[d]		AASHTO TP5	2	
Direct Tension of RTFOT-PAV residue @ 2 temperatures[d]		AASHTO TP3	2	

[a]Only one set of aggregate tests required for each unique aggregate combination used on the project. If all sections use the same aggregate and gradation, then only one set of tests is needed for the project.
[b]Sufficient material should be conditioned for the required tests
[c]Conditioning time extended to 24 h $\pm$ 10 min at 10°C above the min performance temp
[d]See section 4 5.1 2 of the Specific Pavement Studies Material Sampling and Testing Requirements, experiment SPS-9A, for temperature selection guidelines.
[e]Three penetration values obtained from each test

Table 14. Superpave mix design tests to be performed by participating highway agency on AC surface layer materials from sections 300901 and 300903.

Test Name	Test Designation	Protocol	No. of Tests	Material Source
Mixed and Compacted AC				
Gyratory Compaction @ design asphalt content at N_{max}		AASHTO M-002	3	BC01A01,BC01A0, BU01A01-BU03A01,BU01A03,BU03A03
Gyratory Compaction @ 7% Air Voids		AASHTO M-002	6	BC01A01,BC01A03,BU04A01-BU09A01,BU04A03,BU09A03
Bulk Specific Gravity	AC02	LTPP P02	3	LA01A01-LA03A01,LA01A03-LA03A03
Maximum Specific Gravity	AC03	LTPP P03	1	NA01A01,NA01A03
Moisture Susceptibility	AC05	LTPP P05	6	LA01A01-LA09A01,LA04A03-LA09A03
Volumetric Calculations				
Volume Percent of Air Voids		AASHTO PP19	3	LA01A01-LA03A01,LA01A03-LA03A03
Percent Voids in Mineral Agg		AASHTO PP19		
Voids Filled with Asphalt		AASHTO PP19		

Notes 1 NA samples are laboratory mixed using BU10 aggregate samples from table 8

2. LA specimens are laboratory compacted, produced from BC and BU samples.

Table 15. Tests on compacted laboratory and field bulk samples of AC from test section 300902.

Name Test	Test Designation	Protocol	No of Tests	Material Source/Material Sample
HMA Specimen Compaction by Participating Highway Agency				
Gyratory Comp @ N_{max} (lab samples)		AASHTO M-002	6	NA01A02-NA06A02[a]
Gyratory Comp @ 3% Air Voids (lab samples)		AASHTO M-002	2	NA07A02,NA08A02[a]
Gyratory Comp. @ 7% Air Voids (lab samples)		AASHTO M-002	32	NA09A02-NA40A02[a]
Gyratory Comp @ 3% Air Voids (field samples)		AASHTO M-002	2	BA01A02, BA34A02[a]
Gyratory Comp @ N_{max} (field samples)		AASHTO M-002	6	BA02A02,BA04A02[a],BA31A02,BA33A02[a]
Gyratory Comp @ 7% Air Voids (field samples)		AASHTO M-002	26	BA05A02-BA30A02[a]
Mix and Compacted HMA Tests by Participating Agency				
Bulk Specific Gravity	AC02	LTPP P02	18	LA01A02,LA07A02,LA15A02,LA38A02,DA02A02, DA03A02,DA04A02,DA06A02,DA16A02,DA22A02, DA31A02,DA32A02,DA33A02
Asphalt Content (Extraction) (Uncompacted Material)	AC04	LTPP P04	6	BA01A02,BA06A02,BA11A02,BA16A02,BA22A02, BA34A02
Aggregate Gradation (Extracted Aggregate)	AG04	LTPP P14	2	BA06A02,BA22A02
Maximum Specific Gravity	AC03	LTPP P03	3	NA14A02,BA06A02,BA22A02
Moisture Susceptibility	AC05	LTPP P05	6	LA09A02-LA14A02
Volumetric Calculations by Participating Highway Agency				
Air Voids, VMA, VFA		AASHTO PP19	6[d]	LA01A02-LA06A02
LTPP Performance Tests by Braun Intertec				
Indirect Tensile Strength	AC07	LTPP P07	2[c]	LA15A02,DA09A02
Resilient Modulus	AC07	LTPP P07	2[b,c]	LA16A02,LA17A02,LA18A02,DA05A02,DA17A02, DA29A02
Creep Compliance	AC06	LTPP P06	8[c]	LA19A02,LA20A02,LA21A02,LA22A02,DA15A02, DA16A02,DA18A02,DA30A02

Table 15. Tests on compacted laboratory and field bulk samples of AC from test section 300902 (cont'd)

Name Test	Test Designation	Protocol	No of Tests	Material Source/Material Sample
Superpave Shear Tester Performance Tests by Superpave Regional Test Center (Store @ MRL)				
Frequency Sweep at Constant Height & Simple Shear at Constant Height	SST-1	AASHTO M-003, P-005	6,2[e]	LA23A02,LA24A02,LA25A02,LA26A02,DA06A02, DA10A02,DA24A02,DA28A02
Volumetric Test & Uniaxial Strain	SST-2	AASHTO M-003, P-005	6,2[e]	LA27A02,LA28A02,LA29A02,LA30A02,DA07A02, DA11A02,DA23A02,DA27A02
Repeated Shear at Constant Stress Ratio	SST-3	AASHTO M-003, P-005	4	LA07A02,LA08A02,DA01A02,DA34A02
Superpave Indirect Tensile Tests by Superpave Regional Test Center (Store @ MRL)				
Indirect Tensile Creep Compliance & Indirect Tensile Strength	SP-IT	AASHTO M-005	18,2[e]	LA31A02,LA32A02,LA33A02,LA34A02,LA35A02, LA36A02,LA37A02,LA38A02,LA39A02,LA40A02, DA08A02,DA12A02,DA13A02,DA14A02,DA19A02, DA20A02,DA21A02,DA22A02,DA25A02,DA26A02

[a]For the purposes of this table, a single specimen is compacted from each bulk sample. Test specimen DA01A02 is produced from BA01A02 and LA01A02 is produced from NA01A02, etc Up to three specimens can be produced from the sample, depending on its size

[b]Three specimens are needed for one test

[c]Test specimen of 4 inch diameter will be cored from compacted 6 inch specimens produced by the gyratory compactor

[d]The corrected bulk density at N_{design} shall be estimated from the gyratory compaction curves for calculation of the volumetric properties

[e]Spare specimens (one laboratory and one field compacted sample)

Table 16 Quality control related tests on compacted specimens from test sections 300901, 300903, and 300902.

Name Test	Test Designation	Protocol	No of Tests	Material Source/Material Sample
HMA Specimen Compaction				
Gyratory Comp @ N_{max}		AASHTO M-002	6	BA01A01-BA06A06[a],BA01A03-BA06A03
Volumetric Tests				
Bulk Specific Gravity	AC02	LTPP P02	6	DA01A01-DA06A01,DA01A03-DA06A03
Asphalt Content (Extraction)	AC04	LTPP P04	2	BA02A01,BA04A01,BA02A03,BA04A03
Aggregate Gradation (Extracted Aggregate)	AG04	LTPP P14	2	BA02A01,BA04A01,BA02A03,BA04A03
Maximum Specific Gravity	AC03	LTPP P03	2	BA02A01,BA04A01,BA02A03,BA04A03
Volumetric Calculations by Participating Highway Agency				
Volume Percent of Air Voids		AASHTO PP19	6	BA01A01-BA06A01,BA01A03-BA06A03
Percent Voids in Mineral Aggregate		AASHTO PP19	6	BA01A01-BA06A01,BA01A03-BA06A03
Voids Filled with Asphalt		AASHTO PP19	6	BA01A01-BA06A01,BA01A03-BA06A03

[a]Test specimen DA01A01 is produced from sample BA01A01, etc

[b]Estimate the corrected bulk specific gravity from the gyratory compaction curves at N_{design} and use this value for volumetric computations

Table 17. Tests on core samples from test section 300902 at interval A.

Test Name	Test Designat	Protocol	No Tests	Material Source
Volumetric Tests by Participating Highway Agency				
Core Examination and Thickness	AC01	LTPP P01	8	CA02tXX,CA06tXX CA11tXX,CA15tXX CA19tXX,CA24tXX CA28tXX,CA33tXX
Bulk Specific Gravity	AC02	LTPP P02	8	CA02tXX,CA06tXX CA11tXX,CA15tXX CA19tXX,CA24tXX CA28tXX,CA33tXX
Asphalt Content (Extraction)	AC04	LTPP P04	8	CA02tXX,CA06tXX CA11tXX,CA15tXX CA19tXX,CA24tXX CA28tXX,CA33tXX
Aggregate Gradation (Extracted)	AG04	LTPP P14	2	CA11tXX,CA24tXX
Maximum Specific Gravity	AC03	LTPP P03	2	CA11tXX,CA24tXX
Volumetric Calculations by Participating Highway Agency				
Volume Percent of Air Voids		AASHTO PP19	2	CA11tXX,CA24tXX
Percent Voids in Mineral Aggregate		AASHTO PP19		
Voids Filled with Asphalt		AASHTO PP19		
Recovered Asphalt Cement Tests by Participating Highway Agency				
Abson Recovery	AE01	LTPP P21	8	CA02tXX,CA06tXX CA11tXX,CA15tXX CA19tXX,CA24tXX CA33tXX
Penetration @ 5°C		AASHTO T49	1[c]	
Penetration @ 25°C & 46°C	AE02	LTPP P22	1[c]	
Viscosity @ 60° & 135°C	AE05	LTPP P25	2	
Specific Gravity @ 16°C	AE03	LTPP P23	2	
Dynamic Shear @ 3 temperatures		AASHTO TP5	2	
Creep Stiffness @ 2 temperatures		AASHTO TP1	2	
Direct Tension @ 2 temperatures		AASHTO TP3	2	
Replacement Cores to replace damaged cores				CA05tXX,CA25tXX
LTPP Performance Tests by LTPP Contract Laboratory				
Creep Compliance	AC06	LTPP P06	4[b]	CA03tXX,CA14tXX CA23tXX,CA32tXX
Indirect Tensile Strength	AC07	LTPP P07	1[b]	CA16tXX
Resilient Modulus	AC07	LTPP P07	1[a,b]	CA07tXX,CA21tXX CA31tXX
Superpave Shear Tester Performance Tests by Superpave Regional Test Center				
Frequency Sweep at Constant Height & Simple Shear at Constant Height	SST-1	AASHTO M003,P005 AASHTO M003,P005	2	CA04tXX,CA30txx
Volumetric Test & Uniaxial Strain	SST-2	AASHTO M003,P005 AASHTO M003,P005	2	CA12tXX,CA22tXX
Superpave Indirect Tensile Tests by Superpave Regional Test Center				
Indirect Tensile Creep Compliance & Indirect Tensile Strength	SP-IT	AASHTO M05 AASHTO M005	10	CA01tXX,CA08tXX CA10tXX,CA13tXX CA17tXX,CA18tXX CA20tXX,CA27tXX CA29tXX,CA34tXX

[a]Three specimens are needed for one test
[b]Specimens of 100mm diameter will be cored from 150mm field cores.
[c]Three penetration readings must be taken from each test can
[d]See section 4 5 1 2 of the Specific Pavement Studies Material Sampling and Testing Requirements, experiment

Table 18. Laboratory tests on cores from test sections 300901 and 300903 at all intervals and section 300902 at intervals B-F.

Name Test	Test Designation	Protocol	No of Tests	Material Source/Material Sample[b]
Core Examination/Thickness	AC01	LTPP P01	8	All Cores
Volumetric Analysis				
Bulk Specific Gravity	AC02	LTPP P02	8	All Cores
Asphalt Content (Extraction)	AC04	LTPP P04	8	All Cores
Aggregate Gradation (Extracted Aggregate)	AG04	LTPP P14	2	CA01tXX,CA08tXX
Volumetric Calculations[a]				
Volume Percent of Air Voids		AASHTO PP19	2	CA01tXX,CA08tXX
Percent Voids in Mineral Aggregate		AASHTO PP19	2	CA01tXX,CA08tXX
Voids Filled with Asphalt		AASHTO PP19	2	CA01tXX,CA08tXX
Recovered Asphalt Cement				
Abson Recovery	AE01	LTPP P21	8	
Penetration @ 5°C		AASHTO T49	1[d]	
Penetration @25° & 46°C	AE02	LTPP P22	1[d]	
Viscosity @ 60° & 135°C	AE05	LTPP P25	2	
Specific Gravity @ 16°C	AE03	LTPP P23	2	CA01tXX,CA08tXX
Dynamic Shear @ 3 temperatures[c]		AASHTO TP5	2	
Creep Stiffness @ 2 temperatures[c]		AASHTO TP1	2	
Direct Tension @ 2 temperatures[c]		AASHTO TP3	2	

[a]Estimate the maximum theoretical specific gravity using the extracted AC content and aggregate effective specific gravity determined during construction

[b]The cores shown in this table are for each test section to be tested at each designated testing time interval t, where t represents the sampling time interval after construction, as follows

t=A at time 0 immediately following construction
t=B at 6 months after construction
t=C at 12 months after construction
t=D at 18 months after construction
t=E at 24 months after construction
t=F at 48 months after construction

For example, core CA01E03 is obtained and tested 24 months after construction from section 03.

[c]The test temperatures should be the same as those used for the tests on the RTFOT-PAV conditioned samples performed during the initial binder grading

[d]Three penetration readings required from a single container

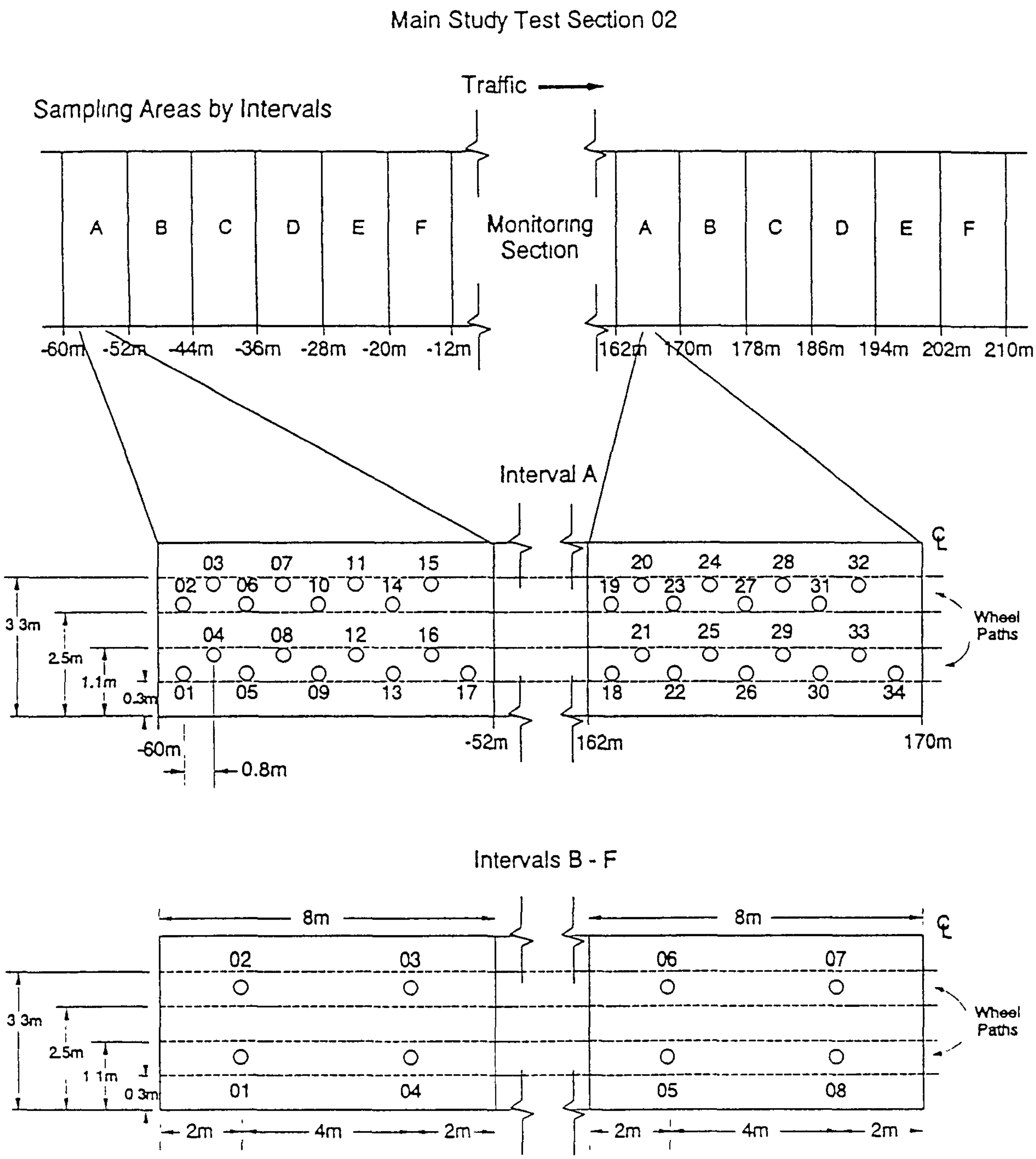


Figure 9 Core locations for main study test section 300902, Superpave standard design mixture at interval A.

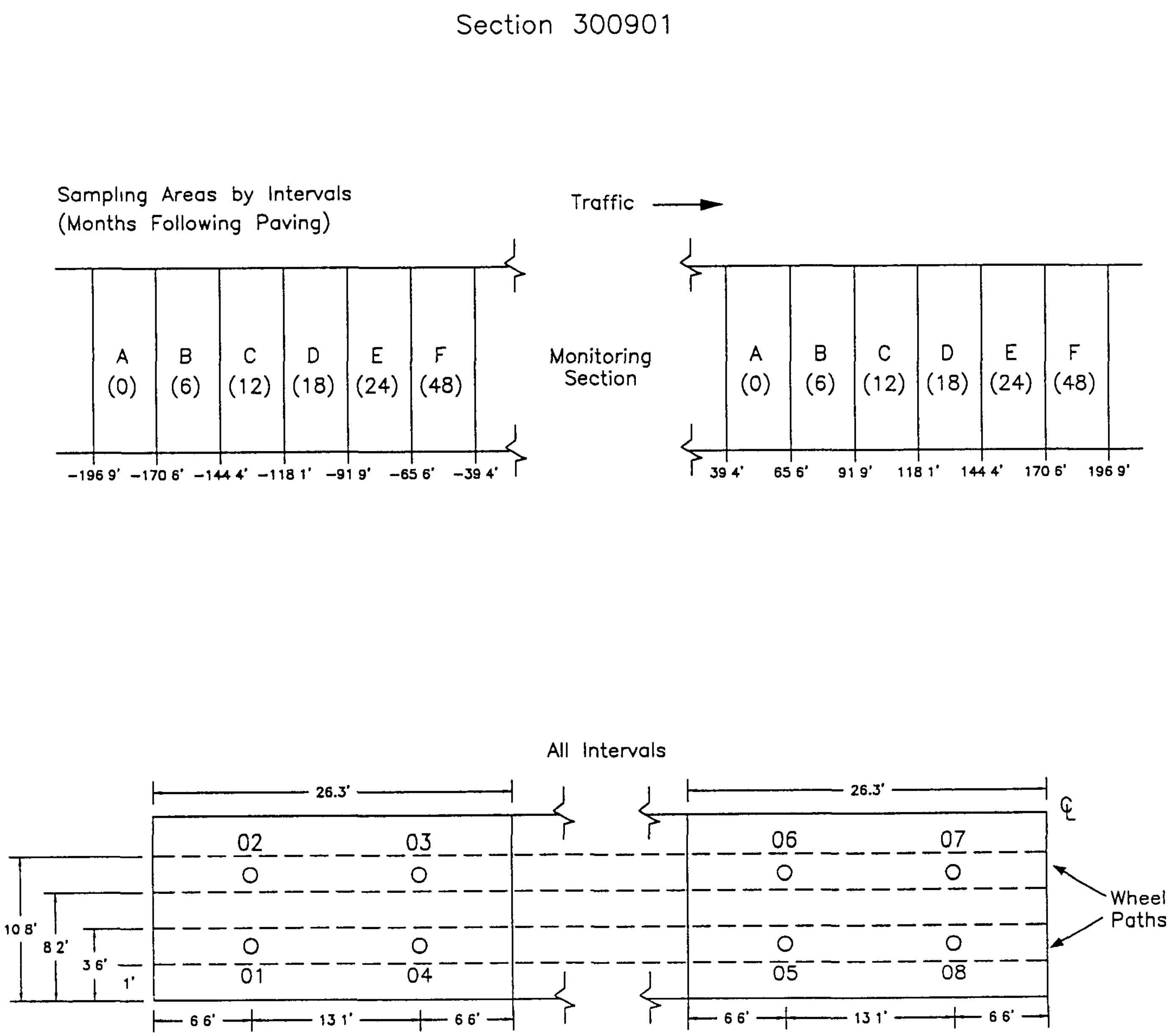


Figure 10. Core locations for test section 300901, Montana SPS-9A.

FWD TESTING OF AC SURFACE

Falling Weight Deflectometer (FWD) testing on the finished AC surface was carried out on November 13, 1998, in accordance with the procedures given in the LTPP FWD Operator's Manual. The deflection profiles are presented in appendix D. The deflection profiles shown are normalized to a 20kN (9000 lb) load. The profiles indicate a very uniform and structurally sound pavement section.

ELEVATION MEASUREMENTS

Elevation measurements of the finished AC surface were recorded to determine as-built thickness at locations indicated in figure 7. These indicated close conformity with the design thickness. The fact that most of the sections are uniformly shy of the design thickness may be due to the lateral spreading and movement under the rollers discussed above.

IV. SUMMARY

Under the LTPP program, three SPS-9A test sections were built on northbound I-15, about 10 miles south of Great Falls, Montana, per the SHRP SPS-9A guidelines. The construction of these SPS-9A sections began in July 1998 and was completed in October 1998. The sections were constructed as part of a milling project on existing embankment. Section 300902, the standard Superpave section, had a PG 66-34 grade binder, section 300903, the alternate Superpave section, had a PG 66-22 grade binder, and section 300901, the standard state agency HMAC section, was constructed using a polymer-modified asphalt. The plans indicated an intermediate layer 5.4 in (132mm) thick of a Pulveried Stabilized Plant Mix (PSPM). However, the PSPM was replaced with 0.1 ft (30mm) thick Crushed Top Surface (CTS). Compaction of the Superpave sections did pose some problems, indicating asphalt and temperature sensitivity of the mix. Key observations that may affect the performance of these test sections are enumerated in section V.

V. KEY OBSERVATIONS

This section of the report lists the key observations that might affect overall performance of the test sections. These are:

- The PSPM was not placed as planned. Instead, the PSPM was replaced with a CTS consisting of crushed 3/8 in (-9.5mm) minus material aggregate with a design in-place thickness of 0.1ft (30mm).

- Placement temperatures in the case of section 300902 were relatively high, about 331 °F (166 °C), but did not pose any problems during compaction. However, the density tests revealed in-place air voids in the range of 3 to 4 percent. The contractor then reduced the asphalt content by 0.1 percent. Reduction in asphalt content resulted in an air void increase of 2 to 3 percent, indicating the asphalt-sensitivity of the mix.

- Compaction of both Superpave sections (300902 and 300903) was not achieved to the specifications. The specifications called for an in-place density of 94 percent of Rice density. Field in-place nuclear density tests indicated an average of 90 percent Rice density.

- Roller marks could be seen on section 300902 for quite some time indicating tender and temperature sensitive mix.

- Both Superpave sections indicated some movement of the mat during rolling on the first lift, which could be due to the presence of CTS layer or due to a tender mix. Movement was not observed during the compaction of the second lift.

- Mix designs were developed using the agency's standard practices, but additional material was sampled in order to complete the required testing.

- Bulk samples from the field were reheated from room temperature to create the gyratory specimens from all sections.

APPENDIX A

CONSTRUCTION PHOTOS

APPENDIX A - MONTANA SPS-9A CONSTRUCTION PHOTOS

Appendix A consists of the following construction photos:

Photo 1. Finished embankment for SPS-9A sections. Approximately 1 in. of asphalt milling and surface remain from surface removal operation.
Photo 2. Red top showing thin layer of remaining surface material.
Photo 3. Sampling SPS-9A embankment materials.
Photo 4. Sampling SPS-9A embankment materials.
Photo 5. Sampling SPS-9A embankment materials.
Photo 6. Placing crushed top surface (CTS) leveling course.
Photo 7. Spreading crushed top surface (CTS) leveling course.
Photo 8. Priming crushed top surface (CTS) leveling course.
Photo 9. Primed crushed top surface (CTS) ready for paving.
Photo 10. Placing second lift of AC surfacing on SPS-9A section.

Photo 1. Finished embankment for SPS-9A sections.
Approximately 1 in. of asphalt milling and surface remain from surface removal operation.

Photo 2. Red top showing thin layer of remaining surface material.

Photo 5. Sampling SPS-9A embankment materials.

Photo 6. Placing crushed top surface (CTS) leveling course.

Photo 7. Spreading crushed top surface (CTS) leveling course.

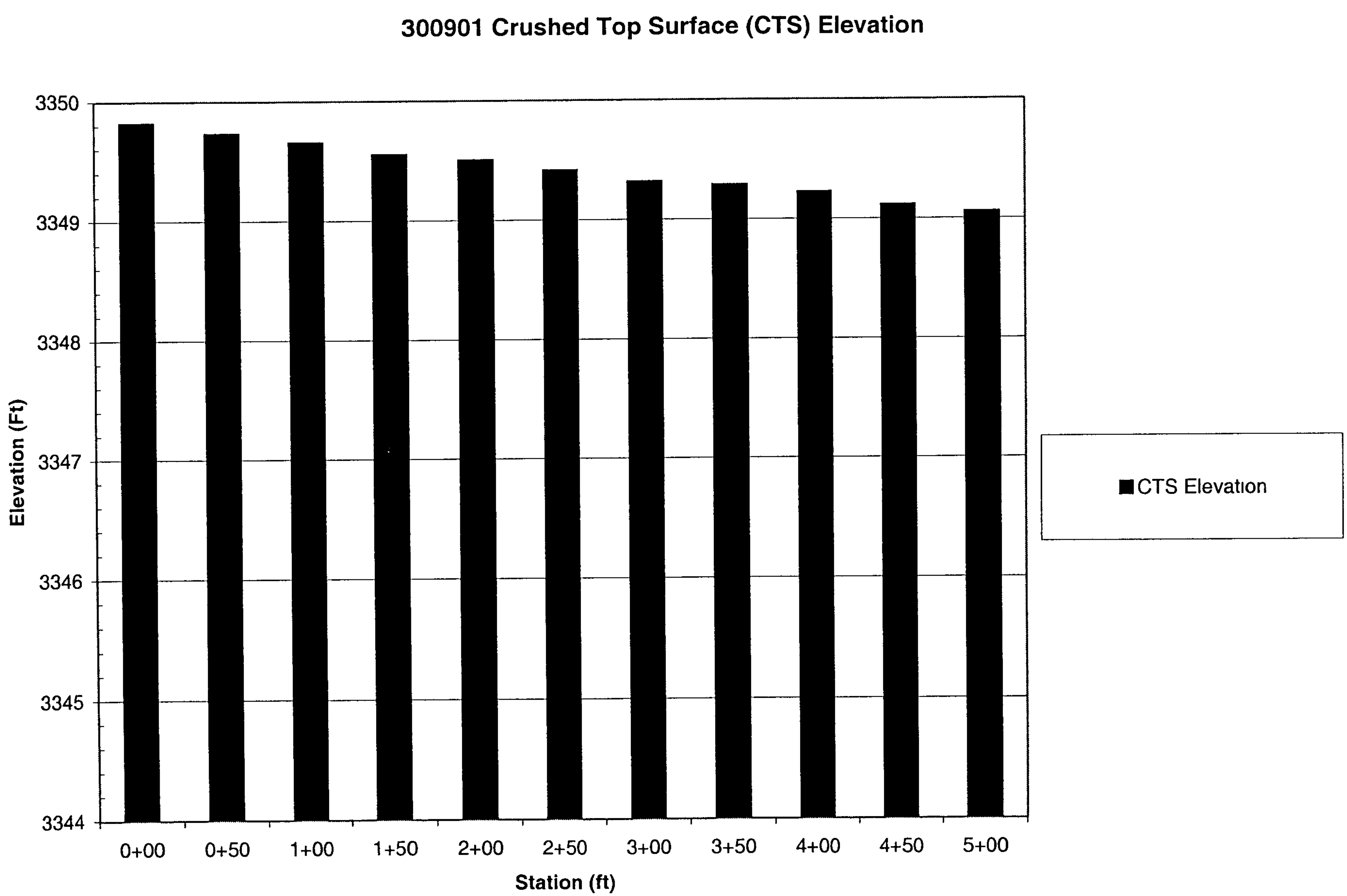
Photo 8. Priming crushed top surface (CTS) leveling course.

Photo 9. Primed crushed top surface (CTS) ready for paving.

Photo 10. Placing second lift of AC surfacing on SPS-9A section.

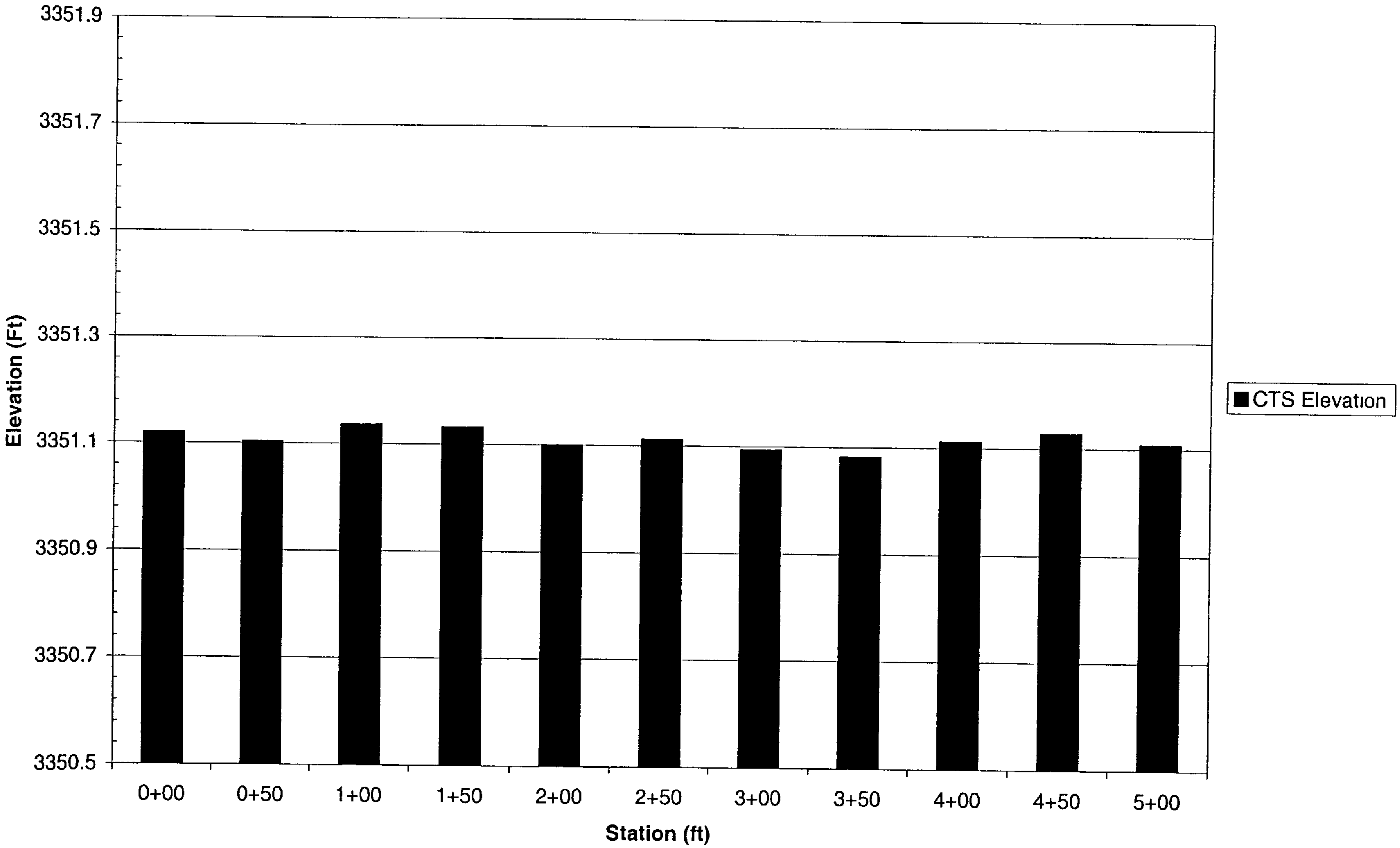
APPENDIX B

EMBANKMENT ELEVATION
AND
AC LAYER THICKNESSES

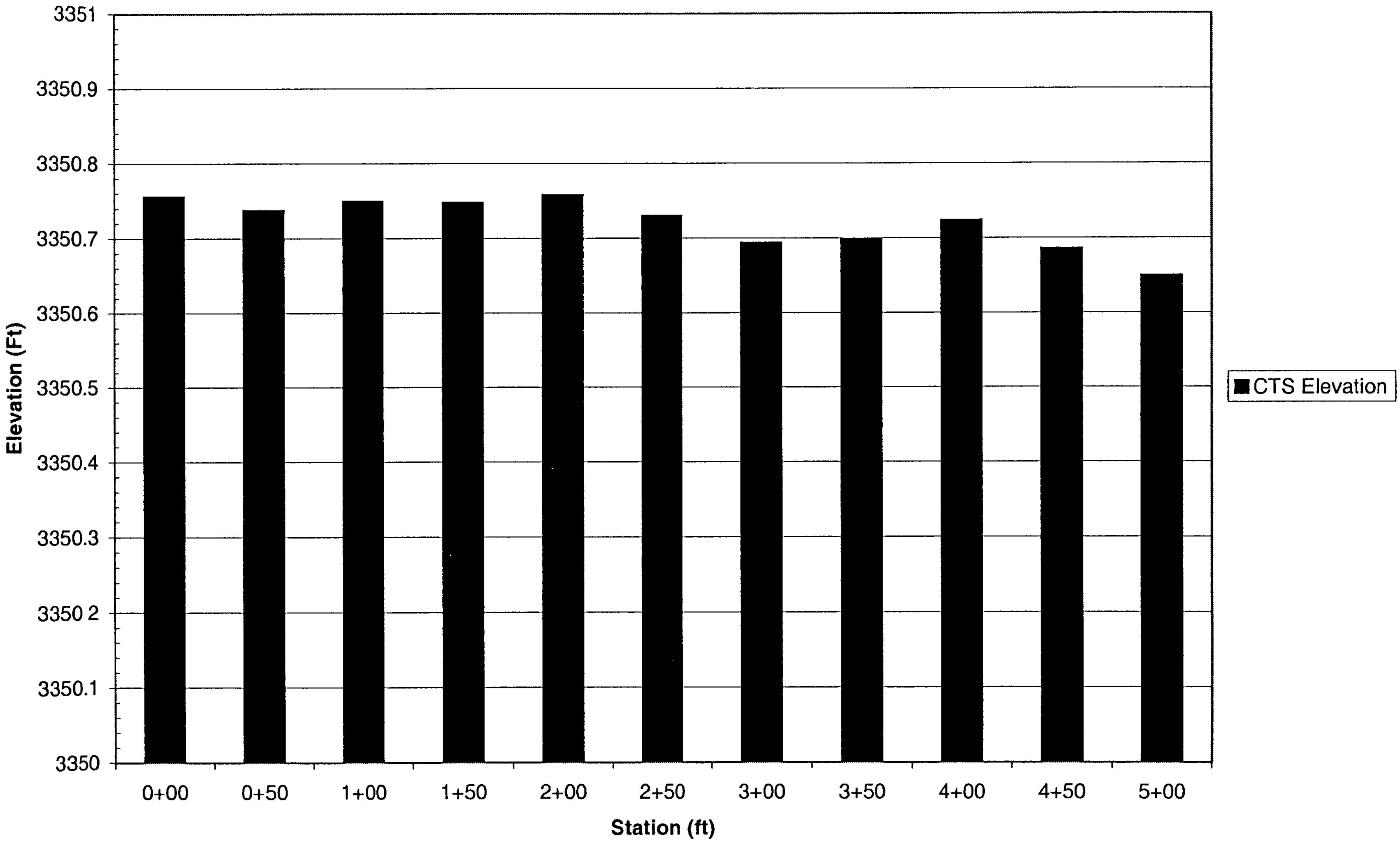


300901 Crushed Top Surface (CTS) Elevation
3350
3349
3348
3347
3346
3345
3344
Elevation (Ft)
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
Station (ft)
CTS Elevation

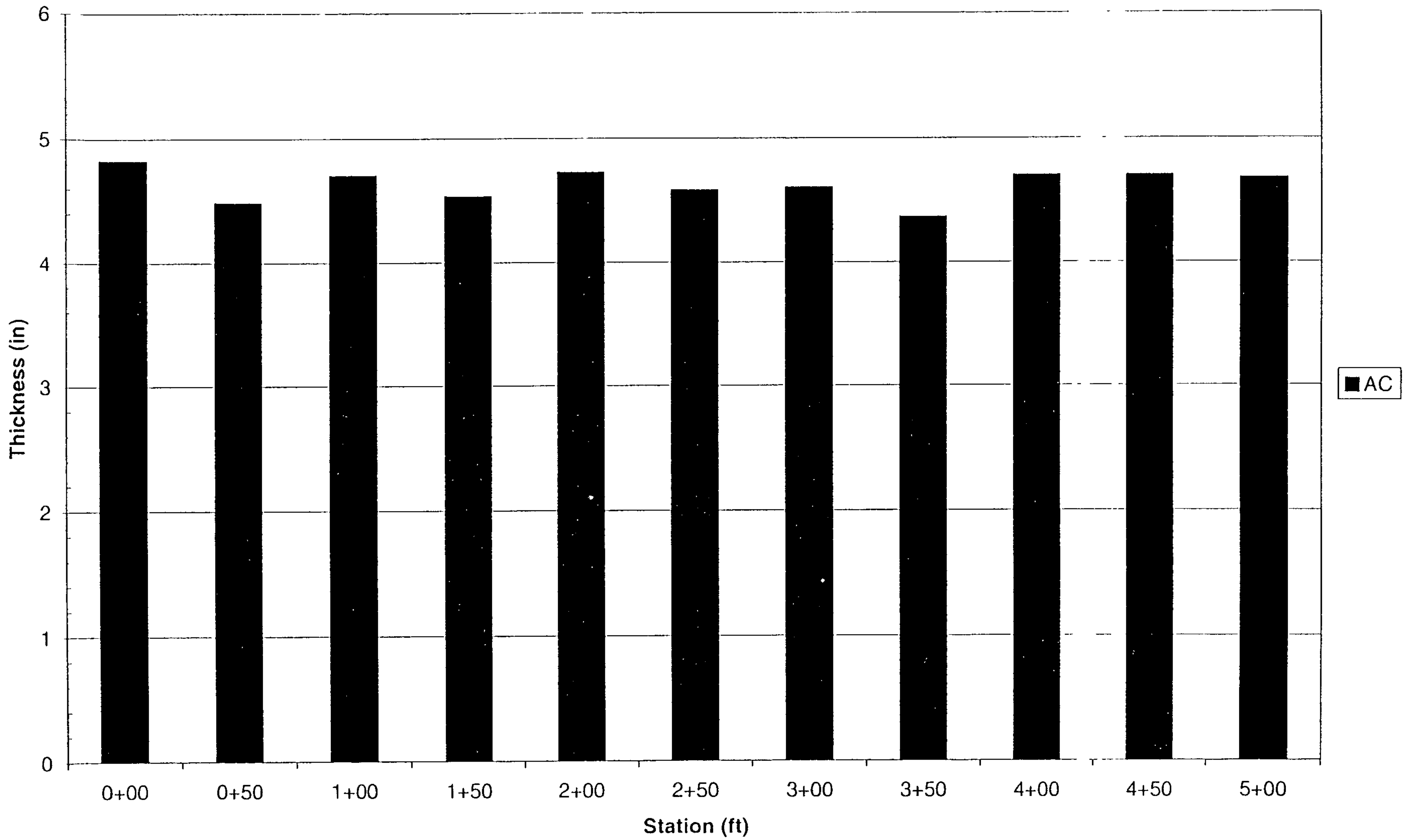
Sectioni 300902 Crushed Top Surface (CTS) Elevation

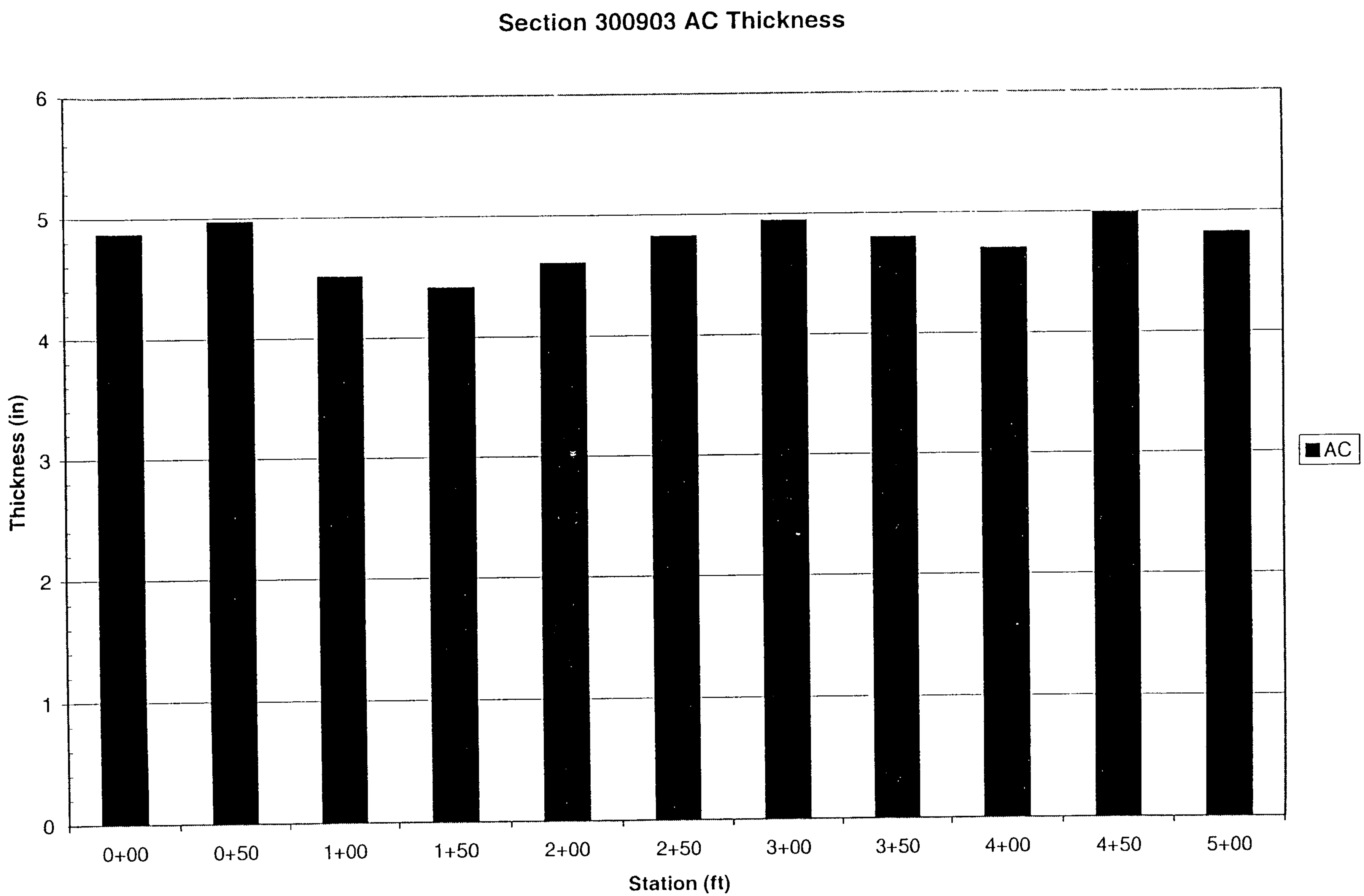


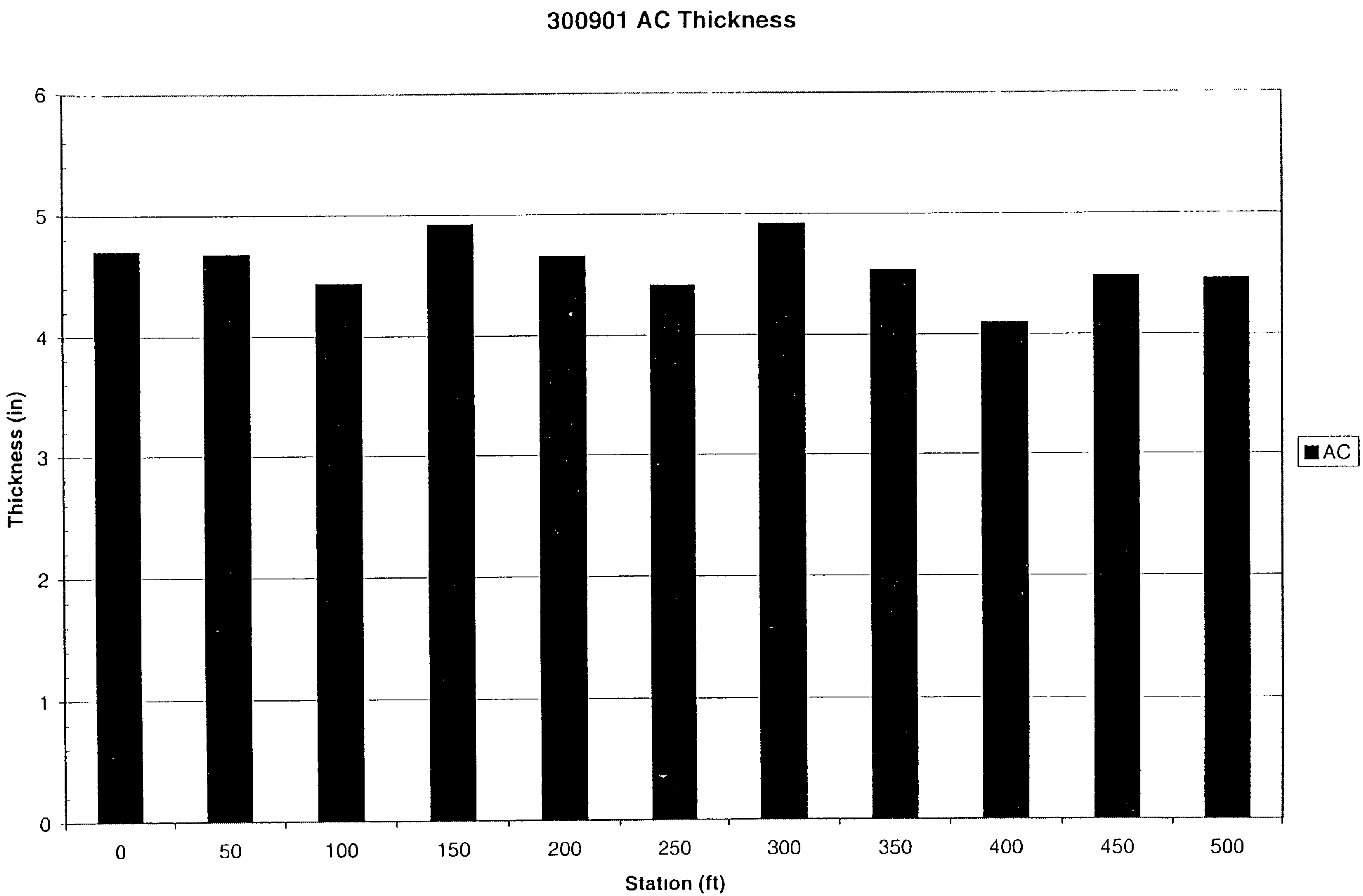
Section 300903 Crushed Top Surface (CTS) Elevation



Sectioni 300902 AC Thickness




Section 300903 AC Thickness
Thickness (in)
0
1
2
3
4
5
6
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
Station (ft)
AC


300901 AC Thickness
Thickness (in)
0
1
2
3
4
5
6
Station (ft)
0
50
100
150
200
250
300
350
400
450
500
AC

APPENDIX C

MIX DESIGN INFORMATION

13

MASTER FILE COPY

Montana Department of Transportation
Helena, MT 59620-1001

Memorandum

To: Eugene W. Stettler, P.E.
District Administrator-Great Falls

From: R. Scott Barnes, P.E.
Physical Testing Supervisor

Date: July 23, 1998

Project: IM15-5(93)256 SHRP Test Site #13

Termini: Hardy Creek - Ulm NB SHRP Test Site #13

Bit. Surf. Type: 19 mm PMS Grade S PG64-34 Superpave

Lab No.: 750499 02 Mix

Attached please find the results of tests performed on aggregate submitted from the Henen & Bogden source, Pit Lab No. 744809-16.

The separate stockpile aggregates were analyzed and a combined gradation was selected that would meet or exceed the aggregate criteria required for a Superpave mix. The gradation shown "As Tested" was identified as an acceptable aggregate combination. The as tested gradation is the product of combining 45% of the coarse stockpile, 20% of the intermediate stockpile, 35% of the fine stockpile.

The temperature used during mixing was 305°F. The manufacturer's recommended mixing range is between 290°F and 315°F.

Gyratory compaction was performed at 285°F. The manufacturer's recommended compaction range is between 225°F and 300°F. Manufacturer's recommendations for field mixing and compacting temperatures are attached.

The following Rice Gravities are taken from a best fit curve of the actual Rice Gravities used in the mix design. They may be used at the start of production to determine the percent voids of the field gyratory test specimens.

% Asphalt	Max. Density
4.0	2.500
4.5	2.481
5.0	2.462
5.5	2.444
6.0	2.426

Field Rice Gravity testing should be started and continued throughout Bituminous Plant Mix production to determine any change in the voids.

Based on the laboratory data contained in this report, we recommend that production commence at 5.0% PG 64-34 Asphalt Cement from Montana Refining Company and 1.0% hydrated lime.

If you have any questions or recommendations regarding these results, please contact us.

RSB:tms:hardyu13

Attachments

5/28/98

3400 ADT 1994	STATE OF MONTANA
6100 ADT 2014	DEPARTMENT OF TRANSPORTATION
479 18K DAILY	Materials Bureau
N_{ini} 8 N_{des} 96 N_{max} 152	19mm PLANT MIX SURFACING, GRADE S

Lab. No. 750499 Sample No. 1 Project No. IM 15-5(93)256 [22
Termini HARDY CREEK-11LM (NB) SHRP TEST SITE #13
Date Sampled 2-19-98 Date Received 5-5-98
Sampled by G. CHRISTIANSEN Title MLT II Address GREAT FALLS, MT
Submitted by J. BLOSSOM Title DMS Address GREAT FALLS, MT
Area Source Represented by Lab. No. 744809-16 Sample taken at
Owner HENEN & BOGDEN Address CASCADE, MT

TEST RESULTS ON AGGREGATE

	% Passing As Tested
25mm	100
19	97
12.5	80
9.5	68
4.75	42
2.36	29
1.18	20
.600	15
.300	10
.150	7
.075	4.5

LL NP Fracture 1 face 92% Volume Swell
PL NP 2 face 85% NO ___ % ___
PI NP FAA 46 HL ___ % ___
SE 55 Flat/ CF A6 % FIRM
Wear 18 Elongated(5:1) 4% INT 2.4 % HARD

Absorption CS 1.319 Fine 1.488 Blend 1.390

Bulk Dry Sp. Gr. of Agg. Fine 2.637 CS 2.632

NOTE: VMA of this Mix Design 14.6 VFA 73.7

Dust/Effective Asphalt Ratio 1.0

GYRATORY TEST RESULTS

AC Sp. Gr. 1.0

%AC	G_{mm} Rice	Unit Wt. Kg/m^3 @N_{des}	%Air Voids @N_{des}	% VMA	% VFA	%G_{mm} @N_{INI}	%G_{mm} @N_{des}	%G_{mm} @N_{max}
4.0	2.504	2325	7.1	15.3	53.3	84.0	92.9	93.8
4.5	2.479	2350	5.2	14.8	65.0	85.8	94.8	96.1
5.0	2.463	2368	3.8	14.6	73.7	86.8	96.2	97.5
5.5	2.445	2382	2.6	14.6	82.2	87.9	97.4	98.7

Modified Lottman

Mineral Filler %	Mineral Filler Type	Percent Asphalt	Breaks (PSI) Dry	Breaks (PSI) Wet	Retained Strength	Adhesion
---	None	5.0	50.0	33.8	67.6 %	80 %
1.0	HydLime	5.0	46.0	35.4	77.0 %	90 %

	Admin. Maintenance Div.
2	District Admin./Eng. GREAT FALLS
1	District Const. Eng. "
1	Project Manager "
1	Dist. Mat. Supr. "
	Area Lab
1	Chief Const. Bureau
1	Chief Materials Bureau
2	Bit Mix Design Sect.
1	FHWA
1	Materials Bureau File
1	SHRP Sect

REMARKS:

Recommended: 5.0% PG64-34 A/C 1.0% HYDRATED LI[ME]

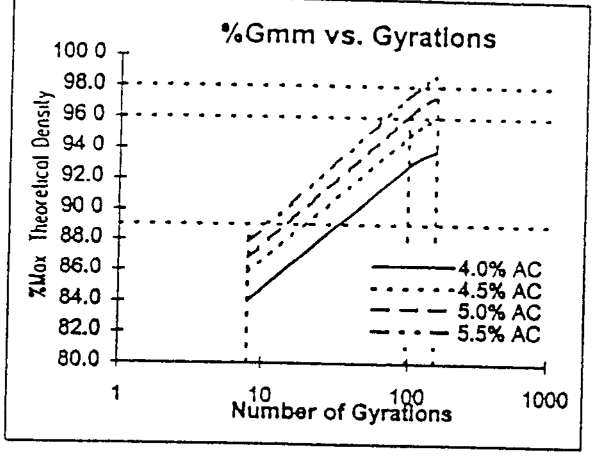
Asphalt Supplier MONTANA REFIN[ING] COMPAN[Y]

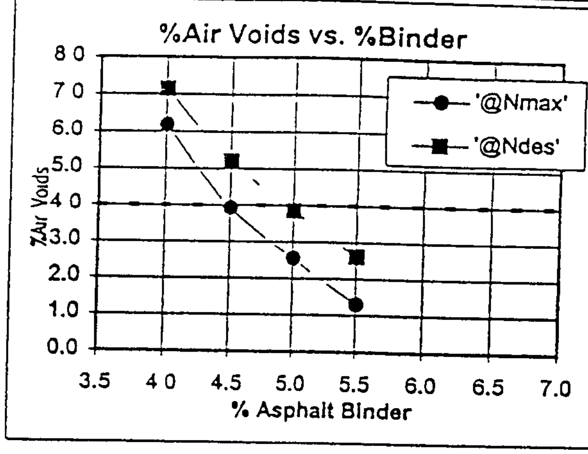
Discussed with R.D. THOLT
RSB

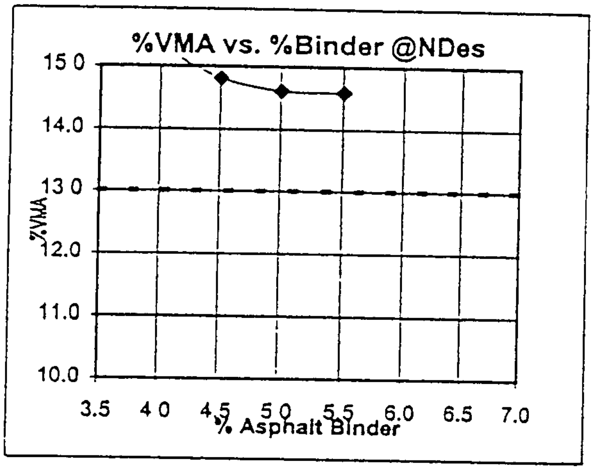
Date 8/12/98 Name TM SAUER
Checked

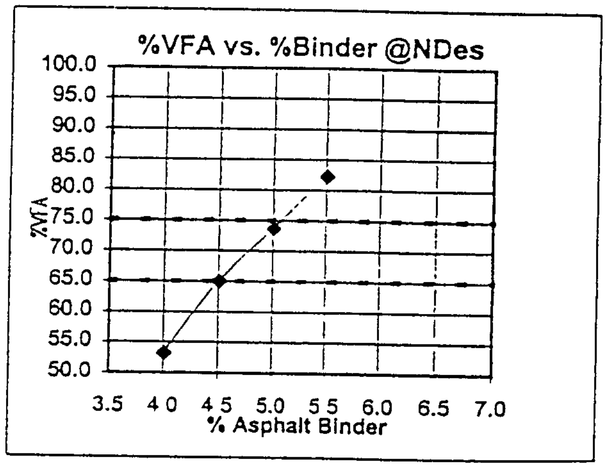
TMS grdS1

Project Name:	Hardy Cr.-Ulm(NB) SHRP Site #13 45	**N Initial:**	8
Workbook Name:	2MD13.XLS	**N Design:**	96
Technician:	T. Sauer	**N Max:**	152
Date:	6/29/98	**Nom. Sieve Size:**	19mm
Asphalt Grade:	PG 64-34	**Design Temperature:**	38°C
Compaction Temp:	150°C	**Design ESAL's (millions):**	4





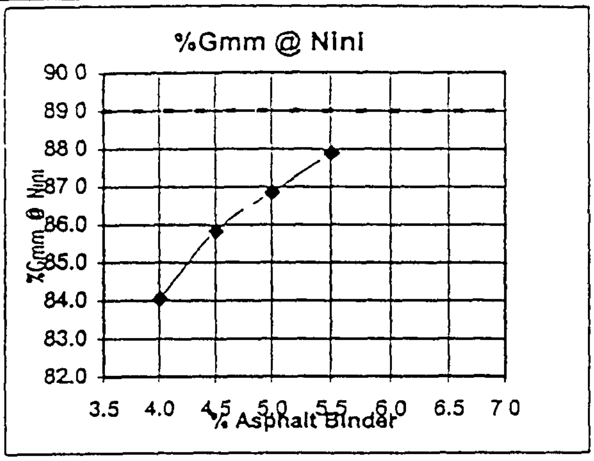


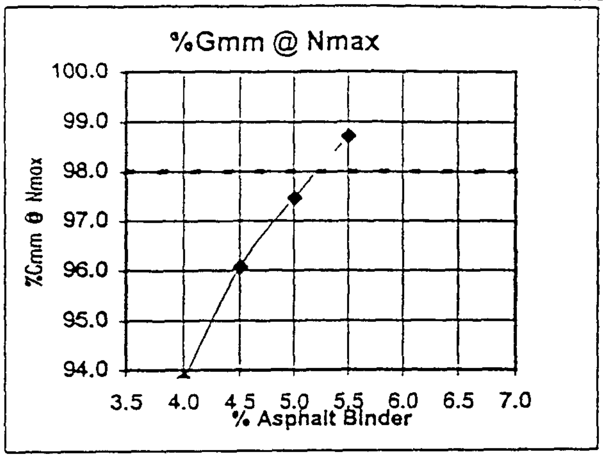


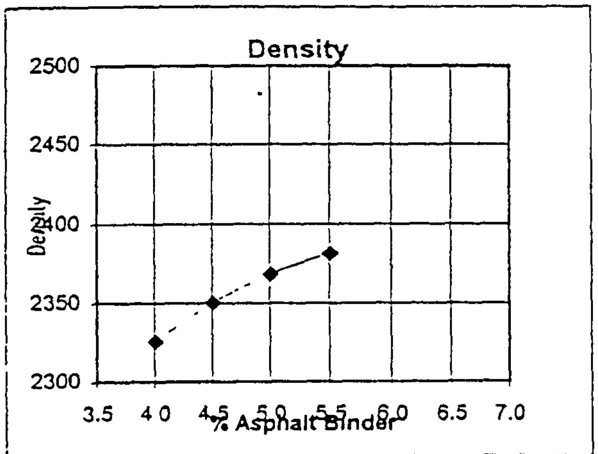
Blend	%AC	Air Voids @ NMax	Air Voids @ NDesign	%VMA NDesign	%VFA @ NDesign
4.0% AC	4.0	6.2	7.1	15.3	53.3
4.5% AC	4.5	3.9	5.2	14.8	65.0
5.0% AC	5.0	2.5	3.8	14.6	73.7
5.5% AC	5.5	1.3	2.6	14.6	82.2

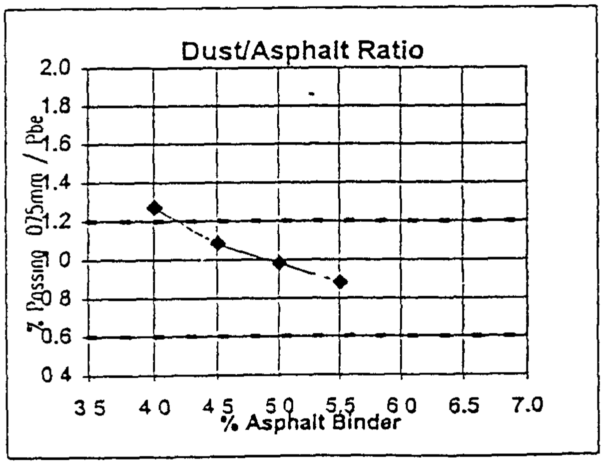
Varying %AC Report

Project Name:	Hardy Cr.-Ulm(NB) SHRP Site #13 45	**N Initial:**	8
Workbook Name:	2MD13 XLS	**N Design:**	96
Technician:	T. Sauer	**N Max:**	152
Date:	6/29/98		
Asphalt Grade:	PG 64-34	**Design Temperature:**	38°C
Compaction Temp:	150°C	**Design ESAL's (millions):**	4





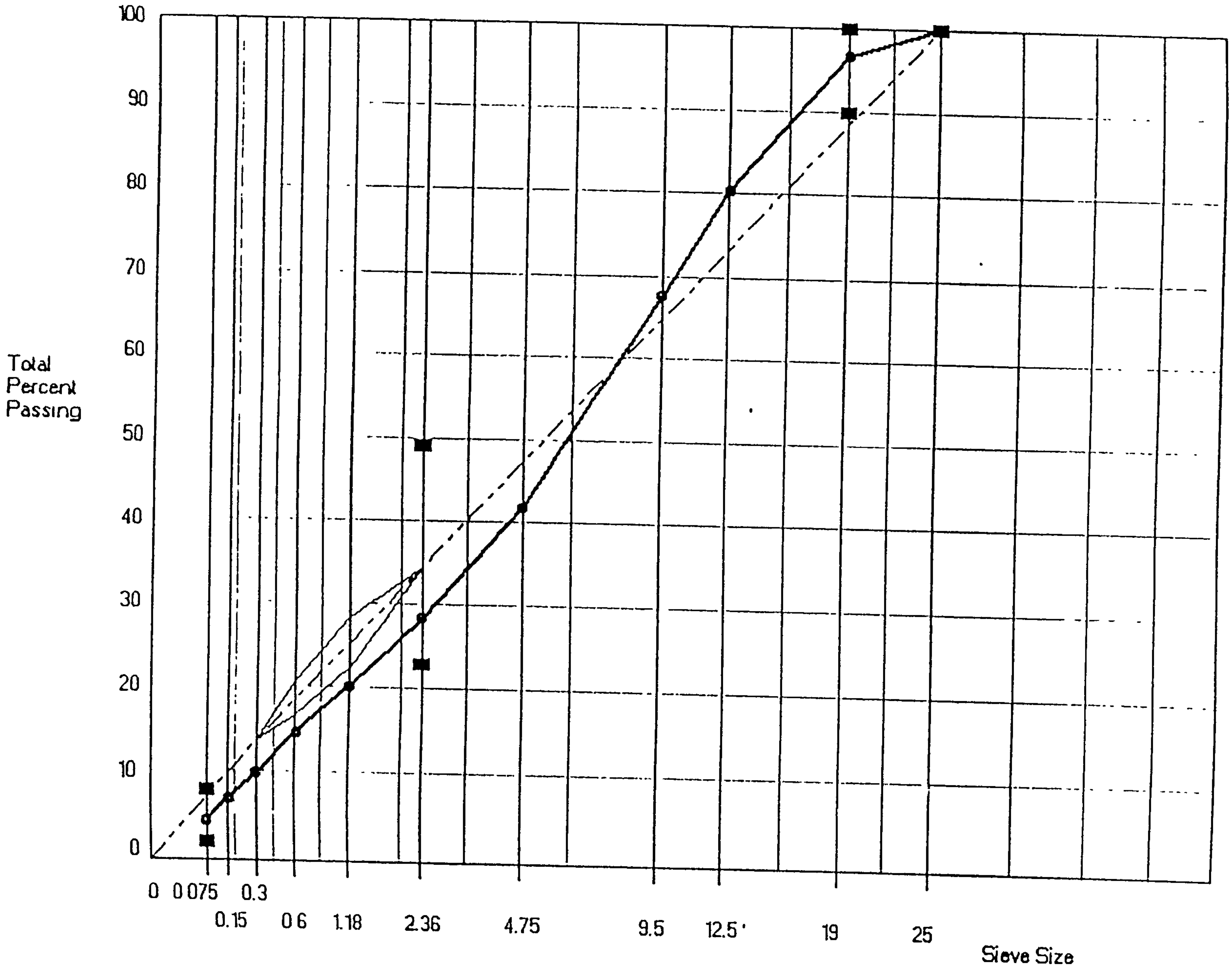




Blend	%AC	%Gmm @ NInitial	%Gmm @ NMax	Unit Wt. (kg/m³) NDesign	Dust/Asph Ratio
4.0% AC	4 0	84.0	93.8	2325	1.3
4.5% AC	4.5	85.8	96.1	2350	1.1
5.0% AC	5.0	86.8	97.5	2368	1.0
5.5% AC	5.5	87.9	98.7	2382	0.9

Lab No .75c499

Sieve Size Raised to 0.45 Power



When Polymer Modified Asphalt is in a contract, the MDT requires that this completed form and all of the attachments must be provided.

Project ______ ______

Termini ______

Prime Contractor ______

Send a five gallon sample of the proposed Polymer Modified Asphalt Cement (PMAC), accompanied by the following information, to the Materials Bureau for approval at least 30 days prior to use.

Company providing Polymer Modified Asphalt Cement Montana Refining Company

Identity of Base Asphalt Montana Refining Company

Identify of Polymer Modifier EVA

(1) Attached Materials Safety Data Sheets

(2) Attached temperature-viscosity chart and/or table for viscosity from 275 degrees F. to 340 degrees F. or to the maximum mixing temperature of the asphalt.

(3) Mix Design Information

a. Marshall Mixing temperature range no special range F ______ °F

b. Marshall Compaction temperature range no special range ______ °F

c. How to do reblending of the polymer asphalt and other special requirements when performing laboratory procedures such as mix designs with this Modified Asphalt.

(4) Field Temperatures Requirements

a. Plant Mix Discharge Temperatures

Maximum 315 degrees F.

Minimum 290 degrees F.

b. Roadway Compaction Temperatures

Maximum 300 degrees F.

Minimum 225 degrees F.

(5) What adjustments in placement or compaction techniques are needed.

(6) Describe any special laboratory or field handling procedures which should be followed.

Individual providing Information Alan L. Hobbs

Address Montana Refining Company 1900 10th Street N. E., Great Falls, MT 59404-1955

Phone No. 406-761-4100

Signature ______ Date Jan. 14 1996 (prime contractor)

Return the completed form to MDT's Project Manager for this contract.

BJB:Q:MT:176.cg

MASTER FILE COPY

Montana Department of Transportation
Helena, MT 59620-1001

Memorandum

To: Eugene W. Stettler, P.E.
District Administrator-Great Falls

From: R. Scott Barnes, P.E.
Physical Testing Supervisor R. Scott Barnes

Date: May 7, 1998

Project: IM 15-5(93)256

Termini: Hardy Creek - Ulm (NB)

Bit. Surf. Type: 3/4" PMS Grade D (1st Mix Design)

Lab No.: 749481

Agency Standard Mix

Attached please find the results of tests performed on aggregate submitted from the Bogden & Henen source, Pit Lab Nos. 744809-16.

The material was graded to the job mix target before testing. The gradation shown "As Tested" results by combining 5% of the chip stockpile, 41% of the crushed fine stockpile, and 54% of the coarse stockpile.

The temperature used during mixing was 305°F to conform to the manufacturer's recommendations. Field production within the range of 290°F to 315°F should provide similar bituminous mixture.

Laboratory Marshall compaction was performed at 285°F. The supplier recommends roadway compaction be performed between 225°F and 300°F. A temperature viscosity chart and manufacturer's recommended mixing and compaction temperatures are attached.

The following Rice Gravities should be used at the start of production only to determine the percent voids of the field Marshall test specimens. These values are as follows:

% Asphalt	Max. Density
5.0	2.474
5.5	2.454
6.0	2.434
6.5	2.414
7.0	2.394

Field Rice Gravities testing should be started and continued throughout Bituminous Plant Mix production to determine any change in the voids.

1. Based on this data, we recommend that production commence at 5.6% PG 70-28 Asphalt Cement from the MRC refinery.

2. 1.4% hydrated lime is required as a chemical additive to improve the Modified Lottman and the Marshall Stabilities. The attached data indicates this mixture is susceptible to moisture induced damage. Uniform dispersal of the hydrated lime throughout the entire mixture is essential to avoid structural damage by moisture intrusion.

3. No monitors are required.

If you have any questions regarding these results or recommendations, please contact us.

RSB:PE:G:MT:10.cg

Attachments

Lab. Form No. 606
(Rev. 12/15/97)

2639
MT-306/14

1994 ADT 3400
2014 ADT 6100
ESALS 479

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS
Materials Bureau

PLANT MIX SURFACING, GRADE ___

Lab No 749481 Sample No 1 Project No IM 15-5(93)256
Termini Hardy Ck.-Ulm(NB)
Date Sampled 2-19-98 Date Received APR 03 1998
Sampled by B.Stremcha Title MLT I Address Gt. falls Mt.
Submitted by L. Blossom Title DMS Address
Area Source Represented by Lab No 744809-16 Sample taken at
Owner Bogden & Henen Address Cascade,Mt

TEST RESULTS ON AGGREGATE

	% Passing As Tested
1-½"	
1"	
¾"	100
½"	83
⅜"	68
4M	44
10M	28
40M	14
200M	5.0

LL NP
PL NP
PI NP
SE 74
Wear 16

Fracture: 1 face 96, 2 face 91
Dust
Asphalt Ratio 0.89

Volume Swell
NO 24 % hard
HL 16 % hard
CF 26 % hard
___ % ___

Absorption CS 1.227 Fine 1.319 Blend 1.267

Bulk Dry Sp. Gr. of Agg. Fine 2.622 CS 2.652

NOTE: VMA of this Mix Design 15.1 VFA 80.1%

MARSHALL TESTS

%	Type	% Asphalt	Rice Gravity	Unit Weight Lbs./Ft.^{3}	% Voids	Lb. Stability	Flow	Appearance
	NONE	5.0	2.474	144.8	6.2	2031	9	NORMal
		5.5	2.454	146.8	4.1	2008	10	Slightly Rich
		6.0	2.434	147.3	3.0	1960	10	Slightly Rich
		6.5	2.414	148.2	1.6	1895	10	Rich
		7.0	2.394	147.3	1.4	1898	12	Very Rich
1.4	hydliME	5.0	2.474	146.9	4.9	2406	11	NORMal
		5.5	2.454	148.1	3.3	2119	10	Slightly Rich
		6.0	2.434	148.5	2.2	2096	11	Slightly Rich
		6.5	2.414	149.1	1.0	2002	11	Rich
		7.0	2.394	148.3	0.8	1872	12	Very Rich
1.4	hydliME	5.6	2.450	148.1	3.0	2100	11	interpolated

MODIFIED LOTTMAN

Mineral Filler %	Mineral Filler Type	Percent Asphalt	Breaks (PSI) Dry	Breaks (PSI) Wet	Retained Strength	Adhesion	
---	None	6.0	65.3	46.0	70.4%	80 %	PMAC
1.4	Hyd. Lime	5.7	83.4	51.3	61.5 %	95+ %	
—	NONE	6.0	93.1	44.3	47.6%	75 %	CONV
1.4	hyd lime	5.7	101.9	68.5	67.2	90	

Admin. Maintenance Div.
2 District Admin./Eng. Great Falls
1 District Const. Eng. Great Falls
1 Project Manager Great Falls
1 Dist. Mat. Supr. Great Falls
Area Lab
1 Chief Const. Bureau
1 Chief Materials Bureau
2 Bit. Mix Design Sect.
1 FHWA
1 Materials Bureau File
1 Empire Sand & Gravel

Date 5/7/98 Name B Bruce CETII
Checked

Recommended: 5.6 PG 70-28 A/C 1.4 hydrated lime
Refinery MRC

REMARKS

75 Blow Compaction

Discussed with Bob Passow BJB

CB30~A MONTANA DEPARTMENT OF TRANSPORTATION 1-94

CONTRACTOR'S PROPOSED JOB MIX AGGREGATE GRADATION

PROJECT NO IM 15-5(93)256 DESIGNATION Hardy Creek - Ulm (northbound)

CONTRACTOR Empire Sand & Gravel Inc. PREPARED BY Todd Talkington

PLANT MIX GRADE GR "D" DATE DESIGN NEEDED as soon as possible

PIT NAME Hanen/Bogden Pit PIT LAB NO'S. 744809-16

PIT DESCRIPTION NE¼ sec 34, SE¼ sec 27 SECTION SW¼ 26 TOWNSHIP 19 north RANGE 1 east

TYPE OF BLEND PG 70-28 SOURCE MT Refinery

ASPHALT GRADE SOURCE

ASPHALT MODIFIER TYPE Poly Mod.

MDL SPEC____	YES___	NO___
MEETS MDL____	YES___	NO___

CONTRACTOR - Enter the type, stockpile production gradation averages, and proposed blend ratio for each aggregate. Complete the combined gradation, the single proposed job mix target value, the specified target range, and tolerances for each specified sieve size.

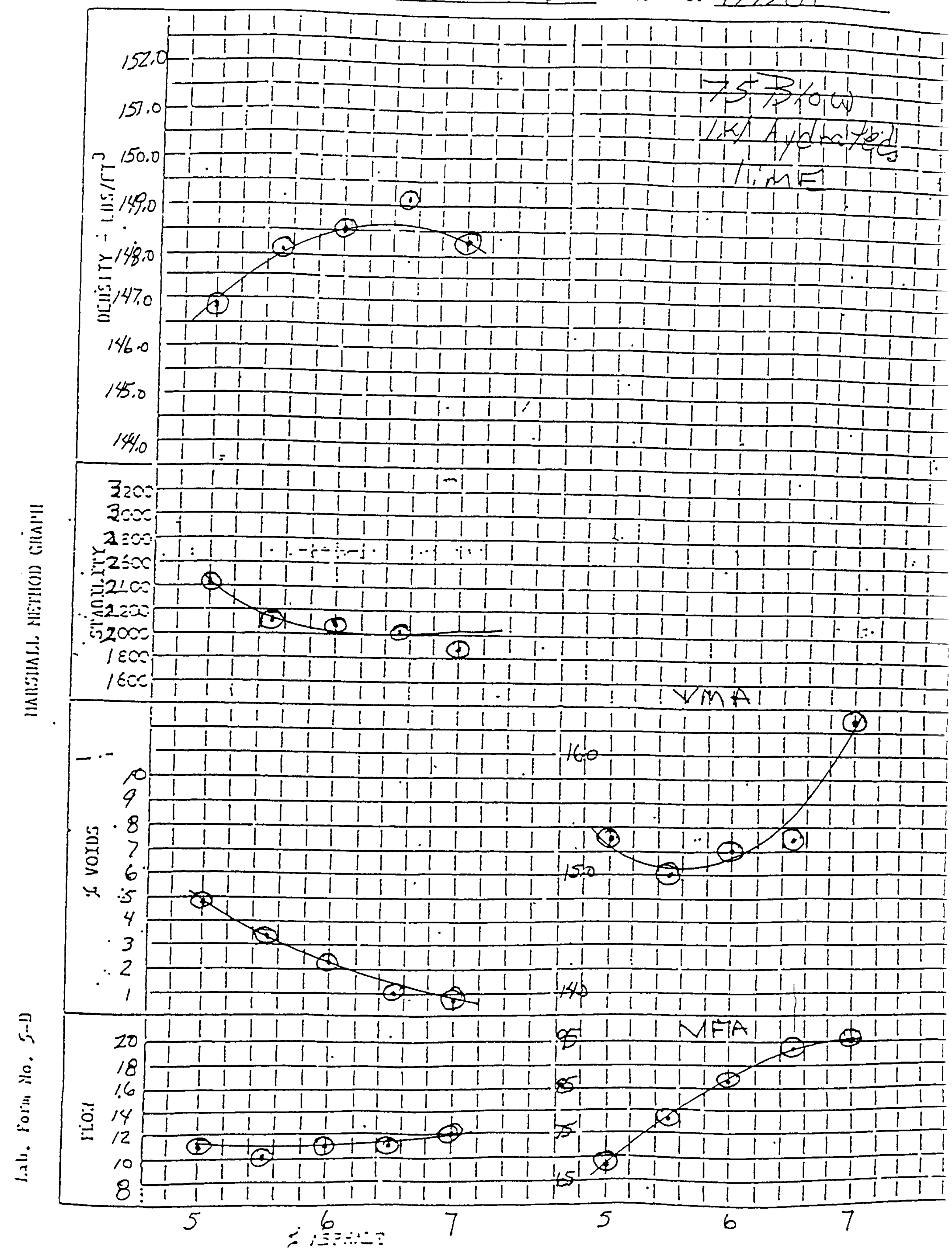
STOCKPILE BLENDING DATA										SPECIFICATIONS		
AGGR TYPE	3/4" Rock		3/8" Crushed Fines		3/8" Chips				COMB GRAD	JOB MIX TARGET	TOTAL +/-	SPECIFIED TARGET RANGE LO - HI
% USED	54 %		41 %		5 %							
Sieve Sizes	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total	Total % Pass	% of Total				
1 1/2"												-
1"												-
3/4"	100	54.0	100	41.0	100	5.0			100			-
5/8"	—	—	—	—	—	—						-
1/2"	71.6	38.7	100	41.0	100	5.0			84.7	83	7	76 - 90
3/8"	40.0	21.6	100	41.0	100	5.0			67.6	68	7	61 - 75
4 M	4.5	2.4	98.0	40.2	31.7	1.6			44.2	44	7	37 - 51
10 M	1.7	0.9	65.2	26.7	5.9	0.3			27.9	28	6	22 - 34
40 M	1.4	0.8	30.7	12.6	3.0	0.2			13.6	14	4	10 - 18
200 M	1.1	0.6	10.6	4.3	2.2	0.1			5.0	5	1.5	3.5 - 6.5

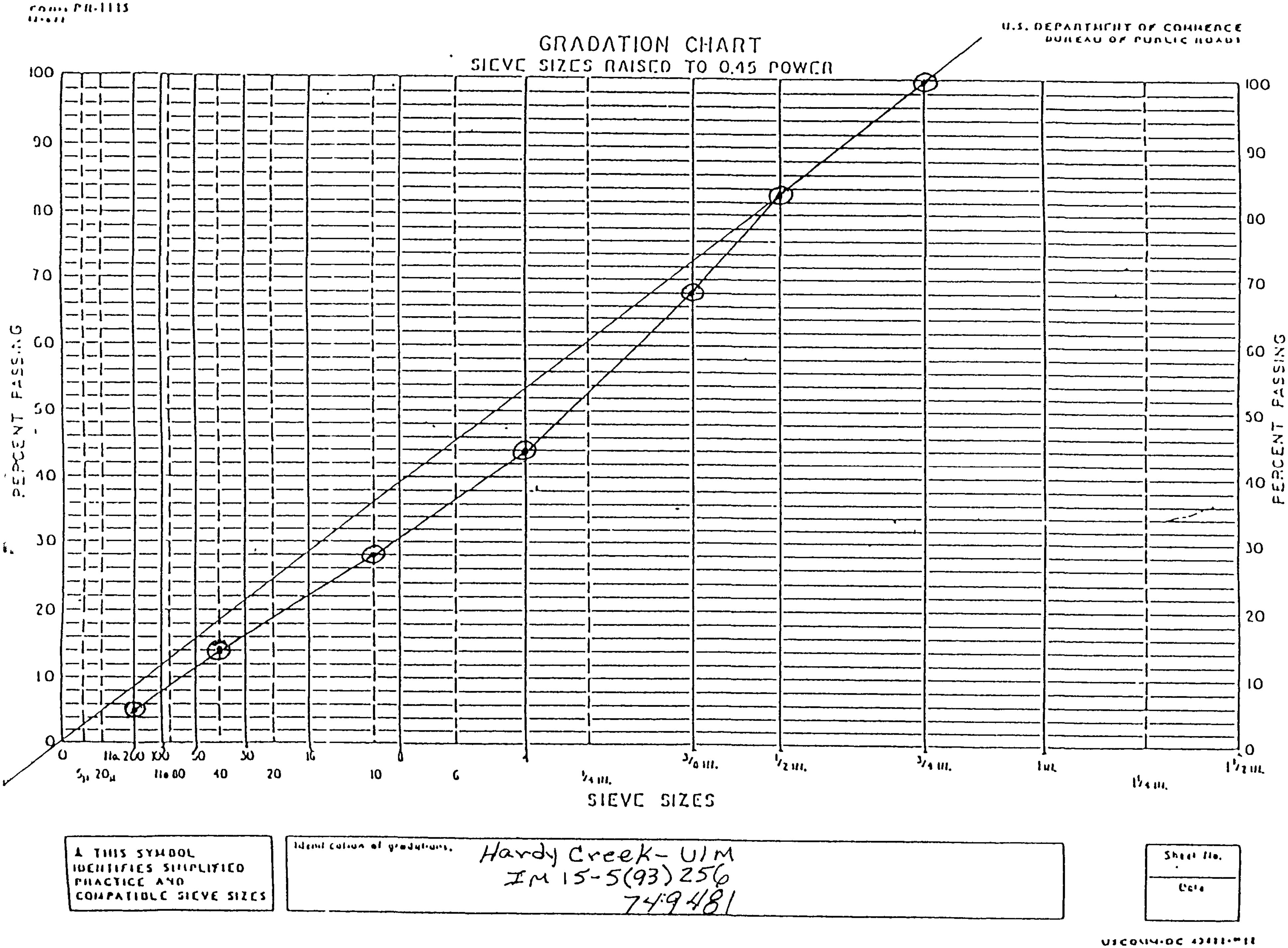
CONTRACTOR SIGNATURE: Todd Talkington Date: 2/3/98

Samples submitted for mix design. James Q Blossom Date 2-17-98

Project Manager or Lab Supervisor

PROJECT NO. IM-15-5(93)256 LAB. NO. 749481





Form PR-1115
U.S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS
GRADATION CHART
SIEVE SIZES RAISED TO 0.45 POWER
PERCENT PASSING
0
10
20
30
40
50
60
70
80
90
100
No. 200
100
50
30
16
8
4
3/8 in.
1/2 in.
3/4 in.
1 in.
1 1/2 in.
No. 80
40
20
10
6
1/4 in.
1 1/4 in.
SIEVE SIZES
THIS SYMBOL IDENTIFIES SIMPLIFIED PRACTICE AND COMPATIBLE SIEVE SIZES
Identification of gradations.
Hardy Creek - UIM
IM 15-5(93)256
749481
Sheet No.
Date

When Polymer Modified Asphalt is in a contract, the MDT requires that this completed form and all of the attachments must be provided

Project ______________________________

Termini ______________________________

Prime Contractor ______________________________

Send a five gallon sample of the proposed Polymer Modified Asphalt Cement (PMAC), accompanied by the following information, to the Materials Bureau for approval at least 30 days prior to use.

Company providing Polymer Modified Asphalt Cement: Montana Refining Company

Identity of Base Asphalt: Montana Refining Company

Identify of Polymer Modifier: EVA

(1) Attached Materials Safety Data Sheets

(2) Attached temperature-viscosity chart and/or table for viscosity from 275 degrees F to 340 degrees F. or to the maximum mixing temperature of the asphalt.

(3) Mix Design Information

a. Marshall Mixing temperature range no special range F ________ °F

b. Marshall Compaction temperature range no special range ________ °F

c. How to do reblending of the polymer asphalt and other special requirements when performing laboratory procedures such as mix designs with this Modified Asphalt.

(4) Field Temperatures Requirements

a. Plant Mix Discharge Temperatures		b. Roadway Compaction Temperatures	
Maximum	315 degrees F.	Maximum	300 degrees F.
Minimum	290 degrees F.	Minimum	225 degrees F.

(5) What adjustments in placement or compaction techniques are needed.

(6) Describe any special laboratory or field handling procedures which should be followed.

Individual providing information: Alan L. Hobbs

Address: Montana Refining Company 1900 10th Street N. E., Great Falls, MT 59404-1955

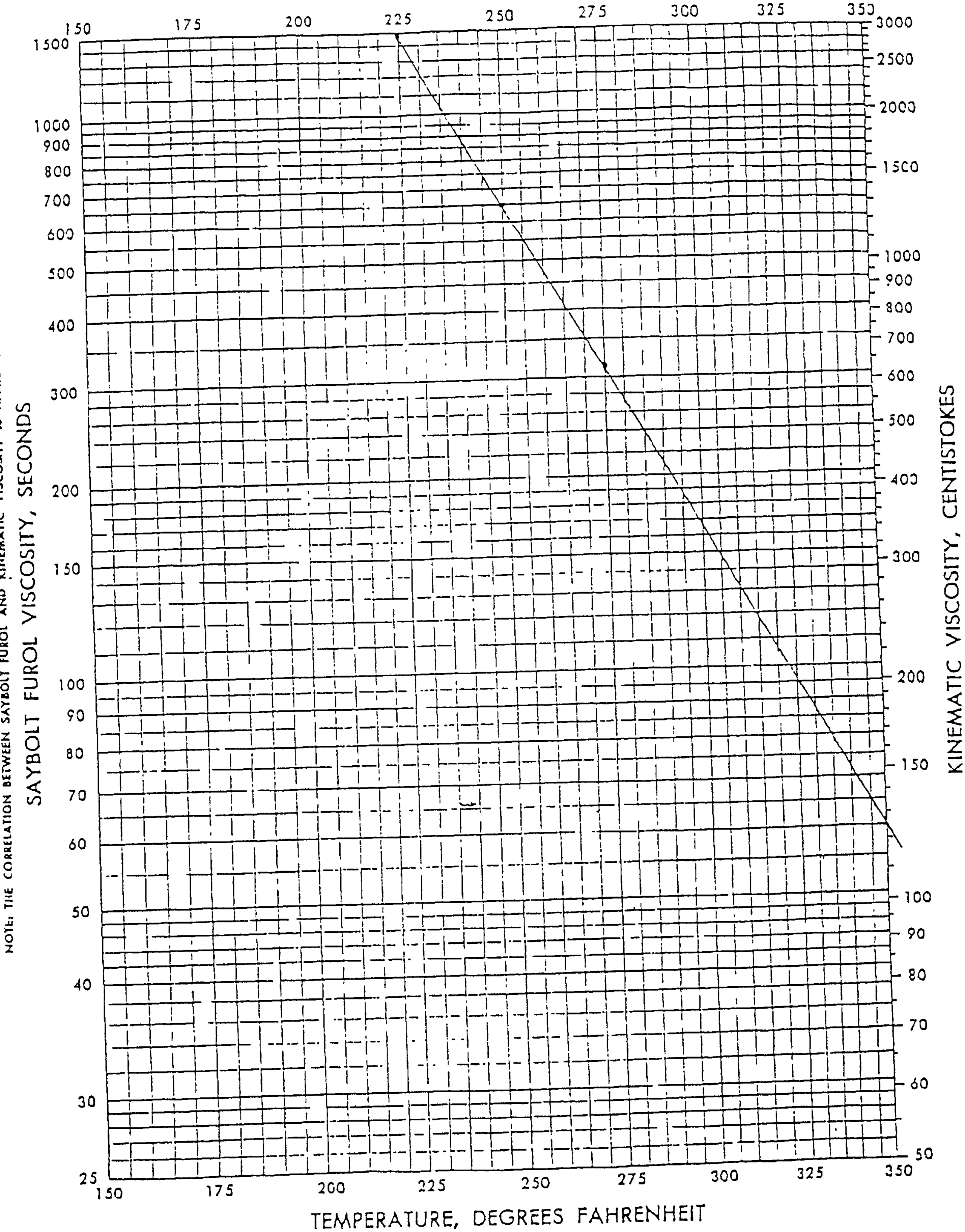
Phone No. 406-761-4100

Signature [signature] Date 9-14-1996 (prime contractor)

Return the completed form to MDT's Project Manager for this contract.

BJB:Q:MT:176.cg

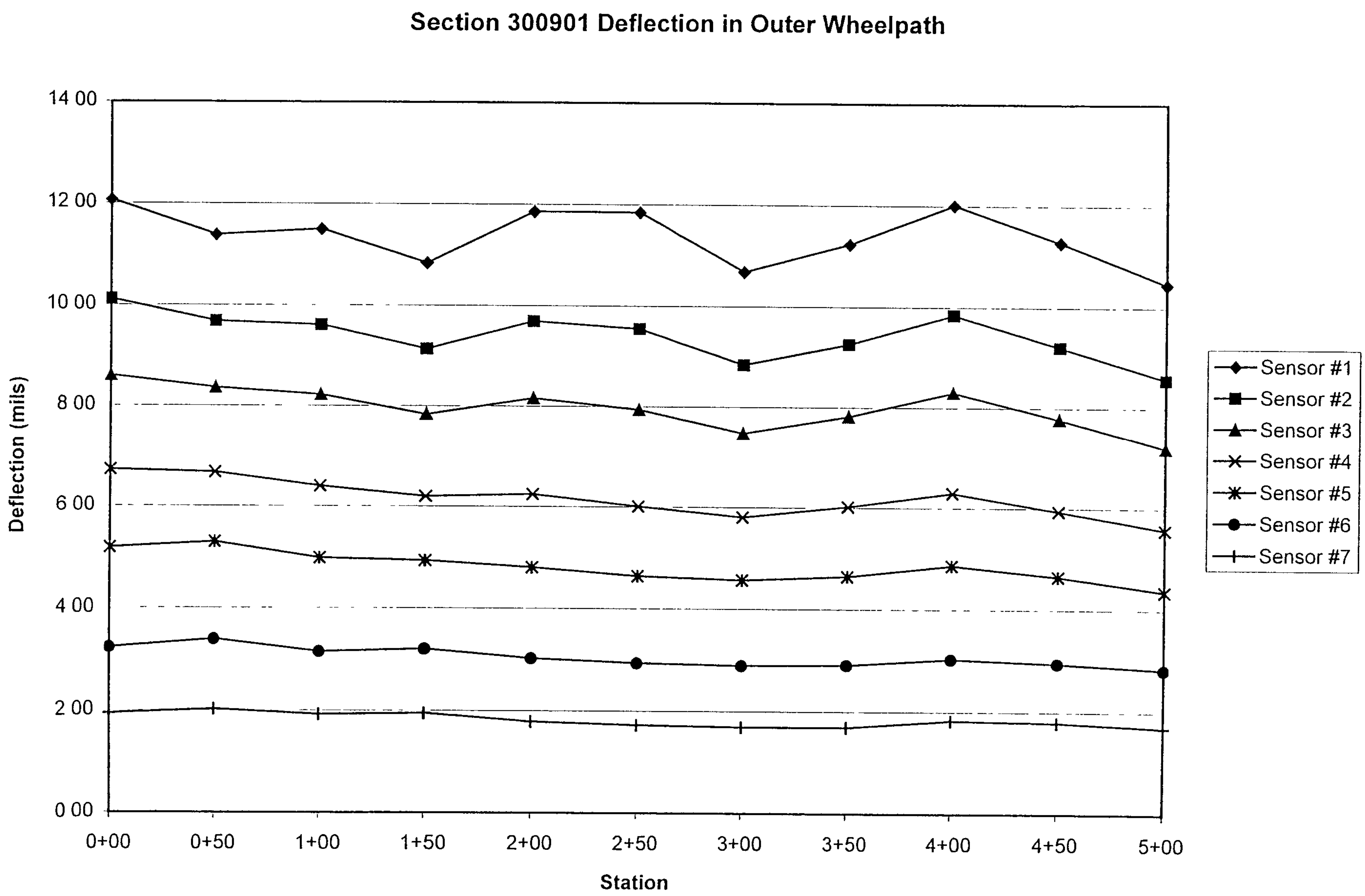
VISCOSITY VS. TEMPERATURE FOR ASPHALTS



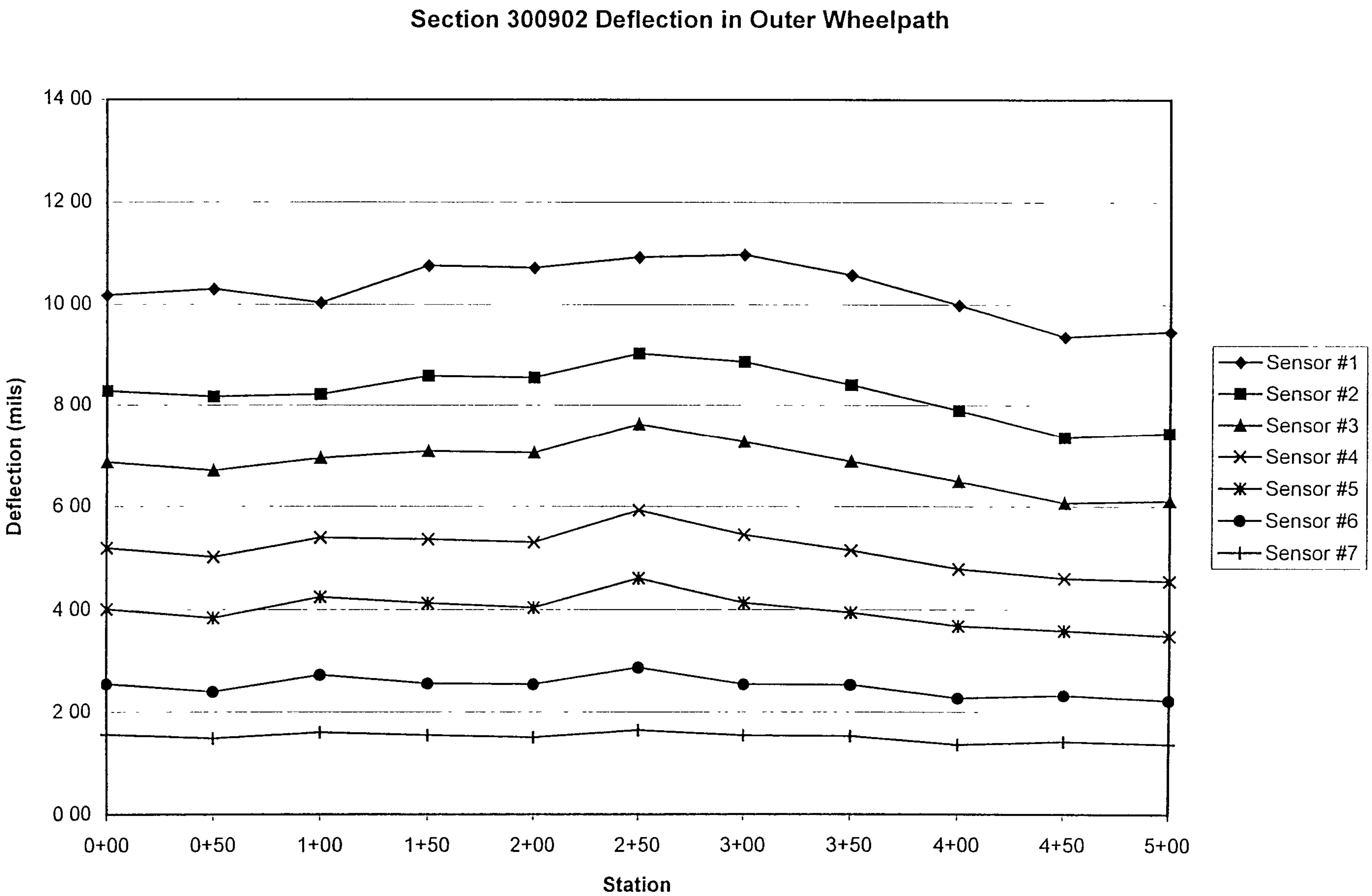
Prepared By
THE ASPHALT INSTITUTE
COLLEGE PARK, MARYLAND
Form No. TV-1

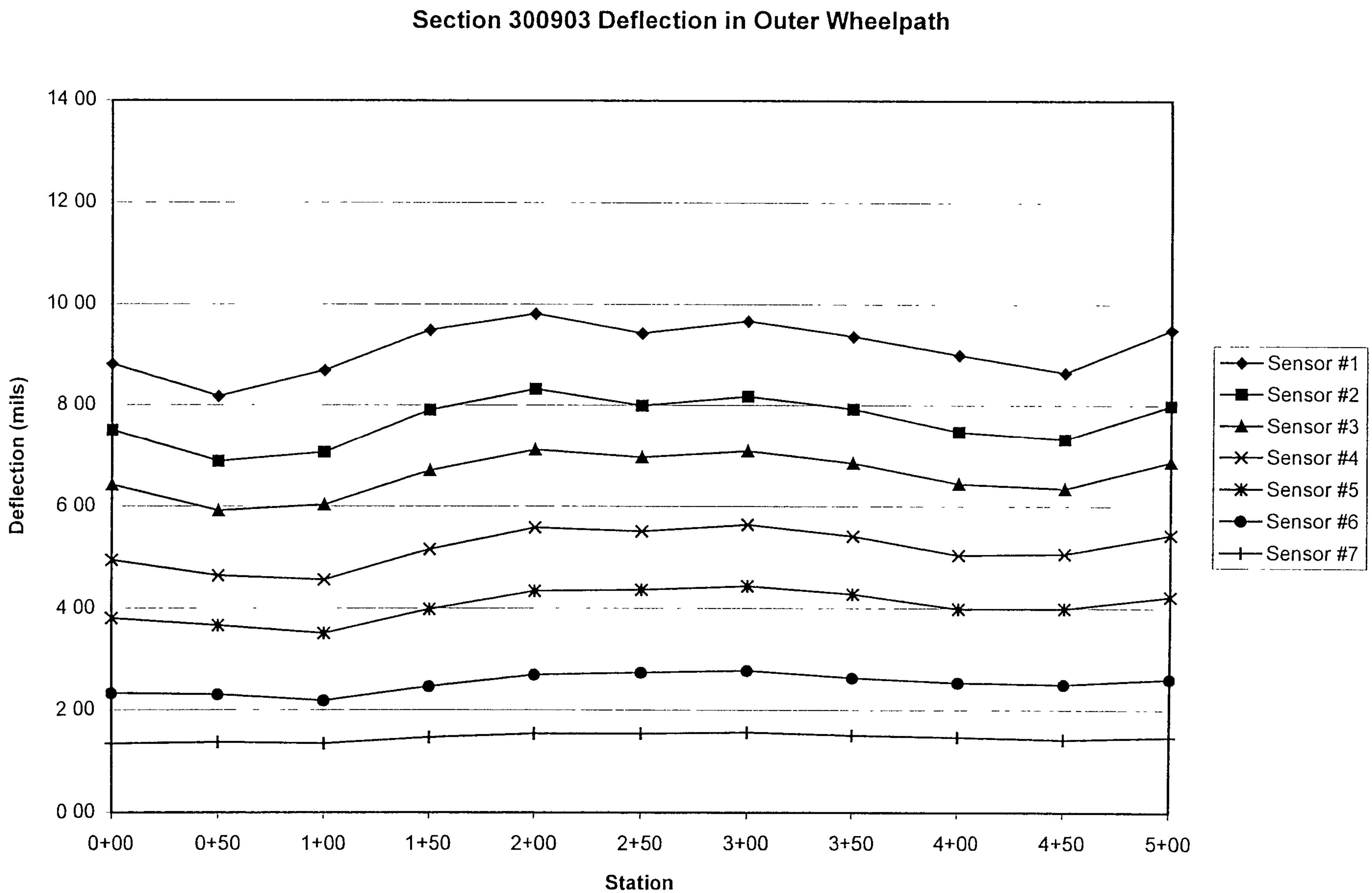
APPENDIX D

FWD DEFLECTION PROFILES OF AC SURFACE LAYER



Section 300901 Deflection in Outer Wheelpath
14 00
12 00
10 00
8 00
6 00
4 00
2 00
0 00
Deflection (mils)
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
Station
Sensor #1
Sensor #2
Sensor #3
Sensor #4
Sensor #5
Sensor #6
Sensor #7


Section 300902 Deflection in Outer Wheelpath
Deflection (mils)
14 00
12 00
10 00
8 00
6 00
4 00
2 00
0 00
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
Station
Sensor #1
Sensor #2
Sensor #3
Sensor #4
Sensor #5
Sensor #6
Sensor #7


Section 300903 Deflection in Outer Wheelpath
Deflection (mils)
14 00
12 00
10 00
8 00
6 00
4 00
2 00
0 00
0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
Station
Sensor #1
Sensor #2
Sensor #3
Sensor #4
Sensor #5
Sensor #6
Sensor #7