FEDERAL HIGHWAY ADMINISTRATION

Long Term Pavement Performance
Specific Pavement Studies

Colorado SPS-5
Construction Report on SHRP 080500
Colorado Department of Transportation

Prepared By:

Western Region Contractor
Nichols Consulting Engineers, Chtd.

October 1994

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SPS-5 CONSTRUCTION REPORT
SHRP SECTION 080500
LIMON, COLORADO
SEPTEMBER 28th TO OCTOBER 8th, 1991

INTRODUCTION

The Strategic Highway Research Program (SHRP) SPS-5 (Specific Pavement Study) experimental test sections were designed to study the effectiveness of various rehabilitation techniques on asphalt concrete pavements. The SPS-5 sections were constructed throughout the United States and Canada. This report summarizes the construction of the SPS-5 located near Limon, Colorado.

SPS GENERAL CRITERIA

The SPS-5 experiment was developed to investigate the performance of selected hot-mix asphalt concrete (AC) rehabilitation treatment factors. A standard SHRP SPS-5 experiment consists of nine 500-foot test sections. These sections include 8 experimental sections and a control section.

The experimental design for an SPS-5 project is shown in Figure 1. Four sections are constructed on a minimally prepared surface and four on an intensively prepared surface. On each type of surface preparation both recycled (RAP) and virgin asphalt concrete mixtures are placed in 2 and 5 inch thicknesses. The primary factors being studied are:

A. Primary design response variables:

   1. effect of degree of surface preparation
   2. overlay material (recycled or Virgin AC)
   3. thickness of AC overlay

B. Secondary independent variables:

   1. existing condition of pavement
   2. subgrade soil
   3. traffic volume and load
   4. environmental factors

Figure 1. Experimental Design for SPS-5, Rehabilitation of Asphalt Concrete Pavements

REHABILITATION PROCEDURES \ FACTORS FOR MOISTURE, TEMPERATURE, AND PAVEMENT CONDITION			WET				DRY			
			FREEZE		NO FREEZE		FREEZE		NO FREEZE	
			FAIR	POOR	FAIR	POOR	FAIR	POOR	FAIR	POOR
Surface Prep.	Overlay Material	Overlay Thickness								
Routine Maint. (Control)		0	xx	xx	xx	xx	xx	xx	xx	xx
Minimum	Recycled AC	2-inch	xx	xx	xx	xx	xx	xx	xx	xx
		5-inch	xx	xx	xx	xx	xx	xx	xx	xx
	Virgin AC	2-inch	xx	xx	xx	xx	xx	xx	xx	xx
		5-inch	xx	xx	xx	xx	xx	xx	xx	xx
Intensive	Recycled AC	2-inch	xx	xx	xx	xx	xx	xx	xx	xx
		5-inch	xx	xx	xx	xx	xx	xx	xx	xx
	Virgin AC	2-inch	xx	xx	xx	xx	xx	xx	xx	xx
		5-inch	xx	xx	xx	xx	xx	xx	xx	xx

Each "x" designates a test section

COLORADO PROJECT

Subgrade Soil: Fine

Traffic: >85 KESAL/Year

Figure 2 illustrates the surface preparation, overlay material, and thickness each of the nine SPS-5 sections received. The states were encouraged to add any additional test sections they wished to study and SHRP agreed to monitor them just as they monitor the SHRP SPS-5 sections. The control section is designed to indicate the rate of change that could be expected for the test sections had they not been rehabilitated.

Other requirements are that the recycled mixture contain a fixed 30% RAP (recycled asphalt pavement) and the milled material on the intensive preparation sections be replaced with the same material (virgin AC or RAP) as is used for the overlay on that section.

An SPS-5 project falls into one of 4 environmental zones, (Dry Freeze, Dry No-Freeze, Wet Freeze, Wet No-Freeze), and one of two existing pavement conditions, fair or poor. Every section in a SPS-5 project is required to be rated the same, either all fair or all poor. This project fits the dry freeze, poor category, as was shown in Figure 1.

Pavements at least eight years old and having no prior overlays were selected for the SPS-5 experiment. The pavements were intended to have traffic levels above 85k ESAL per year, and to be built on fine subgrade soils. These criteria were not always met, but the intention was to comply as closely as possible so different SPS-5 projects would not have too many conflicting variables.

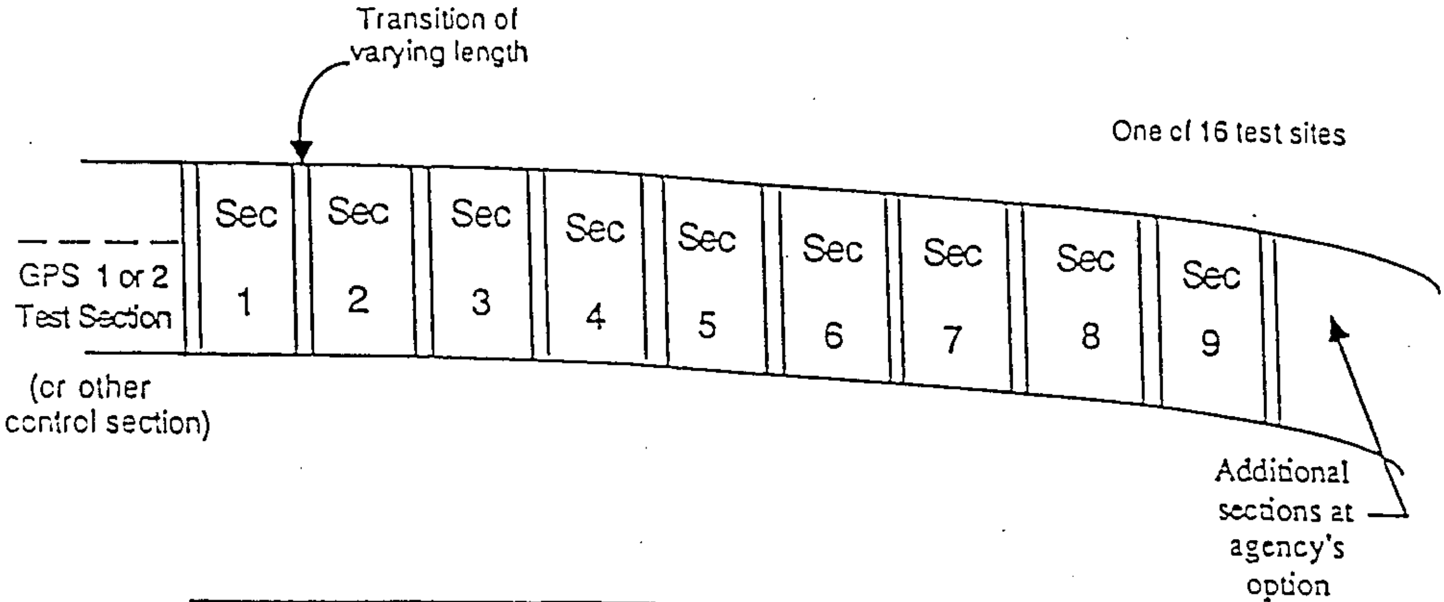
SPS-5 MONITORING AND MATERIALS SAMPLING

Field sampling, testing and monitoring for an SPS-5 project is performed in 3 phases: preconstruction, during construction, and post-construction. All testing and monitoring is done in the outer (driving) lane. The information and data gathered is used to evaluate the effectiveness and long term performance of the different rehabilitation techniques. The field work consists of:

1. Materials Coring and Sampling
2. Distress Survey (Manual or Automated)
3. Profile Data Collection using a high speed profilometer
4. Non-destructive testing using a Falling Weight Deflectometer

Materials coring and sampling is done by state and/or private laboratories. The samples obtained are used to determine the material properties of the test sections before, during, and after rehabilitation. Coring and soil sampling includes extracting 4-inch, 6-inch, and 12-inch diameter pavement cores, 6-inch auger probes, 12-inch bore holes, and 6-foot by 4-foot test pit to a depth of 12 inches below the top of the untreated subgrade.

Figure 2. SPS-5 Rehabilitation Methods



SPS-5 SECTION	SURFACE PREPARATION	OVERLAY MATERIAL	OVERLAY THICKNESS
1	Routine Maintenance	Control Section	0
2	Minimum	Recycled AC	2-inch
3	Minimum	Recycled AC	5-inch
4	Minimum	Virgin AC	5-inch
5	Minimum	Virgin AC	2-inch
6	Intensive	Virgin AC	2-inch
7	Intensive	Virgin AC	5-inch
8	Intensive	Recycled AC	5-inch
9	Intensive	Recycled AC	2-inch

The automated distress survey records the distress on a 35mm film and prints a transverse profile every 50 feet. This survey is currently contracted out to and completed by PASCO (Photographic Aerial Survey Co.). The manual distress survey is done as a backup to the PASCO data, and also to supplement PASCO when it is not possible for PASCO to be present. The manual survey entails visually rating the distress throughout a section, and mapping the results. The amounts and lengths of all distress types are then totaled for each section.

The longitudinal profile is measured with a high speed profilometer, which travels over a section of roadway at 50 miles per hour and records the longitudinal surface deviations at 6 inch increments.

The Falling Weight Deflectometer drops a group of weights from four heights at 50 foot intervals. The four heights are intended to simulate loads on the pavement of 6000, 9000, 12,000, and 16,000 pounds. (26.7, 40, 53.3, and 71.1 kilinewtons) Four drops are made at each height. Pavement deflections are recorded for each drop height using seismic movement sensors. The sensors are located on a sensor bar situated parallel to the roadway.

COLORADO SPS-5 BACKGROUND

The Colorado SPS-5 project is located in Lincoln County, Colorado on Interstate 70, East of Limon, Colorado and lies within Colorado Highway District 1. The start of the section is 3.0 miles east of the Arriba exit, (Exit 383) and the Flagler exit (Exit 395) is 7.9 miles east of the start of the section (Figure 3.)

The project is located in a Dry-Freeze environmental zone, and had a "poor" condition rating before rehabilitation, therefore falls into the Dry-Freeze-Poor category for the SPS-5 Experiment Design as was shown in Figure 1.

The project is situated completely on a fill section, in a semi-flat farmland area of Colorado. The original roadway was opened to traffic in 1974, and has two divided lanes in each direction, with 12 foot lanes, a 10 foot outside shoulder, and a 4 foot inside shoulder. No subsurface edge drains were used on the original road.

The original roadway structure consisted of 3 inches of Class 7 (Table 1) emulsified asphalt treated base, and 5 inches of Grading E (see Table 1) hot bituminous pavement (one 2" lift followed by two 1.5" lifts). The subgrade was a silty clay soil (CL classification).

The original road was straight, with no curves or super elevation and a transverse slope of 0.015 ft/ft.

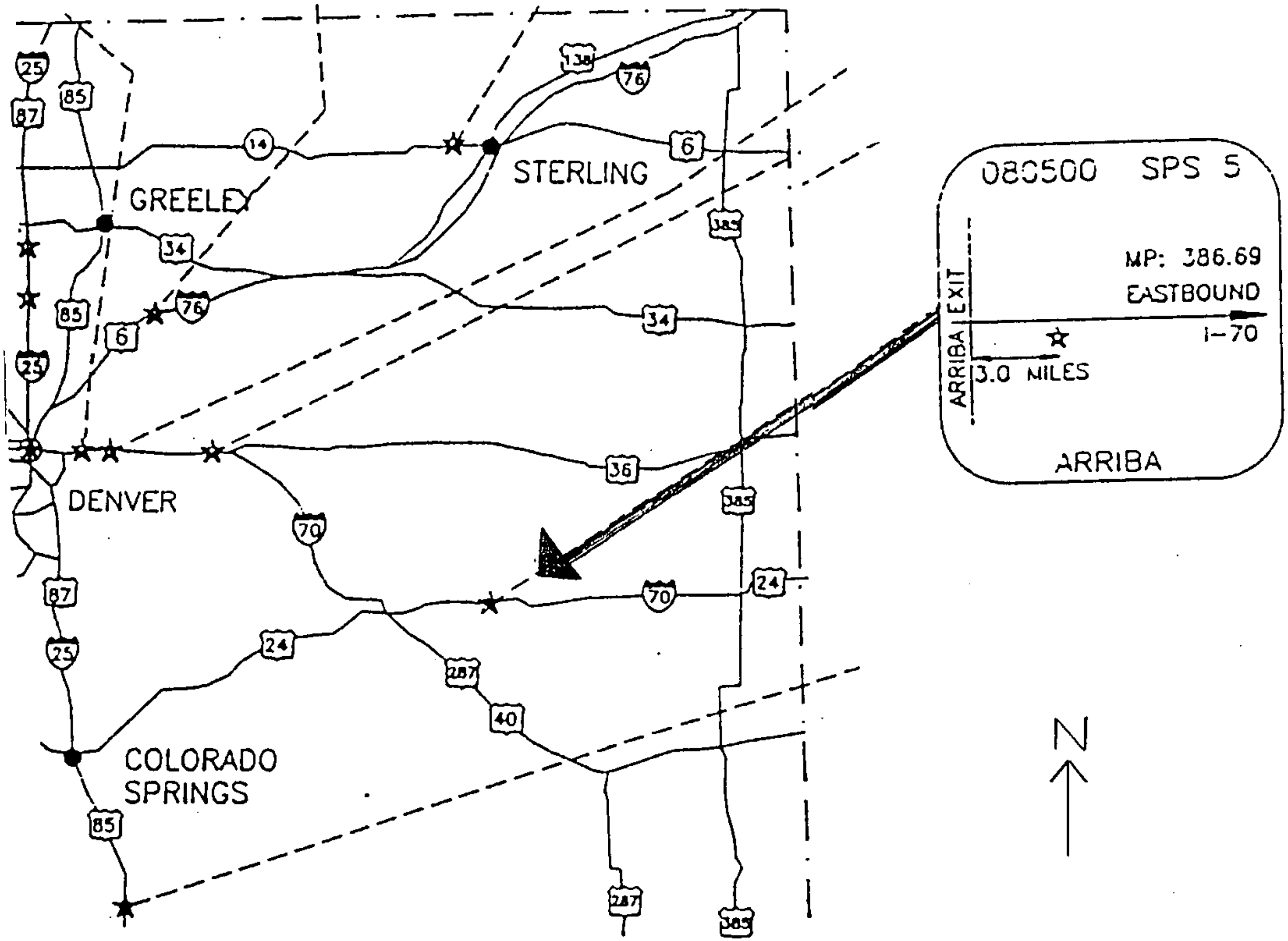


Figure 3. Location of Colorado SPS-5 Project

Table 1. Class 7 and Grading E Designations

Sieve Designation	Class 7 (% passing) (*) Treated Base	Grading E (% passing) HMAC
1"	100	
3/4"		100
1/2"		
3/8"		
No. 4		44-72
No. 8	20-85	30-58
No. 50		
No. 200	5-15	3-12

(*) Liquid Limit not greater than 30

Single, double, and triple cross culverts are located throughout the original project, but none are located within the SHRP test sections. The culverts are at a sufficient depth so as not to cause any detrimental distress to the roadway structure. A double channel is located near station 855+00, outside of any SHRP sections. No bridges or other structures are located within the test sections.

In 1989, this section of I-70 carried 5400 vehicles per day, with 21% heavy truck and combinations. In 1990, the asphalt surfacing had some transverse cracking, moderate to severe rutting, and moderate ravelling of the existing pavement. The rutting was in the driving lane and had rut depths ranging between 0.3" and 1.3". Maintenance crews had placed some thin (< 1") patches in the driving lane, which showed moderate to high severity deterioration at the time of the distress survey. The shoulder condition was good throughout the project. Drainage from the asphalt surface was poor due to the severity of rutting present.

The contractor for the rehabilitation of this project was Popejoy Construction from Colorado, with William Bain the Superintendent, John Goetzcke the Resident Engineer, and Larry Torline the Project Engineer.

COLORADO SPS-5 MONITORING AND MATERIALS SAMPLING

Preconstruction

Table 2 lists the number and type of samples collected and Figure 4 gives a description of the type of samples collected.

The laboratory testing plan for these samples is shown in Table 3. All samples were tested by Western Technologies Inc., Phoenix, Arizona, under contract to CDOT. All sampling was done outside of the 500' test sections. Figures 5 through 7 show the sampling details for all sections.

A distress survey and deflection and profile measurements were done 3 months prior to rehabilitation.

Construction

The bulk material sampling during construction is shown in Table 4. Samples of both virgin material and recycled material were collected. The laboratory testing done on these samples is shown in Table 5, the post construction lab testing plan. The samples are labeled BV for bulk virgin samples, or BR for bulk recycled samples.

Table 2. Program Scope for Field Material Sampling and Field Testing for Colorado SPS-5

MATERIAL AND SAMPLE DESCRIPTION	NUMBER OF MATERIAL SAMPLES	SAMPLE TYPE DESIGNATION
PRE-CONSTRUCTION SAMPLING		
1. Asphalt Concrete		
Coring – 4" diam. cores	29	C1-C29
Coring – 6" diam. cores	13	A1-A13
Coring – 12" diam. cores	8	BA1-BA8
Bulk Sampling (12" by 12" slab)	2	TP1,TP2
2. Unbound Base/Subbase Layers (per layer)		
Augering 6" diam. holes	13	A1-A13
Bulk sampling in 12" diam. holes	8	BA1-BA8
Bulk sampling in test pit	2	TP1,TP2
In situ density and moisture content (nuclear gauge)	2	TP1,TP2
Moisture content samples	10	TP1,TP2,BA1-BA8
3. Bound Base/subbase Layers (per layer)		
Coring – 4" diam. cores	6	C4,C5,C15,C16,C23,C24
Coring – 6" diam. cores	13	A1-A13
Coring – 12" diam. cores	8	BA1-BA8
4. Subgrade		
Splitspoon sampling	13	A1-A13
Thin-walled tube sampling (* 2 tubes or 2 spoons or combination per hole)	13	A1-A13
Bulk sampling in 12" diam. holes	8	BA1-BA8
Bulk sampling in test pit	2	TP1,TP2
In situ density and moisture content (nuclear guage)	2	TP1,TP2
Moisture content samples	10	BA1-BA8, TP1,TP2
5. Shoulder Auger Probes	3	S1-S3

Figure 4. Drilling and Sampling Symbols and Descriptions

● 4' OD Core of the surfacing and treated base.

○ 6' OD Core of AC pavement surface; augering of base and subbase; Shelby tube sampling or splitspoon sampling as directed to a depth of 5 feet below the top of subgrade.

● 12' OD core of ac pavement surface; augering of base, subbase, and subgrade to 12' below top of subgrade for bulk sample retrieval.

▭ Test pit (4' x 6' x 12' below top of subgrade). Removal of pavement layers; collection of pavement slab; nuclear density measurements and moisture measurements on unstabilized layers and subgrade; bulk sampling of unstabilized layers and subgrade.

⊗ Auger shoulder probe. To be taken at midpoints of sections 080509 and 080505.

Table 3. SPS-5 Laboratory Testing Plans (Pre-Construction)

Material Type and Properties	SHRP Test Designation	SHRP Protocol	No. of Tests per Layer	Material Source/ Sample Type Designation
PRE-CONSTRUCTION				
I. ASPHALT CONCRETE				
A. ASPHALTIC CONCRETE:				
Core Examination/Thickness	AC01	P01	26	ALL C-TYPE CORES
Bulk Specific Gravity	AC02	P02	9	[C3 C4 C5], [C13 C14 C15], [C22 C23 C24] (see note 3)
Maximum Specific Gravity	AC03	P03	3	[BA1-3], [TP], [BA4-6]
Asphalt Content (Extraction)	AC04	P04	3	[BA1-3], [TP], [BA4-6]
Creep Compliance	AC06	P06	3	C2, C9, C20 (see note 1)
Resilient Modulus	AC07	P07	6	[C4 C5], [C14 C15], [C23 C24]
Tensile Strength	AC07	P07	9	[C3 C4 C5], [C13 C14 C15], [C22 C23 C24]
Field Moisture Damage	AC08	P08	3	A1, A2, A3
B. EXTRACTED AGGREGATE:				
Type and Classification:				
Coarse Aggregate	AG03	P13	3	[BA1-3] [TP] [BA4-6]
Fine Aggregate	AG03	P13	3	[BA1-3] [TP] [BA4-6]
Gradation of Aggregate	AG04	P14	3	[BA1-3] [TP] [BA4-6]
NAA Test for Fine Aggregate Particle Shape	AG05	P14A (note 2)	3	[BA1-3] [TP] [BA4-6]
C. ASPHALT CEMENT:				
Abson Recovery	AE01	P21	3	[BA1-3] [TP] [BA4-6]
Penetration at 77 and 115° F	AE02	P22	3	[BA1-3] [TP] [BA4-6]
Specific Gravity (60F)	AE03	P23	3	[BA1-3] [TP] [BA4-6]
Viscosity at 77F	AE04	P24	3	[BA1-3] [TP] [BA4-6]
Viscosity at 140F,275F	AE05	P25	3	[BA1-3] [TP] [BA4-6]

NOTES:
1 Creep compliance will be performed when suitable procedures are developed -- cores will be stored.
2 National Aggregate Association will perform tests at no cost to the State.
3 Cores within brackets are from the same sampling area.

Table 3. (cont.) Laboratory Testing Plans (Pre-Construction)

Material Type and Properties	SHRP Test Designation	SHRP Protocol	No. of Tests per Layer	Material Source/ Sample Type Designation
II. BOUND (TREATED) BASE AND SUBBASE				
Type and Classification of Material and Treatment	TB01	P31	3	[C4 C5] [C15 C16] [C23 C24]
Pozzolanic/Cementitious: Compressive Strength	TB02	P32	3	[C4 C5] [C15 C16] [C23 C24]
Asphalt treated: Dynamic Modulus (77F)	TB03	P33	3	[C4 C5] [C15 C16] [C23 C24]
HMAC: Resilient Modulus	AC07	P07	3	[C4 C5] [C15 C16] [C23 C24]
III. UNBOUND GRANULAR BASE AND SUBBASE				
Particle Size Analysis	UG01	P41	3	[BA1-3] [TP] [BA4-6]
Sieve Analysis (washed)	UG02	P41	3	[BA1-3] [TP] [BA4-6]
Atterberg Limits	UG04	P43	3	[BA1-3] [TP] [BA4-6]
Moisture-Density Relations	UG05	P44	3	[BA1-3] [TP] [BA4-6]
Resilient Modulus	UG07	P46	3	[BA1-3] [TP] [BA4-6]
Classification	UG08	P47	3	[BA1-3] [TP] [BA4-6]
Permeability	UG09	P48	3	[BA1-3] [TP] [BA4-6]
Natural Moisture Content	UG10	P49	3	[BA1-3] [TP] [BA4-6]
IV. SUBGRADE				
Sieve Analysis	SS01	P51	3	[BA1-3] [TP] [BA4-6]
Hydrometer to 0.001mm	SS02	P42	3	[BA1-3] [TP] [BA4-6]
Atterberg Limits	SS03	P43	3	[BA1-3] [TP] [BA4-6]
Classification	SS04	P52	3	[BA1-3] [TP] [BA4-6]
Moisture-Density Relations	SS05	P55	3	[BA1-3] [TP] [BA4-6]
Resilient Modulus	SS07	P46	3	A1 A2 A3 or [BA1-3] [TP] [BA4-6]
Unit Weight	SS08	P56	3	[BA1-3] [TP] [BA4-6]
Natural Moisture Content	SS09	P49	3	[BA1-3] [TP] [BA4-6]
Depth to Rigid Layer			3	S1 S2 S3

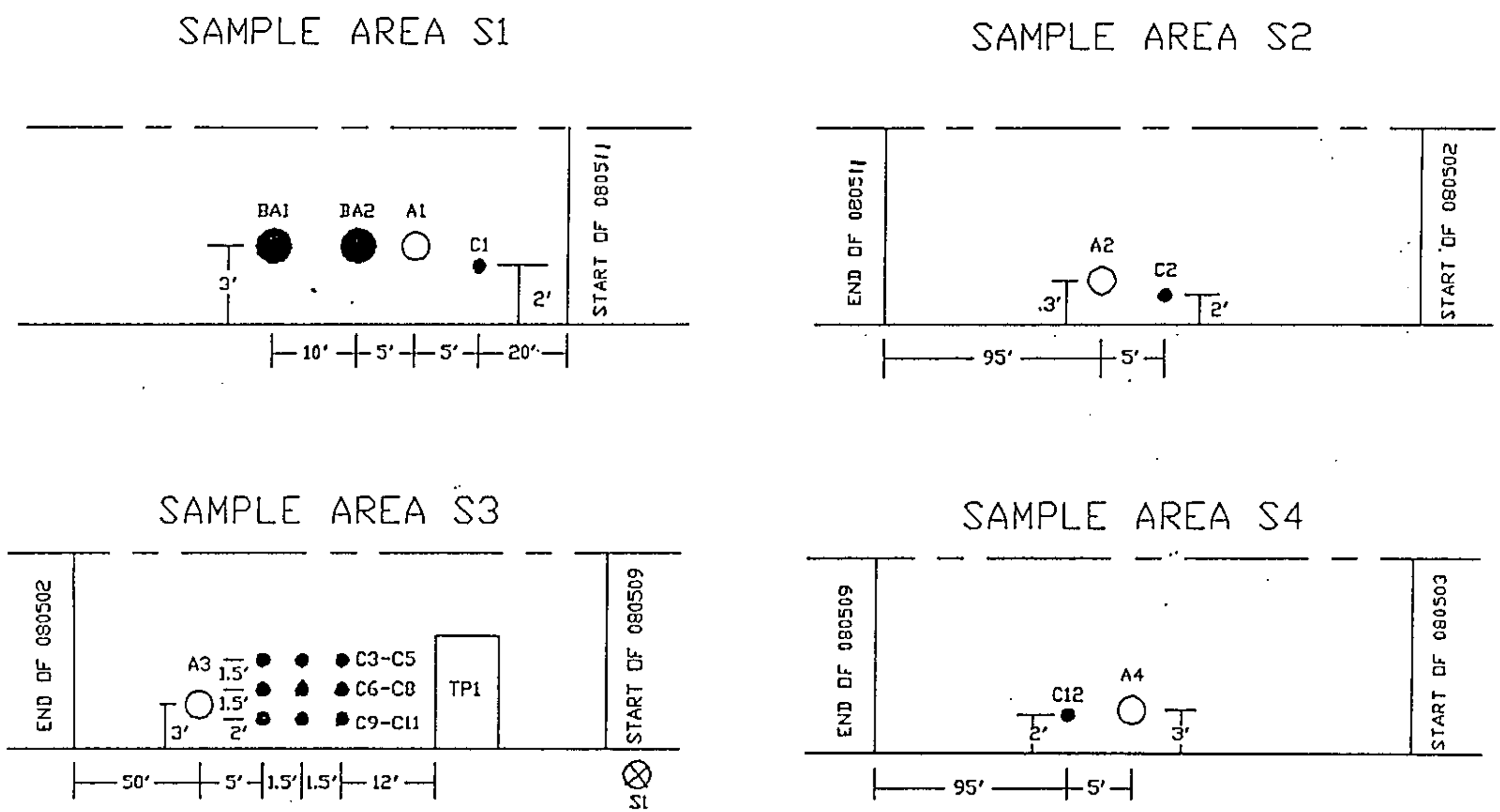


Figure 5. Preconstruction Drilling and Sampling, 080511, 080502, 080509

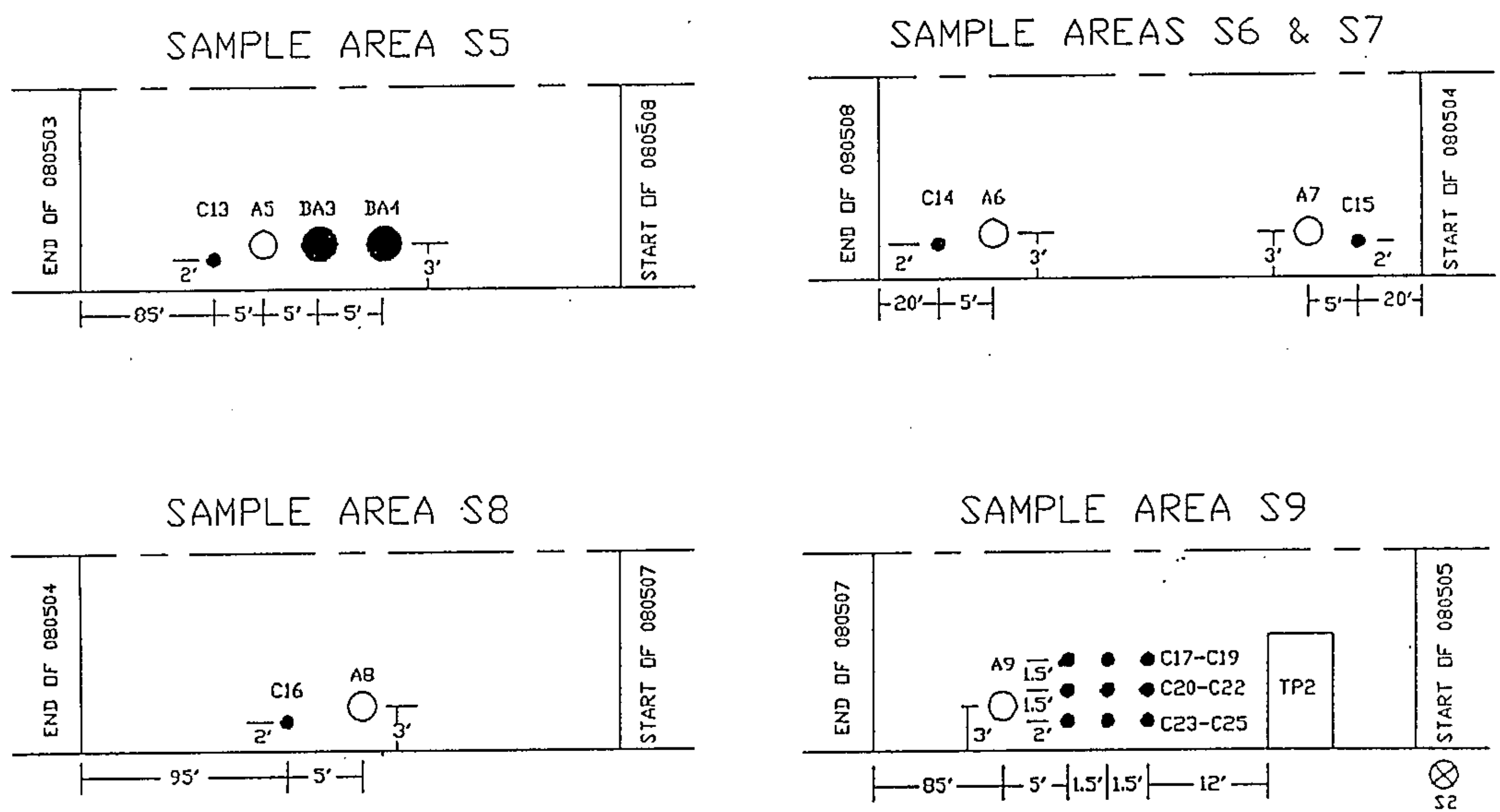


Figure 6. Preconstruction Drilling and Sampling, 080503, 080508, 080504, 080507

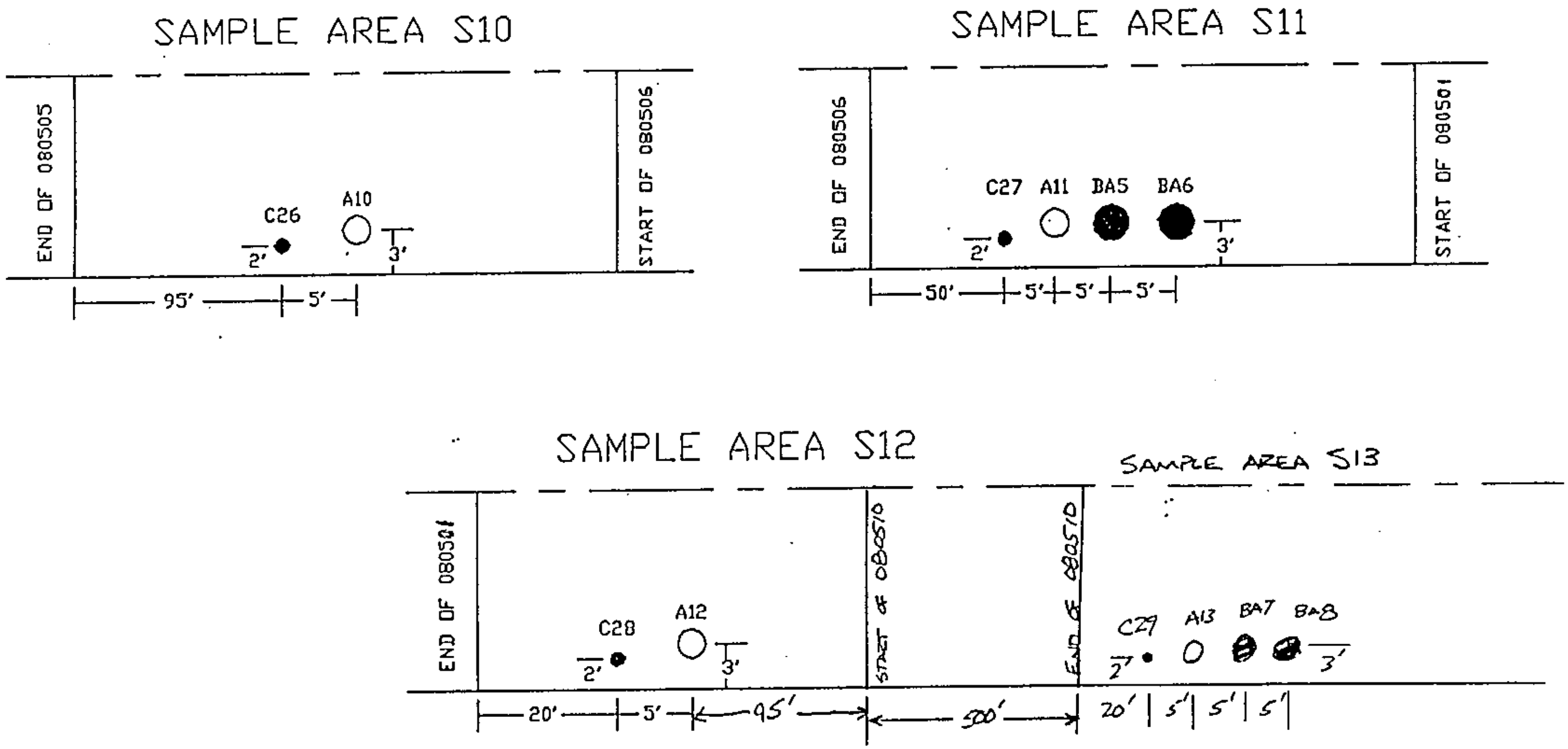


Figure 7. Preconstruction Drilling and Sampling, 080505, 080506, 080501, 080510

Table 4. Bulk Material Sampling During Construction

A. Materials to be tested as part of LTPP.

MATERIAL AND SAMPLE DESCRIPTION	NUMBER OF MATERIAL SAMPLES	SAMPLE LOCATION
1. Virginia Asphalt Concrete Mix	3 - 100 lbs	With-in Sections
2. Recycled Asphalt Concrete Mix	3 - 100 lbs	With-in Sections

B. Materials to be shipped to the SHRP asphalt reference library.

MATERIAL AND SAMPLE DESCRIPTION	NUMBER OF MATERIAL SAMPLES	SAMPLE LOCATION
1. Asphalt Cement (virgin mix)	11	Mix Plant
5 gallon containers		
2. Asphalt Cement (recycled mix)	11	Mix Plant
5 gallon containers		
3. Aggregate		
Used in virgin mix (55 gal. drums)	1000 lbs	Mix Plant
Used in recycled mix (55 gal. drums)	1000 lbs	Mix Plant
4. Recycled Asphaltic Concrete (prior to remixing)	1000 lbs	Mix Plant
5. Finished Asphaltic Concrete Mix		
Virgin AC mix	200 lbs	Mix Plant
Recycled AC mix	200 lbs	Mix Plant

Table 5. SPS-5 Laboratory Testing Plans (Post-Construction)

Material Type and Properties	SHRP Test Designation	SHRP Protocol	No. of Tests per Layer	Material Source/ Sample Type Designation
A. ASPHALTIC CONCRETE:				
Core Examination/Thickness	AC01	P01	40	ALL CORES
Bulk Specific Gravity	AC02	P02	40	ALL CORES
Maximum Specific Gravity	AC03	P03	6	BV1, BV2, BV3, BR1, BR2, BR3
Asphalt Content (Extraction)	AC04	P04	6	BV1, BV2, BV3, BR1, BR2, BR3
Moisture Susceptibility	AC05	P05	6	BV1, BV2, BV3, BR1, BR2, BR3
Creep Compliance	AC06	P06	2	[C51 C52 C53], [C57 C58 C59] (see note 1)
Resilient Modulus	AC07	P07	6	[C32 C33] [C35 C36] [C38 C39] [C41 C42] [C55 C56] [C61 C62]
Tensile Strength	AC07	P07	18	[C31 C32 C33] [C34 C35 C36] [C37 C38 C39] [C40 C41 C42] [C54 C55 C56] [C60 C61 C62]
B. EXTRACTED AGGREGATE:				
Bulk Specific Gravity:				
Coarse Aggregate	AG01	P11	6	BV1, BV2, BV3, BR1, BR2, BR3
Fine Aggregate	AG02	P12	6	BV1, BV2, BV3, BR1, BR2, BR3
Type and Classification:				
Coarse Aggregate	AG03	P13	6	BV1, BV2, BV3, BR1, BR2, BR3
Fine Aggregate	AG03	P13	6	BV1, BV2, BV3, BR1, BR2, BR3
Gradation of Aggregate	AG04	P14	6	BV1, BV2, BV3, BR1, BR2, BR3
NAA Test for Fine Aggregate Particle Shape	AG05	P14A (note 2)	6	BV1, BV2, BV3, BR1, BR2, BR3
C. ASPHALT CEMENT:				
Abson Recovery	AE01	P21	6	BV1, BV2, BV3, BR1, BR2, BR3
Penetration at 77 and 115 °F	AE02	P22	6	BV1, BV2, BV3, BR1, BR2, BR3
Specific Gravity (60F)	AE03	P23	6	BV1, BV2, BV3, BR1, BR2, BR3
Viscosity at 77F	AE04	P24	6	BV1, BV2, BV3, BR1, BR2, BR3
Viscosity at 140F,275F	AE05	P25	6	BV1, BV2, BV3, BR1, BR2, BR3

NOTES: 1 Creep compliance will be performed when suitable procedures are developed -- cores will be stored.

2 National Aggregate Association will perform tests at no cost to the State.

Post Construction

Four inch cores were taken before and after each section after construction as shown in Figure 8. The location of drilling was different depending on whether 4 or 6 cores were taken, and is shown in Figure 9. The post construction 'C' type cores were tested as shown in Table 5. They were labeled C30 to C83.

Twenty additional 4" cores at section 080504 were drilled for additional study at Penn State University. These cores were to be used to determine physical asphalt properties of the liquid asphalt.

Post-construction deflection, profile, and distress surveys were all done less than a year after construction.

CONSTRUCTION

The Colorado SPS-5 rehabilitation project was started on approximately September 28th, 1991, and completed on October 8th, 1991. The contractor was Popejoy Construction.

Prior to any rehabilitation work, a rut fill layer was placed in the minimum preparation sections. Following this, the supplemental state sections 080510 and 080511 were overlayed with the state virgin and polymer modified mixes. The intensive preparation sections were then milled full width, and a mill replacement layer was placed, consisting of either a virgin or recycled mix. Both virgin and recycled middle lifts were placed next on the sections to receive a 5" overlay. The top lift of both virgin and recycled mixes on all sections was then placed, all on the last day of construction. To finish rehabilitation a polymer modified seal coat was placed on each section. This was placed due to the low asphalt content (to be discussed later) of the mixes.

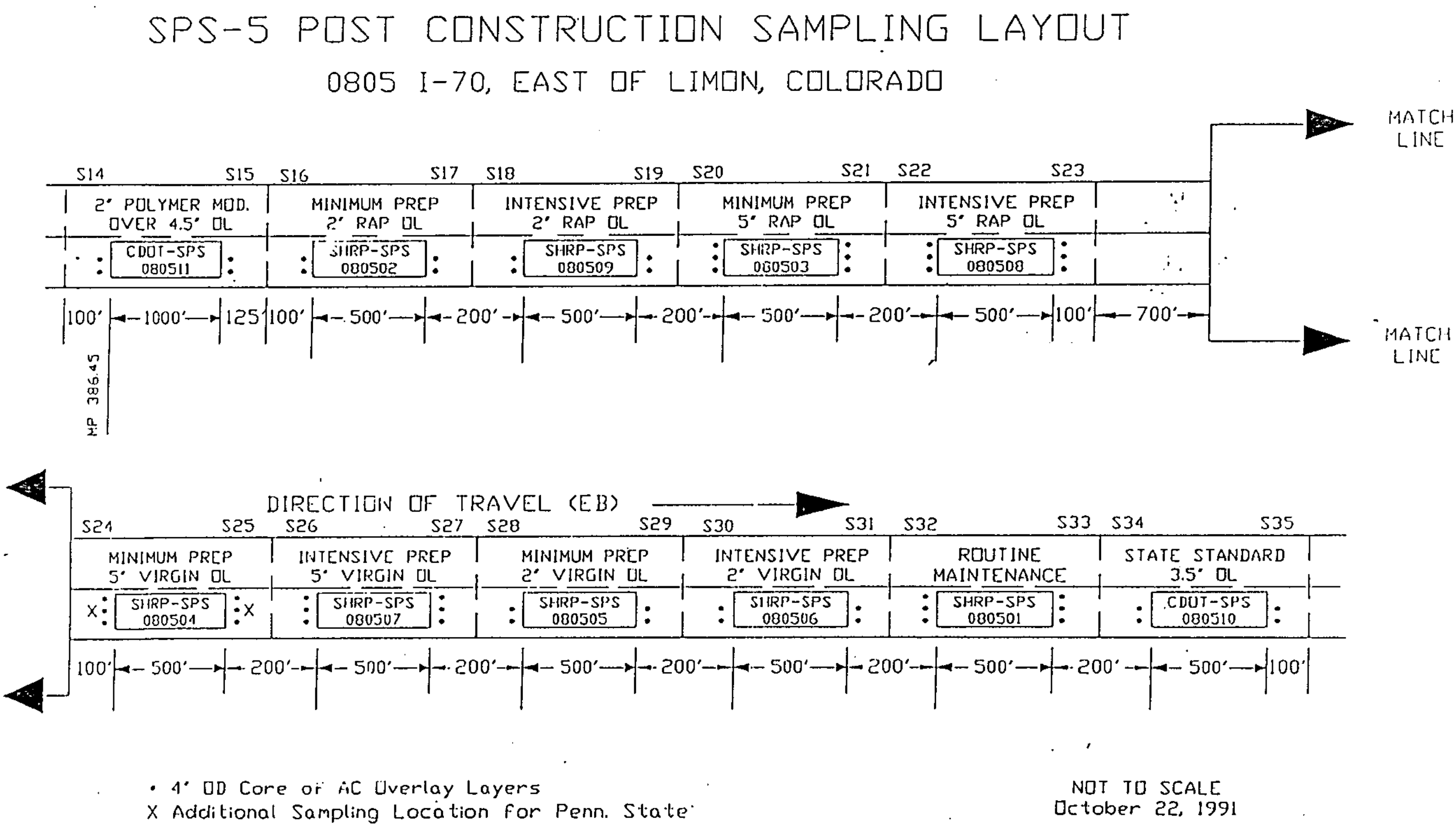
After all rehabilitation was completed, it was decided that a rut fill layer was needed on the control section 080501, and this was placed on October 8th.

In the following sections, the equipment and materials used for construction will be discussed, followed by details of construction.

Equipment

The milling for all of the test sections was done with a Caterpillar PR-450. The milled material was collected in trucks and transported away to be processed for the RAP mix. A 6'3" milling head was used that gave the surface a macro texture.

Figure 8. Colorado SPS-5 Post Construction Sampling Layout



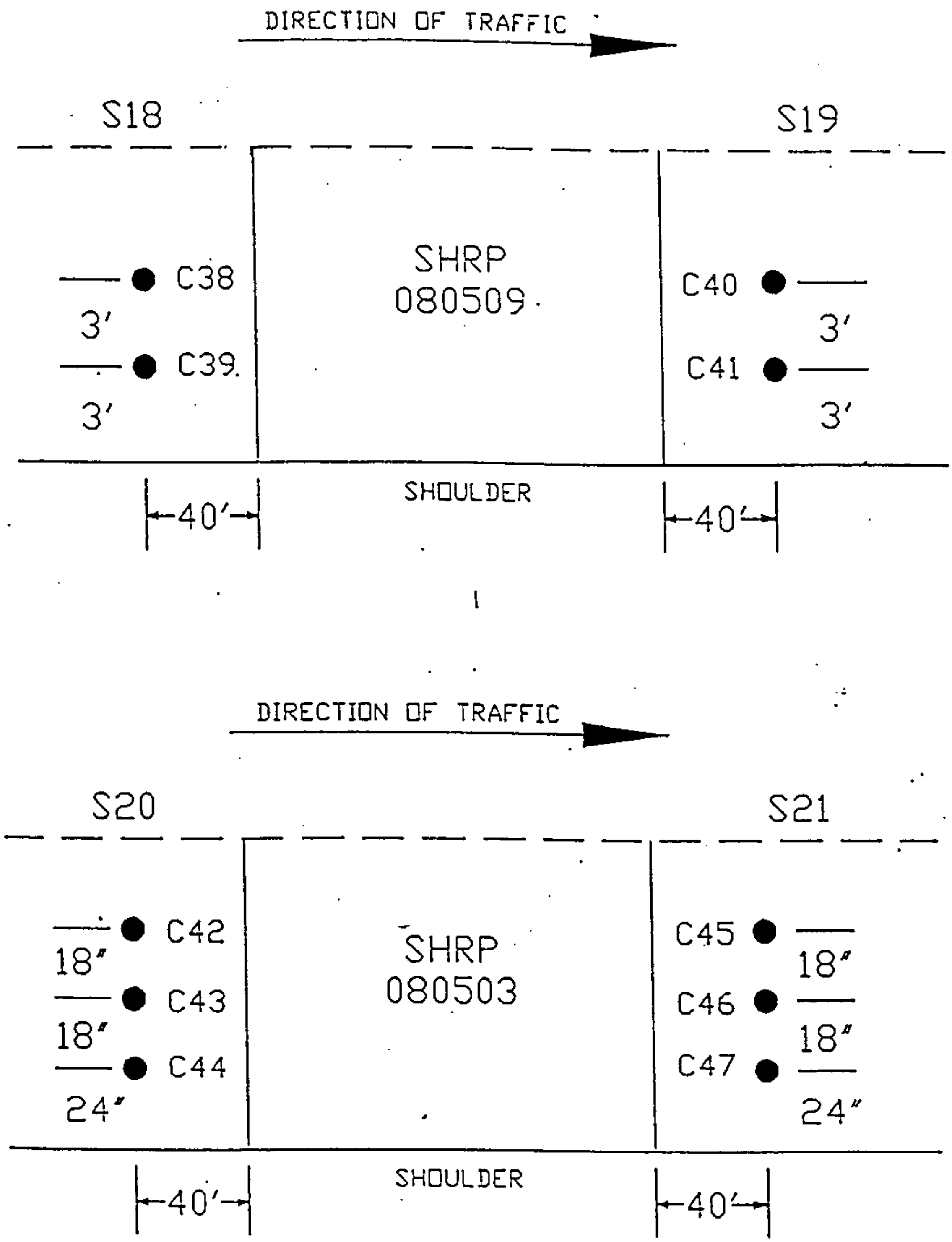


Figure 9. Detailed Post Construction Sampling

The paving was completed with two pavers. The shoulders were paved with a Barber Greene 245. The travel lanes were paved with a Barber Green-260B, with a 12.0' width and a 30' ski. The trucks used for paving were Flowboy CB-4000's.

A double-drum vibratory Dynapac CC-50 was used as the breakdown roller and had a gross weight of 17.5 tons. The manufacturer and weight of the intermediate roller was not recorded. The finish roller was a double-drum vibratory Caterpillar CB-534 with a gross weight of 10.5 tons. Since no rolling patterns were recorded for this project, the typical rolling pattern for Colorado DOT is reported:

Breakdown:

- 1 pass with steel-double drum with vibratory mode off
- 1 pass with steel-double drum with vibratory mode on

Intermediate:

- 1 pass with pneumatic rubber-tired roller

Final:

- 1 pass with steel-double drum with vibratory mode on

Materials

The standard SHRP SPS-5 sections utilized both virgin and recycled mixes. (Grading C, Tables 6 and 7) For this project, a separate rut-fill mix (Grading CX, Table 8) was used for the minimum preparation sections, a standard state mix (Grading G, Table 9) was used for the first lift of the state supplemental sections, and a polymer modified Grading C mix (Table 10) was used for the top lift on state supplemental Section 080511. The mix designs for these four mixes is shown in Tables 6 through 10. The same asphalt (AC-20) and asphalt source was used for all of the mixes on the project. The source was the Conoco Refinery. No asphalt additives were used on the project.

A diluted (1 part emulsified asphalt, 1 part water) slow setting emulsified asphalt (CSS1h) was used for the tack coat on the project. The diluted application rate called for was 0.07 gallons per square yard. Prior to placing the bituminous tack coat, the surface was swept to remove dirt and gravel.

Two aggregate sources (pits) were used for the project: Cooley and Monks aggregates. The Cooley source was manufactured granite material, and supplied the course fraction of the mixes as well as the manufactured sand. The Monks source supplied the natural sand (Monks Course Sand) for all of the mixes, (10-15% by weight of the mix.) A 1% addition of Pete Lien hydrated lime was used for all of the mixes.

Table 6. Virgin Grading C Mix Design

Division of Highways
State of Colorado
Form DOH 429 Rev. 11/88

Date Received 04/04/91

Project No: FRI(CX) 070-5(56)
Location: West of Flagler
District # 15 Subaccount: 91111
Lab # 165x,170x,171x,Hyl
Field Sample # G3289

LABORATORY DESIGN for HOT BITUMINOUS PAVEMENT - CONSTRUCTION

Item 403 Grading C AC 20 Conoco Gyratory
Pit name: Cooley/Morr./Monks CONTRACTOR: Popejoy

SIEVE ANALYSIS: T11 & T27, sampled by CP30

Test No.->	165x	170x	171x	Hyd	As Used		Job Mix
% used-->	48.0	36.0	15.0	1.0			
1 1/2	100	100	100	100	100	1 1/2	
1	100	100	100	100	100	1	
3/4	100	100	100	100	100	3/4	100
5/8	100	75	100	100	91	5/8	
1/2	100	68	100	100	88	1/2	87
3/8	100	36	99	100	77	3/8	77
4	85	4	87	100	56	4	56
8	63	0	63	100	41	8	41
16	47	0	36	100	29	16	
30	38	0	16	100	22	30	22
50	28	0	4	100	15	50	
100	19	0	2	98	10	100	
200	11.9	0.0	1.5	97.0	6.9	200	7

TEST RESULTS				
Percent bitumen	4.5	5.0	5.5	6.0
Max Sp. Gr. T209	2.487	2.467	2.447	2.427
Bulk Sp. Gr. T166	2.393	2.411	2.412	2.415
% Voids CPL 5105	3.8	2.3	1.4	0.5
Stability CPL 5105	39	30	21	18
Modulus CPL 5110	412	479	477	398
Strength coefficient	0.44	0.44	0.35	0.30
VMA (% voids in Agg)	14.5	14.3	14.7	15.0
% of VMA filled	74	84	90	97
Dust / AC ratio	1.36	1.22	1.11	1.01

IMMERSION-COMPRESSION CPL 5104	
% bitumen	
PSI Wet	
PSI Dry	
% Absorption	
% Swell	
% Ret. Strength	
% Additive used	
Asphalt additive type	

LOTTMAN CPL 5109	
4.5	% bitumen
34	Wet D.T.St
30	Dry D.T.St (Not Aged)
7.05	% Voids
5.16	% Perm Vds
117	% T.S.Ret.
0	% Additive

Optimum asphalt content 4.5
Stability at Optimum A.C. 39
Asphalt film thickness at Optimum A.C.: 7.06 microns

Lab Bulk SpG at Optimum 2.393
% Voids at Optimum A.C. 3.77

Date Reported 5/1/91

Dick Hines 757-9724
Flexible Pavement Engineer

Table 7. RAP Grading C Mix Design

Division of Highways
State of Colorado
Form DOH 429 Rev. 11/88

Project No: FRI(CX)070-5(56)
Location: West of Flagler
District # 1 Subaccount: 91111
Lab # 396x-399x
Field Sample # 63929

Date Received 06/19/91

LABORATORY DESIGN for HOT BITUMINOUS PAVEMENT - CONSTRUCTION

Item 403 Grading C Conoco AC-20 30% RAP. Gyratory Compaction
Pit name: Cooley Morr./Monks CONTRACTOR: Popejoy

SIEVE ANALYSIS: T11 & T27, sampled by CP30

Test No.->	396x	398x	399x	493x	Hyd	As Used		Job Mix
% used-->	30.0	34.0	10.0	25.0	1.0			
1 1/2	100	100	100	100	100	100	1 1/2	
1	100	100	100	100	100	100	1	
3/4	99	100	100	100	100	100	3/4	100
5/8	90	100	99	100	100	97	5/8	
1/2	76	100	99	64	100	84	1/2	84
3/8	59	100	98	21	100	68	3/8	62
4	44	88	91	3	100	54	4	54
8	36	60	72	0	100	39	8	39
16	28	44	47	0	100	29	16	
30	19	35	21	0	100	21	30	21
50	9	27	5	0	100	13	50	
100	6	19	3	0	98	10	100	
200	5.2	12.0	2.0	0.0	97.0	6.8	200	7
	RAP 4.81							

TEST RESULTS

Percent bitumen	4.0	4.5	5.0	5.5
Max Sp. Gr. T209	2.519	2.499	2.479	2.458
Bulk Sp. Gr. T166	2.434	2.435	2.437	2.426
% Voids CPL 5105	3.4	2.6	1.7	1.3
Stability CPL 5105	44	27	20	14
Modulus CPL 5110	0	0	0	0
Strength coefficient	0.44	0.40	0.30	0.25
VMA (% voids in Agg)	13.1	13.5	13.8	14.7
% of VMA filled	74	81	88	91
Dust / AC ratio	1.25	1.12	1.01	0.92

IMMERSION-COMPRESSION CPL 5104
% bitumen
PSI Wet
PSI Dry
% Absorption
% Swell
% Ret. Strength
% Additive used
Asphalt additive type

LOTTMAN	CPL 5109
4.2	% bitumen
76	Wet D.T.St.
86	Dry D.T.St.
6.24	% Voids
59	% Saturation
88	% T.S.Ret.
0	% Additive

Optimum asphalt content. 4.2
Stability at Optimum A.C. 37
Asphalt film thickness at Optimum A.C.: 8.1 microns

Lab Max. SpG at Optimum 2.511
% Voids at Optimum A.C. 3.06

Date Reported 8/27/91

Dick Hines 757-9724
Flexible Pavement Engineer

Table 8. Rut Level-up Grading CX Mix Design

Division of Highways
State of Colorado
Form DOH 429 Rev. 11/88

Date Received 04/04/91

Project No: FRI(CX) 070-5(56)
Location: West of Flagler
District # 15 Subaccount: 91111
Lab # 164x - 166x, Hyl
Field Sample # 63287

LABORATORY DESIGN for HOT BITUMINOUS PAVEMENT - CONSTRUCTION

Item 403 Grading CX AC 20 Conoco Gyratory
Pit name: Cooley/Morr./Monks CONTRACTOR: Popejoy

SIEVE ANALYSIS: T11 & T27, sampled by CP30

Test No.->	164x	165x	166x	Hyd	As Used		Job Mix
% used-->	34.0	50.0	15.0	1.0			
1 1/2	100	100	100	100	100	1 1/2	
1	100	100	100	100	100	1	
3/4	100	100	100	100	100	3/4	
5/8	100	100	100	100	100	5/8	
1/2	100	100	100	100	100	1/2	100
3/8	63	100	99	100	87	3/8	87
4	4	85	88	100	58	4	58
8	0	63	67	100	43	8	43
16	0	47	40	100	31	16	
30	0	38	18	100	23	30	23
50	0	28	4	100	16	50	
100	0	19	2	98	11	100	
200	0.0	11.9	1.6	97.0	7.2	200	7

TEST RESULTS

Percent bitumen	4.5	5.0	5.5	6.0	6.5
Max Sp. Gr. T209	2.518	2.497	2.477	2.457	2.436
Bulk Sp. Gr. T166	2.400	2.416	2.423	2.409	2.408
% Voids CPL 5105	4.7	3.[illegible]	2.2	1.9	1.2
Stability CPL 5105	44	4[illegible]	33	21	13
Modulus CPL 5110	0	542	487	0	282
Strength coefficient	0.44	0.44	0.44	0.35	0.25
VMA (% voids in Agg)	15.5	15.3	15.5	16.4	16.8
% of VMA filled	70	79	86	88	93
Dust / AC ratio	1.42	1.27	1.15	1.05	0.96

IMMERSION-COMPRESSION CPL 5104
% bitumen
PSI Wet
PSI Dry
% Absorption
% Swell
% Ret. Strength
% Additive used
Asphalt additive type

LOTTMAN	CPL 5109
5.1	% bitumen
48	Wet D.T.St.
46	Dry D.T.St (Aged)*
7.47	% Voids
4.55	% Perm Vds
105	% T.S.Ret.
0	% Additive

Optimum asphalt content 5.1
Stability at Optimum A.C. 40
Asphalt film thickness at Optimum A.C.: 7.77 microns

Lab Bulk SpG at Optimum 2.417
% Voids at Optimum A.C. 3.06

Date Rep 5/1/91

Dick Hines 757-9724
Flexible Pavement Engineer

Table 9. State Grading G Mix Design

Division of Highways
State of Colorado
Form DOH 429 Rev. 11/88

Project No: FRI(CX) 070-5(56)
Location: West of Flagler
District # 1 Subaccount: 91111
Lab # 165x - 169x, HyLm

Date Received 4 /4 /91

Field Sample # 63288

LABORATORY DESIGN for HOT BITUMINOUS PAVEMENT - CONSTRUCTION

Item 403 Grading G AC 20, Conoco
Pit name: Cooley Morrison, Mon CONTRACTOR: Popejoy

SIEVE ANALYSIS: T11 & T27, sampled by CP30

Test No.->	165x	168x	167x	169x	Hyd	As Used		Job Mix
% used-->	35.0	29.0	21.0	14.0	1.0			
1 1/2	100	100	100	100	100	100	1 1/2	100
1	100	98	44	100	100	88	1	
3/4	100	81	7	100	100	75	3/4	75
5/8	100	65	4	100	100	70	5/8	
1/2	100	33	2	100	100	60	1/2	60
3/8	100	15	1	99	100	54	3/8	
4	85	4	1	89	100	45	4	45
8	63	0	0	65	100	32	8	32
16	47	0	0	37	100	23	16	
30	38	0	0	16	100	17	30	17
50	28	0	0	4	100	11	50	
100	19	0	0	2	98	8	100	
200	11.9	0.0	0.0	1.5	97.0	5.3	200	5

TEST RESULTS				
Percent bitumen	3.5	4.0	4.5	5.0
Max Sp. Gr. T209	2.544	2.523	2.503	2.483
Bulk Sp. Gr. T166	2.370	2.358	2.396	2.419
% Voids CPL 5105	6.8	6.5	4.3	2.6
Stability CPL 5105	0	0	0	0
Modulus CPL 5110	0	0	0	0
Strength coefficient	0.44	0.44	0.44	0.44
VMA (% voids in Agg)	15.1	16.0	15.1	14.6
% of VMA filled	55	59	72	83
Dust / AC ratio	1.34	1.17	1.03	0.92

IMMERSION-COMPRESSION CPL 5104		LOTTMAN	CPL 5109
% bitumen		4.7	% bitumen
PSI Wet		30	Wet D.T.St
PSI Dry		32	Dry D.T.St
% Absorption		6.17	% Voids
% Swell		2.24	% Perm Vds
% Ret. Strength		96	% T.S.Ret.
% Additive used		0	% Additive
Asphalt additive type			

Optimum asphalt content 4.7
Stability at Optimum A.C. 0
Asphalt film thickness at Optimum A.C.: 9.43 microns

Lab Bulk SpG at Optimum 2.405
% Voids at Optimum A.C. 3.60

Date Reported 5/2/91

Dick Hines 757-9724
Flexible Pavement Engineer

Table 10. State Grading C Polymer Mix Design

Division of Highways
State of Colorado
Form DOH 429 Rev. 11/88

Date Received 04/04/91

Project No: FR(CX)070-5(56)
Location: West of Flagler
District # 1 Subaccount: 91111
Lab # 165x,170x,171x
Field Sample # 63289

LABORATORY DESIGN for HOT BITUMINOUS PAVEMENT - CONSTRUCTION

Item 403 Grading C One Point AC-20(PMS) Gyratory Compaction
Pit name: Cooley/Morr./Monks CONTRACTOR: Popejoy

SIEVE ANALYSIS: T11 & T27, sampled by CP30

Test No.->	165x	170x	171x	Hyd	As Used		Job Mix
% used-->	48.0	36.0	15.0	1.0			
1 1/2	100	100	100	100	100	1 1/2	
1	100	100	100	100	100	1	
3/4	100	100	100	100	100	3/4	100
5/8	100	75	100	100	91	5/8	
1/2	100	68	100	100	88	1/2	87
3/8	100	36	99	100	77	3/8	77
4	85	4	87	100	56	4	56
8	63	0	63	100	41	8	41
16	47	0	36	100	29	16	
30	38	0	16	100	22	30	22
50	28	0	4	100	15	50	
100	19	0	2	98	10	100	
200	11.9	0.0	1.5	97.0	6.9	200	7

TEST RESULTS

Percent bitumen	3.5	4.0
Max Sp. Gr. T209	2.542	2.521
Bulk Sp. Gr. T166	2.429	2.431
% Voids CPL 5105	4.4	3.6
Stability CPL 5105	47	41
Modulus CPL 5110	0	0
Strength coefficient	0.44	0.44
VMA (% voids in Agg)	12.9	13.3
% of VMA filled	66	73
Dust / AC ratio	1.44	1.27

IMMERSION-COMPRESSION CPL 5104

% bitumen
PSI Wet
PSI Dry
% Absorption
% Swell
% Ret. Strength
% Additive used
Asphalt additive type

LOTTMAN	CPL 5109
4.0	% bitumen
78	Wet D.T.St
78	Dry D.T.St
7.24	% Voids
4.68	% Perm Vds
100	% T.S.Ret.
0	% Additive

Optimum asphalt content 4.0
Stability at Optimum A.C. 41
Asphalt film thickness at Optimum A.C.: 7.34 microns

Lab Bulk SpG at Optimum 2.431
% Voids at Optimum A.C. 3.57

Date Reported 7/23/91

Dick Hines 757-9724
Flexible Pavement Engineer

Detailed Construction

Eleven test sections were constructed by the Colorado Department of Transportation for this SPS-5 experiment. Table 11 gives an account of daily construction activities. The rut level-up layers were placed before September 30th, prior to SHRP personnel being on site.

The weather during construction was generally clear with temperatures ranging from 50°F to 83°F. On October 4th, rain fell and temperatures dropped to between 34°F and 50°F, but this was after all sections had been completed except for the rut level-up layer on Section 080501.

The laydown temperatures for all sites fell between 255°F and 280°F, while the mixing temperatures were generally close to 280°F. Density testing was done on the sections listed in Table 12, on the various top, middle, and bottom lifts. All of the values fall within the specified 92%-96% of optimum density.

A Drum mixing plant operated by Popejoy Construction was used for this project, and was located 4 miles and approximately 10 minutes from the test sections. No major delays or problems were encountered during the construction of the test sections.

The planned pavement structure for each of these sections is shown in Table 13 and follows the experimental design for an SPS-5 project. The test sections were constructed full width, i.e., passing lane, travel lane, and shoulders. Figure 10 shows the section layout for all 11 Colorado SPS-5 test sections.

The minimum surface preparation consisted of a full lane width (i.e., not confined only to the ruts) rut level up layer, with no crack repair, sealing, or patching done. The grading of the rut level-up layer was grading CX, (Table 8) which had a maximum aggregate size of ½" compared to the maximum of ¾" for the Grading C overlay layers. Appendix A contains the transverse profile of each section before and after rehabilitation, visually showing the extent of rutting.

The intensive preparation consisted of cold milling two inches of the entire surface area, with no crack sealing or patching done after milling. The milled material was then replaced with either a virgin or recycled mix, depending on the overlay type.

After the minimum or intensive surface preparation, the sections received either a 2 or 5 inch virgin or recycled overlay. On sections which were milled, the overlay consisted of the same mix as the mill replacement layer. The 5 inch overlay was placed in two lifts; a 3 inch lift followed by a 2 inch lift.

Table 11. Detailed Construction Activities and Weather

Date	Activity	Weather
9/30/91	Place top mat on State Sections 080510 and 080511, (polymer–modified)	Cloudy, 54F to 70F
	Rotomill intensive preparation sections	
10/1/91	Place bottom mats on 080506, 080508	Clear, 56F to 82F
	Place bottom and middle mats on 080507	
10/2/91	Place remaining bottom and/or middle lifts, 080502, 080503, 080504, 080509	Clear, 60F to 81F
	both virgin and recycled.	
10/3/91	Place top mats on all sections except for 080501, 080510, and 080511.	Clear, 50F to 79F
10/4/91	No Construction Activity on SHRP Sections	Rain, 34F to 50F
10/5–7/91	No Construction Activity on SHRP Sections	
10/8/91	Place leveling course on Control 080501	Clear, 52F to 83F

Note** A Polymerized Seal Coat was placed to seal all top layers.

Table 12. Pavement Densities During Construction

Test Section	Lift	Density (% of Optimum)
080502	Top	95
080503	Bottom	92
080504	Top	92,92,93,93
080507	Top	93,93
080507	Bottom (*)	94,94,94,94
080508	Bottom (*)	94
080508	Middle	92
080509	Top	92,93
080509	Bottom (*)	93

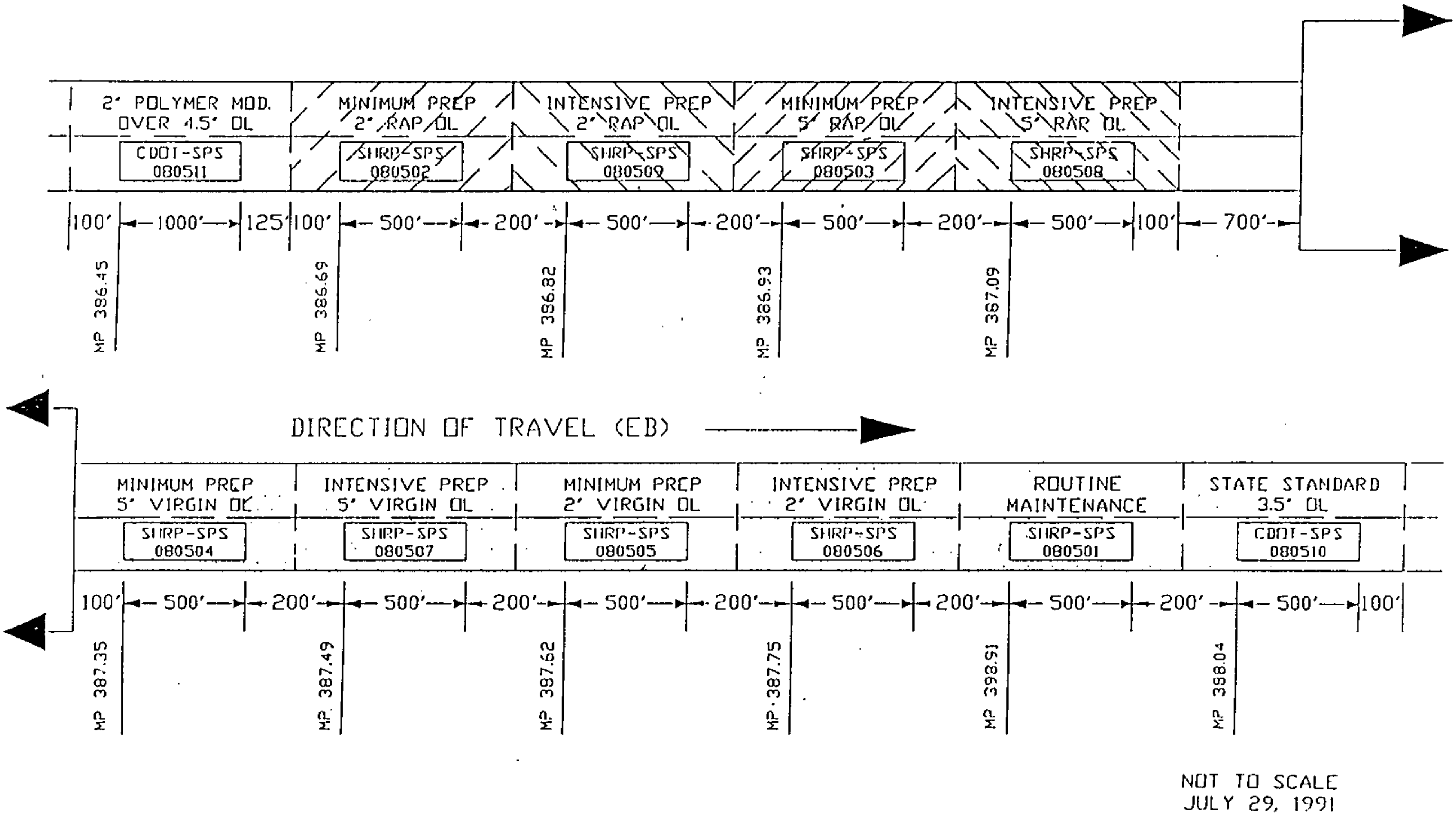
(*) Mill Fill Layer

Table 13. Planned Pavement Structure for Colorado SPS-5

Section/ Agency	Surface Preparation	Cross Section	HMAC Overlay Grading
080501 (SHRP)	Routine Maintenance	Rut Level-up Treatment	Grading CX
		Original HMAC Surface	
		Original EATB	
080502 (SHRP)		2" RAP Overlay	Grading C
	Minimum	Rut Level-up Treatment	Grading CX
		Original HMAC Surface	
		Original EATB	
080503 (SHRP)		5" RAP Overlay	Grading C
	Minimum	Rut Level-up Treatment	Grading CX
		Original HMAC Surface	
		Original EATB	
080504 (SHRP)		2" Virgin Overlay	Grading C
	Minimum	Rut Level-up Treatment	Grading CX
		Original HMAC Surface	
		Original EATB	
080505 (SHRP)		5" Virgin Overlay	Grading C
	Minimum	Rut Level-up Treatment	Grading CX
		Original HMAC Surface	
		Original EATB	
080506 (SHRP)		5" Virgin Overlay	Grading C
	Intensive	2" Virgin Mill-Fill	Grading C
		Original HMAC Surface	
		Original EATB	
080507 (SHRP)		2" Virgin Overlay	Grading C
	Intensive	2" Virgin Mill-Fill	Grading C
		Original HMAC Surface	
		Original EATB	
080508 (SHRP)		5" RAP Overlay	Grading C
	Intensive	2" RAP Mill-Fill	Grading C
		Original HMAC Surface	
		Original EATB	
080509 (SHRP)		2" RAP Overlay	Grading C
	Intensive	2" RAP Mill-Fill	Grading C
		Original HMAC Surface	
		Original EATB	
080510 (STATE)		2" HMAC Overlay	Grading C
	None	4.25" HMAC Overlay	Grading G
		Original HMAC Surface	
		Original EATB	
080511 (STATE)		2" Polymer Modified Overlay	Grading C
	None	4.25" Virgin Overlay	Grading G
		Original HMAC Surface	
		Original EATB	

Standard SHRP SPS-5 Overlay

Figure 10. Colorado SPS-5 Section Layout



The control section was originally intended to be left untreated. But due to the severity of the ruts present, there was concern about water standing in them. This could have potentially caused vehicles coming off the newly rehabilitated sections to hydroplane. There was also concern that the new raised pavement at each end of the section would cause a damming effect. Due to these concerns, a rut level-up layer was placed on the control section.

State Section 080510 consisted of 4¼" of Grading G (see mix design) asphalt concrete, followed by 2" of Grading C (see mix design) asphalt concrete. State Section 080511 received a 4¼" grading G overlay followed by a rubber modified 2" Grading C overlay. Both state sections had been scheduled for a Grading CX rut level-up layer in the special provisions. In place of the CX layer, the thickness of the 4¼" Grading G overlay was increased enough to fill in the ruts. The 4¼" overlays were placed in one lift.

Prior to completion of the SHRP 080500 project, the Colorado D.O.T. determined that they had designed the asphalt contents of their mixes too low. The mix designs for the Colorado SPS-5 were done early in 1991 during an experimental stage with the Texas Gyratory compactor. Later in 1991, it was determined that the early method of design using the Gyratory compactor resulted in optimum asphalt contents of 0.2% to 0.3% lower than the standard Hveem method of mix design. The early Gyratory design used 2½" samples, and higher compaction pressures. Upon refinement, the Gyratory design used 2" samples at lower pressures. The refinements resulted in the optimum asphalt content using the Gyratory design to be similar to the optimum using the Hveem mix design.

At the recommendation of the District Materials Engineer, a High Float Rapid Set Polymerized (HFRS-2P) seal coat was placed on the top mat of all sections as a preventative measure (to prevent stripping) due to the low asphalt content of the mixes. The HFRS-2P was used in lieu of an asphalt rejuvenating agent because CDOT felt it would provide a more durable sealant. The application rate was as directed by the resident engineer, and was approximately 0.05 gallons per square yard.

Table 14 lists the approximate after construction layer thicknesses, the planned layer thicknesses, and the thickness range. The thickness range column lists the range of pre- vs. post-construction elevations taken from Appendix A Tables A1-A11. (i.e., to develop Appendix A, an elevation survey was done prior to and after construction at the same points. Figures A1 through A33 visually show the pre- vs. post-construction elevation differences and the extent of rutting. No individual elevation surveys were done for each layer on the project.) The ranges include the rut fill material, and any excess mill/fill material over the depth that was milled. The total range therefore includes the rut fill or mill/fill layer in addition to the overlay. For example, for section 080502, the thickness range was 2.6" to 4.4" for the 2" RAP overlay over the rut fill layer. The average final thickness (from cores taken) of both layers totaled 3.8". The post construction final thicknesses were obtained from actual core measurements, and correlate well with what was planned for each section.

Table 14. Planned vs. Final Layer Thicknesses

Section/ Agency	Planned Cross Section	Planned Thickness (in)	Average Final Thickness (in) (core measurements)	Thickness Range: Rut–level or Mill–fill and/or Overlay (in)
080501 (SHRP)	Rut Level–up Treatment		1.3	0.7 – 2.3
	Original HMAC Surface		5.4	
	Original EATB		3.6	
080502 (SHRP)	RAP Overlay	2	2.5	2.6 – 4.4
	Rut Level–up Treatment		1.3	
	Original HMAC Surface		5.4	
	Original EATB		2.7	
080503 (SHRP)	RAP Overlay	5	4.5	3.8 – 7.7
	Rut Level–up Treatment		0.9	
	Original HMAC Surface		5	
	Original EATB		2.1	
080504 (SHRP)	Virgin Overlay	5	5.1	3.7 – 7.1
	Rut Level–up Treatment		0.7	
	Original HMAC Surface		4.6	
	Original EATB		3.5	
080505 (SHRP)	Virgin Overlay	2	2.5	1.7 – 4.3
	Rut Level–up Treatment		0.7	
	Original HMAC Surface		6.4	
	Original EATB		3	
080506 (SHRP)	Virgin Overlay	2	2.4	1.3 – 4.0
	Virgin Mill–Fill	2	2	
	Original HMAC Surface		4.5	
	Original EATB		3.4	
080507 (SHRP)	Virgin Overlay	5	4.8	3.8 – 7.4
	Virgin Mill–Fill	2	2	
	Original HMAC Surface		3.8	
	Original EATB		2.9	
080508 (SHRP)	RAP Overlay	5	5.1	3.4 – 6.6
	RAP Mill–Fill	2	2.8	
	Original HMAC Surface		2.2	
	Original EATB		2	
080509 (SHRP)	RAP Overlay	2	2.2	1.6 – 3.8
	RAP Mill–Fill	2	2	
	Original HMAC Surface		3.1	
	Original EATB		2.7	
080510 (STATE)	HMAC Overlay	2	2.5	3.0 – 9.2
	HMAC Overlay	4.25	4.1	
	Original HMAC Surface		6.4	
	Original EATB		3.9	
080511 (STATE)	Polymer Modified Overlay	2	1.9	4.6 – 7.7
	Virgin Overlay	4.25	4.2	
	Original HMAC Surface		5.7	
	Original EATB		2.5	

(shaded) Standard SHRP SPS–5 Overlay

APPENDIX A

PRE VS POST CONSTRUCTION
ELEVATION DIFFERENCES

Table A1 Pre vs Post Construction Elevation Differences

SECTION 080501	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	98.69	98.68	98.73	98.7	98.84
	98.78	98.82	98.84	98.87	98.9
EL. DIFF. (FEET)	0.09	0.14	0.11	0.17	0.06
EL. DIFF.(INCHES)	1.08	1.68	1.32	2.04	0.72
0+50	98.36	98.37	98.45	98.41	98.55
	98.46	98.51	98.55	98.58	98.62
EL. DIFF. (FEET)	0.1	0.14	0.1	0.17	0.07
EL. DIFF.(INCHES)	1.2	1.68	1.2	2.04	0.84
1+00	98.06	98.08	98.16	98.14	98.26
	98.17	98.23	98.27	98.3	98.34
EL. DIFF. (FEET)	0.11	0.15	0.11	0.16	0.08
EL. DIFF.(INCHES)	1.32	1.8	1.32	1.92	0.96
1+50	97.76	97.76	97.83	97.79	97.91
	97.86	97.91	97.93	97.97	98
EL. DIFF. (FEET)	0.1	0.15	0.1	0.18	0.09
EL. DIFF.(INCHES)	1.2	1.8	1.2	2.16	1.08
2+00	97.44	97.49	97.54	97.52	97.66
	97.56	97.63	97.66	97.7	97.74
EL. DIFF. (FEET)	0.12	0.14	0.12	0.18	0.08
EL. DIFF.(INCHES)	1.44	1.68	1.44	2.16	0.96
2+50	97.14	97.16	97.23	97.22	97.36
	97.24	97.31	97.37	97.41	97.45
EL. DIFF. (FEET)	0.1	0.15	0.14	0.19	0.09
EL. DIFF.(INCHES)	1.2	1.8	1.68	2.28	1.08
3+00	96.86	96.85	96.93	96.89	97.01
	96.94	96.98	97.01	97.02	97.08
EL. DIFF. (FEET)	0.08	0.13	0.08	0.13	0.07
EL. DIFF.(INCHES)	0.96	1.56	0.96	1.56	0.84
3+50	96.53	96.54	96.6	96.59	96.67
	96.62	96.66	96.7	96.72	96.77
EL. DIFF. (FEET)	0.09	0.12	0.1	0.13	0.1
EL. DIFF.(INCHES)	1.08	1.44	1.2	1.56	1.2
4+00	96.21	96.2	96.26	96.24	96.33
	96.28	96.32	96.35	96.36	96.38
EL. DIFF. (FEET)	0.07	0.12	0.09	0.12	0.05
EL. DIFF.(INCHES)	0.84	1.44	1.08	1.44	0.6
4+50	95.77	95.78	95.84	95.82	95.94
	95.85	95.88	95.91	95.95	96
EL. DIFF. (FEET)	0.08	0.1	0.07	0.13	0.06
EL. DIFF.(INCHES)	0.96	1.2	0.84	1.56	0.72
5+00	95.41	95.38	95.45	95.44	95.56
	95.48	95.5	95.52	95.56	95.62
EL. DIFF. (FEET)	0.07	0.12	0.07	0.12	0.06
EL. DIFF.(INCHES)	0.84	1.44	0.84	1.44	0.72
Average New Thickness/offset	1.10	1.59	1.19	1.83	0.88
Standard Deviation/offset	0.18	0.19	0.24	0.31	0.18
Average New Thickness/section	1.32				
Standard Deviation/section	0.39				

Table A2 Pre vs Post Construction Elevation Differences

SECTION 08502	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	100.27	100.25	100.36	100.32	100.46
	100.49	100.57	100.62	100.65	100.7
EL. DIFF. (FEET)	0.22	0.32	0.26	0.33	0.24
EL. DIFF.(INCHES)	2.64	3.84	3.12	3.96	2.88
0+50	100	99.97	99.99	100.05	100.16
	100.23	100.29	100.34	100.38	100.42
EL. DIFF. (FEET)	0.23	0.32	0.35	0.33	0.26
EL. DIFF.(INCHES)	2.76	3.84	4.2	3.96	3.12
1+00	99.59	99.57	99.7	99.66	99.79
	99.84	99.89	99.96	99.99	100.04
EL. DIFF. (FEET)	0.25	0.32	0.26	0.33	0.25
EL. DIFF.(INCHES)	3	3.84	3.12	3.96	3
1+50	99.24	99.22	99.36	99.27	99.41
	99.48	99.54	99.6	99.64	99.67
EL. DIFF. (FEET)	0.24	0.32	0.24	0.37	0.26
EL. DIFF.(INCHES)	2.88	3.84	2.88	4.44	3.12
2+00	98.95	98.94	99.02	98.98	99.1
	99.21	99.25	99.3	99.35	99.37
EL. DIFF. (FEET)	0.26	0.31	0.28	0.37	0.27
EL. DIFF.(INCHES)	3.12	3.72	3.36	4.44	3.24
2+50	98.59	98.56	98.63	98.61	98.73
	98.84	98.89	98.92	98.97	99.01
EL. DIFF. (FEET)	0.25	0.33	0.29	0.36	0.28
EL. DIFF.(INCHES)	3	3.96	3.48	4.32	3.36
3+00	98.25	98.24	98.32	98.29	98.39
	98.5	98.55	98.6	98.64	98.67
EL. DIFF. (FEET)	0.25	0.31	0.28	0.35	0.28
EL. DIFF.(INCHES)	3	3.72	3.36	4.2	3.36
3+50	97.99	97.95	98.02	97.99	98.09
	98.22	98.27	98.31	98.35	98.37
EL. DIFF. (FEET)	0.23	0.32	0.29	0.36	0.28
EL. DIFF.(INCHES)	2.76	3.84	3.48	4.32	3.36
4+00	97.64	97.61	97.7	97.65	97.75
	97.88	97.93	97.97	98	98.03
EL. DIFF. (FEET)	0.24	0.32	0.27	0.35	0.28
EL. DIFF.(INCHES)	2.88	3.84	3.24	4.2	3.36
4+50	97.32	97.3	97.37	97.38	97.5
	97.56	97.63	97.69	97.73	97.76
EL. DIFF. (FEET)	0.24	0.33	0.32	0.35	0.26
EL. DIFF.(INCHES)	2.88	3.96	3.84	4.2	3.12
5+00	97.18	97.16	97.3	97.24	97.37
	97.4	97.48	97.55	97.59	97.61
EL. DIFF. (FEET)	0.22	0.32	0.25	0.35	0.24
EL. DIFF.(INCHES)	2.64	3.84	3	4.2	2.88
Average New Thickness/offset	2.87	3.84	3.37	4.20	3.16
Standard Deviation/offset	0.15	0.07	0.36	0.17	0.18
Average New Thickness/section	3.49				
Standard Deviation/section	0.54				

Table A3 Pre vs Post Construction Elevation Differences

SECTION 080503	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	100.02	100	100.08	100.06	100.19
	100.37	100.45	100.5	100.56	100.61
EL. DIFF. (FEET)	0.35	0.45	0.42	0.5	0.42
EL. DIFF.(INCHES)	4.2	5.4	5.04	6	5.04
0+50	99.96	99.94	100.03	99.99	100.15
	100.32	100.58	100.45	100.5	100.55
EL. DIFF. (FEET)	0.36	0.64	0.42	0.51	0.4
EL. DIFF.(INCHES)	4.32	7.68	5.04	6.12	4.8
1+00	99.92	99.9	100	99.98	100.12
	100.29	100.35	100.42	100.47	100.52
EL. DIFF. (FEET)	0.37	0.45	0.42	0.49	0.4
EL. DIFF.(INCHES)	4.44	5.4	5.04	5.88	4.8
1+50	99.86	99.88	99.97	99.95	100.08
	100.23	100.32	100.39	100.45	100.49
EL. DIFF. (FEET)	0.37	0.44	0.42	0.5	0.41
EL. DIFF.(INCHES)	4.44	5.28	5.04	6	4.92
2+00	99.69	99.71	99.8	99.79	99.93
	100.1	100.19	100.27	100.32	100.37
EL. DIFF. (FEET)	0.41	0.48	0.47	0.53	0.44
EL. DIFF.(INCHES)	4.92	5.76	5.64	6.36	5.28
2+50	99.67	99.63	99.75	99.71	99.84
	100.05	100.11	100.17	100.24	100.28
EL. DIFF. (FEET)	0.38	0.48	0.42	0.53	0.44
EL. DIFF.(INCHES)	4.56	5.76	5.04	6.36	5.28
3+00	99.61	99.6	99.68	99.66	99.79
	100.02	100.09	100.05	100.18	100.21
EL. DIFF. (FEET)	0.41	0.49	0.37	0.52	0.42
EL. DIFF.(INCHES)	4.92	5.88	4.44	6.24	5.04
3+50	99.53	99.52	99.59	99.6	99.72
	99.93	100	100.05	100.11	100.13
EL. DIFF. (FEET)	0.4	0.48	0.46	0.51	0.41
EL. DIFF.(INCHES)	4.8	5.76	5.52	6.12	4.92
4+00	99.47	99.43	99.54	99.51	99.63
	99.85	99.93	99.97	100.02	100.06
EL. DIFF. (FEET)	0.38	0.5	0.43	0.51	0.43
EL. DIFF.(INCHES)	4.56	6	5.16	6.12	5.16
4+50	99.39	99.34	99.43	99.38	99.5
	99.73	99.8	99.85	99.9	99.93
EL. DIFF. (FEET)	0.34	0.46	0.42	0.52	0.43
EL. DIFF.(INCHES)	4.08	5.52	5.04	6.24	5.16
5+00	99.27	99.22	99.3	99.26	99.42
	99.59	99.66	99.72	99.78	99.83
EL. DIFF. (FEET)	0.32	0.44	0.42	0.52	0.41
EL. DIFF.(INCHES)	3.84	5.28	5.04	6.24	4.92
Average New Thickness/offset	4.46	5.79	5.09	6.15	5.03
Standard Deviation/offset	0.33	0.64	0.29	0.15	0.17
Average New Thickness/section	5.31				
Standard Deviation/section	0.73				

Table A4 Pre vs Post Construction Elevation Differences

SECTION 080504	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	101.38	101.42	101.49	101.51	101.62
	101.89	101.95	101.99	102.05	102.09
EL. DIFF. (FEET)	0.51	0.53	0.5	0.54	0.47
EL. DIFF.(INCHES)	6.12	6.36	6	6.48	5.64
0+50	101.22	101.19	101.27	101.25	101.37
	101.68	101.74	101.79	101.83	101.87
EL. DIFF. (FEET)	0.46	0.55	0.52	0.58	0.5
EL. DIFF.(INCHES)	5.52	6.6	6.24	6.96	6
1+00	101.01	100.98	101.09	101.07	101.21
	101.48	101.55	101.62	101.66	101.72
EL. DIFF. (FEET)	0.47	0.57	0.53	0.59	0.51
EL. DIFF.(INCHES)	5.64	6.84	6.36	7.08	6.12
1+50	100.86	100.85	100.96	100.95	101.07
	101.35	101.41	101.47	101.52	101.57
EL. DIFF. (FEET)	0.49	0.56	0.51	0.57	0.5
EL. DIFF.(INCHES)	5.88	6.72	6.12	6.84	6
2+00	100.72	100.71	100.81	100.81	100.95
	101.21	101.28	101.33	101.38	101.43
EL. DIFF. (FEET)	0.49	0.57	0.52	0.57	0.48
EL. DIFF.(INCHES)	5.88	6.84	6.24	6.84	5.76
2+50	100.55	100.58	100.67	100.66	100.81
	101.07	101.13	101.19	101.24	101.3
EL. DIFF. (FEET)	0.52	0.55	0.52	0.58	0.49
EL. DIFF.(INCHES)	6.24	6.6	6.24	6.96	5.88
3+00	100.46	100.44	100.55	100.55	100.68
	100.95	101.01	101.07	101.12	101.17
EL. DIFF. (FEET)	0.49	0.57	0.52	0.57	0.49
EL. DIFF.(INCHES)	5.88	6.84	6.24	6.84	5.88
3+50	100.35	100.33	100.45	100.44	100.59
	100.85	100.9	100.96	101.01	101.03
EL. DIFF. (FEET)	0.5	0.57	0.51	0.57	0.44
EL. DIFF.(INCHES)	6	6.84	6.12	6.84	5.28
4+00	100.33	100.31	100.41	100.38	100.5
	100.78	100.84	100.88	100.93	100.96
EL. DIFF. (FEET)	0.45	0.53	0.47	0.55	0.46
EL. DIFF.(INCHES)	5.4	6.36	5.64	6.6	5.52
4+50	100.22	100.19	100.33	100.27	100.4
	100.68	100.73	100.78	100.82	100.85
EL. DIFF. (FEET)	0.46	0.54	0.45	0.55	0.45
EL. DIFF.(INCHES)	5.52	6.48	5.4	6.6	5.4
5+00	100.23	100.19	100.26	100.21	100.33
	100.54	100.6	100.64	100.69	100.72
EL. DIFF. (FEET)	0.31	0.41	0.38	0.48	0.39
EL. DIFF.(INCHES)	3.72	4.92	4.56	5.76	4.68
Average New Thickness/offset	5.62	6.49	5.92	6.71	5.65
Standard Deviation/offset	0.65	0.53	0.51	0.34	0.40
Average New Thickness/section	6.08				
Standard Deviation/section	0.65				

Table A5 Pre vs Post Construction Elevation Differences

SECTION 080505	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	101.6	101.58	101.66	101.64	101.77
	101.8	101.86	101.91	101.96	101.99
EL. DIFF. (FEET)	0.2	0.28	0.25	0.32	0.22
EL. DIFF.(INCHES)	2.4	3.36	3	3.84	2.64
0+50	101.63	101.61	101.66	101.63	101.79
	101.82	101.9	101.95	101.99	102
EL. DIFF. (FEET)	0.19	0.29	0.29	0.36	0.21
EL. DIFF.(INCHES)	2.28	3.48	3.48	4.32	2.52
1+00	101.73	101.71	101.8	101.74	101.89
	101.93	101.99	102.03	102.07	102.07
EL. DIFF. (FEET)	0.2	0.28	0.23	0.33	0.18
EL. DIFF.(INCHES)	2.4	3.36	2.76	3.96	2.16
1+50	101.87	101.81	101.86	101.82	101.92
	102.02	102.06	102.11	102.12	102.14
EL. DIFF. (FEET)	0.15	0.25	0.25	0.3	0.22
EL. DIFF.(INCHES)	1.8	3	3	3.6	2.64
2+00	101.9	101.86	101.93	101.9	102.01
	102.06	102.13	102.16	102.22	102.22
EL. DIFF. (FEET)	0.16	0.27	0.23	0.32	0.21
EL. DIFF.(INCHES)	1.92	3.24	2.76	3.84	2.52
2+50	101.93	101.9	101.96	101.94	102.07
	102.07	102.15	102.21	102.25	102.3
EL. DIFF. (FEET)	0.14	0.25	0.25	0.31	0.23
EL. DIFF.(INCHES)	1.68	3	3	3.72	2.76
3+00	101.9	101.89	102.22	102.2	102.05
	102.07	102.15	102.22	102.25	102.28
EL. DIFF. (FEET)	0.17	0.26	0	0.05	0.23
EL. DIFF.(INCHES)	2.04	3.12			2.76
3+50	101.74	101.78	101.87	101.85	102
	101.97	102.05	102.12	102.17	102.21
EL. DIFF. (FEET)	0.23	0.27	0.25	0.32	0.21
EL. DIFF.(INCHES)	2.76	3.24	3	3.84	2.52
4+00	101.62	101.65	101.73	101.73	101.89
	101.86	101.94	102.01	102.05	102.1
EL. DIFF. (FEET)	0.24	0.29	0.28	0.32	0.21
EL. DIFF.(INCHES)	2.88	3.48	3.36	3.84	2.52
4+50	101.38	101.41	101.49	101.48	101.62
	101.61	101.7	101.75	101.81	101.84
EL. DIFF. (FEET)	0.23	0.29	0.26	0.33	0.22
EL. DIFF.(INCHES)	2.76	3.48	3.12	3.96	2.64
5+00	101.04	101.02	101.11	101.11	101.24
	101.24	101.32	101.39	101.43	101.46
EL. DIFF. (FEET)	0.2	0.3	0.28	0.32	0.22
EL. DIFF.(INCHES)	2.4	3.6	3.36	3.84	2.64
Average New Thickness/offset	2.30	3.31	2.80	3.52	2.57
Standard Deviation/offset	0.39	0.19	0.23	0.18	0.16
Average New Thickness/section	2.90				
Standard Deviation/section	0.62				

Table A6 Pre vs Post Construction Elevation Differences

SECTION 080506	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	102.33	102.31	102.39	102.36	102.48
	102.44	102.5	102.57	102.62	102.65
EL. DIFF. (FEET)	0.11	0.19	0.18	0.26	0.17
EL. DIFF.(INCHES)	1.32	2.28	2.16	3.12	2.04
0+50	102.01	102.02	102.05	102.04	102.16
	102.22	102.26	102.3	102.35	102.37
EL. DIFF. (FEET)	0.21	0.24	0.25	0.31	0.21
EL. DIFF.(INCHES)	2.52	2.88	3	3.72	2.52
1+00	101.66	101.75	101.76	101.76	101.89
	101.89	101.95	102.01	102.05	102.07
EL. DIFF. (FEET)	0.23	0.2	0.25	0.29	0.18
EL. DIFF.(INCHES)	2.76	2.4	3	3.48	2.16
1+50	101.35	101.34	101.41	101.43	101.55
	101.59	101.65	101.68	101.72	101.75
EL. DIFF. (FEET)	0.24	0.31	0.27	0.29	0.2
EL. DIFF.(INCHES)	2.88	3.72	3.24	3.48	2.4
2+00	101.31	101.28	101.37	101.11	101.23
	101.29	101.33	101.36	101.4	101.42
EL. DIFF. (FEET)	-0.02	0.05	-0.01	0.29	0.19
EL. DIFF.(INCHES)				3.48	2.28
2+50	100.63	100.6	100.68	100.7	100.87
	100.87	99.9	99.96	101.01	101.03
EL. DIFF. (FEET)	0.24	-0.7	-0.72	0.31	0.16
EL. DIFF.(INCHES)				3.72	1.92
3+00	100.46	100.18	100.27	100.28	100.42
	100.46	100.5	100.54	100.59	100.63
EL. DIFF. (FEET)	0	0.32	0.27	0.31	0.21
EL. DIFF.(INCHES)				3.72	2.52
3+50	99.79	99.78	99.88	99.84	99.99
	100.06	100.11	100.15	100.17	100.2
EL. DIFF. (FEET)	0.27	0.33	0.27	0.33	0.21
EL. DIFF.(INCHES)	3.24	3.96	3.24	3.96	2.52
4+00	99.49	99.5	99.58	99.56	99.73
	99.74	99.79	99.83	99.87	99.88
EL. DIFF. (FEET)	0.25	0.29	0.25	0.31	0.15
EL. DIFF.(INCHES)	3	3.48	3	3.72	1.8
4+50	99.13	99.14	99.2	99.18	99.32
	99.36	99.4	99.44	99.48	99.5
EL. DIFF. (FEET)	0.23	0.26	0.24	0.3	0.18
EL. DIFF.(INCHES)	2.76	3.12	2.88	3.6	2.16
5+00	98.85	98.8	98.88	98.84	98.98
	99.02	99.05	99.08	99.1	99.12
EL. DIFF. (FEET)	0.17	0.25	0.2	0.26	0.14
EL. DIFF.(INCHES)	2.04	3	2.4	3.12	1.68
Average New Thickness/offset	1.87	2.26	2.08	3.56	2.18
Standard Deviation/offset	0.58	0.56	0.36	0.25	0.28
Average New Thickness/station	2.39				
Standard Deviation/station	0.61				

Table A7 Pre vs Post Construction Elevation Differences

SECTION 080507	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	101.37	101.32	101.38	101.32	101.41
	101.69	101.76	101.8	101.86	101.9
EL. DIFF. (FEET)	0.32	0.44	0.42	0.54	0.49
EL. DIFF.(INCHES)	3.84	5.28	5.04	6.48	5.88
0+50	101.42	101.39	101.47	101.44	101.53
	101.78	101.83	101.88	101.95	101.96
EL. DIFF. (FEET)	0.36	0.44	0.41	0.51	0.43
EL. DIFF.(INCHES)	4.32	5.28	4.92	6.12	5.16
1+00	101.52	101.5	101.57	101.54	101.65
	101.9	101.97	102.03	102.07	102.09
EL. DIFF. (FEET)	0.38	0.47	0.46	0.53	0.44
EL. DIFF.(INCHES)	4.56	5.64	5.52	6.36	5.28
1+50	101.51	101.5	101.59	101.55	101.65
	101.96	102.02	102.08	102.11	102.12
EL. DIFF. (FEET)	0.45	0.52	0.49	0.56	0.47
EL. DIFF.(INCHES)	5.4	6.24	5.88	6.72	5.64
2+00	101.66	101.62	101.72	101.68	101.76
	102.07	102.14	102.17	102.23	102.25
EL. DIFF. (FEET)	0.41	0.52	0.45	0.55	0.49
EL. DIFF.(INCHES)	4.92	6.24	5.4	6.6	5.88
2+50	101.73	101.7	101.82	101.77	101.9
	102.18	102.24	102.31	102.35	102.37
EL. DIFF. (FEET)	0.45	0.54	0.49	0.58	0.47
EL. DIFF.(INCHES)	5.4	6.48	5.88	6.96	5.64
3+00	101.87	101.86	101.95	101.87	102.01
	102.32	102.38	102.45	102.49	102.51
EL. DIFF. (FEET)	0.45	0.52	0.5	0.62	0.5
EL. DIFF.(INCHES)	5.4	6.24	6	7.44	6
3+50	101.96	101.94	102.02	102	102.1
	102.42	102.48	102.55	102.59	102.61
EL. DIFF. (FEET)	0.46	0.54	0.53	0.59	0.51
EL. DIFF.(INCHES)	5.52	6.48	6.36	7.08	6.12
4+00	101.97	101.94	102.06	102.01	102.12
	102.44	102.5	102.56	102.6	102.61
EL. DIFF. (FEET)	0.47	0.56	0.5	0.59	0.49
EL. DIFF.(INCHES)	5.64	6.72	6	7.08	5.88
4+50	102.02	101.97	102.07	102.05	102.2
	102.46	102.52	102.58	102.62	102.63
EL. DIFF. (FEET)	0.44	0.55	0.51	0.57	0.43
EL. DIFF.(INCHES)	5.28	6.6	6.12	6.84	5.16
5+00	102.19	102.13	102.23	102.18	102.29
	102.63	102.67	102.73	102.76	102.77
EL. DIFF. (FEET)	0.44	0.54	0.5	0.58	0.48
EL. DIFF.(INCHES)	5.28	6.48	6	6.96	5.76
Average New Thickness/offset	5.05	6.15	5.74	6.79	5.67
Standard Deviation/offset	0.55	0.49	0.44	0.36	0.32
Average New Thickness/section	5.88				
Standard Deviation/section	2.66				

Table A8 Pre vs Post Construction Elevation Differences

SECTION 080508	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	99.2	99.19	99.29	99.24	99.37
	99.63	99.68	99.74	99.79	99.82
EL. DIFF. (FEET)	0.43	0.49	0.45	0.55	0.45
EL. DIFF.(INCHES)	5.16	5.88	5.4	6.6	5.4
0+50	99.18	99.16	99.22	99.18	99.29
	99.56	99.61	99.67	99.71	99.75
EL. DIFF. (FEET)	0.38	0.45	0.45	0.53	0.46
EL. DIFF.(INCHES)	4.56	5.4	5.4	6.36	5.52
1+00	99.2	99.18	99.23	99.19	99.29
	99.56	99.6	99.66	99.72	99.77
EL. DIFF. (FEET)	0.36	0.42	0.43	0.53	0.48
EL. DIFF.(INCHES)	4.32	5.04	5.16	6.36	5.76
1+50	99.28	99.25	99.32	99.28	99.39
	99.63	99.69	99.74	99.8	99.84
EL. DIFF. (FEET)	0.35	0.44	0.42	0.52	0.45
EL. DIFF.(INCHES)	4.2	5.28	5.04	6.24	5.4
2+00	99.33	99.3	99.36	99.35	99.45
	99.71	99.76	99.81	99.87	99.9
EL. DIFF. (FEET)	0.38	0.46	0.45	0.52	0.45
EL. DIFF.(INCHES)	4.56	5.52	5.4	6.24	5.4
2+50	99.41	99.39	99.45	99.4	99.5
	99.78	99.85	99.89	99.93	99.97
EL. DIFF. (FEET)	0.37	0.46	0.44	0.53	0.47
EL. DIFF.(INCHES)	4.44	5.52	5.28	6.36	5.64
3+00	99.73	99.45	99.51	99.47	99.56
	99.83	99.9	99.94	100	100.02
EL. DIFF. (FEET)	0.1	0.45	0.43	0.53	0.46
EL. DIFF.(INCHES)		5.4	5.16	6.36	5.52
3+50	99.53	99.48	99.55	99.5	99.6
	99.87	99.94	99.97	100.01	100.03
EL. DIFF. (FEET)	0.34	0.46	0.42	0.51	0.43
EL. DIFF.(INCHES)	4.08	5.52	5.04	6.12	5.16
4+00	99.52	99.47	99.54	99.49	99.59
	99.8	99.87	99.93	99.98	100
EL. DIFF. (FEET)	0.28	0.4	0.39	0.49	0.41
EL. DIFF.(INCHES)	3.36	4.8	4.68	5.88	4.92
4+50	99.56	99.53	99.59	99.54	99.63
	99.88	99.95	99.99	100.03	100.06
EL. DIFF. (FEET)	0.32	0.42	0.4	0.49	0.43
EL. DIFF.(INCHES)	3.84	5.04	4.8	5.88	5.16
5+00	99.7	99.66	99.72	99.68	99.78
	100.06	100.1	100.15	100.18	100.19
EL. DIFF. (FEET)	0.36	0.44	0.43	0.5	0.41
EL. DIFF.(INCHES)	4.32	5.28	5.16	6	4.92
Average New Thickness/offset	3.89	5.33	5.14	6.22	5.35
Standard Deviation/offset	0.45	0.29	0.24	0.22	0.27
Average New Thickness/section	5.19				
Standard Deviation/section	0.71				

Table A9 Pre vs Post Construction Elevation Differences

SECTION 080509	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	98.18	98.2	98.33	98.27	98.41
	98.42	98.48	98.55	98.59	98.61
EL. DIFF. (FEET)	0.24	0.28	0.22	0.32	0.2
EL. DIFF.(INCHES)	2.88	3.36	2.64	3.84	2.4
0+00	98.23	98.23	98.32	98.31	98.42
	98.44	98.5	98.54	98.58	98.61
EL. DIFF. (FEET)	0.21	0.27	0.22	0.27	0.19
EL. DIFF.(INCHES)	2.52	3.24	2.64	3.24	2.28
1+00	98.29	98.3	98.43	98.39	98.52
	98.51	98.57	98.62	98.67	98.71
EL. DIFF. (FEET)	0.22	0.27	0.19	0.28	0.19
EL. DIFF.(INCHES)	2.64	3.24	2.28	3.36	2.28
1+50	98.34	98.38	98.49	98.46	98.6
	98.55	98.63	98.7	98.74	98.78
EL. DIFF. (FEET)	0.21	0.25	0.21	0.28	0.18
EL. DIFF.(INCHES)	2.52	3	2.52	3.36	2.16
2+00	98.53	98.58	98.7	98.68	98.83
	98.76	98.83	98.88	98.94	98.96
EL. DIFF. (FEET)	0.23	0.25	0.18	0.26	0.13
EL. DIFF.(INCHES)	2.76	3	2.16	3.12	1.56
2+50	98.74	98.71	98.86	98.85	98.97
	98.91	98.97	98.93	99.1	99.11
EL. DIFF. (FEET)	0.17	0.26	0.07	0.25	0.14
EL. DIFF.(INCHES)	2.04	3.12	0.84	3	1.68
3+00	98.91	98.92	99.04	98.99	99.13
	99.12	99.2	99.24	99.28	99.31
EL. DIFF. (FEET)	0.21	0.28	0.2	0.29	0.18
EL. DIFF.(INCHES)	2.52	3.36	2.4	3.48	2.16
3+50	98.98	99	99.09	99.05	99.16
	99.17	99.24	99.27	99.32	99.35
EL. DIFF. (FEET)	0.19	0.24	0.18	0.27	0.19
EL. DIFF.(INCHES)	2.28	2.88	2.16	3.24	2.28
4+00	99.04	99.05	99.14	99.12	99.28
	99.21	99.29	99.34	99.39	99.41
EL. DIFF. (FEET)	0.17	0.24	0.2	0.27	0.13
EL. DIFF.(INCHES)	2.04	2.88	2.4	3.24	1.56
4+00	99.13	99.14	99.24	99.21	99.34
	99.29	99.37	99.41	99.45	99.48
EL. DIFF. (FEET)	0.16	0.23	0.17	0.24	0.14
EL. DIFF.(INCHES)	1.92	2.76	2.04	2.88	1.68
5+00	99.17	99.19	99.26	99.23	99.4
	99.32	99.39	99.44	99.5	99.55
EL. DIFF. (FEET)	0.15	0.2	0.18	0.27	0.15
EL. DIFF.(INCHES)	1.8	2.4	2.16	3.24	1.8
Average New Thickness/offset	2.36	3.02	2.20	3.27	1.99
Standard Deviation/offset	0.34	0.27	0.47	0.24	0.31
Average New Thickness/section	2.57				
Standard Deviation/section	0.57				

Table A10 Pre vs Post Construction Elevation Differences

SECTION 080510	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	98.51	98.5	98.58	98.55	98.67
	98.76	98.83	98.85	98.9	98.93
EL. DIFF. (FEET)	0.25	0.33	0.27	0.35	0.26
EL. DIFF.(INCHES)	3	3.96	3.24	4.2	3.12
0+50	98.24	98.23	98.29	98.23	98.4
	98.75	98.81	98.84	98.88	98.9
EL. DIFF. (FEET)	0.51	0.58	0.55	0.65	0.5
EL. DIFF.(INCHES)	6.12	6.96	6.6	7.8	6
1+00	98.03	97.99	98.06	98.01	98.16
	98.55	98.6	98.61	98.66	98.69
EL. DIFF. (FEET)	0.52	0.61	0.55	0.65	0.53
EL. DIFF.(INCHES)	6.24	7.32	6.6	7.8	6.36
1+50	97.8	97.77	97.84	97.8	97.91
	98.29	98.36	98.37	98.41	98.44
EL. DIFF. (FEET)	0.49	0.59	0.53	0.61	0.53
EL. DIFF.(INCHES)	5.88	7.08	6.36	7.32	6.36
2+00	97.6	97.58	97.63	97.61	97.74
	98.08	98.14	98.17	98.2	98.24
EL. DIFF. (FEET)	0.48	0.56	0.54	0.59	0.5
EL. DIFF.(INCHES)	5.76	6.72	6.48	7.08	6
2+50	97.49	97.46	97.52	97.49	97.6
	98.02	98.09	98.12	98.16	98.19
EL. DIFF. (FEET)	0.53	0.63	0.6	0.67	0.59
EL. DIFF.(INCHES)	6.36	7.56	7.2	8.04	7.08
3+00	97.42	97.41	97.47	97.43	97.54
	98	98.06	98.09	98.13	98.14
EL. DIFF. (FEET)	0.58	0.65	0.62	0.7	0.6
EL. DIFF.(INCHES)	6.96	7.8	7.44	8.4	7.2
3+50	97.35	97.35	97.4	97.37	97.5
	97.88	97.96	98	98.04	98.05
EL. DIFF. (FEET)	0.53	0.61	0.6	0.67	0.55
EL. DIFF.(INCHES)	6.36	7.32	7.2	8.04	6.6
4+00	97.23	97.21	97.29	97.23	97.36
	97.73	97.8	97.85	97.88	97.9
EL. DIFF. (FEET)	0.5	0.59	0.56	0.65	0.54
EL. DIFF.(INCHES)	6	7.08	6.72	7.8	6.48
4+50	97.04	97.01	97.09	96.99	97.14
	97.57	97.64	97.7	97.76	97.78
EL. DIFF. (FEET)	0.53	0.63	0.61	0.77	0.64
EL. DIFF.(INCHES)	6.36	7.56	7.32	9.24	7.68
5+00	96.95	96.94	97	96.97	97.09
	97.51	97.58	97.63	97.67	97.69
EL. DIFF. (FEET)	0.56	0.64	0.63	0.7	0.6
EL. DIFF.(INCHES)	6.72	7.68	7.56	8.4	7.2
Average New Thickness/offset	6.52	7.65	7.22	8.36	6.96
Standard Deviation/offset	1.00	1.01	1.14	1.22	1.15
Average New Thickness/section	7.34				
Standard deviation/section	1.31				

Table A11 Pre vs Post Construction Elevation Differences

Section 080511	L/E	OWP	CL	IWP	L/L
	0	3	6	9	12
0+00	100.1	100.06	100.15	100.12	100.24
	100.63	100.66	100.7	100.76	100.78
EL. DIFF. (FEET)	0.53	0.6	0.55	0.64	0.54
EL. DIFF.(INCHES)	6.36	7.2	6.6	7.68	6.48
0+50	99.63	99.61	99.72	99.69	99.8
	100.11	100.21	100.25	100.31	100.32
EL. DIFF. (FEET)	0.48	0.6	0.53	0.62	0.52
EL. DIFF.(INCHES)	5.76	7.2	6.36	7.44	6.24
1+00	99.3	99.28	99.35	99.32	99.46
	99.7	99.8	99.85	99.91	99.94
EL. DIFF. (FEET)	0.4	0.52	0.5	0.59	0.48
EL. DIFF.(INCHES)	4.8	6.24	6	7.08	5.76
1+50	99	98.98	99.08	99.06	99.2
	99.39	99.49	99.57	99.63	99.67
EL. DIFF. (FEET)	0.39	0.51	0.49	0.57	0.47
EL. DIFF.(INCHES)	4.68	6.12	5.88	6.84	5.64
2+00	98.67	98.63	98.71	98.68	98.82
	99.08	99.15	99.21	99.27	99.32
EL. DIFF. (FEET)	0.41	0.52	0.5	0.59	0.5
EL. DIFF.(INCHES)	4.92	6.24	6	7.08	6
2+50	98.39	98.32	98.42	98.36	98.55
	98.79	98.85	98.89	98.97	99.02
EL. DIFF. (FEET)	0.4	0.53	0.47	0.61	0.47
EL. DIFF.(INCHES)	4.8	6.36	5.64	7.32	5.64
3+00	98.12	98.1	98.19	98.17	98.32
	98.52	98.59	98.65	98.7	98.77
EL. DIFF. (FEET)	0.4	0.49	0.46	0.53	0.45
EL. DIFF.(INCHES)	4.8	5.88	5.52	6.36	5.4
3+50	97.85	97.81	97.93	97.9	98
	98.23	98.28	98.35	98.41	98.45
EL. DIFF. (FEET)	0.38	0.47	0.42	0.51	0.45
EL. DIFF.(INCHES)	4.56	5.64	5.04	6.12	5.4
4+00	97.47	97.42	97.51	97.47	97.59
	97.87	97.91	97.97	98.02	98.05
EL. DIFF. (FEET)	0.4	0.49	0.46	0.55	0.46
EL. DIFF.(INCHES)	4.8	5.88	5.52	6.6	5.52
4+50	97.14	97.11	97.21	97.16	97.31
	97.52	97.6	97.67	97.72	97.75
EL. DIFF. (FEET)	0.38	0.49	0.46	0.56	0.44
EL. DIFF.(INCHES)	4.56	5.88	5.52	6.72	5.28
5+00	96.82	96.79	96.91	96.87	97.03
	97.25	97.32	97.37	97.42	97.46
EL. DIFF. (FEET)	0.43	0.53	0.46	0.55	0.43
EL. DIFF.(INCHES)	5.16	6.36	5.52	6.6	5.16
Average New Thickness/offset	5.02	6.27	5.78	6.89	5.68
Standard Deviation/offset	0.53	0.49	0.42	0.45	0.39
Average New Thickness/section	5.93				
Standard Deviation/section	0.80				

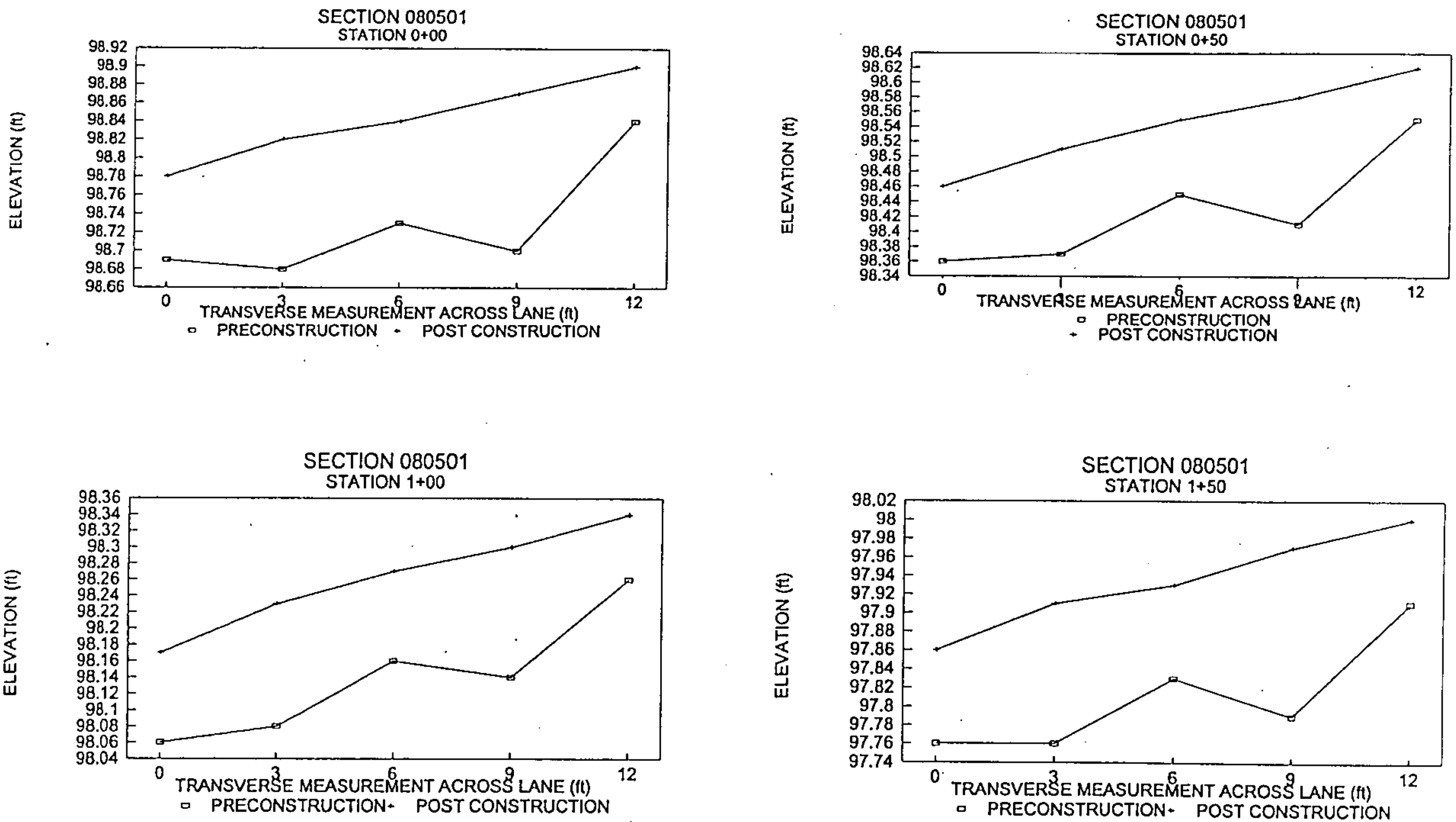
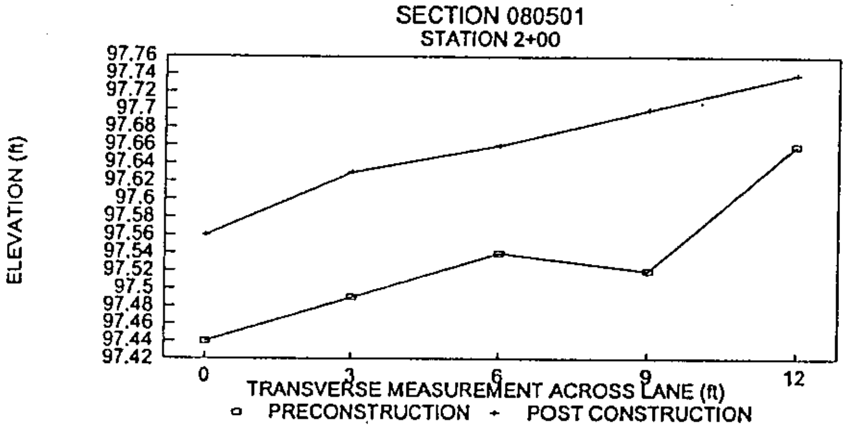
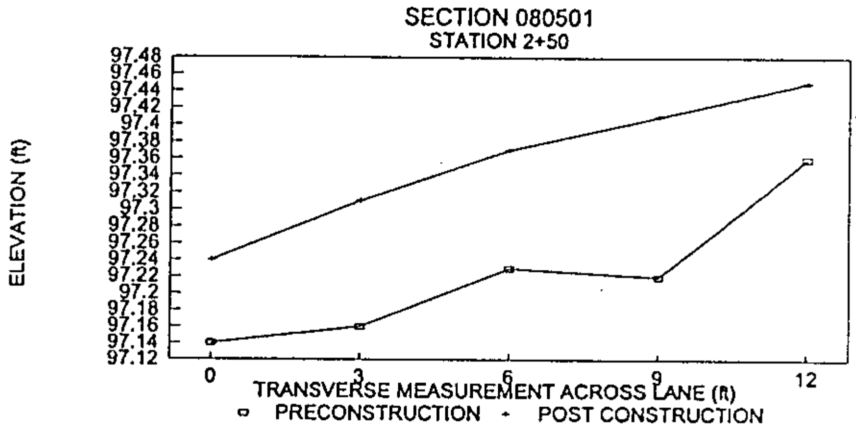
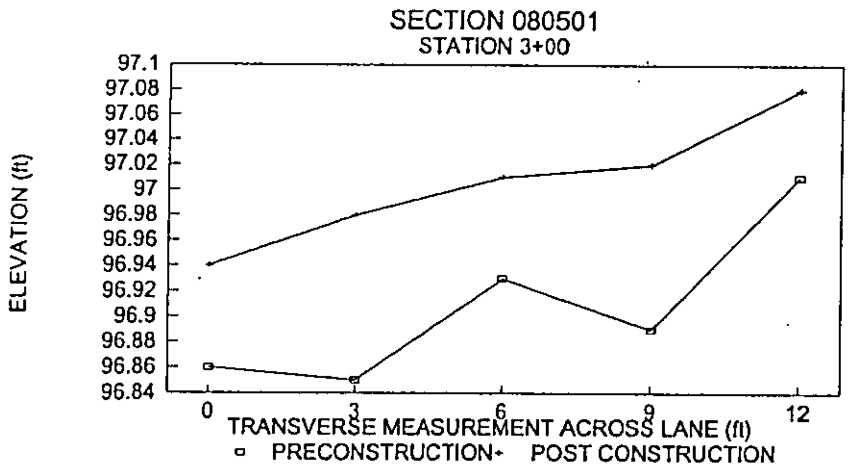


Figure A1. Section 080501







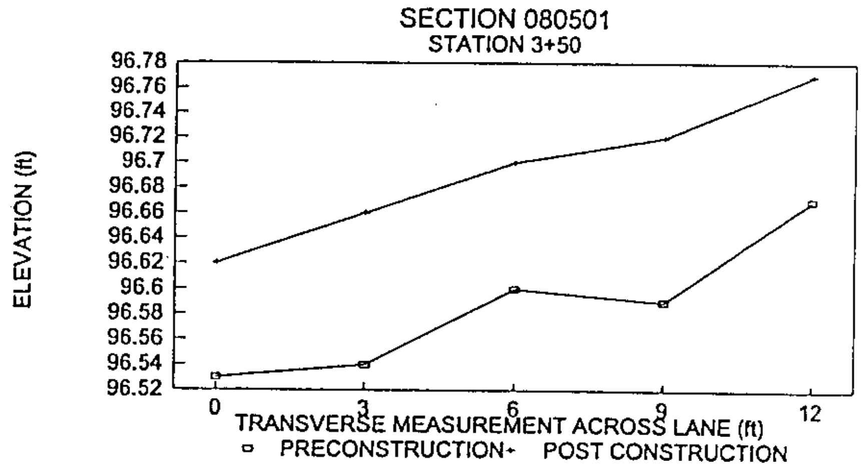
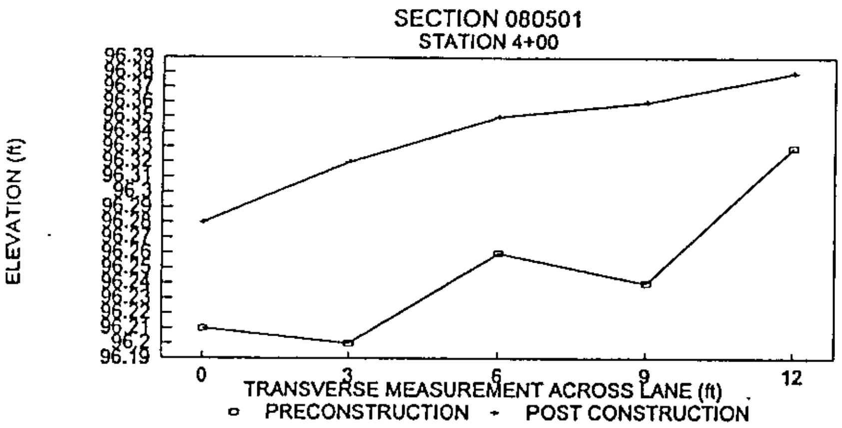
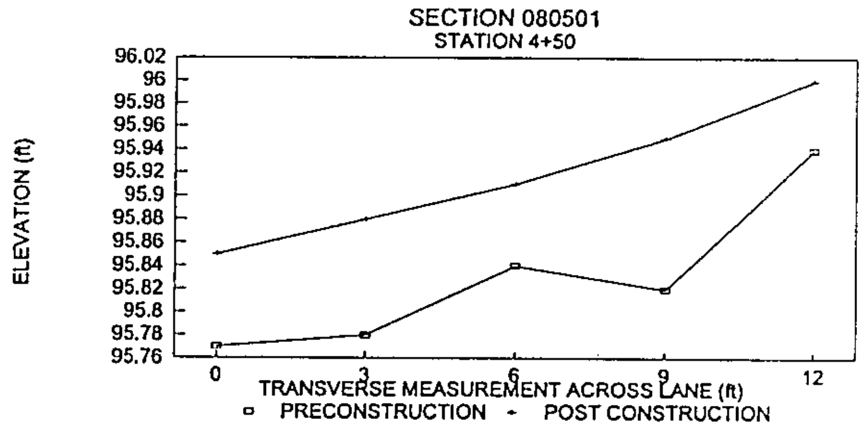


Figure A2. Section 080501 (cont.)





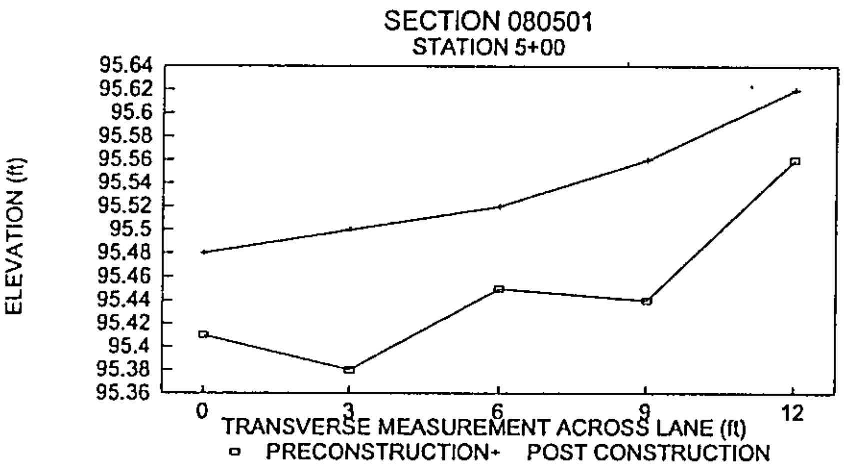


Figure A3. Section 080501 (cont.)

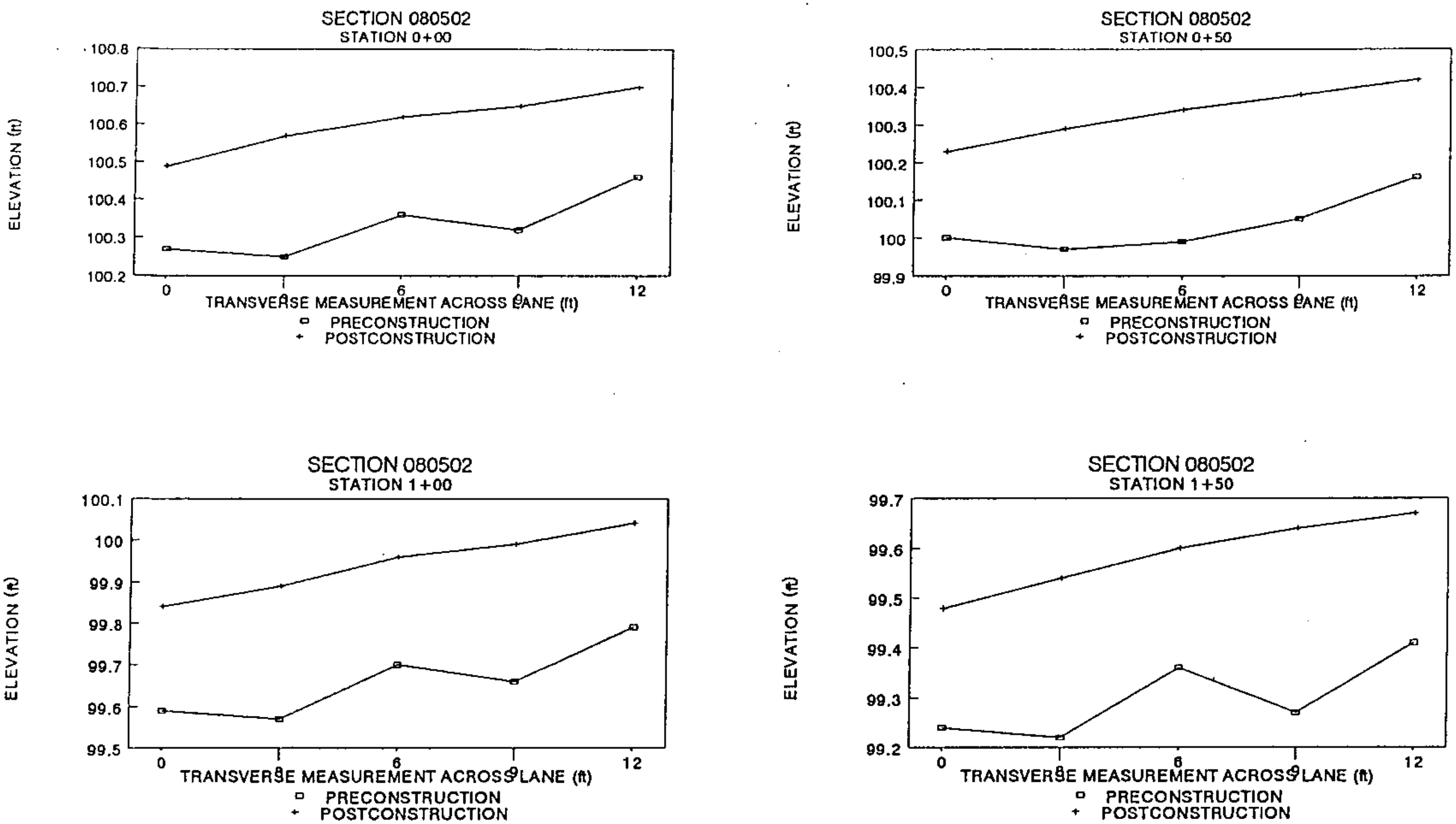


Figure A4. Section 080502

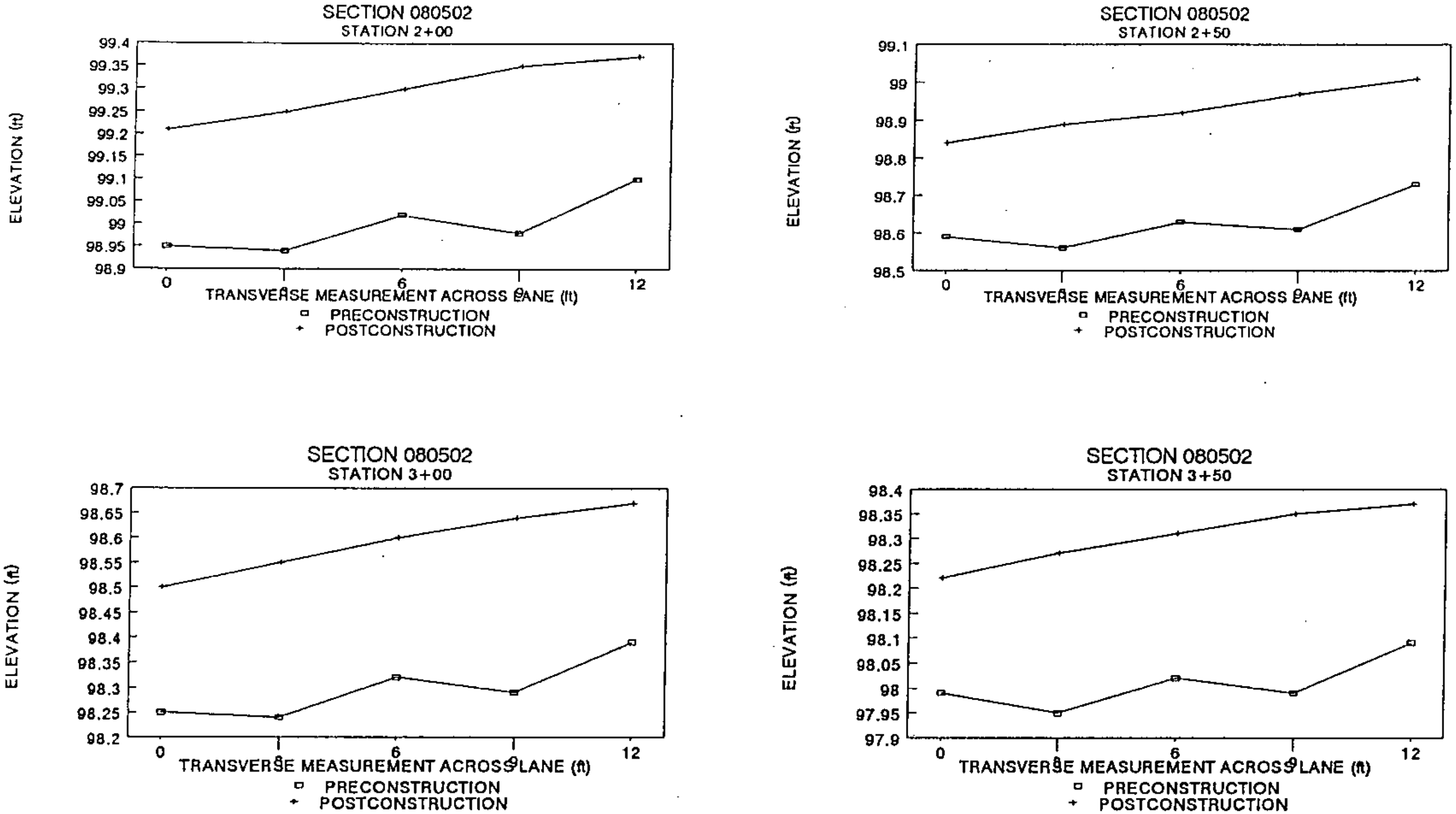
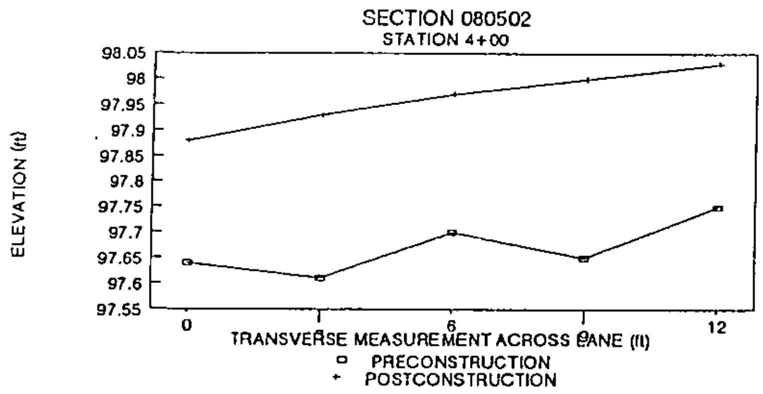
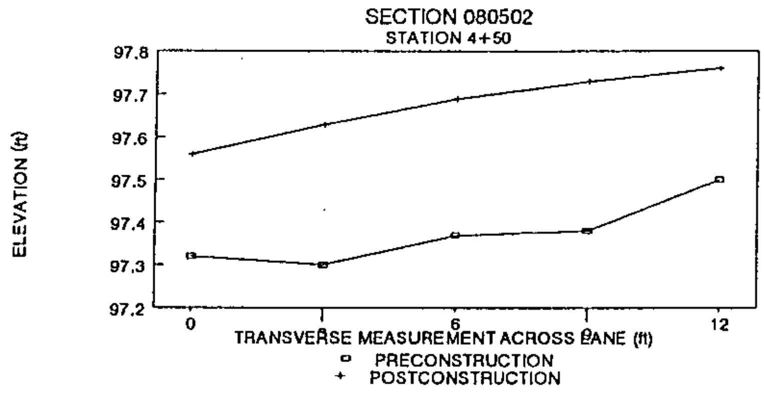


Figure A5. Section 080502 (cont.)





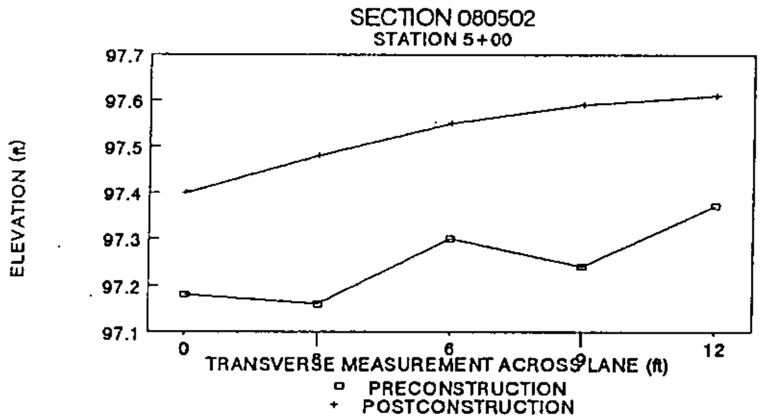


Figure A6. Section 080502 (cont.)

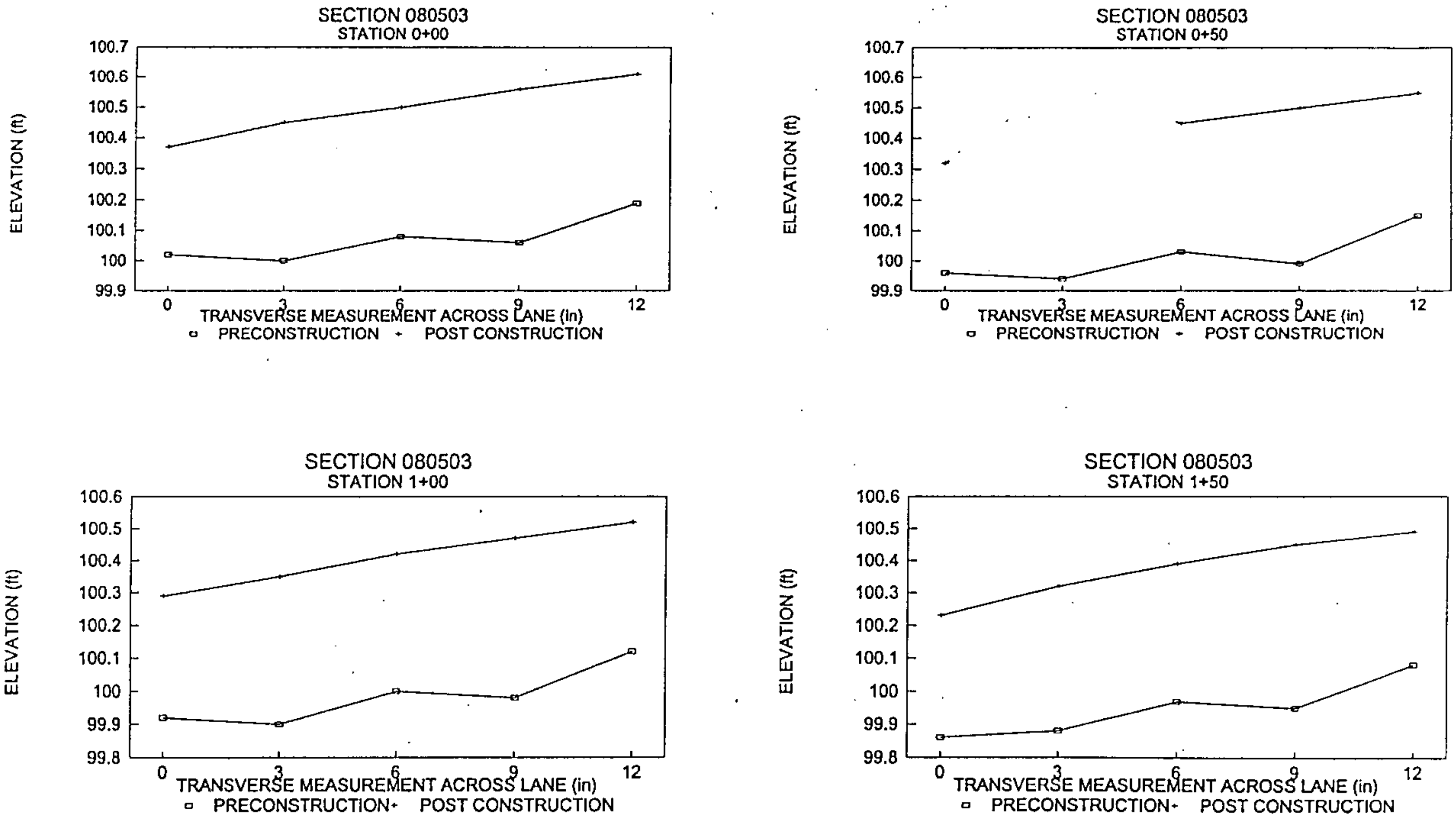


Figure A7. Section 080503

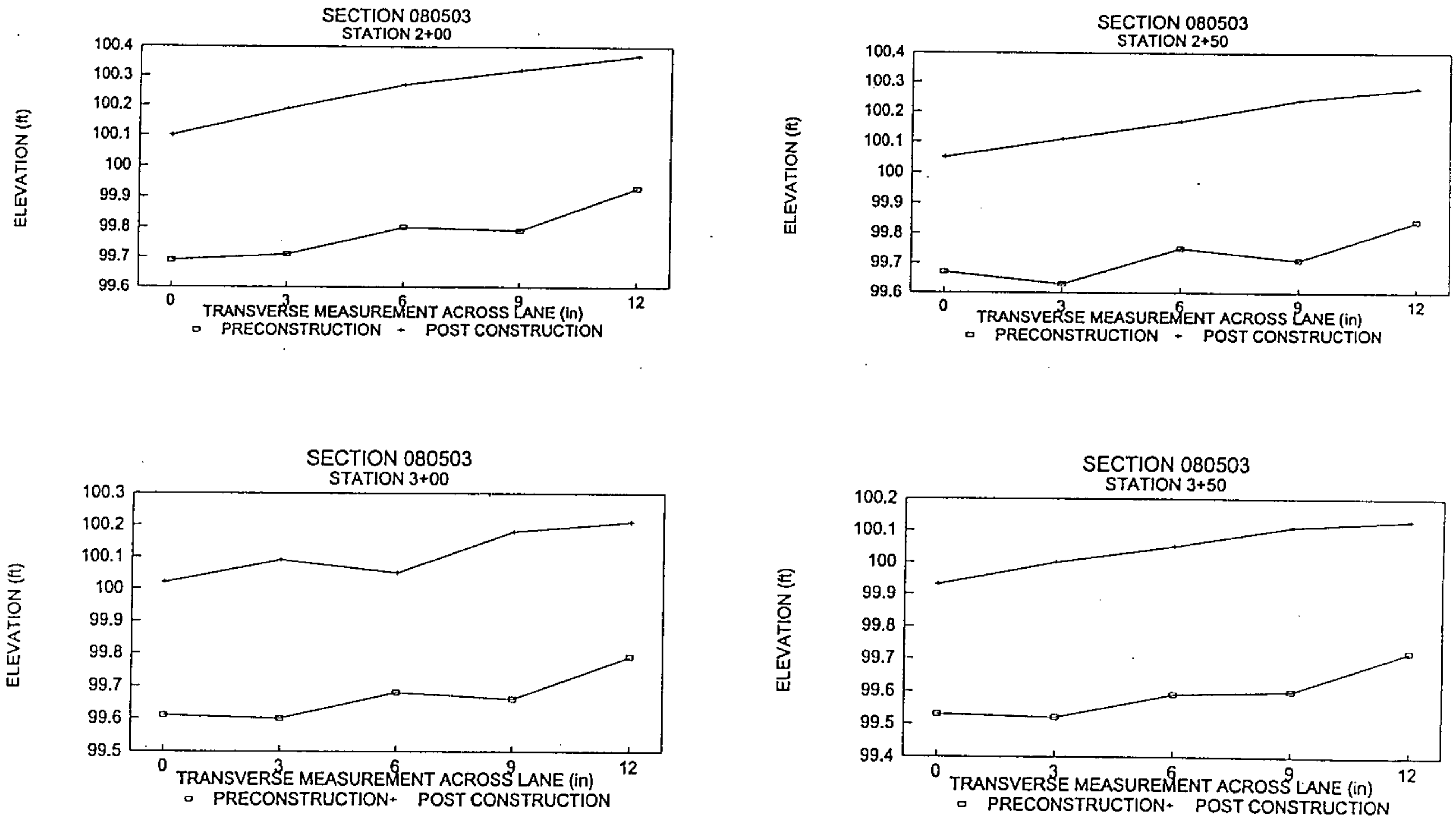
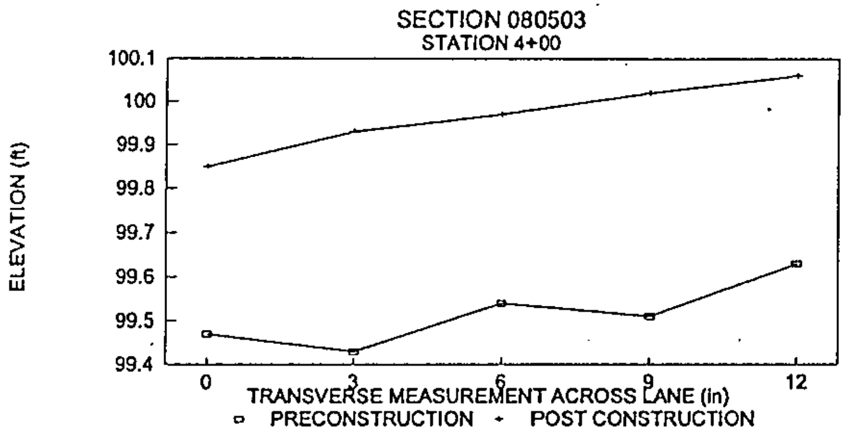
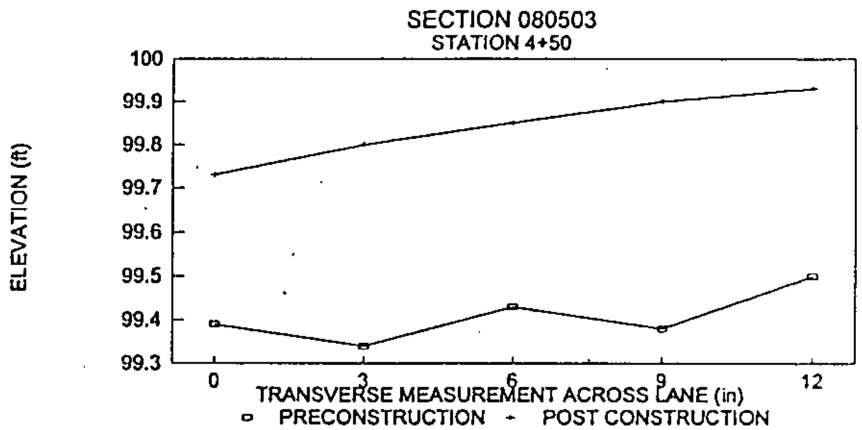


Figure A8. Section 080503 (cont.)





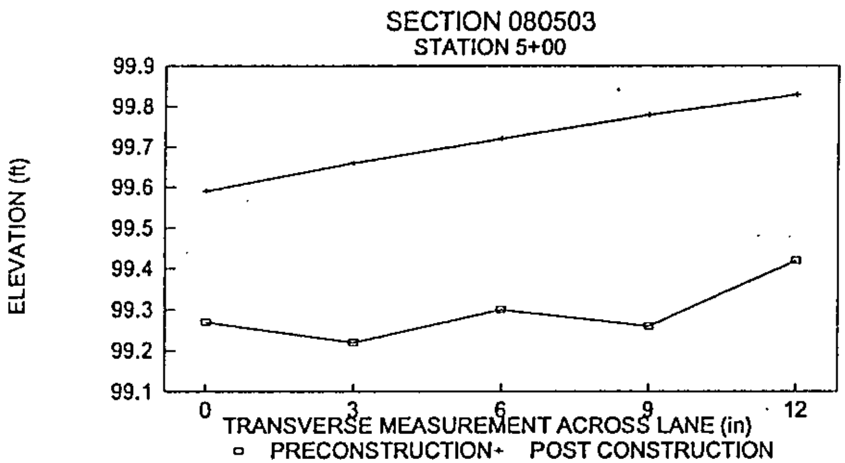


Figure A9. Section 080503 (cont.)

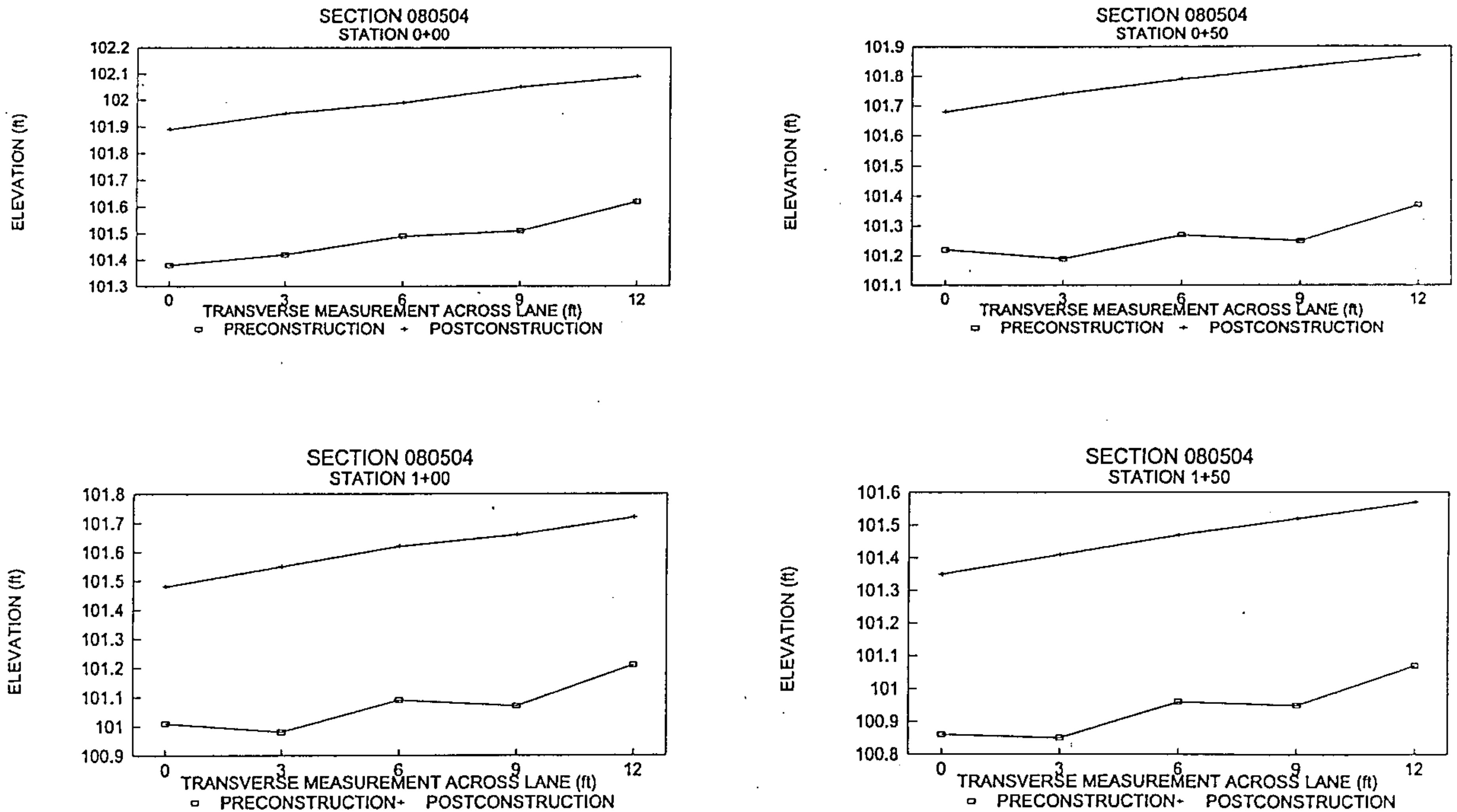
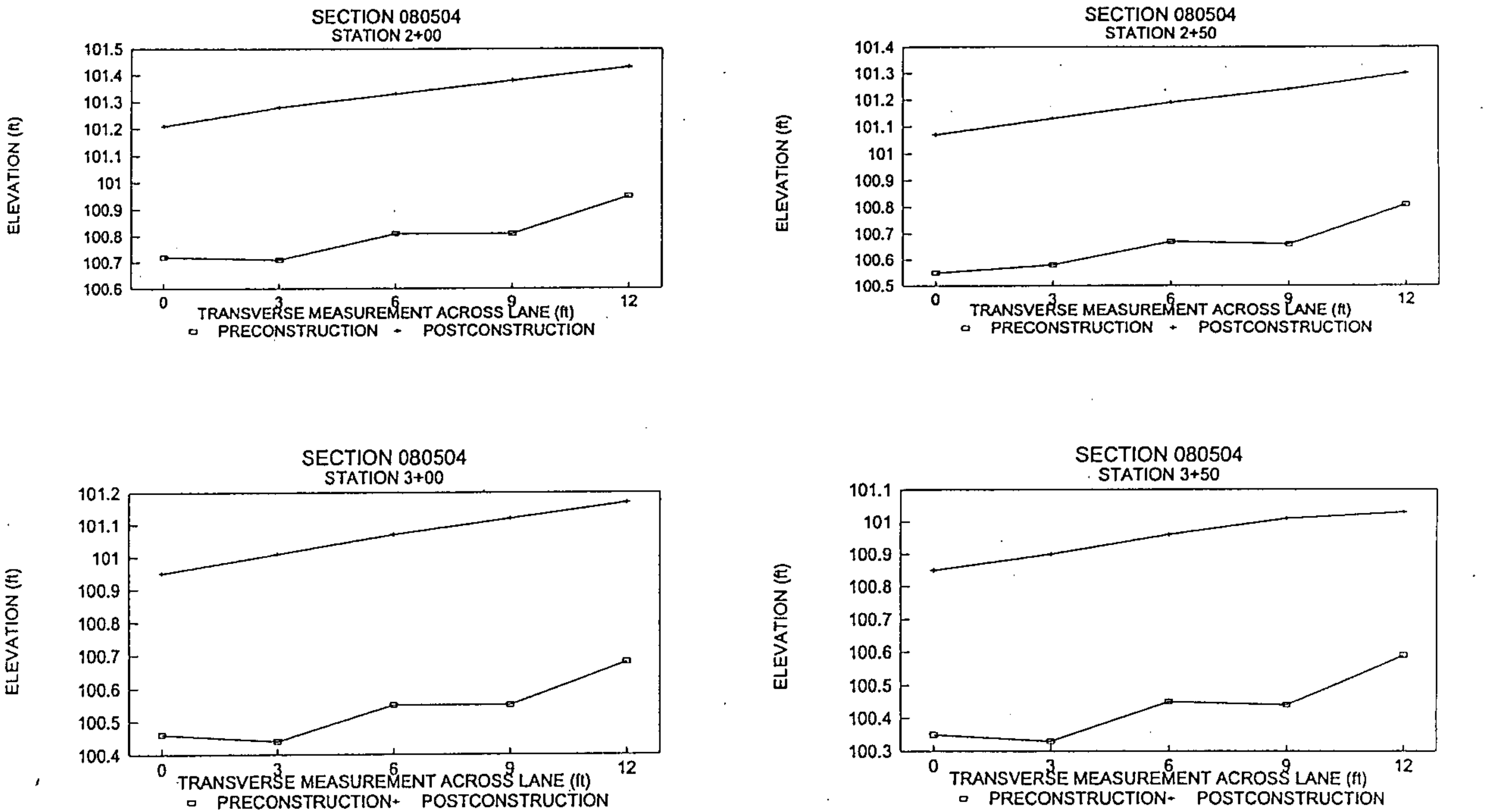


Figure A10. Section 080504



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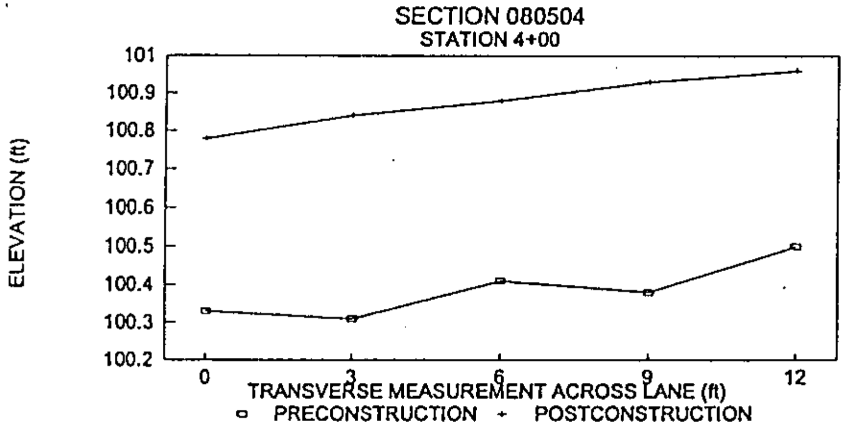

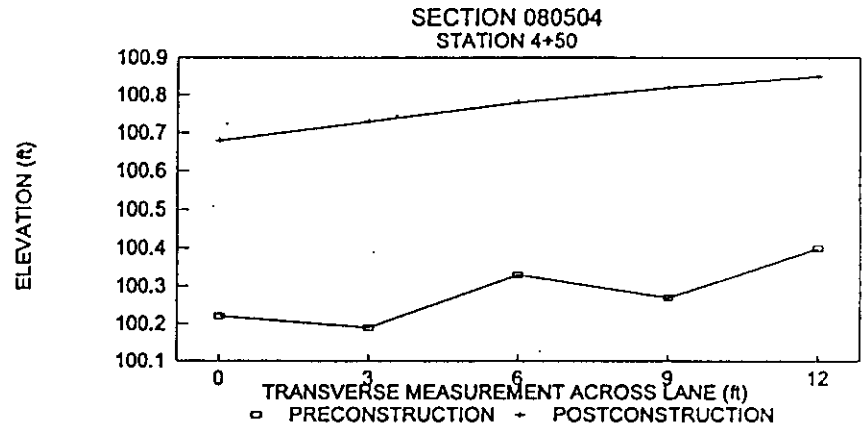

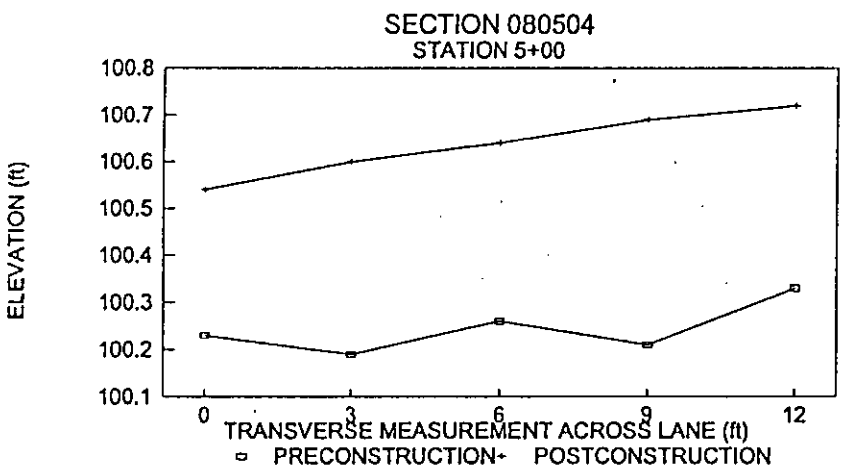

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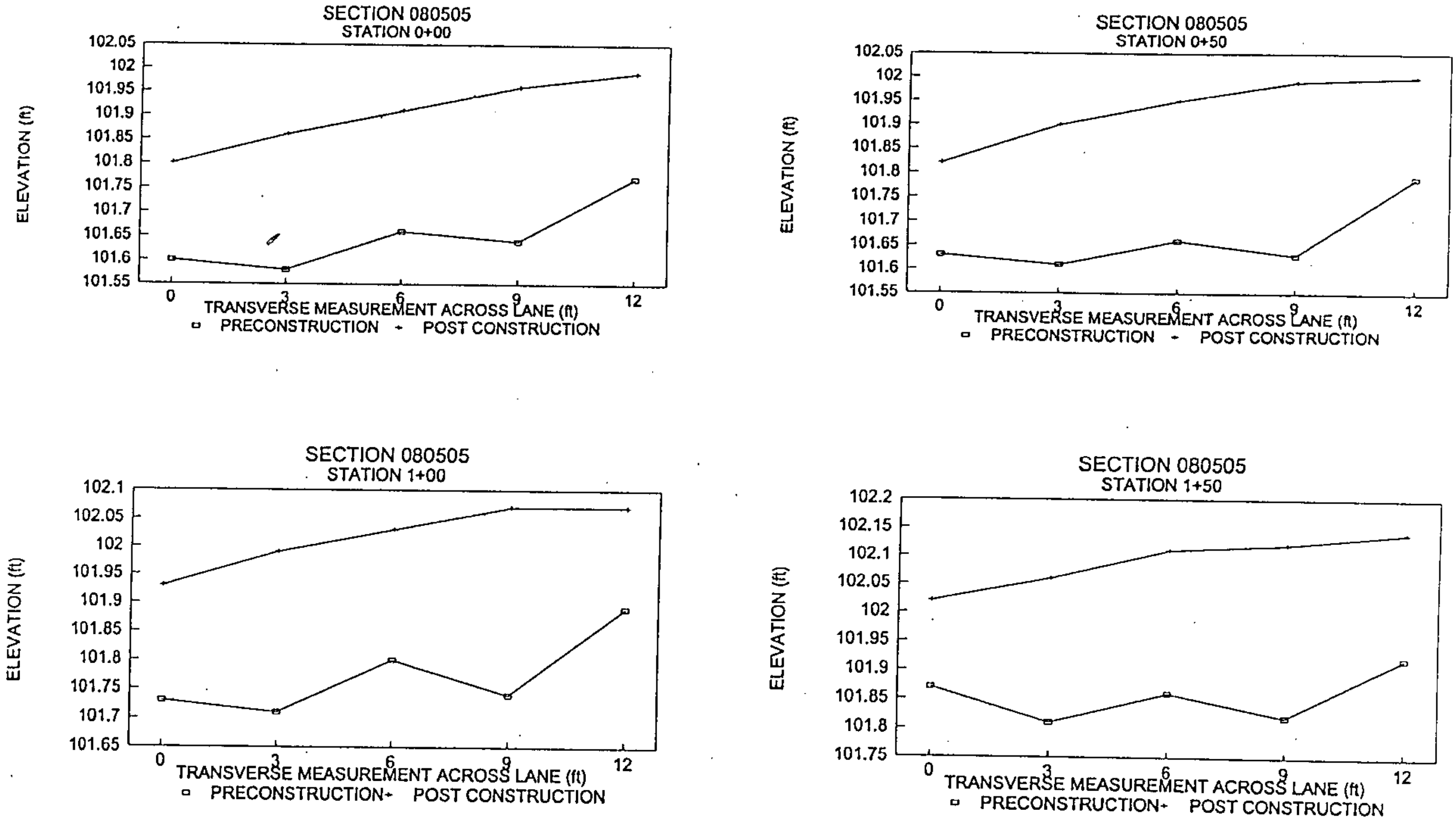

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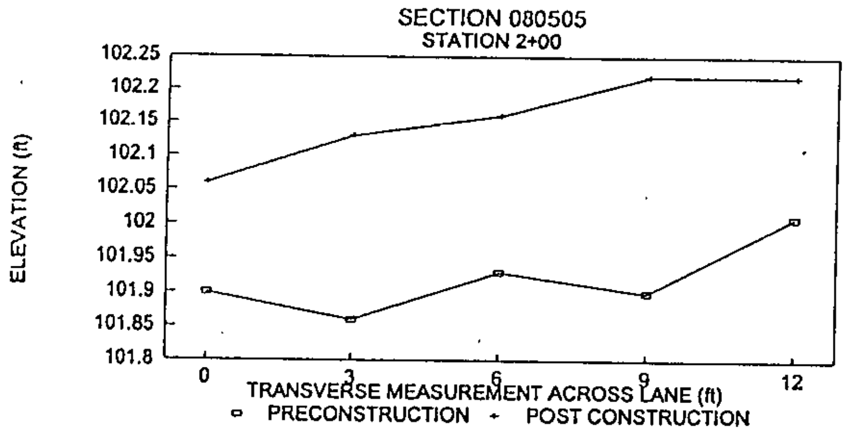
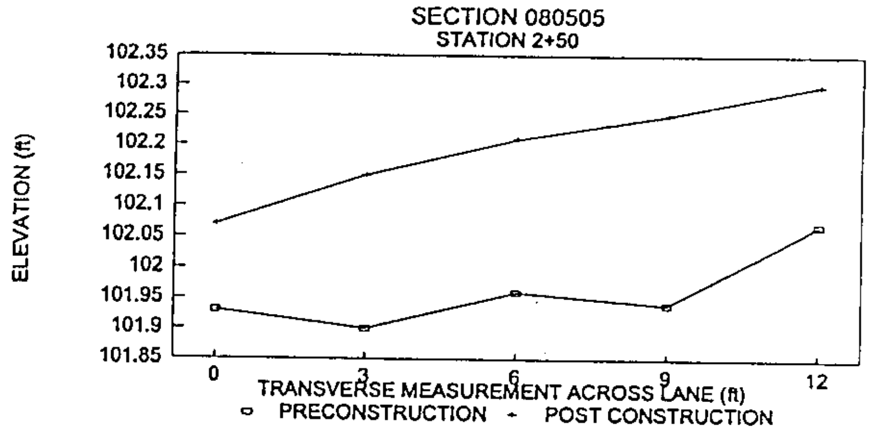
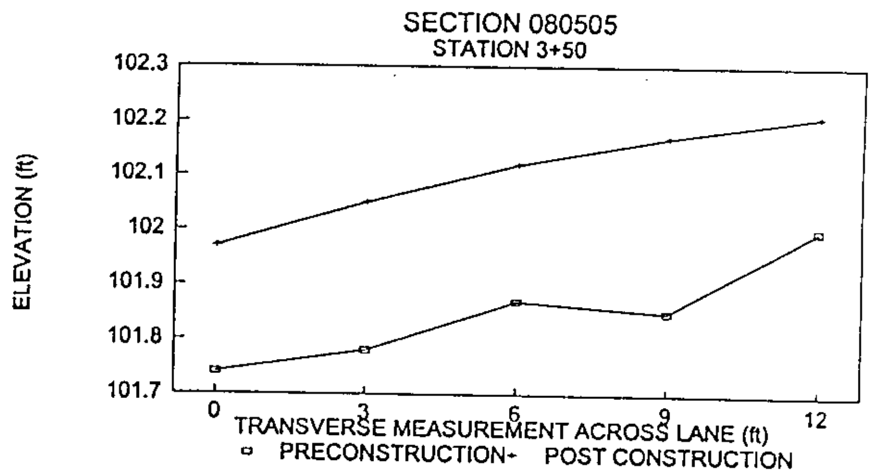




Faulty Data Points



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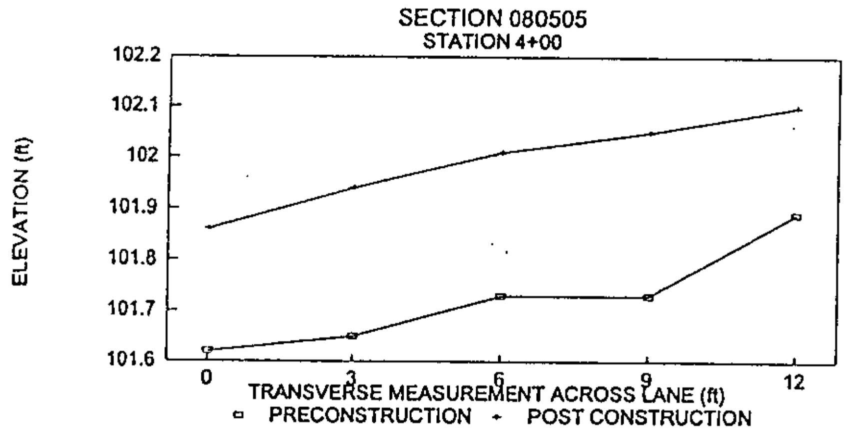

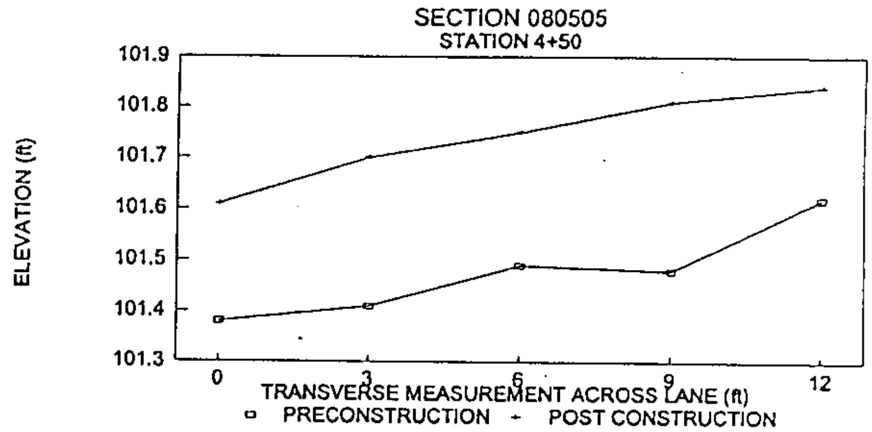

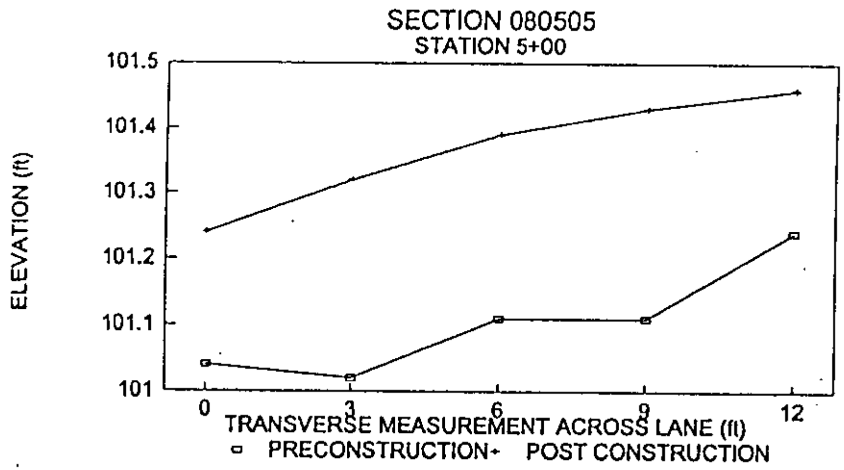

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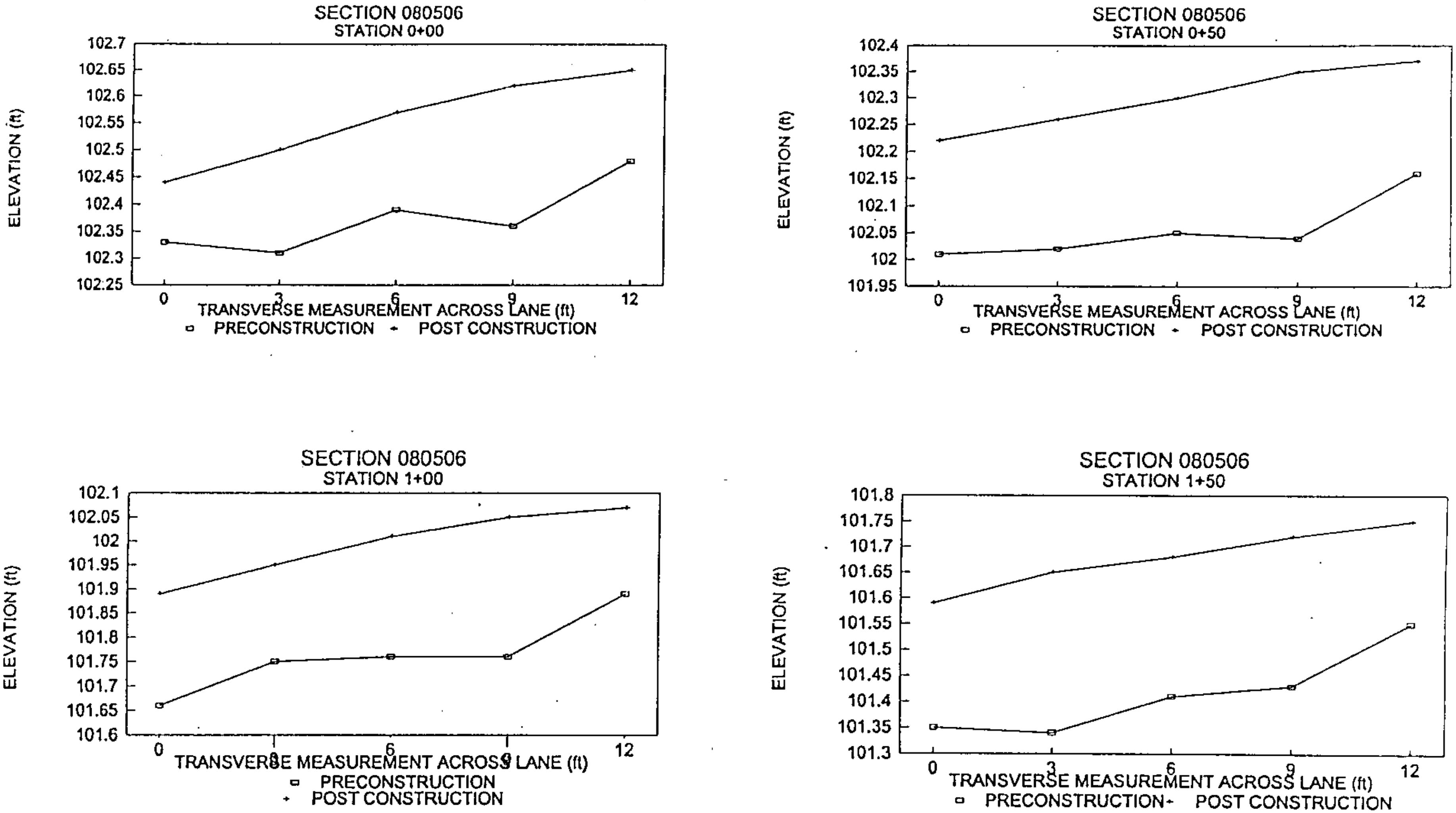
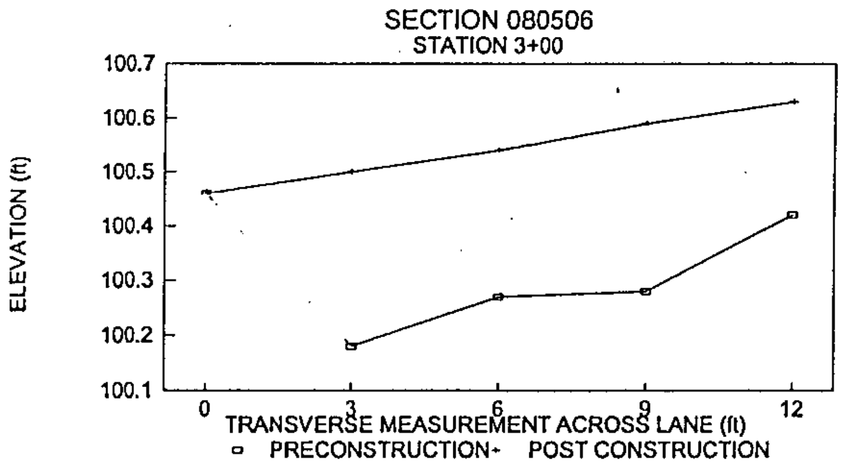
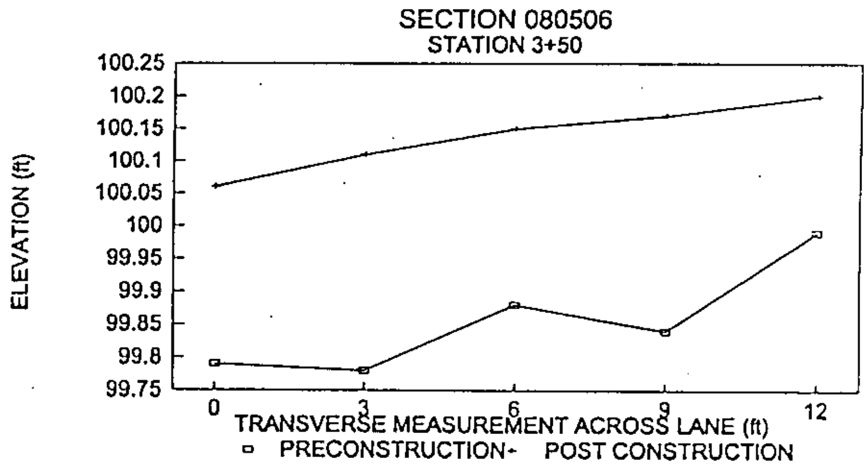


Figure A16. Section 080506

Faulty Data Points

Faulty Data Points





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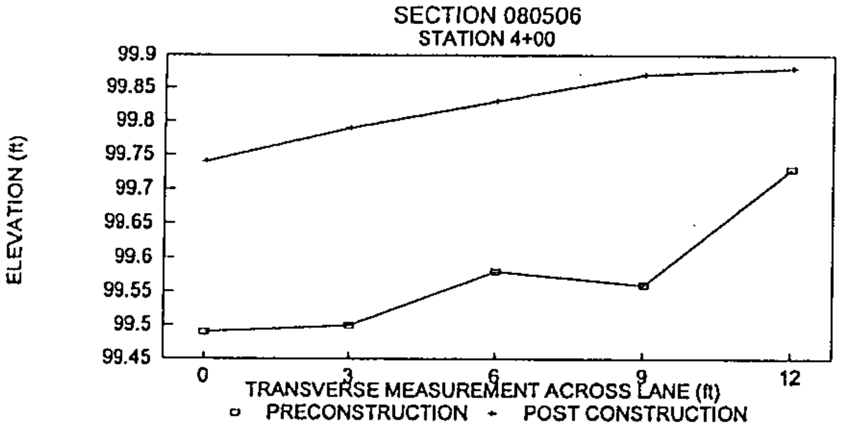

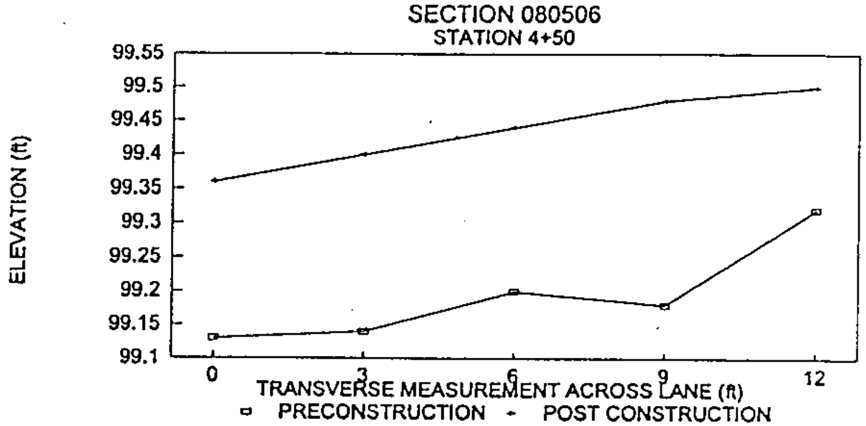

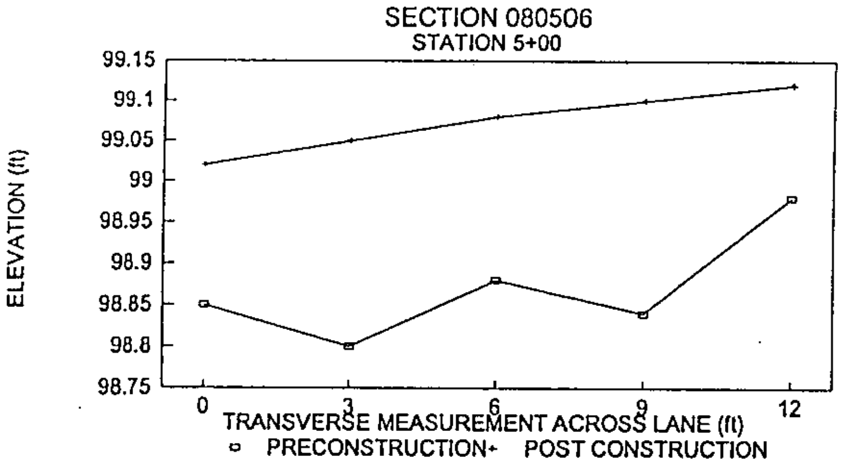

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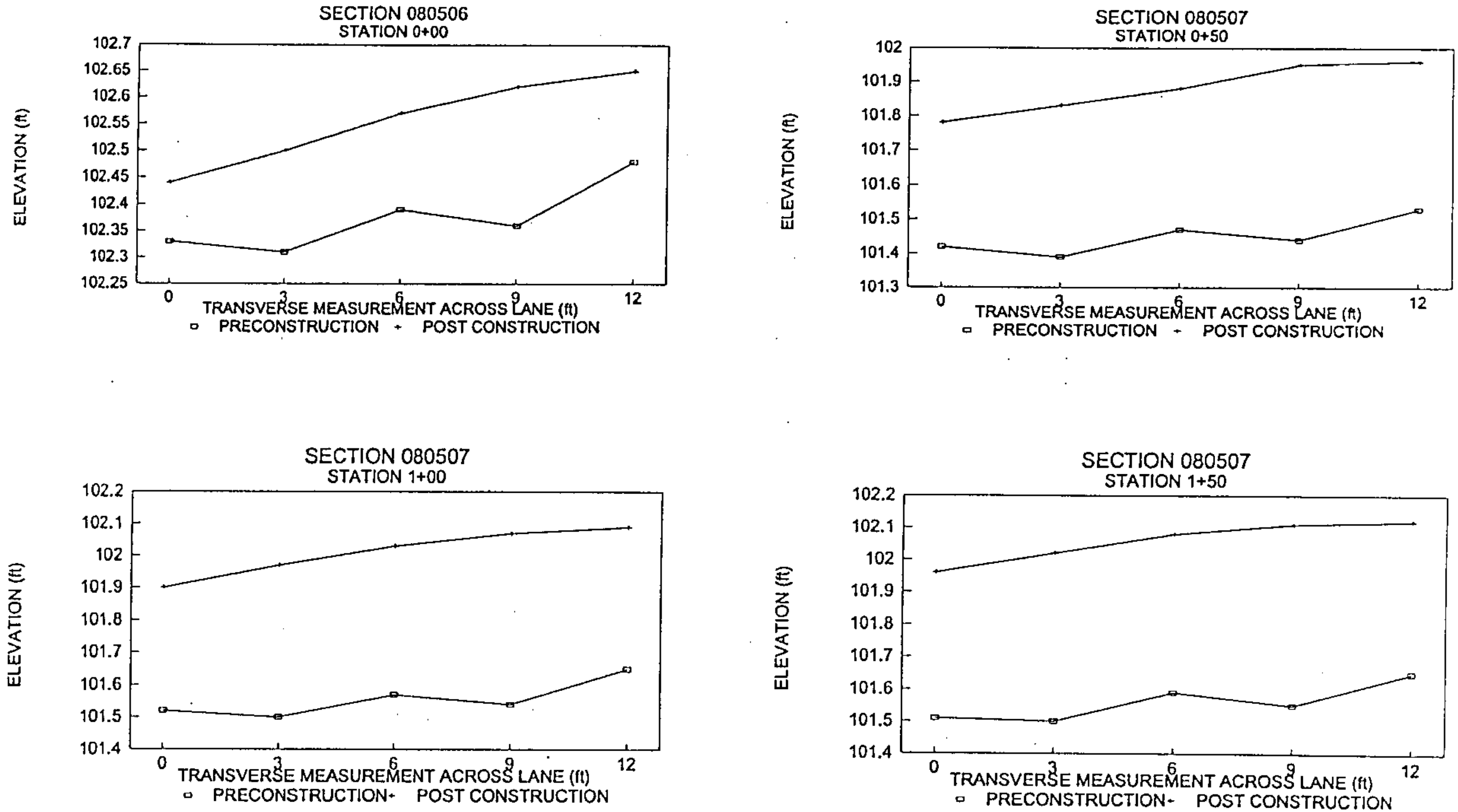

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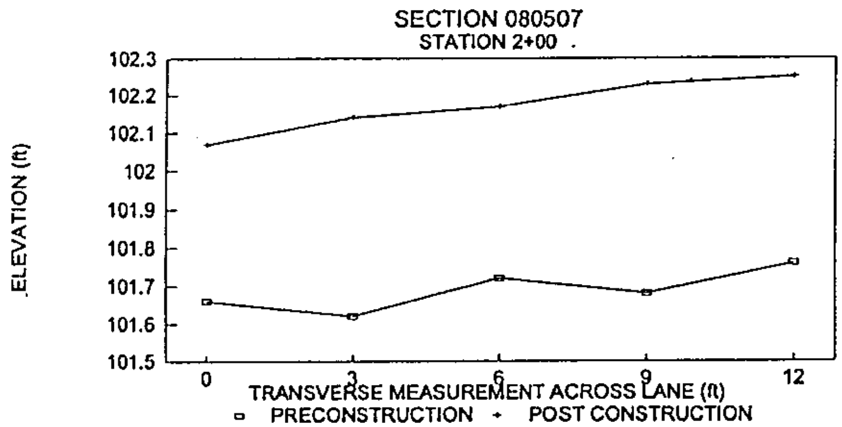

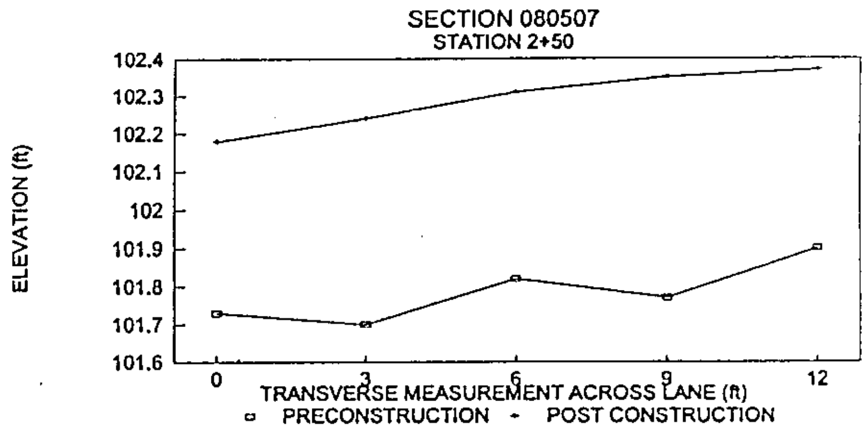

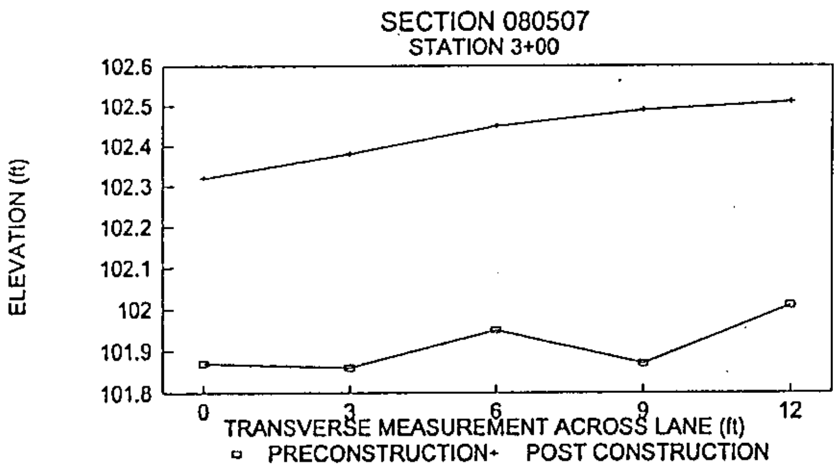

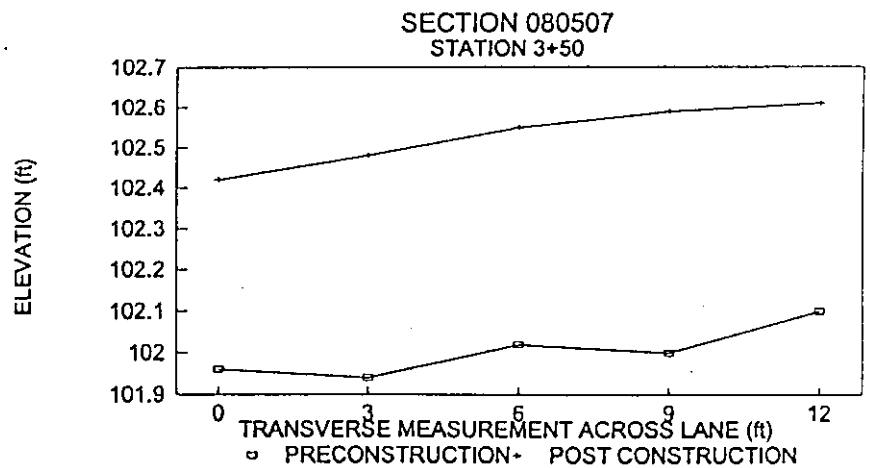

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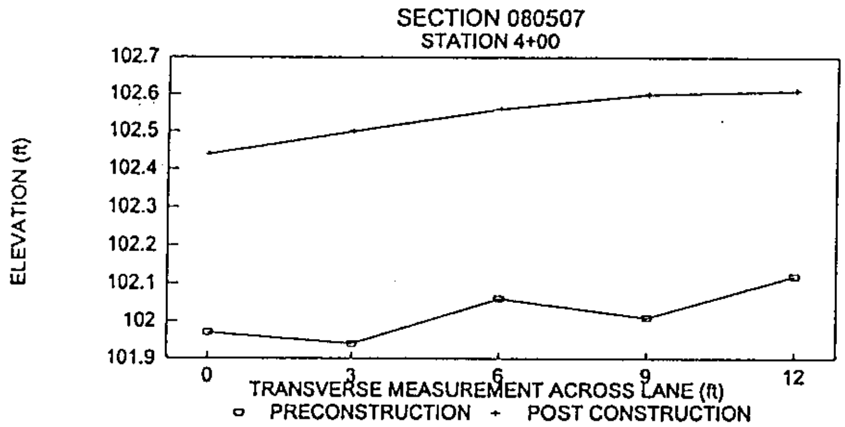

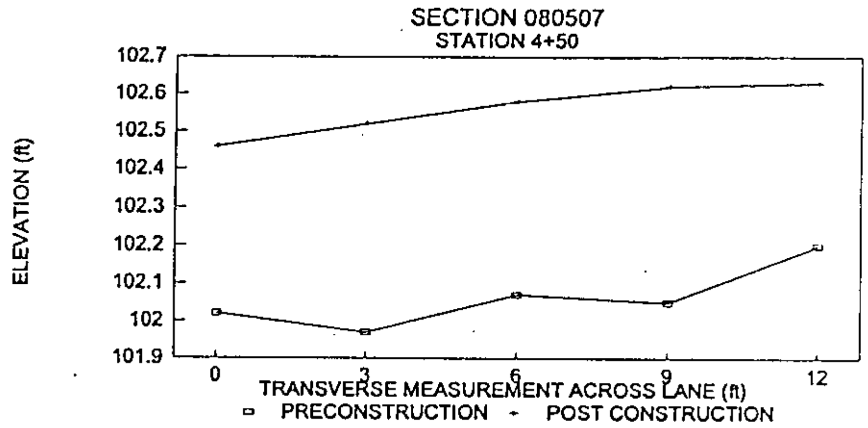

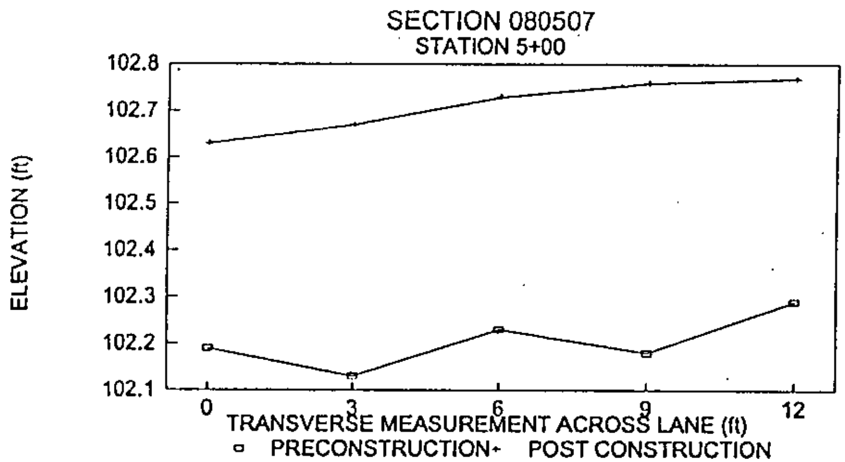

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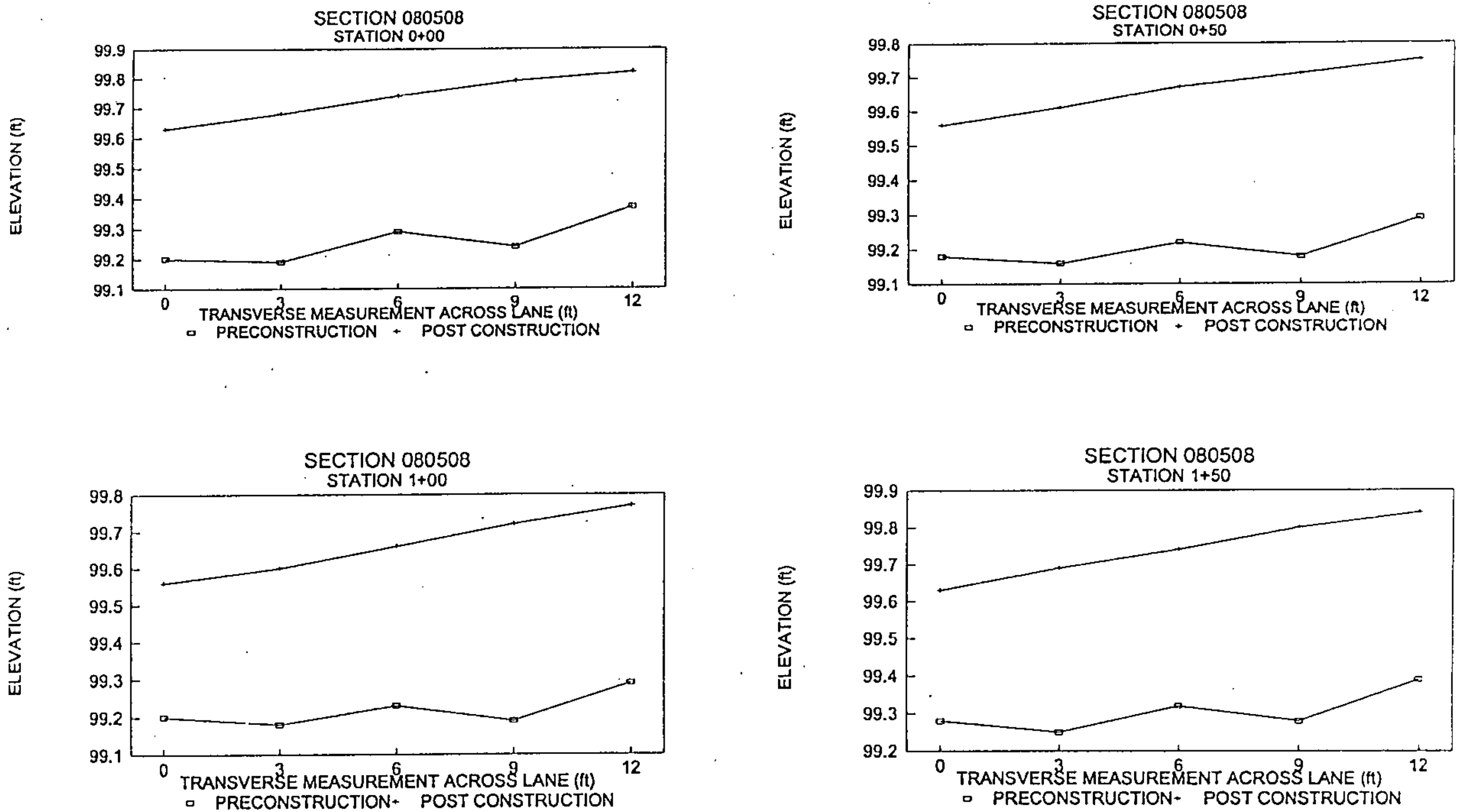
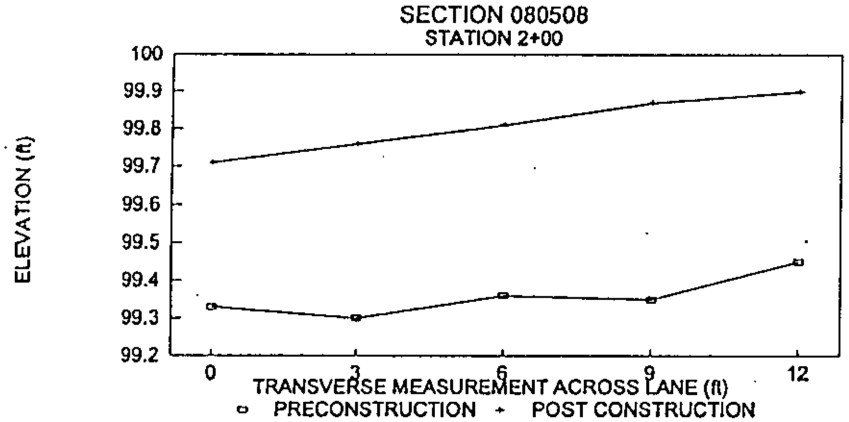
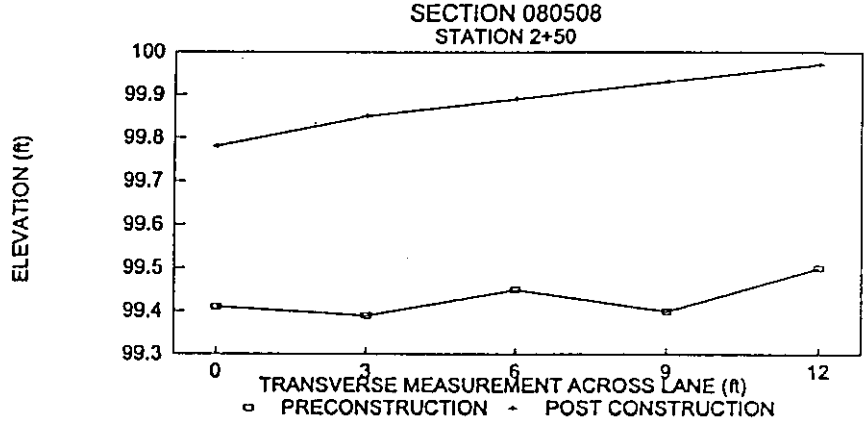
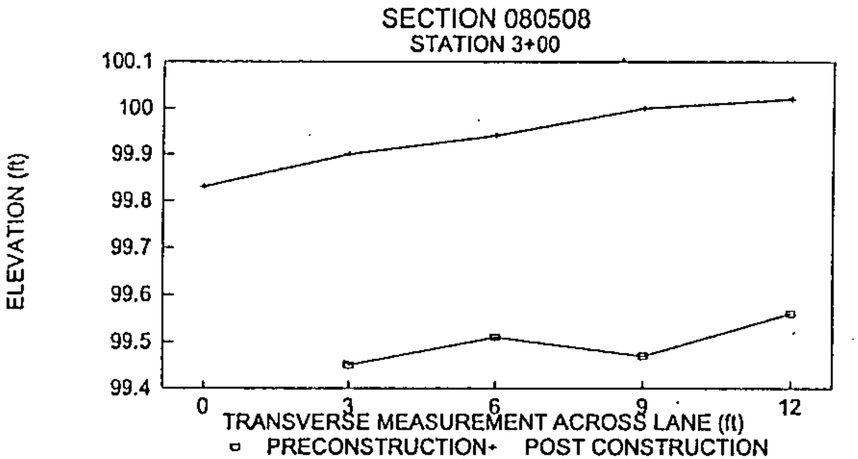
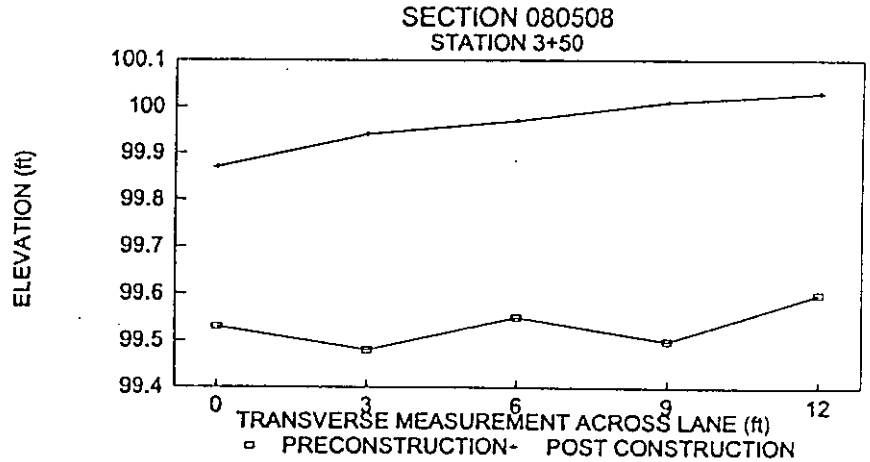


Figure A22. Section 080508









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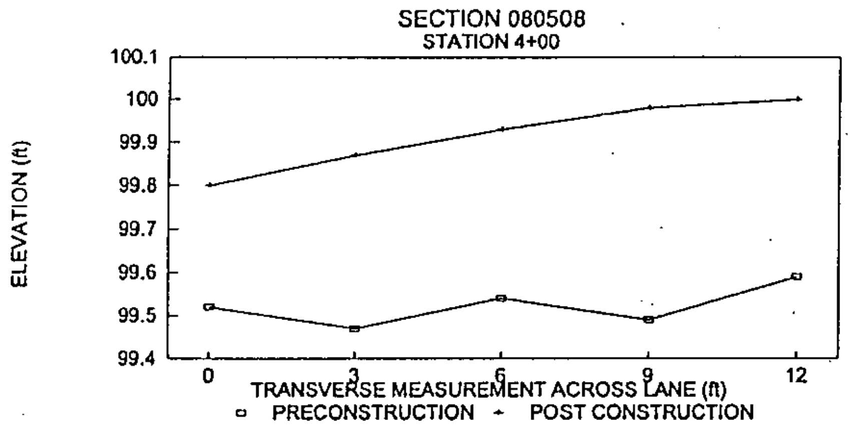

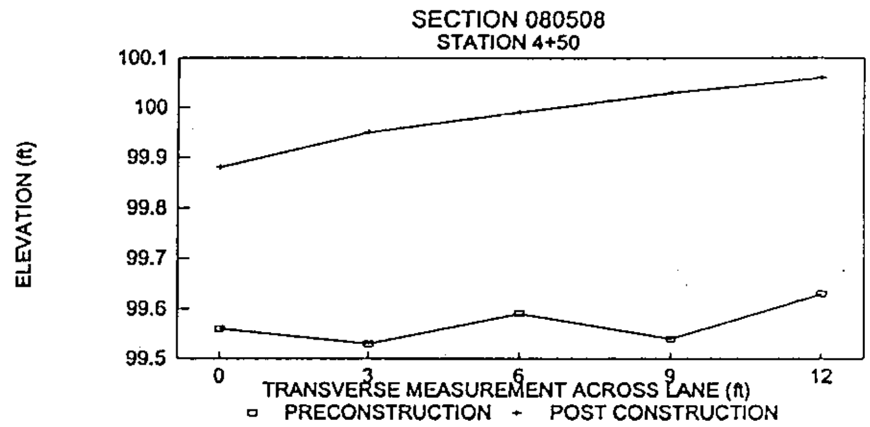

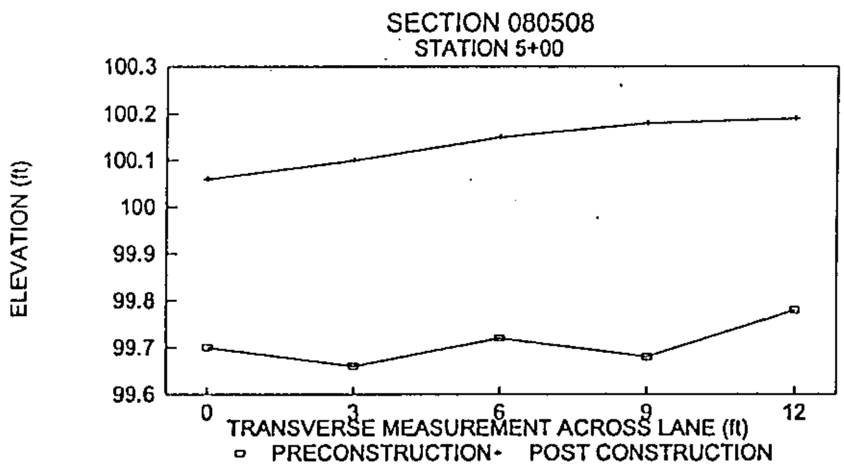

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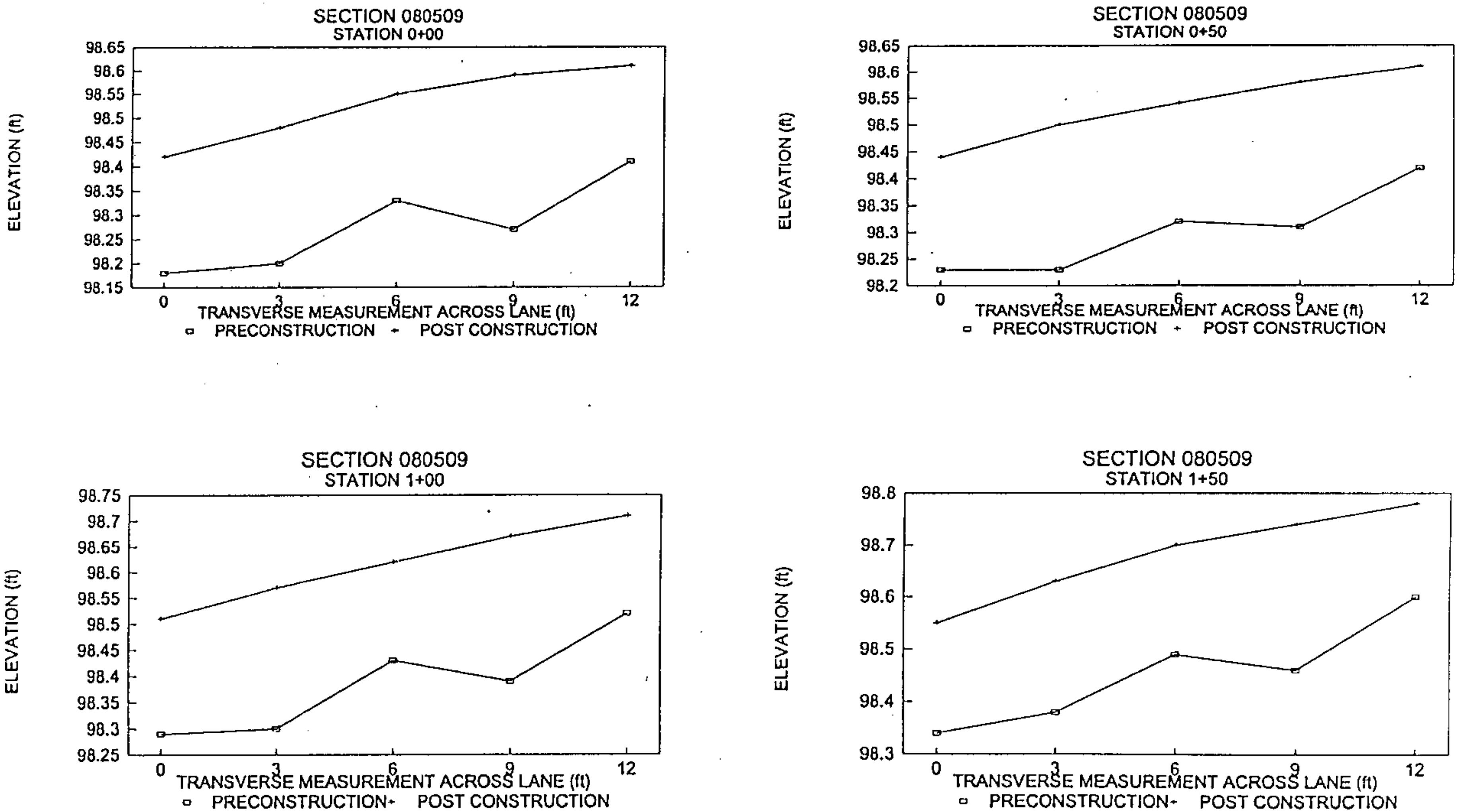

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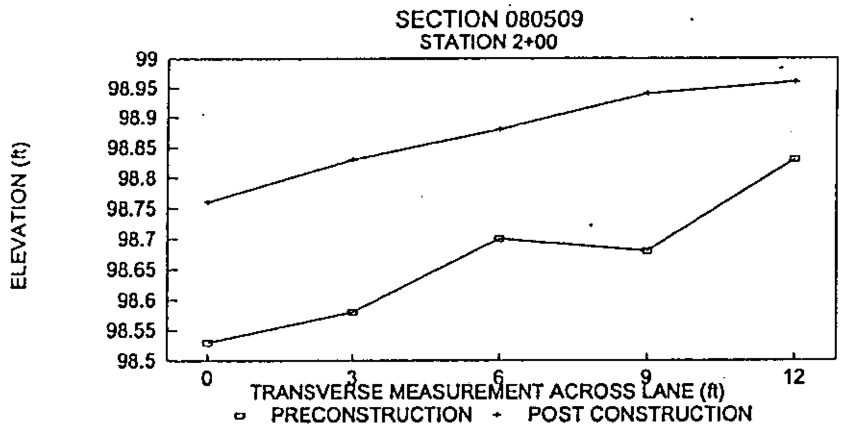

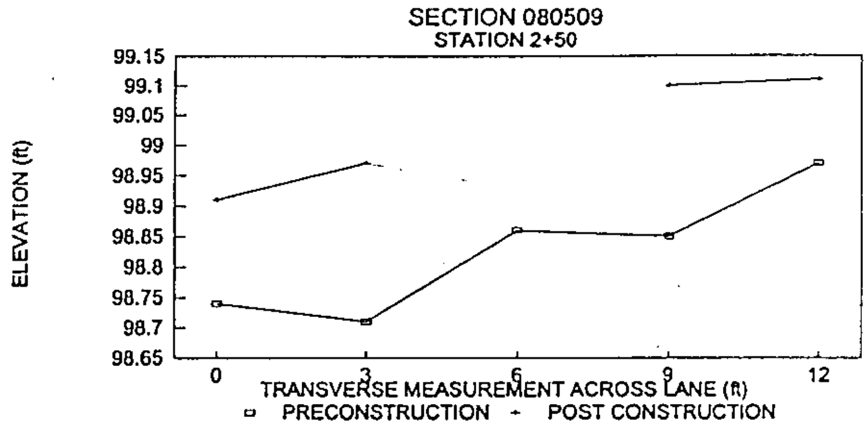

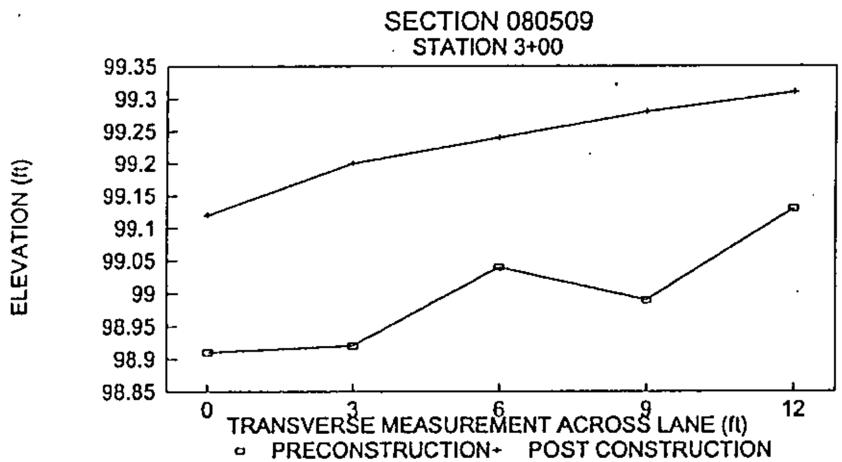

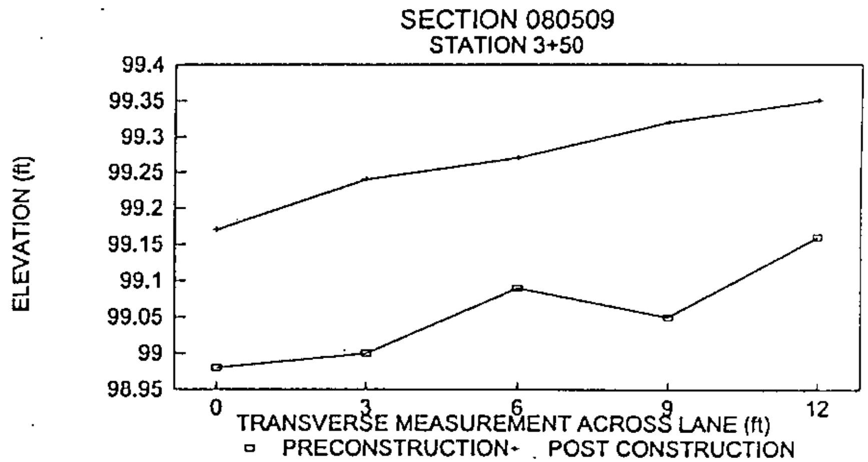

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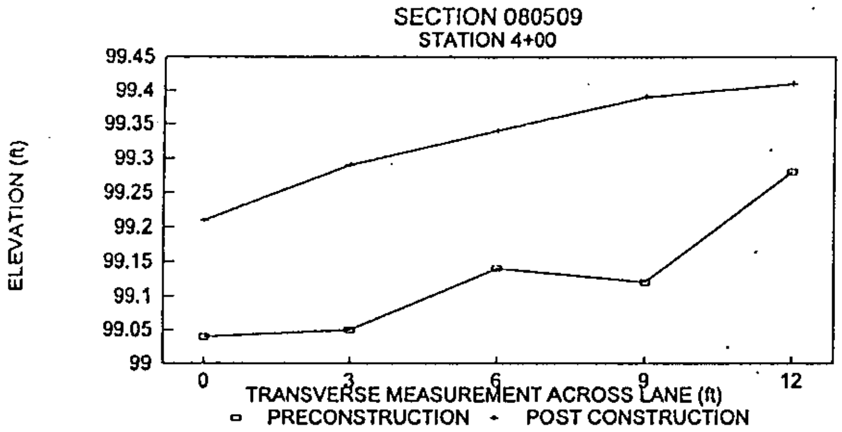

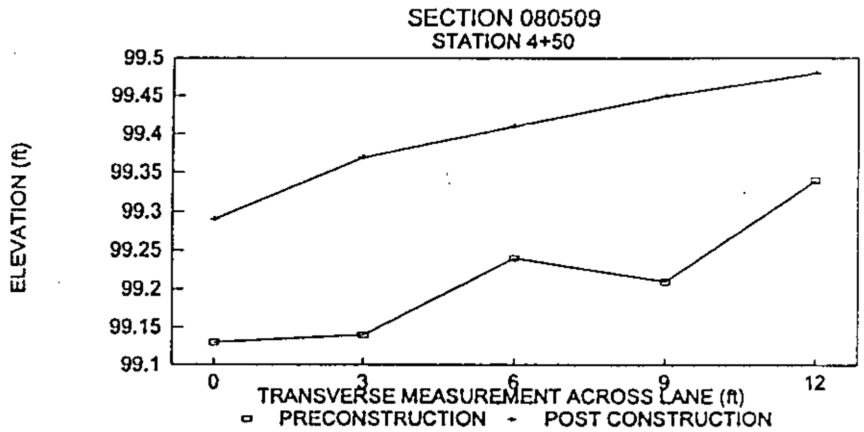

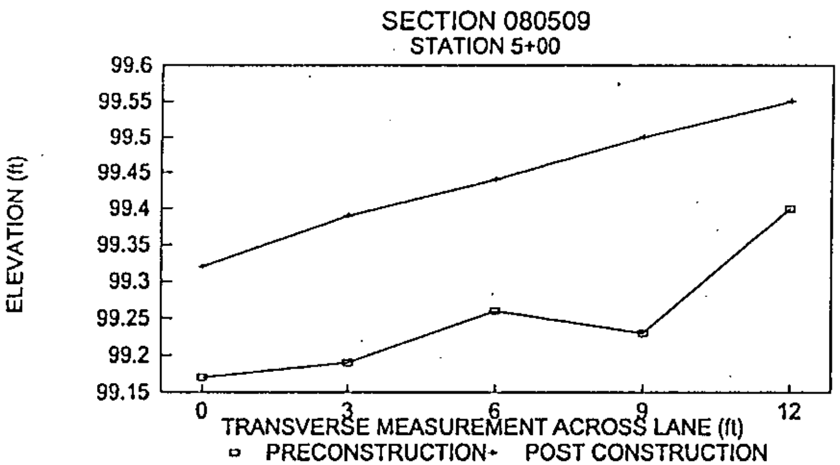

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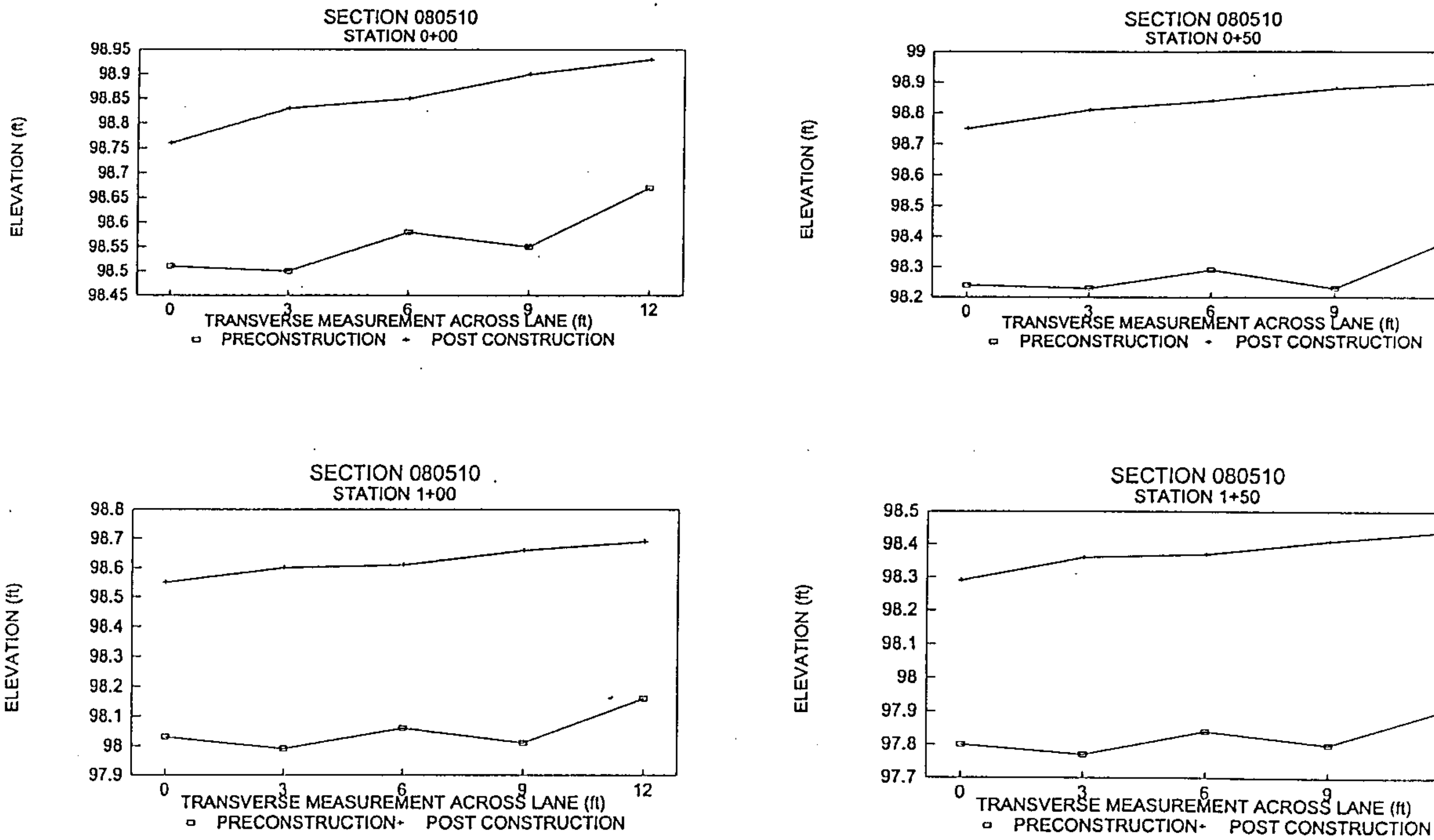

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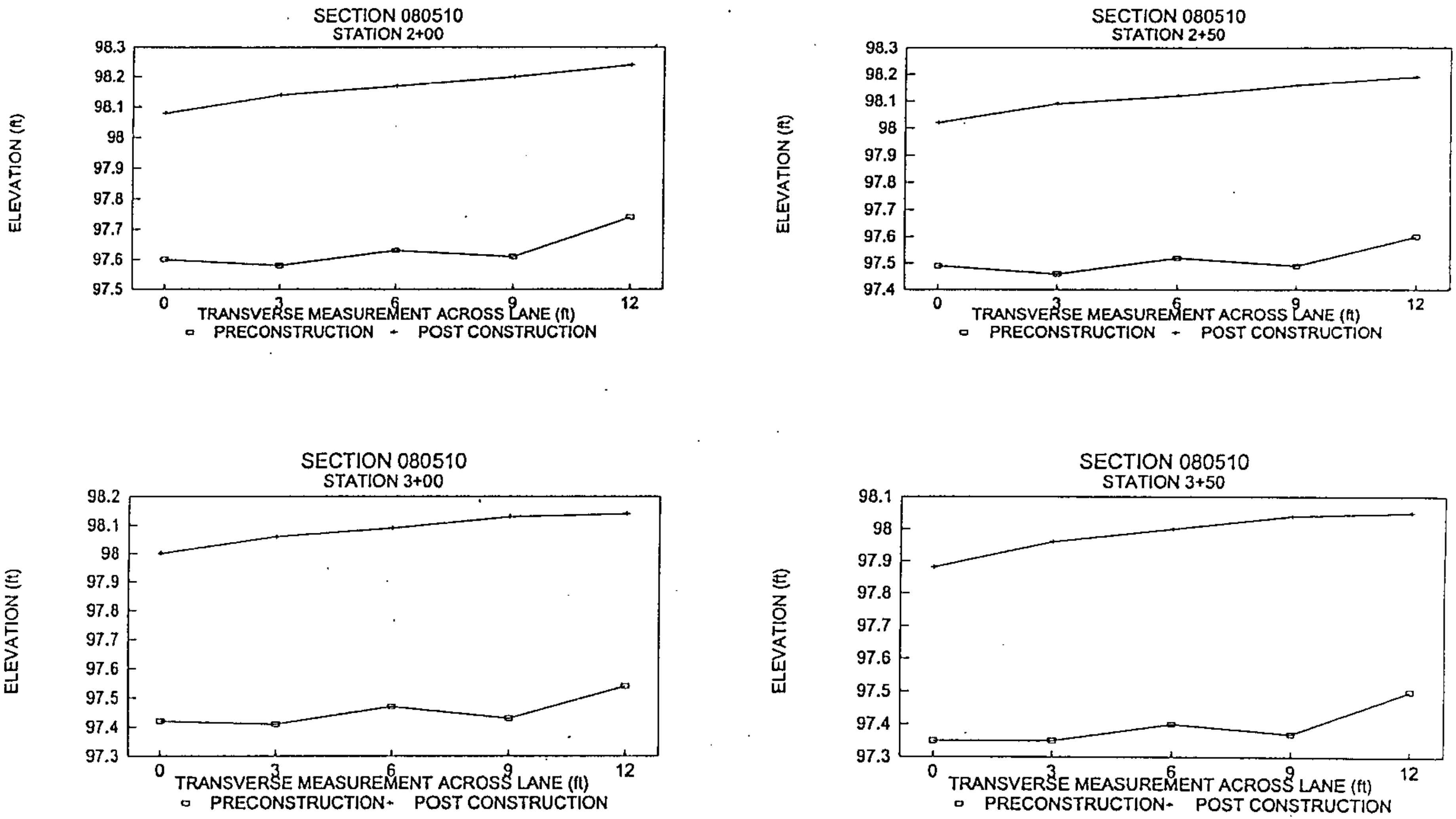

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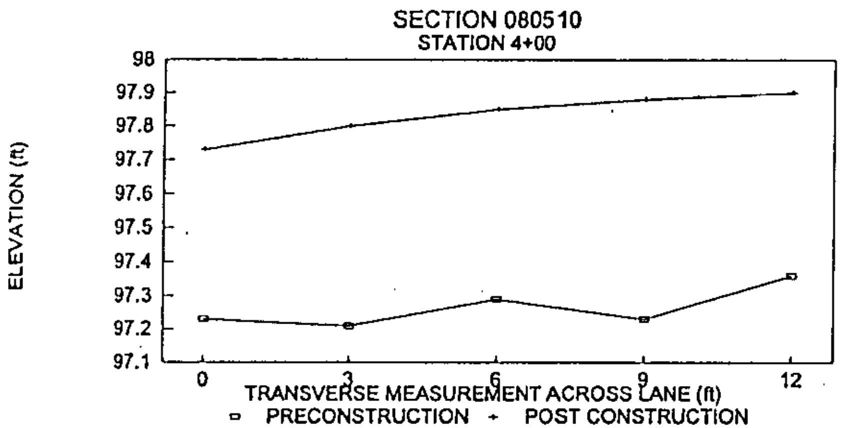

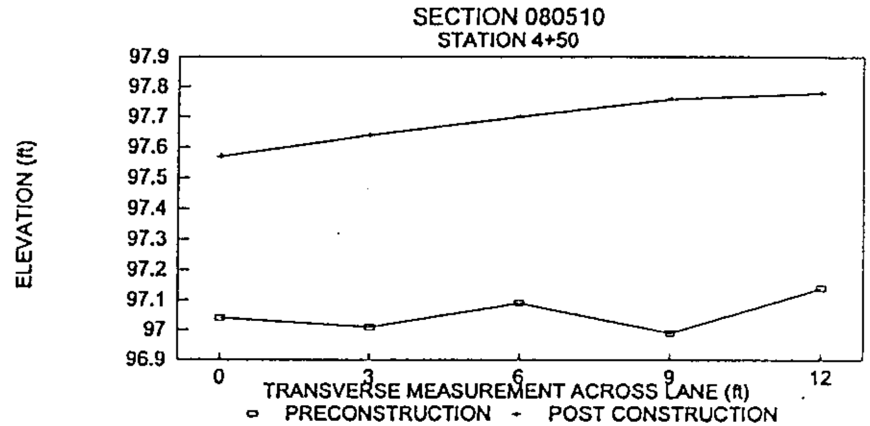

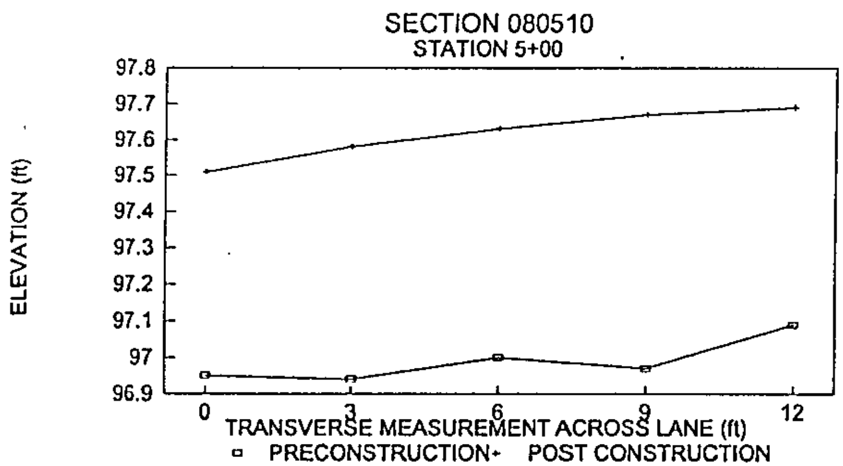

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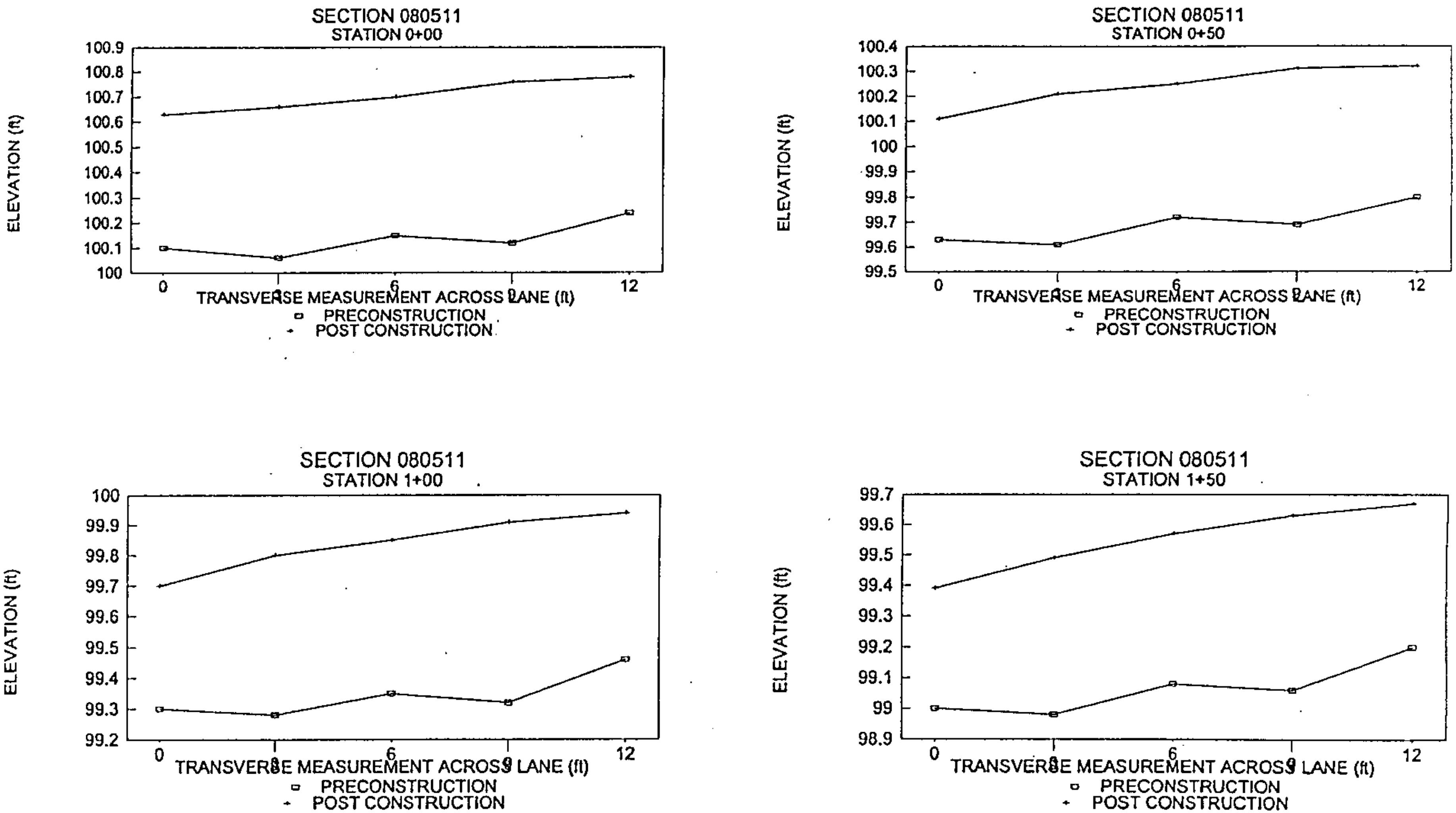
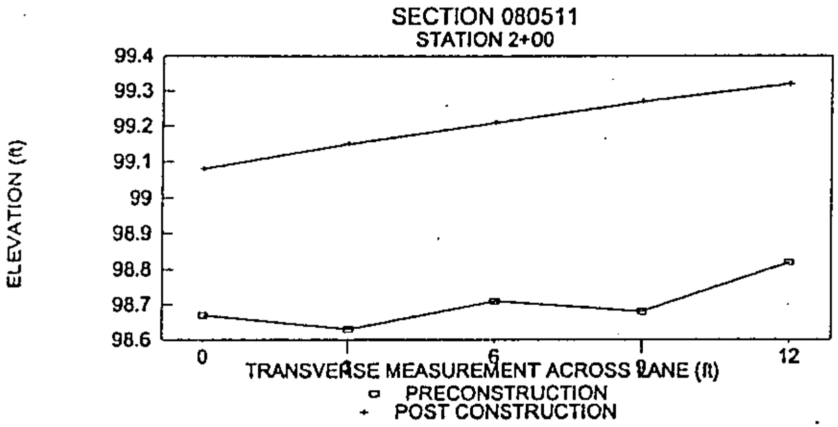
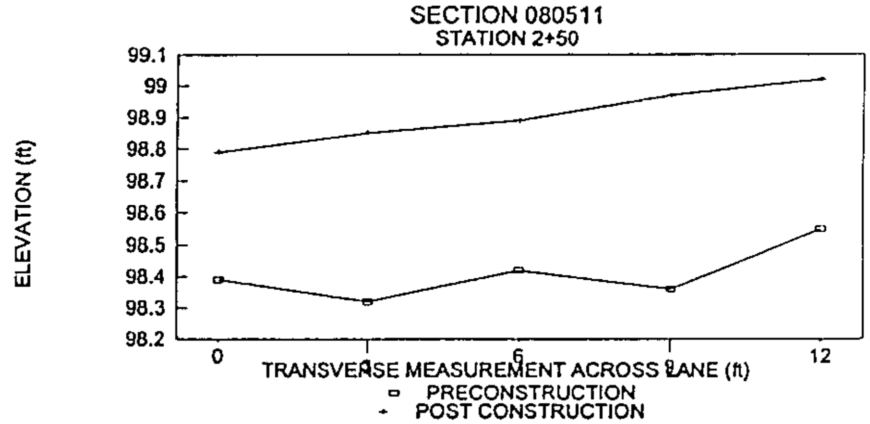
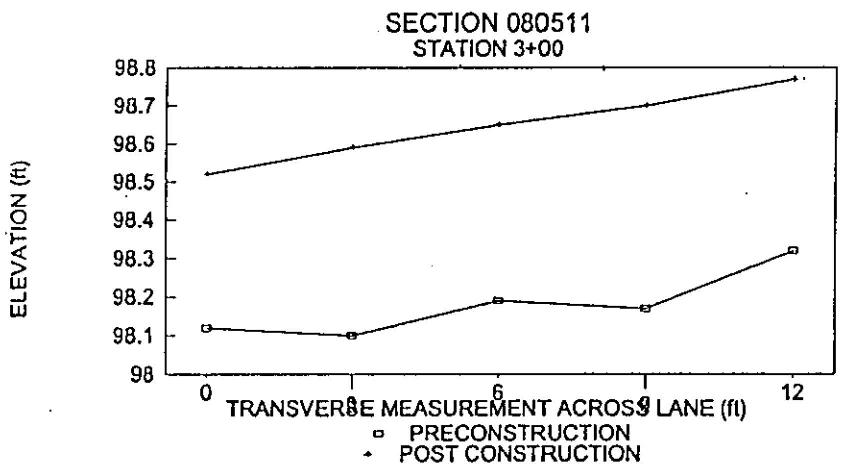
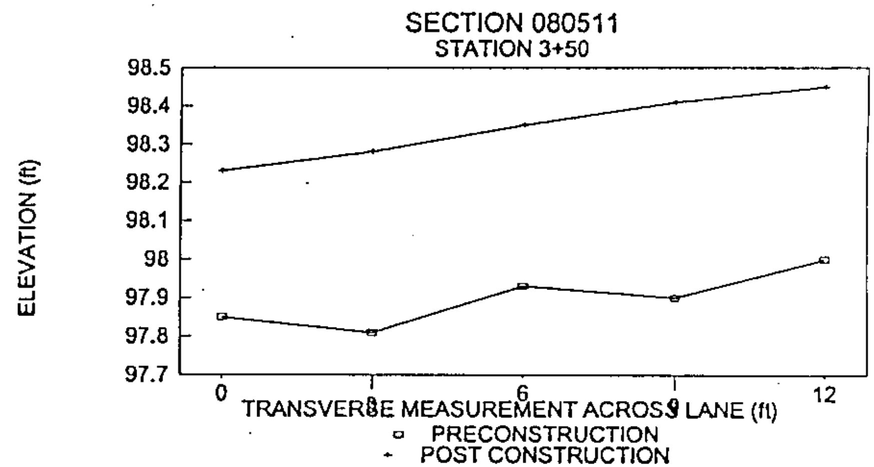


Figure A31. Section 080511









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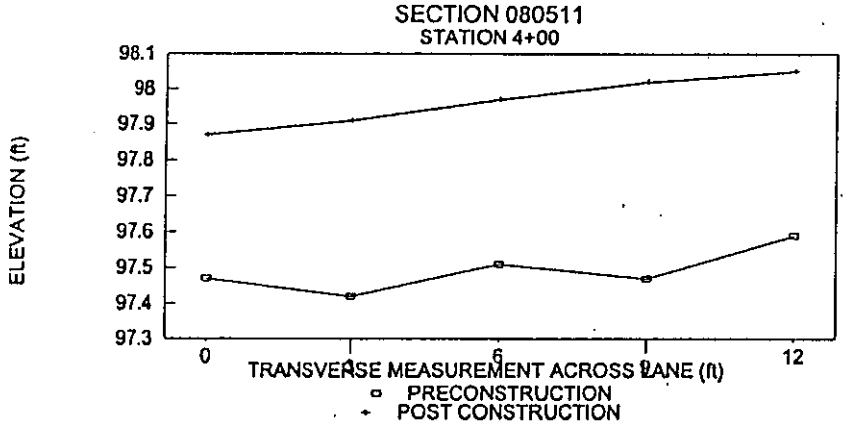

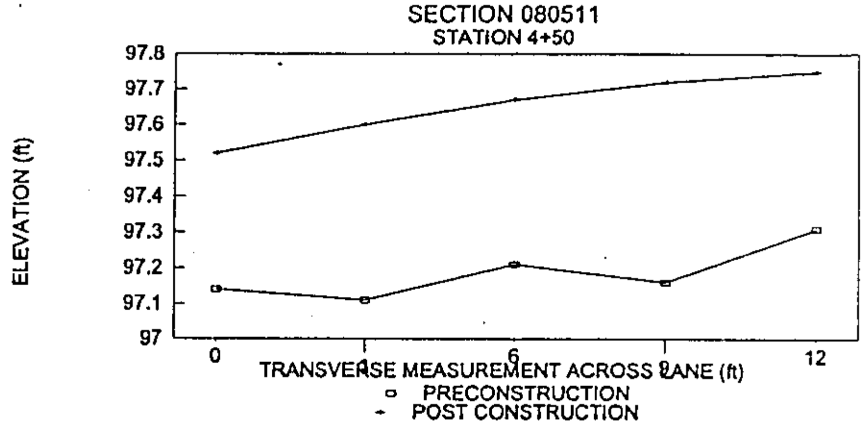

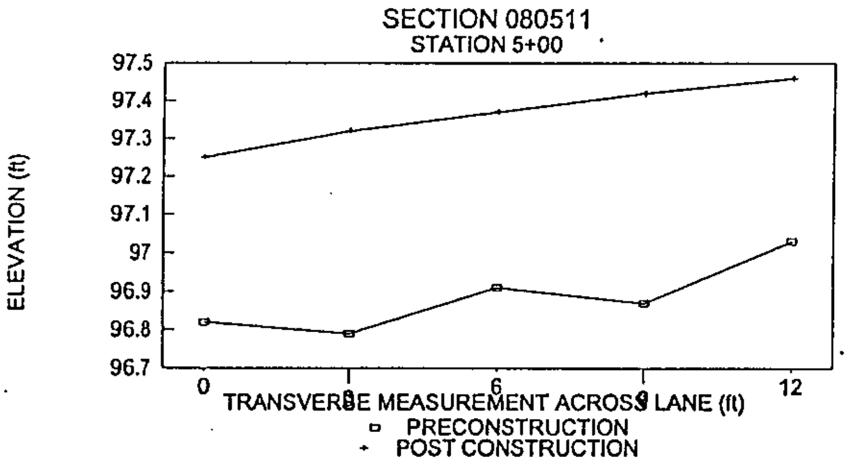

Figure A33. Section 080511 (cont.)

FEDERAL HIGHWAY ADMINISTRATION

Long Term Pavement Performance

Colorado SPS-5

FORENSIC EVALUATION REPORT

January 1995

Prepared By:

Western Region Coordination Office Contractor
Nichols Consulting Engineers, Chtd.

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CONSULTING
ENGINEERS, Chtd.

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FEDERAL HIGHWAY ADMINISTRATION

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Colorado SPS-5

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COLORADO SPS-5
FORENSIC EVALUATION REPORT

INTRODUCTION

Documented within this report is the history, the current status and forensic evaluation results for SPS-5 experimental test Site 080500 located on I-70 in eastern Colorado. Three site reviews have been performed and a forensic study was conducted. This LTPP experimental test site was constructed in October 1991. Construction methods, dates and materials are detailed in the Colorado SPS-5 Construction Report on SHRP 080500, October 1994, developed by Nichols Consulting Engineers. The test site consists of eleven test sections, as shown in Figure 1.

Four different mix designs were used throughout the project as surface mixtures. The standard LTPP experiment has a virgin AC mixture and a 30% recycled mixture. In addition to these two mixes, this project has a polymer modified mix (Section 080560) and a rut level-up mixture on Section 080501.

SITE REVIEWS

The first site review was performed in late September 1994 by the Western Region Tour Group. The group consensus was that all mixes generally were dry, with early hardening, loss of fines, the construction joint was generally poorly compacted and was open and raveling. The group recommended sealing as soon as possible. Segregation of the mix was sporadic throughout the test sections. Deflection data showed no differences between sections of very different structures, clay balls were evident throughout all sections. The group stated a materials analysis should be conducted to evaluate the reasons for early aging. They suggested strategies be developed for preventative maintenance and a forensic analysis be conducted using cores, looking a stability, asphalt content, stripping, gradation, voids, density, etc. The complete site report detailing the section-by-section review is contained in Appendix A.

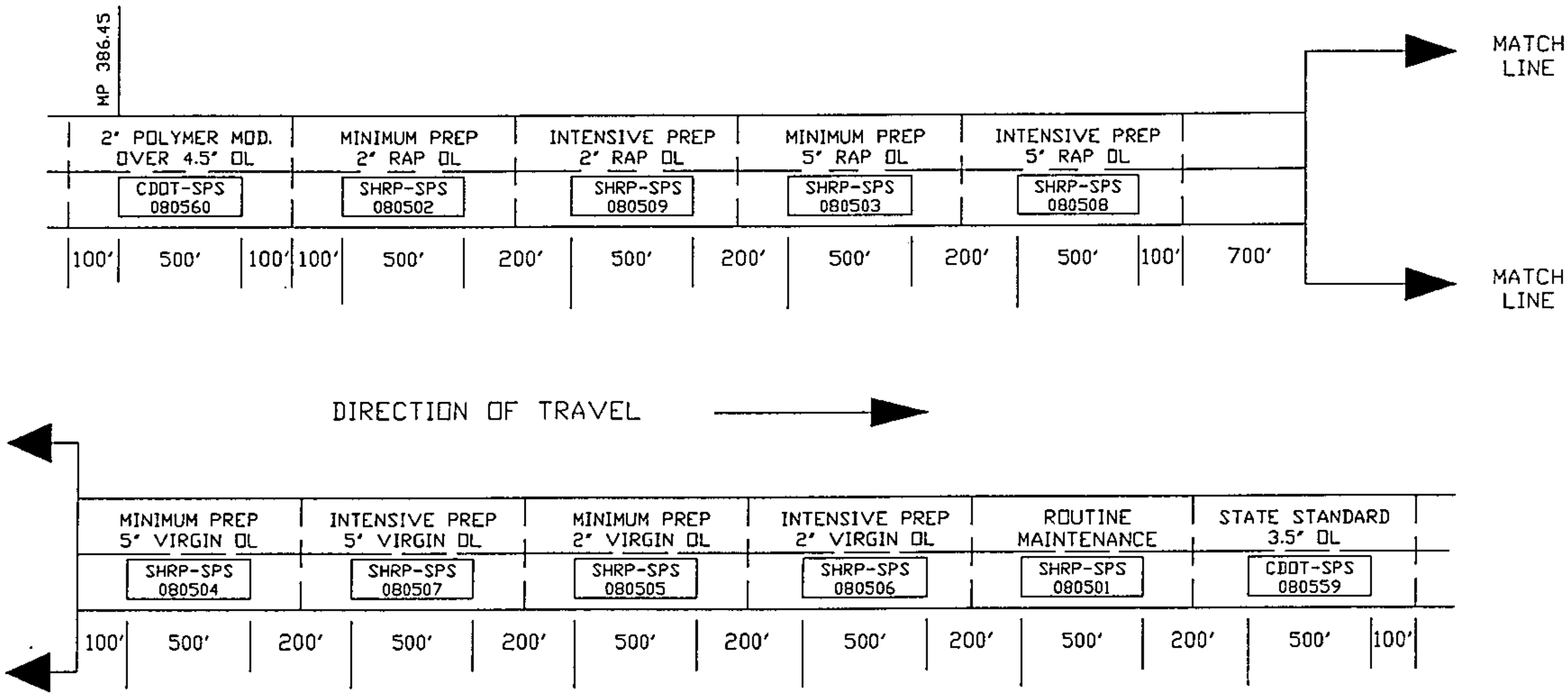
On June 8, 1994, this site was again reviewed by Ahmad Ardani (CDOT) and Doug Frith (NCE), both of which were present for the first site review. As in the previous site evaluation, the primary distress noted was ravelling of the surfacing. It was the reviewers opinion that the ravelling in the polymer modified mixture was not as severe as the virgin or recycled AC which both appeared to be comparable. Several sections were showing reflection cracking from the underlying layers, as well as fatigue cracking. The major distress in all sections was the centerline (paving) joint. The joint was diminishing rapidly due to a poor construction joint which was stripping and ravelling, losing both fine and coarse aggregate. In some locations, the centerline joint was as much as 50mm (2 in.) wide at the surface. The reviewers concluded the surface ravelling was not increasing rapidly, although there were isolated pockets with moderate severity raveling. A problem with the center of the paver was becoming very apparent by a crack, which was starting to ravel, noted at the center of the paving pass within several test sections.

SPS-5 TEST SECTION LAYOUT

0805, EAST OF LIMON, COLORADO

I-70 EASTBOUND

03/15/94



NOT TO SCALE

A third site review was conducted October 14, 1994. This site review was billed as the forensic evaluation review. Representatives from NCE, PCS/LAW, and CDOT were involved. In reviewing the site, several things were noted which could have an adverse impact on "normal" (expected) performance deterioration. Essentially, the asphalt surface appeared to have numerous locations where segregation occurred during laydown. In addition, the surface appeared to have been losing the fine aggregate portion of the asphalt mixture, exposing the coarse aggregate more than expected for a pavement of relatively recent construction. The areas of segregation will eventually result in high severity raveling and formation of potholes. The loss of fines will also result in raveling, but over a wider area. The construction joints were in very poor condition in many of the sections, in some cases opened to 50mm (2 in.) or more.

MAINTENANCE STRATEGY

During the forensic evaluation review, the site conditions and potential maintenance approaches were discussed in the field. CDOT and local district staff were enthusiastic in wanting to keep the SPS-5 project in acceptable condition, i.e., they did not want to perform any maintenance activity which would result in the project not meeting experiment requirements. At the same time, they did not want to allow this section of highway to deteriorate too much, resulting in an expensive fix. They did have maintenance budget sufficient to perform crack filling and periodic fog sealing to attempt to offset the loss of fine aggregate.

A consensus was reached among the CDOT personnel resulting in the following:

- Crack filling will be performed during the Fall 1994
- A fog seal will exceed current budget and schedule limitations, but effort will be made to apply a seal, Summer 1995
- CDOT will continue to keep WRCOC informed of activities affecting this project and maintenance activities will be reported using the appropriate data forms provided to CDOT by WRCOC

FORENSIC EVALUATION

During the forensic evaluation review, it was decided to extract a few cores from the test sections to verify the appearance and depth of the stripping. The coring was performed by CDOT October 24, 1994. Pete Pradere, representing NCE, was also present. Appendix B contains the complete report and photos as developed by Pete Pradere. Conclusions based upon the coring operation are:

(1) the visual appearance indicates distress more severe than actual in-pavement conditions,

(2) it appears the distresses are occurring on the surface and propagating deeper into the mix, and

(3) results from the coring support the proposed maintenance strategies if they are applied in a timely manner.

CONCLUSIONS

Based upon the visual condition of the test sections and the results of the coring operation, the proposed maintenance procedures should significantly prolong the life of this pavement, thus maintaining its effectiveness in the LTPP experimental study.

COLORADO

SPS-5 Limon (I-70EB)

Generally dry mix, early hardening, loss of fines, construction joint is generally poorly compacted and is open or raveling, recommend sealing ASAP. Segregation of mix sporadic throughout the test sections. Deflection data shows no differences between sections of very different structure. Should be a materials analysis conducted on these sections to evaluate the reasons for early aging. Clay balls were evident throughout all the test sections.

Strategies should be developed for preventative maintenance. Forensic analysis should be conducted using cores, looking at stability, AC, Stripping, gradation, void, density, etc.

2" Polymer Modified over 4"Conventional AC (080511)

Remarks

Slight abrasion (raveling) throughout most of section. Construction joint is open and raveled. Surface appears weathered and older than two years. Remaining life approximately 1-2 years before sealing joint and possibly surface treatment to hold fines in place.

Minimum Preparation 2" Recycled Overlay (080502)

Remarks

Abrasion (raveling) throughout but numerous occurrences of sandy material (fat spots). Some minor fatigue cracking noted at end of the section. Recommend fog seal now to preserve fines in surface then rehab at 5 years.

Intensive Preparation 2" Recycled Overlay (080509)

Remarks

Abrasion (raveling) throughout but numerous occurrences of sandy material (fat spots). Some minor fatigue cracking noted at end of the section. Recommend fog seal now to preserve fines in surface then rehab at 5 years.

Minimum Preparation 5 "Recycled (080503)

Remarks

Minor abrasion and loss of fines. The mix is extremely dry looking. Minor traffic densification in the wheel path. Some mix segregation noted. Clayballs were observed throughout the section. The centerline construction joint is raveling and is in need of immediate maintenance. Sandy fat spots throughout section. A forensic investigation should be conducted to determine the reason for the excessive aging of the pavement.

/

Intensive Preparation 5" Recycled (080508)

Remarks

Minor abrasion and loss of fines. The mix is extremely dry looking. Minor traffic densification in the wheel path. Some mix segregation noted. Clayballs were observed throughout the section. The centerline construction joint is raveling and is in need of immediate maintenance. Sandy fat spots throughout section. A forensic investigation should be conducted to determine the reason for the excessive aging of the pavement.

Minimum Preparation 5" Virgin AC (080504)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

Intensive Preparation 5" Virgin AC (080507)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

Minimum Preparation 2" Virgin AC (080505)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

Intensive Preparation 2 " Virgin AC (080506)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

Routine Maintenance (080501)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

State Standard 3" Overlay (080510)

Remarks

Some loss of fines, however it was tighter than the RAP sections. Clay balls and deleterious materials were observed throughout the sections. Some segregation of mix we noted throughout the section. Centerline construction joint was raveled and need of sealing. Sandy fat spots throughout the mix. The pavement looks excessively aged. A forensic analysis should be conducted.

NICHOLS
CONSULTING
ENGINEERS, Chtd.

MEMORANDUM

DATE: June 8, 1994 File: 800.12.4.9.10
080500

TO: Jim Nichols, Cal Berge, Pete Pradere

FROM: Doug Frith DJF

SUBJECT: Summary of Site Review on Colorado SPS-5

May 26, 1994 Ahmad Ardani and Doug Frith performed a site review of the SPS-5 section near Limon, Colorado. As time was short, the review was performed from the shoulder of the roadway without traffic control. As noted from a previous review, the primary distress type noted is raveling (loss of fines) of the AC surfacing.

Three different types of surfacing are present on this site, a polymer modified overlay, the virgin AC overlay and the 30% recycled AC overlay. Although each of these products exhibited surface raveling, the polymer modified was not as severe as the virgin or recycled AC, which both appeared to be comparable. A detailed section-by-section review was not performed, however each type of material was closely reviewed.

Several sections are showing the reflection cracking from the underlying layers as well as fatigue cracking. The major distress in all sections is the centerline (paving) joint. This joint is diminishing rapidly due to a poor construction joint which is stripping out, losing of both fine and coarse aggregate. In some locations, this centerline joint is as much as four inches wide at the surface.

After reviewing this section with the SPS tour last fall, I do not believe the surface raveling has increased rapidly, although there are isolated pockets with moderate severity raveling. A problem with the center of the paver is also very noticeable by a crack, which is starting to ravel, noted at the center of the paving pass within several sections.

It is my opinion that some form of maintenance must be performed on this section, otherwise we will see a premature failure due to mixture and construction related problems which will dilute the effectiveness of this section. I would recommend that the centerline joint be sealed with a sand seal or patched with AC and the entire surface receive some type of seal coat, such as a chip seal, slurry seal or sand seal. I would also recommend a meeting similar to the one held for the California SPS-6 be held in Colorado.

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MEMORANDUM

October 17, 1994

To: Monte Symons

From: John Miller

Subject: SPS-5 CO Site Visit

cc: Cal Berge, Doug Frith, Pete Pradere, Gonzalo Rada

This memorandum will briefly summarize the findings and resulting action items from the site visit to the SPS-5 project on I-70 near Limon Colorado. The visit was conducted by representatives from the western regional coordinating contractor, the LTPP technical assistance contractor and a number of CDOT personnel.

The visit consisted of a site review on the morning of Thursday October 14 followed by a meeting held that afternoon.

In reviewing the site several things were noted which could have an adverse impact on "normal" (expected) performance deterioration. Essentially, the asphalt surface appeared to have numerous locations where segregation occurred during laydown. In addition, the surface appeared to have been losing the fine aggregate portion of the asphalt mixture, exposing the coarse aggregate more than expected for a pavement of relatively recent construction. The areas of segregation will eventually result in high severity raveling and formation of potholes. The loss of fines will also result in raveling, but over a wider area. The construction joints were in very poor condition in many of the sections, in some cases opened to 50 mm or more.

The site conditions and potential maintenance approaches were discussed in the field. CDOT and local district staff are enthusiastic in wanting to keep the SPS-5 project in acceptable condition, i.e., they do not want to perform any maintenance activity which would result in the project not meeting experiment requirements. At the same time, they do not want to allow this section of highway to deteriorate too much, resulting in an expensive fix. They do have maintenance budget sufficient to perform crack filling and periodic fog seal to attempt to offset the loss of fine aggregate.

The LTPP TAC representative assured the CDOT personnel that surface treatments (non-structural) would not violate the experiment requirements. It was made clear to the CDOT personnel that the highway is their responsibility and that whatever maintenance activity may be needed was up to them.

A consensus was reached among the CDOT personnel resulting in the following:

1. Crack filling will be performed this year.

2. A fog seal will exceed current budget and schedule limitations but effort will be made to apply a seal, hopefully next summer.

3. CDOT will continue to keep WRCO informed of activities affecting this project and maintenance activities will be reported using the appropriate data forms provided to CDOT by WRCO.

APPENDIX B

FIELD EVALUATION & CORING OPERATION REPORT

COLORADO SPS5

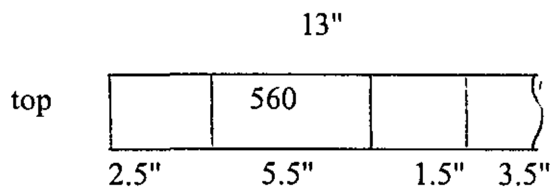
FIELD EVALUATION OF EXISTING PAVEMENT CONDITION AND CORE VISUAL EVALUATION

080560

This is a State supplementary section. There is a considerable loss of fines in the surface throughout the section and some minor loss of the coarse aggregate. There is raveling and cracking at centerline. There was some cracking in the left wheelpath near 3+00. The passing lane showed more raveling than the travel lane. Some of the loss of coarse aggregate appeared to be caused by soft degradable material.

Photo 1 - 1 thru 1 - 9

Core 560 is in good condition. There was not any damage incurred drilling the core, however there was a fair amount of asphalt floating on the drilling water which may indicate a water sensitivity problem.



Sta 0 - 15 2.5' Rt. of centerline

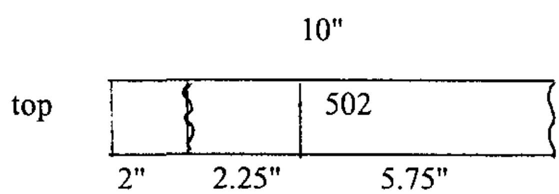
Note: Only readily identifiable lifts are shown.

080502

This is the first SHRP section on the project. There is considerable loss of fines at the beginning of the section and this decreased somewhat near the end of the section. There was raveling at the centerline joint throughout the section. There was midlane cracking near 2+20. Near the end of the section there were some random fat spots of asphalt on the surface. These were 3" to 6" blots.

Photo 1 - 9 thru 1 - 17

Core 502 broke apart 2" from the top debonding at a lift joint. There was minor fines loss due to drilling in the top 2" and at the lift joint, however the rest of the core did not show any visual loss. There was free asphalt floating on the drilling water.



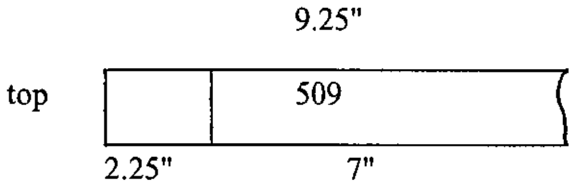
Sta 0 - 29 3.5' Rt of centerline

Note : There is a badly cracked area (3" alligator) 100' past the end of this section in the right wheelpath approximately 4' wide and 6' long. It has indications of pumping and is dished in the middle which leads you to believe this may be a subgrade failure. A core was not taken in this area as it may lead to potholing and we did not have mix to repair an area this big. Photo 1 - 18

080509 There is moderate loss of fines on the surface throughout this section. There is severe raveling at the centerline joint and some raveling at midlane within the first 200' of the section. There was considerably more distress in the passing lane near the end of the section.

Photo 1 -19 thru 1 - 25

Core 509 was taken at the edge of a crack. There was moderate loss of material along the edge of the crack down to the lift interface (2.25"). The remainder of the core did not show any distress or loss of material due to coring. There was free asphalt floating on the drilling water.

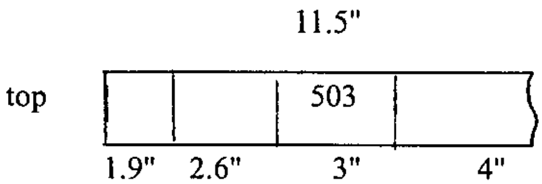


Sta 0 - 15 5' Rt. of centerline

080503 This section has experienced only minor loss of surface fines. The raveling at the centerline joint is considerably less sever and there is some distress at midlane near 1 + 00 which shows raveling and cracking.

Photo 1 - 26 thru 1 - 30

Core 503 showed a very minor loss of fines at the top lift interface. The rest of the core did not show any distress, however there was free asphalt on the drilling water.



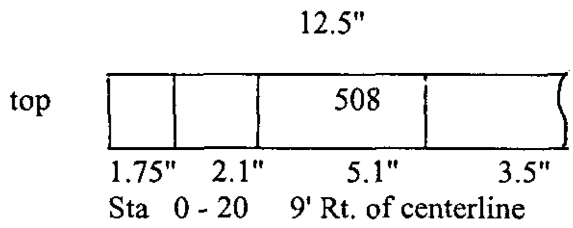
Sta 0 - 26.5 6' Rt of centerline

080508 This section shows very little distress. the surface shows some minor loss of fines. There is more loss of fines 1' to 2' lt. and rt. of centerline than in the rest of the section. There is minor raveling at the centerline joint.

There is a 4' wide by 11' long area in the right wheelpath which appears to have been a construction problem and shows some surface irregularities.

Photo 1 - 31 thru 1 - 33

Core 508 did not indicate any distress. There was free asphalt on the drilling water.

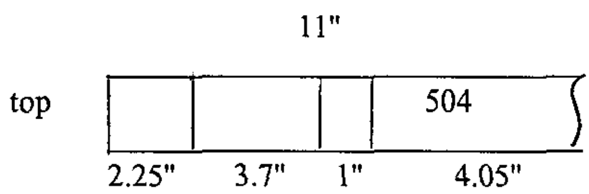


080504

There was minor loss of fines in the surface of this section. There was some cracking in the left wheelpath at the 1+05 and at midlane near the end of the section. There was little raveling at the centerline joint. There were some random fat spots of asphalt on the surface.

Photo 1 - 34 thru 1 - 37

Core 504 showed some minor loss of material at the interface 3.85" below the top surface. There was not any other distress in the core. There was free asphalt on the drilling water.

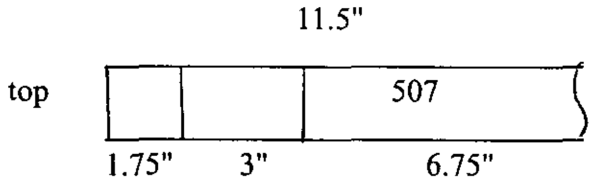


080507

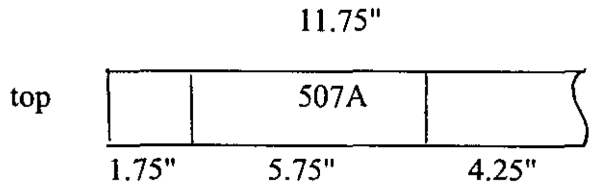
This section shows moderate loss of fines throughout the section. There is some loss of large aggregate, however this appears to be caused by soft and degradable material. There is moderate raveling at the centerline joint and there is some raveling and cracking at midlane. There is some minor longitudinal cracking in the right wheelpath.

Photo 2 - 1 thru 2 - 12

Two cores were taken from this section to compare distress levels. Core 507 was taken from a midlane raveled and cracked area. There was distress in the top lift of this core only. The crack does not extend into the second lift of plantmix. There was loss of material in the top lift, however the core remained in tact. There was free asphalt on the drilling water. Core 507A was taken in the right wheel path in what appeared to be a severely cracked and raveled area. This core showed loss of material in the top lift and minor fines loss in the rest of the core. the cracking and raveling is limited to the top lift and does not extend below it. There was free asphalt on the drilling water.



Sta 0 - 32 6' Rt. of centerline

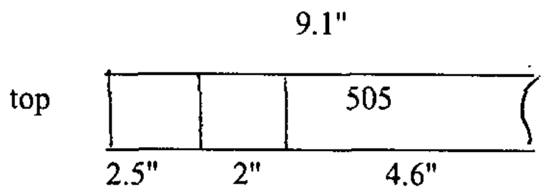


Sta 0 - 10 10.5' Rt. of centerline

080505 The surface of this section shows medium fines loss. There are several random 3' to 5' length cracked areas. There is medium raveling at the centerline joint. There were some random fat spots of asphalt on the surface.

Photo 2 - 13 thru 2 - 20

Core 505 was taken over a fairly wide crack. The top 2.5" lift fell apart and a piece of the next lift to a 1.5" depth also broke apart. There was considerable material loss in the top lift and some fines loss down to 4.5", however there was little damage to the rest of the core except for the broken area. There was free asphalt on the drilling water.

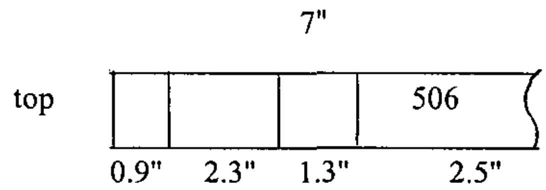


Sta 0 - 25 8' Rt. of centerline

080506 There is a considerable loss of fines in the surface. There is heavy raveling in the centerline joint and some raveling and cracking at midlane throughout the section.

Photo 2 - 21 thru 2 - 25

Core 506 was taken from the right edge of the lane where raveling was more sever. There was loss of fines in the top 1" and a minor loss of fines in the bottom lift. There was free asphalt on the drilling water.



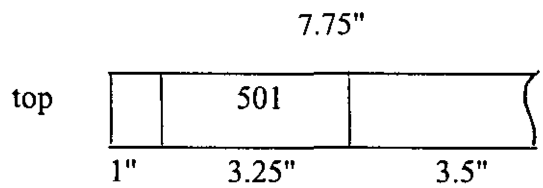
Sta 0 - 13.5 11' Rt. of centerline

080501

Photo 3 - 1 thru 3 - 4

There is only minor loss of fines in the surface of this section. The raveling at the centerline joint is less than other sections. There are some random transverse cracks 3' to 5' in length in the last 150' of this section. There appears to be some light rutting (.25" to .5") in the left wheelpath.

Core 501 shows no distresses. There was free asphalt on the drilling water.



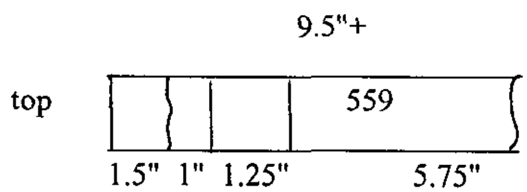
Sta 0 - 13 6' Rt. of centerline

080559

Photo 3 - 5 thru 3 - 10

There was some loss of fines in the surface. There was cracking and raveling in the right wheelpath at the beginning of the section only. There was some minor raveling at midlane and raveling at the centerline joint from 2 + 90 to the end of the section. There were random asphalt fat spots throughout the section. There is minor rutting in both wheelpaths (.25").

Core 559 was taken from a crack in the left wheelpath. The entire length of the core could not be retrieved. It was drilled to a depth to 18", the core barrel length, however this did not reach the total depth and the core broke at 9.5" after considerable effort was made trying to lift the core out. The top 1.5" delaminated and broke apart. The crack extended 2.5" in the core. Visual observation of the core hole showed the crack is propagating from the top down into the lower layers. There was <u>not</u> any free asphalt in the drilling water.



Sta 0 - 15 3' Rt of centerline

SUMMARY

This project is three years old. The surface of all sections appears aged, dry, and brittle. There is loss of fines in the surface throughout all test sections. There is cracking and raveling of the centerline joint and at midlane in almost all sections. There is cracking both longitudinal and transverse to varying degrees in most of the sections.

All of the above distresses appear to be related to a moisture sensitive mix. The stripping of the asphalt during the core drilling tends to substantiate this. The visual appearance indicates distresses more sever than actual condition. From the core evaluations it appears the distresses are occurring at the surface and propagating deeper into the mix. At this time it appears the majority of the distresses are located in the top 1.5" of the mix and only this deep in areas where moisture can penetrate; such as cracks and the raveled centerline joint.

A meeting was held with personnel from Colorado DOT, PCS Law, and NCE prior to coring this project. At this meeting CDOT recommended sealing all cracks and raveled joints this fall and placing a sand seal on the entire surface next spring. The cores from this project support this maintenance strategy and if it can be accomplished in a timely fashion should reduce the deterioration of this project considerably.

Pierre F. Pradere

PIERRE F. PRADERE P.E.

PHOTOLOG COLORADO SPS 5
CORE EVALUATION

TEST SECTION	PHOTO	DESCRIPTION
080560	1-1	Begin section looking east
	1-2	Surface condition at beginning of section
	1-3	Core drilling
	1-4	Core drilling with free asphalt on water
	1-5	Core drilling with core still in place
	1-6	Core 560
	1-7	Raveled areas in passing lane
	1-8	3+00 looking east - distressed area in wheelpath
080502	1-9	Beginning of section looking east
	1-10	Core hole with broken core
	1-11	Core hole with broken core
	1-12	Core 502
	1-13	Centerline joint raveling
	1-14	Closeup of centerline joint raveling
	1-15	2+20 looking east - midlane raveling and cracking
	1-16	Fat spots of asphalt on surface
	1-17	Closeup of fat spots
	1-18	Dished failure 100' past end of section
080509	1-19	Beginning of section looking east
	1-20	Core hole and core with free asphalt on water
	1-21	Core 509
	1-22	Closeup core 509
	1-23	Centerline joint raveling
	1-24	Centerline joint raveling
	1-25	Distress in passing lane near the end of the section
080503	1-26	Beginning of section looking east
	1-27	Core 503
	1-28	Core 503
	1-29	Distress near 1+00
	1-30	Distress near 1+00
080508	1-31	Beginning of section looking east
	1-32	Core 508

	1-33	Distressed area 1+40
080504	1-34	Beginning of section looking east
	1-35	Core 504
	1-36	Cracking at 1+05
	1-37	Cracking at midlane 4+70 to end of section
080507	2-1	Coring on a crack
	2-2	Beginning of section looking east
	2-3	Core 507 top
	2-4	Core 507
	2-5	Core 507
	2-6	Core 507
	2-7	Coring core 507A
	2-8	Core 507A top
	2-9	Core 507A
	2-10	Core 507A
	2-11	Raveling rt. wheelpath around 1+00
	2-12	1+70 Cracking and raveling
080505	2-13	Coring cracked area
	2-14	Core 505
	2-15	Closeup of core 505
	2-16	Closeup of core 505
	2-17	Close up of core 505
	2-18	Core hole on a crack
	2-19	Core hole on a crack
	2-20	Crack with some pumping
080506	2-21	Coring distressed area
	2-22	Core 506 top
	2-23	Core 506
	2-24	1+00 looking east
	2-25	3+70 looking east
080501	3-1	Beginning of section looking east
	3-2	Core 501 top
	3-3	Core 501
	3-4	1+30 looking east rutting lt. wheelpath
080559	3-5	Beginning of section looking east
	3-6	Coring on crack
	3-7	Core 559 top
	3-8	Core 509
	3-9	Core 509
	3-10	Random fat spots of asphalt on the surface